

M.L. 2013 Projects

[MN Laws 2013, Chapter 52](#), Section 2 (beginning July 1, 2013)

Subd. 03 Natural Resource Data and Information

County Geologic Atlases - Part B for Water Resource Sustainability - RESEARCH

Subd. 03c \$1,200,000 TF

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Appropriation Language

\$1,200,000 the first year is from the trust fund to the commissioner of natural resources to continue the analysis and compilation of groundwater data for the production of county geologic atlases, publication of geospatial groundwater data, and continued mapping of springsheds and karst features for Winona and Houston Counties. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

The Minnesota County Geologic Atlas program is an ongoing effort begun in 1979 that is being conducted jointly by the University of Minnesota's Minnesota Geological Survey and the Minnesota Department of Natural Resources (DNR). This portion, called Part B and conducted by the DNR, analyzes water samples to understand water chemistry and sensitivity to pollution. The information is used in planning and environmental protection efforts at all levels of government, by businesses, and by homeowners to ensure sound and sustainable planning, management, and protection of water resources used for drinking, agriculture, industry, and more. This appropriation will continue or complete work on Part B geologic atlases for Blue Earth, Chisago, Nicollet, Sibley, Anoka, Wright, Renville, and Clay counties and potentially begin work on Part B atlases for Sherburne and Morrison counties. Additionally springshed mapping will be continued in the karst area of southeastern Minnesota in Winona, Houston, and Fillmore counties.

OVERALL PROJECT OUTCOME AND RESULTS

The County Geologic Atlas and Special Projects unit provides information about groundwater to help citizens and organizations improve sustainable management of groundwater resources. Delineated and mapped aquifers, recharge areas, and springsheds are essential information to help guide management decisions.

The County Geologic Atlas (CGA) Part B describes the hydrogeologic setting, water levels, chemistry, pollution sensitivity, and groundwater use in a county. It includes selected hydrogeologic cross sections indicating groundwater flow direction, residence time within aquifers and groundwater-surface water interactions. Completed counties that were partially funded by this project include Chisago, Nicollet, Sibley, Blue Earth, and Anoka. Also partially funded by this project, with plans to complete after June 30, 2017, are Renville, Clay, Sherburne, Wright, Houston, Winona, Morrison, and Meeker counties.

The Minnesota Hydrogeology Atlas (MHA) contains statewide thematic maps that have compiled information previously only available in the county format. This wider information is useful in multi-county or watershed evaluations. Statewide thematic maps include "Pollution Sensitivity of the Bedrock Surface" (HG-01), "Pollution Sensitivity of Near-Surface Materials" (HG-02), "Water-Table Elevation and Depth" (HG-03), and Minnesota Regions Prone to Surface Karst Feature Development (GW-01). Method documents (found on the Resources web

page) include: "Methods to Estimate Near-Surface Pollution Sensitivity" (GW-03), and "Methods for Estimating Water-table Elevation and Depth to Water Table" (GW-04).

Springshed Mapping partial funding was provided to determine the size and nature of the land area contributing to groundwater and spring discharge. Studies are conducted by introducing dye into sinkholes or sinking streams and monitoring resurgences at nearby springs. Understanding the extent of springsheds is important for protection of numerous trout fisheries in southeastern Minnesota. Over 100 springshed mapping reports are now available on the "Dye Trace Reports" page. The current area of mapped springsheds in Minnesota is 348 square miles.

PROJECT RESULTS USE AND DISSEMINATION

This funding helps produce three types of products, found at:

http://www.dnr.state.mn.us/waters/groundwater_section/mapping/atlasses.html and described as follows.

Activity 1 – County Geologic Atlas, Part B

DNR staff assisted with development and delivery of training sessions at four Soil and Water Conservation District (SWCD) conferences at various locations in the state in 2015 DNR presented information about CGA content and uses.

Activity 2 – Minnesota Hydrogeologic Atlas

Springshed mapping and preliminary MHA results were presented at the University of Minnesota Water Resources Conference in September 2015.

DNR CGA staff and others presented general groundwater education workshops to Soil and Water Conservation District (SWCD) in Duluth, Thief River, and St. Peter in 2016. The workshops provided examples of how to use the MHA products.

Activity 3 -- Springshed Mapping

The springshed work was the subject of a feature article in the March-April 2016 issue of the Minnesota Conservation Volunteer (113,000 copies in print). The article emphasized the importance of land use management and the discovery that springs emanating from deep strata in the incised valleys of the Driftless Area can be connected to the land surface. The article is available on-line at:

http://www.dnr.state.mn.us/waters/groundwater_section/mapping/atlasses.html

Project Completed: 6/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

Subd. 04 Land, Habitat, Restoration and Recreation

Metropolitan Conservation Corridors (MeCC) - Phase VII

Subd. 04d \$2,000,000 TF

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Appropriation Language

\$2,000,000 the first year is from the trust fund for the acceleration of agency programs and cooperative agreements. Of this appropriation, \$10,000 is to the commissioner of natural resources for agency programs and \$1,990,000 is to the commissioner of natural resources for agreements as follows: \$304,000 with Friends of the Mississippi River; \$368,000 with Dakota County; \$208,000 with Great River Greening; \$310,000 with Minnesota

Land Trust; \$400,000 with Minnesota Valley National Wildlife Refuge Trust, Inc.; and \$400,000 with the Trust for Public Land for planning, restoring, and protecting priority natural areas in the metropolitan area, as defined under Minnesota Statutes, section 473.121, subdivision 2, and portions of the surrounding counties, through contracted services, technical assistance, conservation easements, and fee title acquisition. Land acquired with this appropriation must be sufficiently improved to meet at least minimum management standards, as determined by the commissioner of natural resources. Expenditures are limited to the identified project corridor areas as defined in the work plan. This appropriation may not be used for the purchase of habitable residential structures, unless expressly approved in the work plan. All conservation easements must be perpetual and have a natural resource management plan. Any land acquired in fee title by the commissioner of natural resources with money from this appropriation must be designated as an outdoor recreation unit under Minnesota Statutes, section 86A.07. The commissioner may similarly designate any lands acquired in less than fee title. A list of proposed restorations and fee title and easement acquisitions must be provided as part of the required work plan. Lands that would require payments in lieu of taxes under Minnesota Statutes, section 97A.061 or 477A.12, shall not be acquired with money from this appropriation. Up to \$54,000 is for use by Minnesota Land Trust in a monitoring and enforcement fund as approved in the work plan and subject to subdivision 16. An entity that acquires a conservation easement with appropriations from the trust fund must have a long-term stewardship plan for the easement and a fund established for monitoring and enforcing the agreement. Money appropriated from the trust fund for easement acquisition may be used to establish a monitoring, management, and enforcement fund as approved in the work plan. An annual financial report is required for any monitoring, management, and enforcement fund established, including expenditures from the fund. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Though many parts of the Twin Cities metropolitan area are urbanized, there are also has large areas of natural lands that continue to serve as important habitat for fish, wildlife, and plant communities. However, pressure on these remaining lands continues to intensify as population and development pressures increase. This appropriation represents the seventh phase of an ongoing effort by a partnership of state and non-profit organizations, called the Metro Conservation Corridors (MeCC) partnership, to conduct strategic and coordinated land protection, restoration, and enhancement activities that build connections between remaining high quality natural areas in the greater Twin Cities metropolitan area and ensures their benefits are available for future generations. Efforts will strengthen and protect biodiversity; improve water quality in lakes, rivers, and streams; and improve connectivity and access to outdoor recreation. This phase involves six partners and is expected to result in the permanent protection of more than 260 acres and the restoration and enhancement of more than 260 acres. Organizations involved in this phase include Dakota County, Friends of the Mississippi River, Great River Greening, Minnesota Land Trust, MN Valley National Wildlife Refuge Trust, and Trust for Public Land.

Individual Partner Project Overviews

- *1.1/1.2: Coordination and Mapping - [Minnesota Land Trust](#) (\$20,000)*
The Minnesota Land Trust provides coordination, mapping, and data management for the Metropolitan Conservation Corridors partnership. Funds are being used to coordinate the partnership, guide strategic outreach and implementation efforts, manage project data, and provide reporting and mapping of accomplishments.
- *2.1 & 3.4: Protect, Restore and Enhance Significant Watershed Habitat - [Friends of the Mississippi River](#) (\$304,000)*
Friends of the Mississippi is using this appropriation to permanently protect six acres through fee title acquisition for addition to Fish Creek Natural Area near Maplewood, MN, and to restore and enhance approximately 134 acres of permanently protected prairie, savanna, wetland, and forest habitat in Dakota, Washington, Ramsey, and Hennepin counties. Specific restoration and enhancement activities will include updating management plans, soil preparation, prescribed burning, native vegetation installation, woody encroachment removal, and invasive species control.
- *2.3: Restoring Our Lands and Waters - [Great River Greening](#) (\$208,000)*
These funds will enable Great River Greening to restore approximately 90 acres of permanently protected

forests, savanna, prairie, and wetland habitat and 0.18 miles of shoreland habitat while engaging hundreds of volunteers in the stewardship of the Metropolitan area's remaining natural areas. Specific activities include invasive species control, seeding/planting, prescribed burning, and other associated activities.

