

III. Completed Research Projects

“a summary of any research project completed in the preceding biennium;”

The following documents include:

- Summaries of accomplishments for each appropriation year and short abstracts for all projects completed since the previous biennial report of January 15, 2015. Research projects have been marked as such in the description.
- Spreadsheet of all research projects completed between January 1, 2017 and December 31, 2018.

Additional information:

- The abstracts describe the general accomplishments of each project for completed projects and are current as of 12/31/2018. See <http://www.lccmr.leg.mn> for additional project information, including Final Reports.
- 118 Projects were completed for a total of \$50,888,831.
- Legal Citations
 1. M.L. 2016, Chapter 186, Section 2
 2. M.L. 2015, Chapter 76, Section 2
 3. M.L. 2014, Chapter 226, Section 2
 4. M.L. 2013, Chapter 52, Section 2
 5. M.L. 2012, Chapter 264, Article 4, Section 2
 6. M.L. 2011, First Special Session, Chapter 2, Article 3, Section 2

1. M.L. 2016 Projects Completed
January 15, 2017 – January 15, 2019
MN Laws 2016, Chapter 186, Section 2

M.L. 2016 Projects

[MN Laws 2016, Chapter 186](#), Section 2 (beginning July 1, 2016)

Subd. 04 Water Resources

Roseau Lake Watershed Targeted Water Quality Improvement
Subd. 04w \$65,000 TF

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Appropriation Language

\$65,000 the second year is from the trust fund to the commissioner of natural resources to develop targeted water quality improvements for the Roseau Lake watershed by coordinating with partner agencies to identify the top priority field scale best management and conservation practices to implement in the region.

OVERALL PROJECT OUTCOME AND RESULTS

The Roseau River Watershed District in collaboration with MN state agencies, local governments, and citizens is working to rehabilitate the Roseau Lake basin, which was substantially drained over 50 years ago. The outcomes and results of this project will be essential to strategically invest in water quality improvement projects that will ensure the long-term viability of the lake rehabilitation restoration project. This project resulted in development of a level 3 hydrologically conditioned digital elevation model (hDEM) for the U.S. portion of the watershed, a LiDAR-derived restorable wetland inventory, and complete set of Roseau River Watershed PTMApp data which is available on the Minnesota Board of Water and Soil Resource's PTMApp website and for PTMApp desktop use. The project identified and mapped the top 100 field scale best management and conservation practices to benefit water quality in the Roseau Lake. Output data from the PTMApp and the drained basin inventory has been provided to the Roseau County Soil and Water Conservation District and the Roseau River Watershed District in addition to a series of project implementation and effectiveness map. A Roseau River watershed PTMApp data-training workshop was held for project partners on May 30, 2018. Project partners are now using the data and maps to refine a targeted implementation plan for the Roseau Lake and the Roseau River watersheds. This foundational work has been essential for the Roseau River Watershed District to work with additional partners in Canada and expand the scope of this work to include the entire Roseau River watershed in the U.S. and Canada.

PROJECT RESULTS USE AND DISSEMINATION

This project resulted in the development of a level 3 hydrologically conditioned digital elevation model (hDEM) for the U.S. portion of the watershed, a LiDAR-derived restorable wetland inventory, a complete set of Roseau River Watershed PTMApp data, and a variety of maps to identify the Top 100 conservation and best management practices for water quality protection and improvement. The Roseau River watershed district has copies of all data, maps, and presentation associated with this work. The PTMApp data is also available on the Minnesota Board of Water and Soil Resource's PTMApp website. GIS tools needed to derive a restorable wetland inventory from LiDAR data were refined for this project and are also available from the Board of Water and Soil Resources.

A Roseau River watershed PTMApp data-training workshop was held for project partners on May 30, 2018. This foundational work has been essential for the Roseau River Watershed District to work with additional partners in Canada and expand the scope of the project to include the entire Roseau River watershed in the U.S. and Canada. These partners are now working with these data to further develop and refine and implementation strategy for the Roseau Lake Basin and for the entire watershed.

Project Completed: 06/30/2018

FINAL REPORT

Subd. 05 Environmental Education

Youth-Led Sustainability Projects in 50 Minnesota Communities - Phase III

Subd. 05c \$400,000 TF

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Appropriation Language

\$400,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Prairie Woods Environmental Learning Center to expand the Youth Energy Summit (YES!) program statewide to complete more than 200 new youth-led climate change mitigation and adaptation projects in over 50 Minnesota communities.