- **2.6 & 3.7: Dakota County Lakeshore and Riparian Protection - [Dakota County](#) (\$368,000)**
Through this appropriation Dakota County plans to permanently protect approximately 27 acres of shoreland and contiguous upland in the Marcott Lakes area of Inver Grove Heights by securing a conservation easement from willing landowner. For all acres protected, natural resource management plans will be prepared to ensure their long term stewardship. Additionally, restoration and enhancement activities are expected to occur on approximately 40 acres.
- **3.1: 2013 TPLs Critical Land Protection Program - [Trust for Public Land](#) (\$400,000)**
The Trust for Public Land is using this appropriation to purchase approximately 24 acres of land and 0.2 miles of shoreline with high ecological value and then convey the land to state or local governments for long-term stewardship and protection. Lands being considered for permanent protection in this round of funding include an area around the Rum River in Anoka County, Lindstrom Natural Area in Chisago County, and Carnelian Creek and Keystone Woods area in Washington County.
- **3.2: Protect Significant Habitat by Acquiring Conservation Easements - [Minnesota Land Trust](#) (\$300,000)**
With this appropriation, the Minnesota Land Trust plans to protect 100 acres of high quality forest, prairie, wetland, or shoreline habitat by securing permanent conservation easements and dedicating funds for their perpetual monitoring, management, and enforcement. Lands being considered for permanent protection in this round of funding are located in Chisago, Goodhue, Hennepin, Isanti, and Washington counties.
- **3.3: Priority Expansion of Minnesota Valley National Wildlife Refuge - [Minnesota Valley National Wildlife Refuge Trust Inc.](#) (\$400,000)**
The Minnesota Valley National Wildlife Refuge Trust is using this appropriation to purchase a total of approximately 100 acres of land and donated to the U.S. Fish and Wildlife Service to expand the Minnesota Valley National Wildlife Refuge. Many benefits are anticipated from this project, including improved habitat connectivity, protection of native species, improved water quality in the Minnesota River, and increased public access to natural lands for activities such as hiking, hunting, and fishing. Restoration and management plans will be completed for all acquired lands.

OVERALL PROJECT OUTCOME AND RESULTS

Metro Conservation Corridors partners continued their work to accelerate protection and restoration of high-quality natural lands within the greater Twin Cities Metropolitan Area. Six partner organizations participated - Minnesota Land Trust, Friends of the Mississippi River, Dakota County, Great River Greening, Trust for Public Land, and Minnesota Valley National Wildlife Trust. Minnesota Valley National Wildlife Trust received a 1-year extension to their grant and will report their final outcomes separately. Three specific areas of activity were pursued:

1. **Partnership Coordination, Mapping, and Database Management:** An upgrade to the MeCC web-based project database was completed and the MeCC corridor map was revised and posted for public use. Partners met quarterly to review project accomplishments, share information, and to strategically plan and coordinate conservation activities.
2. **Restore and Enhance Significant Habitat:** Partners restored/enhanced 364.5 acres of habitat (282.6 acres through ENRTF) and 0.42 miles of shoreline (0.35 miles ENRTF), exceeding overall proposed outcomes in both areas and leveraging an additional \$342,658. Despite the Partnership achieving its collective goals, Dakota County fell short of its habitat restoration/enhancement goal by 75%, returning \$17,000 (42%) of its funding for this activity. A landowner with whom they expected to work instead opted to enroll in CRP, ultimately restoring habitat and receiving a payment.

Partner	Proposed (Habitat/Shoreline)	Accomplished Habitat/Shoreline (ENRTF)	Accomplished Habitat/Shoreline (Other)	Expenditures (ENRTF / Other)
Friends of the Mississippi River	134 acres/0 miles	135.5 acres/0 miles	0.0 acres/0 miles	\$142,000/\$4,546

Great River Greening	90 acres/0.18 miles	137 acres/0.35 miles	73 acres/0.07 miles	\$184,270/\$315,178
Dakota County	40 acres/0 miles	10.1 acres/0 miles	8.9 acres/0 miles	\$22,808/\$22,935
Totals	264 acres/0.18 miles	282.6 acres/0.35 miles	81.9 acres/0.07 miles	\$349,078/\$342,658

3. **Acquire Significant Habitat:** Partners protected 308 acres of land (189 acres ENRTF) and 2.5 miles of shoreline (1.25 miles ENRTF) through fee and conservation easement acquisition. This exceeded proposed outcomes for shoreline protection by 625% (0.2 miles proposed vs 1.25 miles achieved), but fell short in acres protected by 28% (189 acres achieved vs 262 proposed). The \$1,053,216 from ENRTF leveraged \$3,373,183 through other sources.

Two partners turned back funding:

- Minnesota Land Trust was unable to complete an easement due to financial considerations or tax implications of easements on the part of landowners. \$251,388 (84% of grant) was returned.
- Dakota County exceeded its proposed protection goals, but turned back \$132,196 (40% of its grant for protection) due to setbacks with two landowners.

The amount of funding returned to the State (33% of total appropriation for protection) is proportional to the shortfall in ENRTF acres protected (28% below goal).

PROJECT RESULTS USE AND DISSEMINATION

Partners publicized accomplishments through a diverse array of press releases, organization newsletters and the internet. Additionally, the MeCC Partnership maintains an interactive public web map that shows the locations of MeCC projects over time. This web map can be directly accessed at:

<http://www.dnr.state.mn.us/maps/MeCC/mapper.html>.

ABSTRACTS AND FINAL REPORTS OF INDIVIDUAL PARTNER PROJECTS (Click project # to go to listing for that project)

- [1.1/1.2](#) - MeCC VII - Coordination and Mapping - [Minnesota Land Trust](#) (\$20,000)
- [2.1/3.4](#) - MeCC VII - Protect, Restore and Enhance Significant Watershed Habitat - Friends of the Mississippi River - [Friends of the Mississippi River](#) (\$304,000)
- [2.3](#) - MeCC VII - Restoring Our Lands and Waters - [Great River Greening](#) (\$208,000)
- [2.6/3.7](#) - MeCC VII - Dakota County Lakeshore and Riparian Protection - [Dakota County](#) (\$368,000)
- [3.1](#) - MeCC VII - 2013 TPL's Critical Land Protection Program - [Trust for Public Land](#) (\$400,000)
- [3.2](#) - MeCC VII - Protect Significant Habitat by Acquiring Conservation Easements - [Minnesota Land Trust](#) (\$300,000)
- [2.6/3.3](#) - MeCC VI - Priority Expansion and Restoration MN Valley NW Refuge - [Minnesota Valley National Wildlife Refuge Trust, Inc.](#) (\$400,000)

[2.6/3.3 FINAL REPORT](#) - MeCC VII-3.3 - Priority Expansion of the MN Valley National Wildlife Refuge - [Minnesota Valley National Wildlife Refuge Trust, Inc.](#) (\$400,000)

Project Outcome and Results

The Minnesota Valley Trust's goal with this \$400,000 ENRTF grant was to acquire 100 priority acres to expand the Minnesota Valley National Wildlife Refuge. The Minnesota Valley Trust exceeded the acreage goal by acquiring in fee title 121.36 acres, while spending only \$246,800 of the grant.

Specifically, the ENRTF grant acquired 23.6 acres for the Bloomington Ferry Unit and 97.76 acres for the Louisville Swamp Unit of the Minnesota Valley National Wildlife Refuge (Refuge).

Another 4.5 acre parcel was acquired by the Minnesota Valley Trust with leveraged, non-state funds for the San Francisco Unit of the Refuge. While we had other non-state funds available to spend as leverage, we did not have the opportunity to close on other acquisitions during the grant timeframe.

Acquisition of the Bloomington Ferry Unit parcel was a high priority for the completion and management of that unit of the Refuge. The parcel acquired contains floodplain forest habitat and frontage on the Minnesota River.

Acquisition of the Louisville Swamp Unit parcel was a high priority for the completion and management of that unit of the Refuge. This protects floodplain forest habitat and gains full management of a large wetland bordered by USFWS and the seller's property.

Many species of wildlife will benefit by Refuge management of these parcels, including wood ducks, mallards, bald eagles, grassland nesting birds as well as numerous resident game species such as turkeys and deer. Both properties will provide opportunities for the public to participate in wildlife dependent outdoor activities. The land will also serve as an outdoor classroom for environmental education activities for schools and environmental organizations.

In addition, public ownership of these properties will ensure long-term access for the State Trail, which ran through the Louisville Swamp Unit under a lease agreement between the DNR and the former landowner and (2) needs to cross the Bloomington Ferry Unit property. We have finalized a new no-cost lease agreement with the DNR for operation of the State Trail on the Louisville Swamp Unit property. The USFWS intends to allow the DNR to complete and manage the State Trail on the Bloomington Ferry Unit property.

Project Results Use And Dissemination

The properties acquired are posted open to the public for Refuge-approved uses. The Minnesota Valley Trust's website (mnvalleytrust.org) has been updated to announce these acquisitions. A press release has been sent to the local newspapers (Jordan Independent and Bloomington Sun Current).

Project Completed: 6/30/2017 [2.6/3.3 MN Valley NW Refuge Only Extended in M.L. 2016, Chapter 186 to 6/30/2017]

[FINAL REPORT](#)

Moose Habitat Restoration Techniques in Northeastern Minnesota - RESEARCH

Research Project

Subd. 04g \$200,000 TF

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Appropriation Language

\$200,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the Natural Resources Research Institute to develop best practices guidelines for creating moose foraging habitat efficiently and cost-effectively. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Moose, one of Minnesota's most iconic wildlife species, are dying at increasingly higher rates in Minnesota and there is uncertainty as to why. Estimates suggest the population declined 35 percent just between 2012 to 2013, and projections suggest moose could be nearly gone from the state by 2020 if this trend is not halted and, ideally, reversed. Scientists at the University of Minnesota are using this appropriation to identify appropriate management and habitat needs and the sorts of actions that can be implemented to help slow or prevent continued population declines amongst Minnesota's moose populations. The project is a continuation and expansion of work completed and underway by two other past Environment and Natural Resources Trust Fund supported projects on determining the cause for the increasing mortality.

OVERALL PROJECT OUTCOME AND RESULTS

The main outcome of this project was documenting browse species regeneration after the Ham Lake, Cavity Lake and Pagami Creek fires in the BWCA, and after forest harvest, shearing, and smaller prescribed burns. These results were used in part to inform habitat restoration decisions for an Outdoor Heritage Fund project. Differences in browse species production were similar to variation in moose range across Minnesota and across North America. About 5 species usually comprise 80% of the browse eaten in summer and in winter.

Winter and summer browsing was measured. At each site 5 transects were walked and browse species use and availability was recorded at 20 plots along each transect. We measured 176 stands covering 11,536 acres that were harvested, sheared, or burned, and 66 sites in the BWCA burns. Browse availability increased within 4 years of treatment, and leveled off within 10 years. Browse species were similar in harvested stands, sheared stands, burned stands, and the large BWCA fires. The most common browse species were hazel, aspen, and paper birch. Other species were mountain maple, willow, balsam fir, pin cherry, chokecherry, juneberry, red osier, and red maple. Mountain ash, a highly preferred browse species, was present on about 10% of stands.

Browsing intensity is affected by species composition and by moose density. All browse species were eaten, with the less common species eaten more frequently. Low browsing levels would be expected with low moose densities in Minnesota. About 2% of twigs were browsed in summer, and about 15% of twigs were browsed in winter. Regardless of whether a stand was harvested, sheared, or burned, browsing level by moose was similar. It is unlikely that browse is limiting the moose population. MN DNR projects show low moose survival rates. Adult mortalities are caused by predation and by health-related issues, calf mortalities are primarily caused by predation. If survival rates increase, browse could be more limiting.

PROJECT RESULTS USE AND DISSEMINATION

Overall this project resulted in significant outreach to the public and to resource management agency personnel. Over the course of the project we had 71 presentations to different audiences, ranging from professional conferences, college courses, and the public. There were 5 M.S. graduate students who were supported in part by this project and have already graduated, and 1 Ph.D. student who defended in spring 2018. Publications arising from this project include 5 M.S. theses, 1 Ph.D. thesis (not quite completed), 9 technical reports, and 9 peer-reviewed publications. There were also at least 8 different media contacts which appeared in print, on the radio, or on television.

Goal 3 identified in the work plan was to continue to involve the public, biologists, and organizations in a coordinated effort to slow or prevent a continuing decline of the NE MN moose population. This is important because of the combined research effort among biologists, agencies, and organizations. Concern about moose in Minnesota is real, and is evident in the way moose research transcends agency jurisdiction and even the international boundary. Collectively, the research project, the meetings of Minnesota moose biologists, and involvement of the public made it possible to meet this goal.

Project Completed: 6/30/2016

[FINAL REPORT](#)

[Bee Lawn Brochure](#)

[Bee Lawn Info](#)

Conservation Grazing to Improve Wildlife Habitat on Wildlife Management Areas

Subd. 04i \$600,000 TF

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Appropriation Language

\$600,000 the first year is from the trust fund to the commissioner of natural resources to develop grazing plans and provide infrastructure to support conservation grazing on approximately 10,000 acres of targeted wildlife management areas in partnership with local livestock producers. Any revenue generated as a result of this appropriation must be reinvested in producing plans, conducting maintenance, or building infrastructure for new or existing conservation grazing efforts. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Grassland ecosystems evolved to depend on periodic disturbances, such as fire and grazing, to maintain their health and stability. Periodic disturbances help control invasive species, add nutrients back into the soil, germinate plant seeds, enhance wildlife habitat, and more. In Minnesota habitat managers have used fire as a disturbance tool for decades but the use of grazing has been much rarer, mostly because of a lack of necessary infrastructure such as fencing. This appropriation is being used by the Minnesota Department of Natural Resources to provide the infrastructure needed to support conservation grazing on 10,000 acres of targeted wildlife management areas to demonstrate that grazing can be effectively and cost-efficiently implemented to improve grassland habitat quality and ecological integrity in Minnesota.

OVERALL PROJECT OUTCOME AND RESULTS

The intent was to use conservation grazing as an added ecological disturbance to the traditional practice of prescribed fire. With this appropriation we were able to install permanent fence 2832 acres on eight Wildlife Management Areas. These units are near major roadways where permanent fencing is required. In more rural areas on gravel township roads we are primarily using temporary electric fencing. Those who have hunted grazed WMAs have reported a high success rate and state that they have seen an abundance of game and nongame wildlife.

Unit	Size	Fence Length
Vermillion River WMA	160 acres	10,770 ft
Fergus WMA	253 acres	17,040 ft
Doran WMA	544 acres	36,650 ft
Rothsay WMA	100 acres	6,740 ft
Barnesville WMA	125 acres	8,420 ft
Sem WMA	417 acres	28,090 ft
Regal Meadows WMA	502 acres	25,470 ft
Hole in the Mountain WMA	731 acres	41,400 ft
TOTAL	2,832 acres	174,590 ft

We did do some pre-grazing data collection on some sites as well as assessments to determine if grazing was a suitable management tool for a WMA. The conservation community (DNR, FWS, TNC, others) is still working to develop monitoring protocols that can be shared that meet multiple uses. Some of the monitoring was simply comparing different methods and protocols to decide on a plan for moving forward with large-scale monitoring under the Prairie Plan. This was a much more challenging issue than anticipated and this work continues. Due to staff turnover in the DNR and after continued conversations with educators we were not able to complete any of the education component of this project.

PROJECT RESULTS USE AND DISSEMINATION

We have used several outreach strategies for our overall conservation grazing initiative. DNR staff have published articles on conservation grazing in three national and one statewide magazines (Pheasants Forever, Ducks Unlimited, American Waterfowler, and Minnesota Conservation Volunteer). DNR staff have also given talks at the Minnesota State Cattlemen's Association and have worked with USFWS staff to present at Pheasants Forever state

conventions. We have also devoted entire afternoons to fencing/grazing issues at the last DNR Wildlife School. This fall, the Wildlife Chief (Paul Telander) and Prairie Habitat Supervisor (Greg Hoch) will visit with each DNR Region to encourage more grazing on WMAs.

Project Completed: 6/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

Subd. 05 Water Resources

Assessment of Natural Copper-Nickel Bedrocks on Water Quality - RESEARCH

Research Project

Subd. 05b \$585,000 TF

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Appropriation Language

\$585,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota in cooperation with the United States Geological Survey to assess impacts of existing mineralization and potential mining on northeastern Minnesota regional water quality, including impacts from copper, nickel, and other metal concentrations in rocks, streambed sediments, and soils in areas of potential base-metal mining. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Large deposits of copper, nickel, cobalt, and other minerals in northeastern Minnesota could provide huge economic and employment benefits to the state while becoming an important source of important metals for the country. However, the mining required to extract them could have significant water quality impacts in a region that includes the Boundary Water Canoe Area Wilderness and other environmentally sensitive watersheds. Up-to-date and accurate geochemical data is needed in order to assess and predict water quality impacts of potential mining and inform decision-making to protect water quality and sensitive ecosystems. Scientists at the University of Minnesota are using this appropriation to gather baseline data for assessing how existing concentrations of these metals in rocks, streambeds, and soils currently influence regional water quality. This information is a critical component for examining the risks posed by any potential future mining.