OVERALL PROJECT OUTCOME AND RESULTS

Our project goal was to engage Minnesota's youth in seeking sustainable solutions to today's environmental and economic challenges through hands-on learning. We accomplished this by:

- Supporting 34 youth-led YES! teams, with over 900 students, in 150 Minnesota communities
- Completing 264 youth-led energy conservation, renewable energy, waste reduction, prairie restoration, local food, climate change education, and water quality related projects
- Engaging 85 communities in climate science and other sustainability topics hosted by YES! students
- Providing 4 Fall Summit events and 26 regional workshops to increase student knowledge of sustainable best practices
- Leveraging the expertise and kindness of 19,000 volunteer hours including 7,000 hours of YES! student volunteer time
- Launching the first statewide YES! championship at the Minnesota Twin's Game (2 years)
- Rebranding of the YES! name to Youth Eco Solutions and upgrading our website (yesmn.org)

YES! staff worked with over 100 teachers and resource experts to engage Minnesota's youth in authentic learning through hands-on projects and community events. Pre and post assessment survey results indicate YES! was successful in impacting student behaviors:

- 20% reported an increase in turning off unneeded lights
- 20% reported an increase in their environmental awareness and were more likely to turn off electronics when not in use, use re-usable beverage containers and bags, and buy used instead of new
- 9% reported they recycled more

YES! students accomplishments benefited Minnesota communities in a variety of ways. Of the 264 completed projects, 25 were related to lake/prairie restorations, 26 improved energy efficiency, 69 involved waste reduction, and 83 additional projects from a range of categories including renewable energy, climate change, and local foods were completed, 61 environmental education events were held and 2,814 pounds of Christmas tree lights were recycled! As one YES! student said, "You can sit around and think about saving energy, or you can get out and do something about it. YES! lets us do something about it!"

Project Completed: 06/30/2018

[FINAL REPORT](#)

Wildlife and Habitat Conservation Education for Southwest Minnesota High Schools

Subd. 05e \$147,000 TF

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Appropriation Language

\$147,000 the second year is from the trust fund to the Minnesota Zoological Garden to engage high school students in critical prairie wildlife and habitat conservation projects by using the zoo's unique animal collections and state-of-the-art technology to deliver hands-on learning in 12 southwestern Minnesota high schools.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Zoo is currently addressing the decline of wildlife populations and tall grass prairie habitats in southwestern Minnesota by returning pure-bred bison herds to Blue Mounds State Park and protecting imperiled prairie butterflies. Complementing this work, the Zoo engaged students in prairie conservation projects in 12 southwestern Minnesota high schools in order to inspire wildlife conservation action and promote lifelong wildlife conservation interest. The Wildlife Champions project included specialized training for high school teachers to equip them to supervise and facilitate student-driven prairie wildlife conservation projects in their communities. Minnesota Zoo naturalists visited each school to deliver hands-on student workshops featuring live Zoo animal ambassadors to inspire students and equip them with the confidence, skills, and guidance required to begin designing local prairie conservation service projects. Projects included introducing fire to prairies, planting native flowers and grasses, protecting native pollinators, prairie land management, creating interpretive areas, protecting native mammals and birds, collecting seeds, and bee keeping. Schools were provided funds in order to procure conservation tools and supplies to implement their projects.

Students presented their projects at a final Wildlife Champions Expo event at the Minnesota Zoo and completed surveys regarding the impact the project had on their knowledge and attitudes towards prairies and conservation. Before beginning this project, 70% of students reported having no or very little knowledge of prairies and the conservation issues facing them. After completion, 86% of respondents reported having high levels of expertise and knowledge in this area. In addition, 76% of respondents reported that they thought that prairies were important and valuable to the Minnesota landscape, and 29% of reporting students said that they planned to work with prairies and prairie restoration in the future.

PROJECT RESULTS USE AND DISSEMINATION

Student prairie conservation projects were featured at the Minnesota Zoo's Wildlife Champions Expo event on May 17, 2017. Eighteen partner teachers and 368 partner high school students attended the event, presenting their work in a science-fair-like exhibition, and engaged with Zoo experts doing work in the field of prairie wildlife management.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Wolf Management Education in the Classroom - Phase II
Subd. 05g \$240,000 TF

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Appropriation Language

\$240,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the International Wolf Center to expand the Wolves at Our Door classroom education program to assist students in understanding wolves and associated management issues.