OVERALL PROJECT OUTCOME AND RESULTS

The Natural Resources Research Institute, the U. S. Geological Survey, and the Minnesota Department of Natural Resources conducted a three-year study to 1) assess copper, nickel, and other metal concentrations in surface water, bedrock, streambed sediments, and soils in watersheds where the basal part of the Duluth Complex is exposed or near the land surface; and 2) determine if these concentrations, and metal-bearing deposits, are currently influencing regional water quality in areas of potential base-metal mining. The data will be used by Federal, State, local, and tribal entities to better assess background water-quality in watersheds with existing mineralization and where mining could occur. Surface-water, streambed sediment, soil, and bedrock samples were collected and analyzed in three largely undisturbed watersheds with different mineral-deposit settings: (1) copper-nickel-platinum group metal mineralization (Spruce Road deposit - Filson Creek watershed), (2) iron-titanium-oxide mineralization (Skibo deposit - upper part of the St. Louis River watershed), and (3) no identified mineralization (Keeley Creek watershed). Streamflow also was monitored in the three watersheds at continuous streamflow

gages and through discharge measurements to determined estimates of trace metal and inorganic constituent loads.

The geochemistry of surface waters and streambed sediments reflects the geochemistry of underlying rock types and glacially transported unconsolidated material. Water-quality data also suggest that streamflow influences concentrations of major constituents, such as Ca, Mg, and K, with lower concentrations during high flow, but has little apparent influence on metal concentrations. Copper-nickel mineralization in the northern Filson Creek watershed contributes both metals to stream waters and streambed sediment. All trace metals concentrations in all surface-water samples were below human-health guidelines and aquatic life standards established by the state of Minnesota and the U.S. Environmental Protection Agency. Dissolved and total organic carbon (DOC and TOC) concentrations in surface waters are very high compared to most surface waters in Minnesota, ranging from 13.7 to 41.4 milligrams per liter (mg/L) in all watersheds. Results from biotic-ligand modeling suggest that the high DOC content may exert some control on copper concentrations in water, such that complexation with DOC may reduce the bioaccessibility of copper.

PROJECT RESULTS USE AND DISSEMINATION

A U.S. Geological Survey Scientific Investigations Report (SIR) is being completed for colleague and USGS review that will summarize analytical results, present interpretations of bedrock, soil, streambed sediment, and water-quality data, and describe conceptual hydrology for the three watersheds (once published, the report will be available through the USGS Publication Warehouse at <https://pubs.er.usgs.gov/>). A draft of the report will be completed for review by June 30, 2017, and an on-line version of the report will completed by December 31, 2017. At that time, a pdf version of the report will be sent to LCCMR staff.

Numerous oral and poster presentations were given at geologic, water-quality, and hydrologic conferences in the State outlining project results. These presentations also were given at meetings with federal (U.S. Forest Service, U.S. Environmental Protection Agency), state (Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Department of Health), local, and tribal agencies, mining companies, and university researchers.

All of the data collected and compiled during this study is too large to be included in the appendix tables of the final LCCMR report, however the data is available in several databases. Geochemical data for bedrock, soils, and streambed samples were entered and stored in the USGS National Geochemical Database (http://minerals.cr.usgs.gov/projects/geochem_database/index.html). Metal and major constituent concentrations for water samples collected in the project were entered and stored in the USGS National Water Information System (NWIS) (<http://waterdata.usgs.gov/nwis>). All continuous streamflow data and streamflow measurements were entered and are available in USGS National Water Information System (NWIS) at <http://waterdata.usgs.gov/nwis>.

Project Completed: 12/31/2016 [Extended in M.L. 2016, Chapter 186]

FINAL REPORT

Measuring Hydrologic Benefits from Glacial Ridge Habitat Restoration - RESEARCH

Research Project

Subd. 05e \$400,000 TF

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Appropriation Language

\$400,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Red Lake Watershed District in cooperation with the United States Geological Survey to compare the hydrology of habitats before and after restorations to evaluate and quantify the impacts on flood reduction and water quality in order to inform improvements to restoration techniques. The United States Geologic Survey is not subject to the requirements in Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Since 2000, a diverse group of partners has been collectively working in northwestern Minnesota on one of the largest prairie-wetland restorations in the world. Spanning 22,000 acres and adjacent to an additional 16,000 acres of public and private conservation land, the goal of the Glacial Ridge Project has been to demonstrate whether large-scale habitat restoration is a viable way to reduce flooding and improve water quality. Prior to beginning restoration efforts on the project, a comprehensive baseline hydrologic study of the area was completed by the U.S. Geological Survey (USGS). The Red Lake Watershed District and USGS are using this appropriation to conduct a post restoration study that will quantify and evaluate the amount of flood reduction, water-quality improvement, and ecosystem-function change that has resulted from the wetland and prairie restoration efforts at Glacial Ridge. This information will be used to guide future restoration efforts throughout the state and beyond.

OVERALL PROJECT OUTCOME AND RESULTS

A comparison between the hydrology of the Glacial Ridge National Wildlife Refuge before and after wetland and prairie restoration shows substantial changes in flows of water through the hydrologic cycle, in behavior of overland runoff and ditch flow during storms, and in water quality. Within the 6 basins measured for this study, the area of cropland decreased by 14 percent, the area of wetlands increased by 6 percent, and the area of native prairie increase by 19 percent between 2002 and 2015 due to restorations. During the same period, hydrologic changes had the benefits of decreasing runoff rate (-33 percent, as a proportion of precipitation) and ditch flow rate(-23 percent) and improving water quality as measured by nitrate concentration (surficial groundwater median: -79 percent, ditchwater median: -53 percent) and suspended sediment in ditchwater (-64 percent) within the study area. Peak ditch flow from storms decreased, ditch flow recessions lengthened, and base flow from groundwater discharge increased, though only a small amount. These changes reduce the amount of water leaving the study area through ditches, reducing flows that contribute to flooding.

Neither the density of restorations nor the beneficial changes in hydrology were evenly distributed throughout the study area. Amount of hydrologic benefits within an individual ditch basin did not correlate directly with amount of restoration in that basin. This is likely because of complicating factors within each basin like the kind of land restored, the amount of surficial aquifer, the amount of remaining ditches, and the density of closed wetland and lake basins.

An analysis of landscape characteristics that correlated with hydrologic benefits in the study area showed that area of surficial aquifer and area of drained wetlands are most important. Surficial aquifers provide a groundwater reservoir that can reduce runoff and slowly release water as base flow to streams. Drained wetlands simply provide the opportunity for restoration of closed basins, which reduces streamflow. Areas with the highest density of surficial aquifers and drained wetlands have the highest potential for hydrologic benefits from prairie and wetland restoration. In western Minnesota, these areas are the uplands the Alexandria Moraine Complex and the beaches of Glacial Lake Agassiz on the eastern side of the western third of Minnesota, north of Wilmar, MN (Cowdery and others, 2017).

Cowdery, T.K., Christenson, C.A., and Zeigwied, J.R., 2017, The hydrologic benefits of wetland and prairie restoration in western Minnesota: lessons learned at the Glacial Ridge National Wildlife Refuge, 2002–15: U.S. Geological Survey Scientific Investigations Report 2017-xxxx, in preparation.

PROJECT RESULTS USE AND DISSEMINATION

The information generated by this grant will be documented in a U.S. Geological Survey Scientific Investigations Report that is in preparation. A draft of the report is attached to the project work plan. We expect the final draft of the report will be completed by 15 August, 2017. The report must be reviewed and approved, which we expect will occur by 31 October 2017. Once published, we will issue press announcements of the project results regionally and nationally. Additionally, the information in this report will be presented at several scientific meetings including that of the Minnesota Groundwater Association, the Minnesota Water-Resources Conference, and at annual conference of either the Geological Society of America or the American Geophysical Union. Presentations of interim result from this project have already been presented at meetings of the Minnesota Groundwater Association, the past Minnesota Water-Resources Conferences.

Project Completed: 6/30/2017 [Extended in M.L. 2015, Chapter 76]

FINAL REPORT

Evaluation of Lake Superior Water Quality Health - RESEARCH

Subd. 05f \$600,000 TF

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Appropriation Language

\$600,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to evaluate impacts to Lake Superior from a changing thermal structure and invasive species in order to implement lake water quality management strategies. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Lake Superior, the world's largest freshwater lake by surface area, is amongst Minnesota's greatest natural resources providing drinking water, shipping, recreation, and tourism. Recently the lake has been undergoing significant changes including increasing water temperatures, decreasing ice cover, increasing nutrient loads, decreasing biological productivity, increasing invasive species, and changes in species abundance and distribution. The reasons behind these changes and the interactions amongst them are not well understood. Scientists at the Large Lakes Observatory at the University of Minnesota - Duluth are using this appropriation to gather critical baseline data on Lake Superior to evaluate the impacts these changes are having on the lake and how natural resource managers and scientific and regulatory entities can best respond to the changes. No prior large lake study has ever included the breadth of measurements, geographic range, and span of seasons to be examined by this study.

OVERALL PROJECT OUTCOME AND RESULTS

Although Lake Superior seems timeless, it has been changing dramatically—with shifting temperatures, ice cover, storminess, and biological activity. This project worked to build our knowledge of how the lake responds to external processes, including climate change and the introduction of invasive species. This will help us to protect and foster this resource during a time of unprecedented change.

We used state-of-the-art techniques to evaluate the lake's behavior from Fall 2013 through Fall 2016. This included an extreme range of winters—the “Polar Vortex” of 2013-14 and the mild conditions of 2015-16. Our field strategy included shipboard sampling (12 stations occupied four times each year) as well as use of autonomous gliders and

moored instruments. These unmanned technologies provide cost-effective measurements at more places and times than possible with ship operations.

Major results include:

Lake circulation. Building on observations in the lake, we created a hydrodynamic numerical model of the St. Louis Estuary/Duluth Harbor/Lake Superior system that runs in real-time, providing estimates of currents and water levels across Lake Superior. Such information is useful to boaters and fishermen, and is being used in St. Louis River Estuary wastewater studies, and for studies of riverine nutrient dispersion and of nearshore wave action around the Apostle Islands

Lake acidity. We quantified seasonal shifts in lake pH due to river runoff, atmospheric inputs, and biological activity. Increased atmospheric CO₂ has acidified many lakes. In Lake Superior this appears to be mitigated by reductions in acid rain after clean air legislation of the 1990s.

Algae and plankton. We now have measurements of biological productivity from 2006 through 2016. Broadly, we see increased productivity in warmer years, with lower biomass of small algae that photosynthesize rapidly. These productive small algae might dominate a future, warmer Lake Superior. Such a shift could lead to significant changes for animals higher on the food chain.

Exotic species. Our work demonstrates that the invasive spiny water flea has damaged Lake Superior's lower food web. Our data provide a baseline for future evaluation of shifts in zooplankton.

Fish. We assessed historical patterns in growth of lake herring (cisco) using archived ear bones in combination with our current data. It appears that climate change and invasion by the spiny water flea have not greatly affected cisco growth rates to date. Nevertheless, spiny water fleas are a relatively poor prey item and could reduce growth rates of cisco that consume them.

Data obtained through this project have been utilized in proposals to the US National Science Foundation. Three successful proposals yielded ~\$2.0M for Lake Superior research including 70 days of ship time. A large proportion of this funding supports personnel and thus has a real impact on our local economy.

PROJECT RESULTS USE AND DISSEMINATION

We have worked to disseminate our results and information about Lake Superior science to the general public and the scientific community in several ways. These include: news reports on our work through print, television and radio; an ongoing social media presence; outreach events with public tours of UMD's research vessel; and publication of results in the scientific literature.

Project Completed: 6/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

[Changes in the cladoceran community of Lake Superior and the role of *Bythotrephes longimanus* Report](#)

Subd. 06Aquatic and Terrestrial Invasive Species

An Aquatic Invasive Species Research Center - RESEARCH

Subd. 06a \$8,700,000 TF

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Appropriation Language

\$4,350,000 the first year and \$4,350,000 the second year are from the trust fund to the Board of Regents of the

University of Minnesota to develop and support an aquatic invasive species (AIS) research center at the University of Minnesota that will develop new techniques to control aquatic invasive species including Asian carp, zebra mussels, and plant species. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

Project Overview

Aquatic invasive species pose critical ecological and economic challenges for the entire state and beyond. They can cause irreparable harm to fisheries and aquatic habitat as well as damage to infrastructure. The problems posed by aquatic invasive species continue to grow as existing infestations expand and new exotic species arrive, most of which are poorly understood. New ideas and approaches are needed to develop real solutions. In 2012 the Minnesota Legislature provided the University of Minnesota with \$3,800,000 (\$2,000,000 from the Environment and Natural Resources Trust Fund; \$1,800,000 from the Clean Water Fund) to launch a new, first-of-its-kind research center specifically focused on developing and implementing solutions to control aquatic invasive species. This appropriation provides this new center with additional initial operating funds for conducting research aimed at slowing the spread, reducing, controlling, and/or eradicating aquatic invasive species including Asian carp, zebra mussels, Eurasian watermilfoil, and more. Proven tools and techniques developed at the center are intended to be implemented statewide.

Sub-Projects M.L. 2013, 06a:

- *02: Metagenomic approaches to develop biological control strategies for aquatic invasive species - \$299,363*
- *03: Attracting carp so their presence can be accurately assessed - \$682,269*
- *04: Common carp management using biocontrol and toxins - \$384,231*
- *05: Developing and evaluating new techniques to selectively control invasive plants phase I: manipulating sunfish to enhance milfoil weevils and factors influencing selective herbicide control of curlyleaf pondweed - \$194,415*
- *06: Determining Heterosporosis Threats to Inform Prevention, Management, and Control - \$111,889*
- *07: Developing eradication tools for invasive species Phase II: Virus Discovery and evaluation for use as potential biocontrol agents - \$445,210*
- *08: Aquatic Invasive Species Research Center Sub-Project 8: Risk assessment, control, and restoration research on aquatic invasive plant species - \$822,000*
- *09: Population genomics of zebra mussel spread pathways, genome sequencing and analysis to select target genes and strategies for genetic biocontrol. - \$427,950*
- *10: Citizen Science and Professional Training Programs to Support AIS Response - \$566,550*
- *11: Reducing and controlling AIS: Risk analysis to identify AIS control priorities and methods – Phase 2: Risk Analysis - \$126,676*
- *12: Characterizing spiny water flea impacts using sediment records - \$207,766*
- *13: Eco-epidemiological Model to Assess Aquatic Invasive Species Management - \$215,000*
- *14: Cost-effective monitoring of lakes newly infested with zebra mussels - \$266,500*
- *15: Determining Highest Risk Vectors of Spiny Waterflea Spread - \$122,640*
- *16: Sustaining walleye populations: assessing impacts of AIS - \$198,700*
- *17: Building scientific and management capacity to respond to invasive Phragmites in Minnesota - \$246,800*
- *18: Eurasian and hybrid watermilfoil genotype distribution in Minnesota - \$221,375*
- *19: Decision-making tool for optimal management of AIS - \$172,465*

Sub-Project 02: Metagenomic approaches to develop biological control strategies for aquatic invasive species - \$299,363 TF

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OVERALL PROJECT OUTCOME AND RESULTS

Aquatic invasive species (AIS), including Eurasian watermilfoil (EWM) and invasive mussels pose a serious threat to the health, structure, and function of aquatic ecosystems. Traditional approaches for AIS control, including the use of chemicals and manual removal, have been ineffective. This requires development of new management and eradication strategies, such as the use of (micro)biological control agents. Some microorganisms have evolved to live in close association with aquatic organisms and such relationships could potentially be exploited to develop microbe-mediated AIS management strategies. As a first step in identifying potential biocontrols, this project (Phase I) had proposed to characterize the microbial communities (bacterial and fungal) associated with invasive mussels and EWM, across time and space, using amplicon-based high-throughput sequencing approaches. To accomplish this, zebra mussels (ZMs), water, and sediment samples were obtained from 15 lakes twice a year, whereas EWM were sampled from 10 lakes, once a month for six months. Field samples were processed, DNA extracted and high-throughput sequencing was performed on all field samples using the Illumina platform. Sequencing analysis (188 million reads) showed a distinct clustering of each sample type, irrespective of sampling time and location. Core microbial communities were characterized and several taxonomic groups were identified that were either specific or present in high relative abundance in ZMs and EWM, when compared to sediment and water samples. This gives us a promising lead on microbes to pursue in Phase II of this study, which will evaluate potential pathogenic characteristics and species- specificity of any pathogens.

In addition, our results also indicated that EWM was associated with elevated concentrations of fecal indicator bacteria, such as *E. coli* and *Enterococcus*. This means that not only are these aquatic plants a nuisance, but they may present a hazard to human health as well, especially if they harbor known human pathogens in addition to fecal indicator bacteria. Overall, the results obtained in Phase I have helped to define the distribution of microbes associated with these AIS, and will be useful for the development of future microbiological control strategies (Phase II).