OVERALL PROJECT OUTCOME AND RESULTS

This project was undertaken to provide engaging, unbiased programs about wolves to public school 2-12 grade classrooms, nature centers, state parks, public park summer programs, and state parks in Minnesota. International Wolf Center outreach specialists presented programs to help participants understand the complicated issues surrounding wolves and wolf management. Chasms divide people on all sides of the issues around wolves and wolf management- rural, urban and suburban communities; hunters and non-hunters, trappers and non-trappers, residents and non-residents of areas with wolf populations. Because of divided opinions and the repeated delisting and relisting of wolves from the Endangered Species List, this project was invaluable in educating the public. Programs were presented to individual school classrooms and several other venues throughout the state. They covered wolf biology, predator/prey dynamics, role of wolves in healthy ecosystems, myths and opinions of wolves, wolf management and importance in wildland habitat. The PowerPoint based programs included engaging video clips and photos. Students were also able to learn from handling artifacts such as wolf, deer and moose bones and pelts.

Participants in 2-6 grades were surveyed pre-and post-program using clicker survey technology to collect data on the attitudes of participants as well as their knowledge of wolves and wolf issues. Survey data showed an increase in knowledge of wolf facts and understanding of issues between wolves and humans. In 7-12 grade, students wrote short essays on various topics covered in the program to demonstrate how the program expanded their knowledge of the facts about wolves and discuss how humans can coexist with wolves more effectively. Over the course of the grant 1,513 programs were given to 37,166 participants. This included 52 counties, 124 school districts, and 232 schools.

PROJECT RESULTS USE AND DISSEMINATION

A copy of the primary PowerPoint is included with the final report. In addition, copies of the booklets participants were provided to take home after the program are included. In the last year, a short video was created to be shown to 7-12 grade classes to cover the wolf biology portions to be watched before of the program to allow more time during the program with limited class times at higher grade levels.

Information on the results of the project will be available on the International Wolf Center Website at www.wolf.org and will be presented at the upcoming International Wolf Symposium in October 2018.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Promoting Water Quality Stewardship through Student Mentoring and River Monitoring
Subd. 05i \$39,000 TF

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Appropriation Language

\$39,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Southwest Minnesota State University to partner with area schools to deliver inquiry-based, hands-on learning and mentoring on water quality stewardship between university agriculture students and high school and middle school students.

OVERALL PROJECT OUTCOME AND RESULTS

In southwest Minnesota, over 80% of a typical watershed is used for agriculture which impacts stream water quality. Area citizens must be engaged in water quality efforts if progress is to be made in protecting local waterways. An ENRTF grant facilitated a partnership between Southwest Minnesota State University (SMSU), area public schools, and state agencies. SMSU agricultural undergraduates served as mentors to high school and middle school students while promoting stewardship of clean waters through river monitoring. Agricultural education undergraduates took a semester long course that taught water quality content and mentoring techniques. Students then traveled to public schools where they mentored 10th grade and 7th grade students in hands-on experience with test kits and meters. All students then traveled to the Redwood River to monitor ten parameters at three sites. A total of 644 students were involved in the project. Pre-post content quizzes showed significantly improved water conservation knowledge at all grade levels. A water conservation attitude scale indicated that after participating in the program, 100% of students at all grade levels agreed that water conservation is important. A civic engagement scale administered at the end of the semester indicated that students felt a responsibility to help conserve and improve water quality in their communities. Civic engagement and stewardship scale scores were also significantly higher for students at all three grade levels compared to control groups not involved in the project. Our results indicate that through these hands-on experiences, agricultural education students gained both content knowledge and a sense of civic responsibility and were able to successfully pass this information on to younger students. Educating agriculture students and engaging them in conservation and monitoring efforts will bridge the perceived conflict between agriculture production and water conservation efforts, while collecting useful water quality data for the state.

PROJECT RESULTS USE AND DISSEMINATION

The project is described in detail on the SMSU website (<https://www.smsu.edu/academics/programs/environmentalscience/redwood-river-monitoring-project.html>) and includes information about the sampling sites, the parameters measured and acknowledgement of the funding sources. It also displays graphs of all the data from the beginning of the project in 2004 to present for each of the 10 parameters. One useful result of this project is the development of Civic Engagement and Stewardship scales that were used for evaluation of water conservation attitudes in the experimental group versus the controls (students not involved in the project). These are available for use with any future projects aiming to assess these values. Fall 2017, this project was highlighted on the DNR Website and in packets of information provided to the media as part of the Governor's Pheasant Opener which was held in Marshall on Oct. 14, 2017. An article appeared in the local newspaper, the Marshall Independent at that time. Several professional presentations were produced - an extended abstract was published and a poster presentation was given at the 2017 North Central Regional Conference of the American Association for Agricultural Education (AAAE) on Sept. 21-23, 2017 in Ames, Iowa, and an hour-long interactive