PROJECT RESULTS USE AND DISSEMINATION

Results obtained in this study (Phase I) helped us define the distribution of microbes specifically associated with these AIS, and will be useful for the development of future microbiological control strategies. Experiments that will be performed during Phase II will build upon the results obtained in Phase I.

Oral presentations have been made at the 'AIS Research Management Showcase' each year to update the public on research findings and progress, the next one is September 2017. In addition, project results will be presented at the 20th International Conference on Aquatic Invasive Species at Fort Lauderdale in October. Three manuscripts are currently under preparation and will be submitted for publication in peer-reviewed journals.

Subproject 02 Completed: 06/30/2017

[FINAL REPORT](#)

Sub-Project 04: Common carp management using biocontrol and toxins - \$384,231 TF

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OVERALL PROJECT OUTCOME AND RESULTS

We tested two new methods to control common carp, which are invasive fish that degrade lakes of south-central Minnesota. First, we tested biocontrol, which is the ability of bluegill sunfish (native fish) to control carp reproduction by consuming their eggs and larvae. This was tested in 6 small lakes. All lakes were stocked with adult carp and every other lake was stocked with bluegills. Carp offspring survival was assessed through electrofishing and mark-recapture. At the end of the season, lakes with bluegills had 11 times fewer carp offspring than those without bluegills. This shows that biocontrol by bluegill is an important element of common carp management strategies. Bluegill populations can be strengthened in many shallow lakes by winter aeration to prevent winter fish kills.

Second, we tested if toxic bait could be developed to target carp without impacting native fish. This is important in lakes where biocontrol is unlikely. We incorporated an EPA-approved toxin antimycin-A (ANT-A) into corn pellets, which the carp consume with high specificity and performed 4 experiments: 1) using gavage trials we showed that the bait was toxic at 8 mg/kg; 2) using leaching trials we showed that less than 1% of ANT-A leached out of the bait and did not cause mortality among native fish; 3) using lab tanks where carp were stocked with three native fish we showed that 46% of carp and 76% of fathead minnows perished after one application of pellets, but perch and bluegill were not impacted; 4) using ponds with carp, bluegills and perch we showed that 37% adult carp perished after 6 days of pellet application, while no perch and bluegill did. Our results suggest that corn-based toxic pellets could be developed to selectively target carp but more work is needed to minimize impacts on native minnows. This is being addressed by ongoing work.

PROJECT RESULTS USE AND DISSEMINATION

Information collected in these experiments were disseminated and will continue to be disseminated in a variety of ways. Presentations were given at MAISRC showcases, the Minnesota and National American Fisheries Society meetings, and will be given at the International Conference for Invasive Species. We anticipate publishing 3 papers, one of which is in revisions, another written, and one to be completed. We have also shared this work with colleagues, watershed association, and MAISRC extension.

Subproject 04 Completed: 06/30/2017

[FINAL REPORT](#)

Sub-Project 05: Developing and evaluating new techniques to selectively control invasive plants phase I: manipulating sunfish to enhance milfoil weevils and factors influencing selective herbicide control of curlyleaf pondweed - \$194,415 TF

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PART A: Manipulating sunfish to enhance milfoil weevils - \$167,080 TF

PART B: factors influencing selective herbicide control of curlyleaf pondweed - \$27,335 TF

PART A: OVERALL PROJECT OUTCOME AND RESULTS

Eurasian watermilfoil (*Myriophyllum spicatum*) is one of the most widespread and problematic invasive aquatic plants in Minnesota. Approaches to improve its management are needed to reduce economic and ecological costs of invasive control. We focused on assessing factors that limit biological control of Eurasian watermilfoil by the native milfoil weevil and other herbivores.

Enclosure experiments to assess the effect of sunfish predation on herbivore and milfoil abundance were largely unsuccessful. Weevil populations developed in the enclosures but there were no differences in weevil or milfoil abundance due to fish stocking. We failed to recover stocked fish from the enclosures and suspect that predation by herons removed the fish. Realistic enclosure experiments in natural lakes may not be feasible and experimental manipulations might be better conducted in small natural or artificial ponds or in large tanks.

We assessed herbivore abundance in metro lakes and found milfoil weevils in 12 of the 19 lakes surveyed. Herbivore abundance was higher in 2015 than 2016, but abundance during both years was lower than some prior years. Only 1 weevil was found in over 450 sunfish stomachs examined, in part due to low milfoil weevil density in many lakes. Milfoil weevil abundance was negatively correlated ($r=-0.44$) with sunfish abundance; lakes with high sunfish populations (> 50 sunfish/trapnet) will likely not support sufficient herbivore populations and biological control should not be considered in these lakes until sunfish are reduced.

However, some lakes with low sunfish populations also have low herbivore densities and factors other than sunfish are apparently limiting herbivores and biocontrol in these lakes. Possible limiting factors include lack of access to shoreline overwinter habitat, extensive mechanical harvesting or herbicidal control, and poor water or plant quality. Further work that also accounts for environmental variability is needed to identify factors limiting milfoil herbivores and biocontrol.

PART A: PROJECT RESULTS USE AND DISSEMINATION

Information on milfoil ecology and biological control has been provided on the MAISRC website and twice at the MAISRC showcase. A summary of the project was presented at the Upper Midwest Invasive Species Conference in La Crosse, WI. We provided overviews of our work to Ramsey-Washington Lake Association and the Minnesota Invasive Species Advisory Council.

PART B: OVERALL PROJECT OUTCOME AND RESULTS

Curlyleaf pondweed (*Potamogeton crispus*) is one of the most widespread and problematic invasive aquatic plants in Minnesota. It sprouts from turions (winter buds) in the fall and winter and grows rapidly to the surface in the spring before senescing in early summer. Selective control can be attained with early-season herbicide treatments. To provide an analysis of factors affecting curlyleaf abundance in untreated and herbicide-treated lakes, we collated pre-existing data from a variety of agencies and researchers; we analyzed data on curlyleaf pondweed frequency of occurrence and relative density from 60 lakes across Minnesota. The lakes had surveys conducted in May (pretreatment timing) or June (peak curlyleaf coverage) between 2006-2015; several lakes had data for all ten years. Forty-nine lakes had data for years not treated with herbicide, with one to eight years of data from each (mean of three years). Twenty-two lakes had data associated with curlyleaf pondweed herbicide treatments (one to nine years of treatment; mean of 3.8 years).

For the untreated lakes, productivity (as indicated by prior summer Secchi depth) and over-winter conditions (snow cover or ice duration) were important predictors of curlyleaf with greater curlyleaf abundance in lakes with higher productivity and milder overwinter conditions (shorter duration of ice cover and lesser snow depth). For herbicide treated lakes, consecutive years of treatment was also important; early season abundance decreased with more years of prior treatment. There were diminishing returns from repeated treatment and curlyleaf abundance can rebound quickly once treatment stops. June density and frequency appeared less affected by overwinter conditions and more by spring growing conditions and the effect of treatment that year. Mild winters will likely result in more abundant populations that spring, and managers should plan for more extensive treatments following mild winters. Repeated treatments will decrease curlyleaf frequency and abundance, but must be sustained.

PART B: PROJECT RESULTS USE AND DISSEMINATION

Information on curlyleaf pondweed ecology and control has been provided on the MAISRC website and at the MAISRC showcase. The results of the curlyleaf pondweed analysis were presented at the 56th Annual meeting of the Aquatic Plant Management Society in Grand Rapids, MI and a summary of the analysis was presented at the Upper Midwest Invasive Species Conference in La Crosse, WI. We provided overviews of our work to Ramsey-Washington Lake Association and the State of Waters Conference. We plan to develop and submit a manuscript on the curlyleaf pondweed responses to a peer-reviewed journal by July 2017. The data set assembled and organized will also be used by a graduate student to further assess the response of native plants to curlyleaf pondweed abundance and control.

Subproject 05 Completed: 06/30/2017

[FINAL REPORT - PART A](#) / [PART B](#)

[MAISRC Report - PART A](#) / [PART B](#)

Sub-Project 06: Determining Heterosporosis Threats to Inform Prevention, Management, and Control - \$111,889 TF

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OVERALL PROJECT OUTCOME AND RESULTS

Heterosporosis is an emerging disease of concern in Minnesota that is caused by the parasite *Heterosporis sutherlandae*. It damages fish muscle and renders them inedible. Heterosporosis was discovered in Leech Lake in 1990 and has since been detected in ~30 waterbodies and in over a dozen species. Heterosporosis was identified as a high research priority by the 2014 MAISRC Research Needs Assessment because it can infect up to 40% of fish and we knew little about the disease or its population-level effects. Our objectives were to collect data to better understand this disease, and to estimate the threat that heterosporosis poses to perch harvest in a typical Minnesota lake.

We collected perch and other fishes from Leech Lake seasonally from fall 2015 to winter 2017, and from Cass and Winnibigoshish lakes in fall 2015 and 2016. Heterosporosis was rare among all species, seasons, and lakes. We detected the disease in only 9% of perch, and 20-30% of these fish had visible muscle damage. Heterosporosis did vary seasonally, and infected perch were not more susceptible to angling. In the lab, we found a 32-34% infection rate when fish were fed infected tissue and a 2-17% infection rate with passive transmission from cohabitating healthy and infected fish. We found no evidence of a relationship between growth or survival and infection. We used this and other information to develop a population model that suggested that heterosporosis can have short-term impacts on yellow perch harvest (e.g., in a naïve population or after a bad year), but that long-term impacts are unlikely. Sensitivity analysis indicated that disease associated parameters had little effect on overall harvest. Based on the results of this project, we do not consider heterosporosis to be a significant threat to Minnesota fish, but recommend further research to improve the model, because threats to aquaculture or laboratory fish may be higher.

PROJECT RESULTS USE AND DISSEMINATION

We generated a heterosporosis fact sheet that is available on the MAISRC website (<http://www.maisrc.umn.edu/fishdisease/>) and was distributed to participating resorts and an interested fishing

guide. We have maintained contact with two resorts (one on Leech Lake and one on Cass Lake), both of which contributed angler log book data that we used to estimate heterosporosis prevalence. We also had many positive conversations with individuals who approached us during field work. We have given numerous presentations of this work to a combined audience of over 300 researchers, managers, policymakers, and stakeholders. These include three presentations at MAISRC Showcase events, a presentation at the MN DNR's summer 2017 Fisheries Research Meeting, presentations at four academic conferences, and internally at the University of Minnesota. Our research has been highlighted in local and national media outlets, and our first paper is currently in review with the Journal of Aquatic Animal Health. Masters student Megan Tomamichel was recently awarded a competitive, \$2,500 Judd Fellowship through the University of Minnesota to travel to Chile and adapt her model to sea lice infestations in salmon farms.

Subproject 06 Completed: 06/30/2017

[FINAL REPORT](#)

Sub-Project 11: Reducing and controlling AIS: Risk analysis to identify AIS control priorities and methods – Phase 2: Risk Analysis - \$126,676 TF

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OVERALL PROJECT OUTCOME AND RESULTS

Bighead and silver carps (bigheaded carps) pose a threat to Minnesota's waterways and there is a need to better understand their potential impacts to inform management actions. Towards this end, project researchers designed and conducted a risk assessment for bigheaded carps in Minnesota. Results from previous (Phase 1) research and a survey with risk assessment participants were used to focus the scope of the risk assessment on four potential adverse effects: impacts to game fish, non-game fish, species diversity/ecosystem resilience, and recreation (from the silver carp jumping hazard). Four watersheds were focused on, selected to be both geographically diverse and relevant to the current decision making context.

The risk assessment was conducted with the participation of twenty-three experts on bigheaded carps and Minnesota's waterways. A workshop was held to discuss the risk assessment findings and their implications for the management of bigheaded carps in Minnesota, and 50 people attended including stakeholders, researchers, managers, decision makers, and members of the public. Insights garnered from this workshop informed the final version of the risk assessment report, "Minnesota Bigheaded Carps Risk Assessment" which was released in May 2017.

This risk assessment represents the first systematic analysis of the risks posed to Minnesota from bigheaded carps and will both justify and inform future management efforts. Specific findings from this report include that the risk from bigheaded carps varies greatly depending on the watershed and potential adverse effect considered. The risk was higher for the species diversity/ecosystem resilience and recreation potential adverse effects and for the Minnesota River-Mankato and Lower St. Croix River watersheds. These findings emphasize the need for a timely management response to protect watersheds identified as most at risk, while ensuring that any collateral damage from management actions leads to less ecological harm than bigheaded carps are likely to cause.

PROJECT RESULTS USE AND DISSEMINATION

Project results were disseminated through conference presentations, presentations to stakeholders, media news stories, a journal article, and a project report. Professional conference presentations included: 1) The 2016 American Fisheries Society Meeting on August 24th, 2016; 2) The 2016 Upper Midwest Invasive Species Conference on October 18th, 2016; and 3) The 2016 Society for Risk Analysis meeting on December 13th, 2016. Project results were also presented to academics and researchers at the November 22nd, 2016 Semi-annual All-MAISRC (Minnesota Aquatic Invasive Species Research Center) Meeting.

Presentations to stakeholders and members of the public included: 1) the Minnesota Invasive Carp Forum on March 10th, 2016; 2) the St. Croix River Association's AIS Group Meeting on June 8th, 2016; 3) the MAISRC Research Showcase on September 12th, 2016; 4) the "Risk Based Management for Bigheaded Carps" workshop held to discuss project findings and implications on March 15, 2017; and 5) the Minnesota Invasive Carp Forum on March 29th, 2017. Project outcomes and findings were also covered in a news update on Minnesota Public Radio on March 15, 2017.

Subproject 11 Completed: 06/30/2017

[FINAL REPORT](#)

[Minnesota Bigheaded Carps Risk Assessment DNR Report](#)
[Environmental Science & Policy Journal Paper Report](#)

Sub-Project 13: Eco-epidemiological Model to Assess Aquatic Invasive Species Management - \$215,000 TF

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OVERALL PROJECT OUTCOME AND RESULTS

Aquatic invasive species (AIS) are spreading at an alarming rate in Minnesota, putting the urgent need for prevention at odds with limited budgets and capacity. To inform decision making, we have developed a series of integrated models that provide the cumulative risk of introduction and establishment of zebra mussels and starry stonewort in all Minnesota lakes. We first answered the question of 'can the species get there?' using network models to describe lake connections. The watercraft network was built with 1.6M MN DNR watercraft inspections from 2014-2017, with gaps and biases accounted for with a variety of statistical approaches. The water connectivity network was created at a finer resolution and larger geographic area than currently available using multiple sources of GIS data and satellite imagery. Next, we answered the question of 'will the species survive?' using advanced methods of ecological niche modeling. With current species distribution of the invaded and native ranges, paired with local environmental data, we projected suitability at the lake level. These three massive data sources fed into the development of an integrated model that quantified the risk of AIS invasion for each waterbody from 2018-2025. Not surprisingly the results suggest the number of infested waterbodies will increase in the years to come. However, with the integration of hypothetical management scenarios developed and incorporated during two project workshops, we demonstrated the value of this approach to assess management effectiveness by determining the number of new infestations averted. While the model is not perfect (no models are), the results are robust and provide useful information from which to make decisions. When considered across a watershed, county or state, the ability to rank waterbodies based on actual, not perceived, risk is a game changer for the prioritization of intervention strategies.

SUBPROJECT PROJECT RESULTS USE AND DISSEMINATION

The outcomes of this projects received considerable attention from AIS managers, lake associations and other researchers. We took full advantage of this opportunity and far exceed expectations to disseminate the results. We communicated to the scientific community with the publication of seven related manuscripts and have three more in preparation, and presentations at three scientific conferences. The project was presented to stakeholder audiences 11 times in formal settings and many informal settings. We worked closely with MAISRC to disseminate project updates through MAISRC's newsletter and social media. We have helped develop a project page on the MAISRC website (<https://www.maisrc.umn.edu/modeling-ais>) that has links to finalized risk ranking for each lake in Minnesota, project reports, and communications. In addition, all raw data and products generated as part of this project will be stored in the MAISRC-DRUM (Data Repository at UMN) for indefinite public access (web addressed TBD).

Subproject 13 Completed: 06/30/2018

FINAL REPORT

[A Probability Co-Kriging Model to Account for Reporting Bias: Publication](#)

[Aquatic Invasive Species in the Great Lakes Region: An Overview - Publication](#)

Improving Emerald Ash Borer Detection Efficacy for Control

Research Project

Subd. 06c \$600,000 TF

PART A - \$240,000 TF

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PART B - \$360,000 TF

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Appropriation Language

\$600,000 the first year is from the trust fund to evaluate and implement options for effective detection of the presence of emerald ash borer. Of this appropriation, \$240,000 is to the commissioner of agriculture and \$360,000 is to the Board of Regents of the University of Minnesota. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

The Emerald Ash Borer (EAB) is an invasive insect that has been decimating ash trees throughout the Great Lakes states. It was first discovered in Minnesota in 2009 and is now found in four counties (Hennepin, Houston, Ramsey, and Winona). EAB poses a particularly serious threat to Minnesota because it is home to nearly 1 billion ash trees that occur throughout the state - the second most of any state. Loss of these trees would devastate ecosystems throughout Minnesota and have major economic impacts for the forest products industry as well as through the costs associated with treatment, removal, and replacement of lost trees. Much work has already been done to

stem the spread of EAB in Minnesota, including education, quarantine, detection surveys, and biological control efforts. Effective detection remains a key obstacle, though, as current detection tools have not been calibrated to estimate population densities. The Minnesota Department of Agriculture and the University of Minnesota are using this appropriation to attempt to fill this critical information gap necessary for best determining how and where to implement control measures. The effort will evaluate a range of detection tools and measure their ability to detect EAB at different population densities in order to improve and implement better detection practices.