session was presented at the Minnesota Science Teachers' Association Conference (MnCOSE) in St. Cloud, MN on November 10, 2017. In December of 2017 the SMSU alumni magazine, SMSU Focus, had a cover story about this project titled "Taking Water Testing to a Whole New Level". Another extended abstract was published and another poster presentation was given at the 2018 American Association for Agricultural Education (AAAE) National Conference on May 14-18 in Charleston, South Carolina. A video was also created by Alex Peterson at Studio 1-Marshall Community Access TV from footage taken on Oct. 13, 2017 at the middle sampling site, near the 7th Street Bridge. The video is accessible through One Drive at <https://1drv.ms/v/s!AnulpG6ag3kyiUUopAdu1VpHxqZ>.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Subd. 07 Air Quality, Climate Change, and Renewable Energy

Community Solar Garden Installation

Subd. 07a \$490,000 TF

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Appropriation Language

\$490,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Rural Renewable Energy Alliance to install a 200-kilowatt community solar garden to provide for electrical distribution in Cass, Beltrami, Hubbard, and Itasca Counties, to assist households in the Minnesota low-income housing energy assistance program in meeting electrical energy needs and serve as a model for low-income energy assistance elsewhere in the state. This appropriation is not subject to Minnesota Statutes, section 116P.10.

OVERALL PROJECT OUTCOME AND RESULTS

This project installed a community solar garden to provide for electrical distribution in Cass, Beltrami, Hubbard, and Itasca Counties, to assist households in the Leech Lake Band of Ojibwe low-income home energy assistance program in meeting electrical energy needs and serve as a model for low-income energy assistance elsewhere in the state. Beneficiaries are to be residents of the Leech Lake Band of Ojibwe Reservation.

Low-income households devote a significantly greater percentage of their income to home energy than the average household. Currently, energy assistance programs offer temporary relief but don't provide a long-term solution to low-income energy poverty, and depend on imported fossil fuels. Utilizing Minnesota solar energy to meet this need is innovative and desirable in preserving Minnesota's valuable natural resources.

This project responds to the growing natural resource impacts of using imported, fossil fuels to supply Minnesota's low-income energy needs. The community solar system help increase the state's annual renewable energy production, and offsetting an estimated 217 tons of carbon dioxide emissions. This project has reduced carbon emissions to help slow climate change, increasing utilization of local power generation, improve energy security and affordability, and create low-income access to renewable energy.

This project successfully installed 217.58kW of solar energy that is producing 281,420kWh annually, enough to completely power 27 Minnesota homes. The systems will serve low-income Leech Lake families for the next 30

years. This was celebrated as the first community solar installation on Tribal lands in the country, and is providing inspiration to individuals around the nation seeking to deploy solar energy for the benefit of low-income people.

PROJECT RESULTS USE AND DISSEMINATION

As a central feature of the Rural Renewable Energy Alliance's efforts to increase access to solar energy for low-income households as a means of permanently addressing energy poverty, the results of this project have been disseminated at the national level. Presentations specifically about this project have been given at the following national events: National Energy Utility Affordability Conference (NEUAC), Clean Energy States Alliance webinar (CESA), American Solar Energy Society – US Department of Energy – Solar in Your Community Challenge conference. The project has further been presented at the following regional events: Connecting Low Income Communities to Efficiency and Renewable Sources meeting, Clean Energy Resource Teams Conference, RE-AMP Network Conference, Northern New England Community Action Conference, Minnesota Department of Commerce presentations, Great Plains Institute presentations, and at two Midwest Renewable Energy Fair. Reports resulting from this project have been disseminated at all the above venues, as well as being available through our website <https://www.rreal.org/cs4ca> , and Facebook page https://www.facebook.com/pg/ruralrenewableenergyalliance/photos/?tab=album&album_id=10154750786849241

Project Completed: 06/30/2018

[FINAL REPORT](#)

Subd. 10 Administration

Contract Agreement Reimbursement

Subd. 10a \$135,000 TF

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Appropriation Language

\$135,000 the second year is from the trust fund to the commissioner of natural resources, at the direction of the Legislative-Citizen Commission on Minnesota Resources, for expenses incurred for contract agreement reimbursement for the agreements specified in this section. The commissioner shall provide documentation to the Legislative-Citizen Commission on Minnesota Resources on the expenditure of

OVERALL PROJECT OUTCOME AND RESULTS

This appropriation was used to support the ENRTF contract management program, which ensured that ENRTF grantees expended grant funds in compliance with state law, session law, approved work plans, and Office of Grants Management grants policies.

The DNR Grants Unit managed 67 grants active in FY 2017. In FY 2018, the Grants Unit managed 71 active grants. Between 7/1/2016 when the services began and 06/30/2018 when they ended, the DNR Grants Unit:

- Made 359 reimbursements to grantees totaling \$13,053,825.58
- Prepared and executed 21 ML 2017 grant agreements
- Published 6 editions of the quarterly newsletter for all grantees
- Billed 350 hours at the FY 2017 professional services rate of \$63.00/hr

- Billed 1,534 hours at the FY 2018 professional services rate of \$63.00/hr
- Monitored all grants in compliance with Office of Grants Management policies.

PROJECT RESULTS USE AND DISSEMINATION

Project personnel were in frequent contact with appropriation recipients and LCCMR staff. Information was disseminated through manuals, training sessions, orientations, meetings, memos, letters, emails, newsletter, and phone.

Project Completed: 06/30/2018

[FINAL REPORT](#)

2. M.L. 2015 Projects Completed
January 15, 2017 – January 15, 2019
MN Laws 2015, Chapter 76, Section 2

M.L. 2015 Projects

[MN Laws 2015, Chapter 76](#), Section 2 (beginning July 1, 2015)

Subd. 03 Foundational Natural Resource Data and Information

County Geologic Atlases - Part A

Subd. 03a \$2,040,000 TF

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Appropriation Language

\$2,040,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the Minnesota Geological Survey to continue acceleration of the production of county geologic atlases for the purpose of sustainable management of surface water and groundwater resources. This appropriation is to complete Part A of county geologic atlases, which focuses on the properties and distribution of earth materials in order to define aquifer boundaries and the connection of aquifers to the land surface and surface water resources. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

This award is the seventh dedicated to creating County Geologic Atlases statewide. Geologic atlases provide maps and databases essential for management of ground and surface water resources. The program currently produces nearly 5 atlases per year, and only 32 counties have not yet been started. An average county atlas requires about \$400,000 and 3 to 4 years to complete. Projects in very large or distant counties, those with particularly complex geology, and those with challenging data sets take more resources and time. This award included work in Lake, St. Louis, and Hennepin counties, all of which required greater than average resources. However, of the 12 atlases we are currently working on 9 are past the halfway mark and a few are nearly finished. This grant funded work in Lake and St. Louis (\$882,684), Olmsted (\$152,975), Kandiyohi (\$129,244), Hennepin (\$372,668), Dodge (\$102,057), Hubbard (\$222,582), Becker (\$136,284), and Aitkin (\$40,791) counties. An additional \$715 supported initiation of work in new project areas. At this time bedrock mapping in Lake and St. Louis counties is about two thirds complete, and glacial mapping is slightly more than half complete. Federal cost-sharing has been applied to this work each year. The Olmsted CGA bedrock map is about 80% complete, and the surficial map about 90% complete. In Dodge County both those maps are at the 90% mark. In Kandiyohi County the surficial map has been drafted, the bedrock topography is about 50% complete, and the bedrock geology is just starting. For the Hennepin CGA the bedrock map is complete, the surficial geology is complete, the bedrock topography is complete, and the mapping of sand bodies is about 40% done. Similarly, in Hubbard County all products are ready except the sand model. In Aitkin County field work was the focus.

PROJECT RESULTS USE AND DISSEMINATION

Every atlas is produced in portable document format, as geographic information systems files, and in printed form. The digital files are compiled as a DVD, and are also available from the University of Minnesota Digital Conservancy <https://conservancy.umn.edu/handle/11299/57196>, and via link from the MGS web page. Each project culminates with a meeting held in the project area to present the results to the county staff, and any other interested parties.

At these meetings the products are described, access to the products is explained, and examples of applications of the products to common resource management situations are demonstrated. The products of subprojects in St. Louis and Lake counties are released in digital form immediately following technical review. When all the subproject areas are complete county-wide compilations will be created and distributed digitally and in print. The printed copies are shared with the county, who in turn can distribute them to libraries, schools, townships, and other agencies. They are also distributed by the MGS map sales office.