PART A: OVERALL PROJECT OUTCOME AND RESULTS

Emerald ash borer (EAB) was first discovered in Minnesota in 2009 in St Paul and has since spread to 15 counties. Minnesota has more ash than any other area of the U.S. and it's an important component of our rural and urban forests. Detection is a key obstacle to controlling EAB and many of the detection tools have not been calibrated to provide an estimate of what population density of EAB they are able to detect. This is a critical information gap as EAB population density is a critical parameter in determining how and where to implement control measures. This project was undertaken to evaluate detection tools and measure their ability to detect EAB at different population densities and to determine whether these detection tools can inform EAB management in urban areas. Methods included: visual inspection of ash trees during winter months, purple prism trapping during active EAB flight periods and branch sampling under a range of emerald ash borer population densities at 8 sites for three consecutive field seasons throughout the state. This work was conducted in close cooperation with local city governments.

A total of 840 trees were visually inspected, 615 purple prism traps set, 1724 branches and 48 whole trees sampled. Results showed branch sampling was more sensitive than visual observation but the labor costs were approximately four times greater. Visual sampling provided the most positive detections at all levels of EAB densities in the least amount of time and at the lowest cost. However, all survey methods evaluated had some utility at detecting EAB at sites before significant canopy decline had occurred. This is important information as the project demonstrated the value of monitoring to prevent opportunities for EAB management from being lost.

PART B: OVERALL PROJECT OUTCOME AND RESULTS

The emerald ash borer is an extremely challenging insect to manage because (1) there is a long lag phase between initial infestation and tree decline/mortality and (2) the insect is difficult to monitor and detect. There are several detection tools available, such as laboriously peeling the bark from branches harvested from trees, visual inspection of trees for evidence of woodpecker feeding, and attraction to purple prism traps hung in ash trees during periods of adult flight. We calibrated these detection tools to provide an estimate of the efficacy of these tools across different population densities of emerald ash borer. We found that visual evaluations to monitor trees for woodpecker damage are an effective method for identifying EAB at low densities prior to wide-spread tree decline. We found that 50 to 78% of trees at an infestation site will show signs of woodpecker damage before larval densities are high enough to cause irreparable damage to the tree. Visual inspections during leaf-off conditions are more inexpensive than other methods, and can be used by local communities to detect and respond to populations early.

We were able to use these project funds to leverage a federal grant to investigate the impact of strategic and targeted tree removals if emerald ash borer is detected early in a community. We published a scientific paper (Fahrner, Abrahamson, Venette, and Aukema 2017 "Strategic removal of host trees in isolated, satellite infestations of emerald ash borer can reduce population growth" *Urban Forestry & Urban Greening* 24:184-194) that found that removal of two thirds of the trees in the Twin Cities area where EAB was first detected in 2009 reduced populations by just over one half over the course of five years. These strategic removals slowed population growth considerably, and set populations back by at least one year. The most significant impact was achieved by targeting trees with evidence of woodpecker feeding.

Finally, studying potential tradeoffs between Minnesota's colder climate (than other places in emerald ash borer's range) and dispersal capacity, we found that overwintering location affects survival rates, but not energy reserves or flight capacity. In other words, Minnesota might be cold, but surviving insects do not appear to be less capable of dispersing in the spring.

PART B: PROJECT RESULTS USE AND DISSEMINATION

This was a joint partnership with the Minnesota Department of Agriculture. The primary audience for this work was disseminated to municipalities and other entities responsible for managing EAB at the local level. Information was conveyed through meetings held throughout the year, both at MDA through the EAB Forum (bimonthly meeting) and also through conferences, meetings and workshops held around the state and also at professional and technical conferences.

Project Completed: 6/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT - PART A \[Abrahamson\]](#)

[FINAL REPORT - PART B \[Aukema\]](#)

[Emerald Ash Borer Management Guidelines - PART A \[Abrahamson\]](#)

[Emerald Ash Borer Regional Meeting Presentation - PART A \[Abrahamson\]](#)

[Emerald Ash Borer General Municipal Staff Presentation - PART A \[Abrahamson\]](#)

[Urban Forestry & Urban Greening Journal Article - PART B \[Aukema\]](#)

Controlling Terrestrial Invasive Plants with Grazing Animals

Subd. 06g \$52,000 TF

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Appropriation Language

\$52,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Hiawatha Valley Resource Conservation and Development, Inc. to develop cost effective best management practices to control invasive terrestrial species through planned grazing. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Project Overview

Terrestrial invasive plants such as buckthorn, wild parsnip, garlic mustard, and others are becoming widespread threats throughout many sites in Minnesota. Present chemical and mechanical control methods tend to be costly, effective only in the short-term, or have other negative environmental impacts. However, an alternative practice of using grazing animals for invasive species management is used successfully in many parts of the western United States. Grazing animals can help put target plant species at a competitive disadvantage if plants are grazed at times when they are most vulnerable in order to prevent flower and seed production. The Hiawatha Valley Resource Conservation & Development Council is using this appropriation to develop and demonstrate cost effective and environmentally friendly best management practices for using grazing as a component of invasive species management in Minnesota.

OVERALL PROJECT OUTCOME AND RESULTS

The Hiawatha Valley Resource Conservation and Development Council, Inc., (HVRCD) began implementation of a program to control terrestrial invasive species through grazing with a pilot project in 2011. With the help of the USDA-NRCS a baseline inventory of selected sites was initiated along with documenting the effects of grazing on terrestrial invasive species.

In 2013 HVRCD received funding through the Environmental and Natural Resources Trust Fund (ENRTF). The project goals were: (1) develop a cost effective and environmentally friendly alternative to chemical and

mechanical control methods for these species, (2) demonstrate that multi-species grazing techniques can be used effectively to control invasive plants, (3) distribute results during field day demonstrations to connect livestock producers with landowners and (4) develop a Best Management Practice for invasive species control using grazing management as a component.

Three sites were selected as part of this project; Gamehaven Boy Scout Camp, approximately 10 miles southeast of the City of Rochester; River Bend Nature Center in the City of Faribault; and Eden Acres, roughly 5.4 miles southeast of the City of Faribault.

Results show little change in seasonal buckthorn sapling density, an increase in buckthorn seedlings, and variable results for adult buckthorn mortality. However, results show a change in the age stand of buckthorn within treatment areas as fewer live adult and large saplings were documented within the treatment sites. This change makes further treatments by various means more attainable.

Garlic mustard density was dramatically reduced in two growing seasons at the River Bend site, showing a 94% decrease in density by 2016.

Additional documents included with this report: Prescribed Grazing (Goat) Project Final Report Covering Years 2014, 2015, and 2016; Final Project Report Gamehaven Boy Scout Camp; Minnesota Practice 528 Biological Brush Management Implementation Guide; Minnesota Practice Implementation Guide Biological Herbaceous Weed Control 528.

PROJECT RESULTS USE AND DISSEMINATION

1. We were very fortunate to have one of our sites within the River Bend Nature Center near Faribault, MN. Small grazing animals created a great deal of interest amongst their visitors and staff. Handouts were available explaining the project, local newspapers did feature stories, and River Bend shared photos and explanations on their website. Signs were posted at the River Bend Nature Center grazing site appropriately crediting the project and to provide basic information of why there are goats there. These signs also had qr code allowing cell phone users more detailed information on the project. This kept the project in the news during 2015 and 2016 on a regular basis.
2. Tours were conducted involving garden clubs, Soil and Water Conservation District employees, USDA-NRCS, other professionals, public land managers, farmers and potential grazers.
3. The project has been featured on several radio and television stations in the Twin Cities market over the projects timeframe
4. Project information was shared through brochures at annual conferences of the Association of MN Counties and also the MN Association of Soil and Water Conservation Districts through the MN Association of RC&D Councils exhibit booth.

Project Completed: 6/30/2017 [Extended in M.L. 2014, Chapter 226]

[FINAL REPORT](#)

[Brochure](#)

[Minnesota Practice Implementation Guide Biological Herbaceous Weed Control 528](#)

[Minnesota Practice 528 Biological Brush Management Implementation Guide](#)

[Hiawatha Valley Resource Conservation & Development Final Project Report \(Gamehaven Boy Scout Camp\)](#)

[Hiawatha Valley Resource Conservation & Development Prescribed Grazing \(Goat\) Project Final Report](#)