Project Completed: 06/30/2018

FINAL REPORT

Minnesota Biological Survey

Subd. 03c \$2,450,000 TF

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Appropriation Language

\$2,450,000 the first year is from the trust fund to the commissioner of natural resources for continuation of the Minnesota biological survey to provide a foundation for conserving biological diversity by systematically collecting, interpreting, monitoring, and delivering data on plant and animal distribution and ecology, native plant communities, and functional landscapes.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota Biological Survey plant and vegetation surveys continued towards statewide coverage, focusing on the last counties in the state for MBS to deliver: St. Louis, Koochiching, Beltrami and Lake of the Woods. Over 1,000 rare and notable terrestrial and aquatic vascular plant species were documented with specimens. Over 200 vegetation plots were placed in representative or rare forests, wetlands and peatlands.

MBS continued towards statewide collection of lake aquatic plant surveys, focusing in central and north-central Minnesota counties and putting the total to 2,025 lakes in 48 counties. This effort provides highly-valued foundational data to broaden DNR efforts to establish indices of biotic integrity for Minnesota lakes.

MBS continued to collaborate on monitoring efforts in prairies and forests. Long-term monitoring of rare prairie plant species continued from previous biennia. Prairie vegetation monitoring continued in high-priority prairie sites subject to cattle grazing. Surveys to establish baseline conditions for forest plant and animal monitoring projects were initiated in northern, north-central and southeast Minnesota. All of these monitoring efforts were selected and continued for their relevance to goals and desired outcomes found in Minnesota prairie and forest management and conservation plans.

MBS continued in several west-central counties to target sites in Minnesota Prairie Plan core areas that had not previously been surveyed by MBS. This involves use of LiDAR and high resolution aerial photography not available when MBS first surveyed these counties in the 1980s and 1990s. Over 200 previously undocumented high quality sites were completed.

MBS compiled and entered field survey and monitoring data to MBS databases. MBS information systems improvements were made that enhance data integration and accessibility. MBS continues to provide leadership in the management and use of the DNR's Native Plant Community database.

MBS provided survey and monitoring results to DNR and other partners and projects. MBS delivered a final manuscript to UMN Press for a new book on Minnesota sedges and rushes and completed major updates and improvements to the DNR Rare Species Guide (<http://dnr.state.mn.us/rsg/index.html>). MBS outreach included highly popular plant and native plant community field workshops throughout the state targeted at natural resource professionals and volunteers.

MBS Data Summary Table

Data Type	# added since July, 2015	Total Since 1987
Rare species records (Biotics) (all taxa)	360	21,838
Rare aquatic plant species records	6	1,251
Lakes with MBS botanical surveys	42	2,025
Counties with MBS lake botanical surveys	2	48
Vegetation plots (relevés)	174	5,540
Sites of Biodiversity Significance GIS polygons*	8	10,732
Native Plant Community GIS polygons*	1,929	84,626
Plant specimens submitted to the University of MN Bell Museum	640	~50,000 (source: Welby's estimate, includes Heritage Program submissions too)
Exotic aquatic plant species locations**	NA	302

Numbers reported based on data available on the Minnesota Geospatial Commons

**Encountered incidentally during the course of native aquatic plant surveys

PROJECT RESULTS USE AND DISSEMINATION

MBS data are stored primarily in the Division of Ecological and Water Resources information systems, which are increasingly linked to other databases in the MN DNR. In addition, MBS procedures, updates, recent maps, and links to related data are presented on the DNR website. Many GIS datasets are delivered to clients through the online data portal, Minnesota Geospatial Commons. MBS regularly provides vegetation plot data from the relevé database to researchers at academic institutions, other agencies and organizations. Data on rare species are available through agreements with the requesting agency and the DNR. For data on locations or rare features, a data request form is available via the web: <http://www.dnr.state.mn.us/nhnrp/nhis.html>

MBS publishes and distributes survey results in a variety of formats for various audiences. Many products are available as enterprise datasets on the DNR website, including GIS shape files of native plant communities and MBS sites, native plant community field guides, and guides to sampling techniques such as vegetation plot data collection using the relevé method. MBS web pages are updated with new information and have links to associated resources. <http://www.dnr.state.mn.us/mbs/index.html>

The DNR and Legislative libraries and other local information repositories (such as libraries within counties) have access to published products, including books, maps, reports, field guides and digital media. MBS has published several books and field guides.

Staff routinely make presentations that describe MBS methodologies and results to a wide range of audiences including county boards, local planning groups, citizen advisory groups, other biologists, land managers, and students. MBS staff provide local planners with ecological interpretations describing important sites of biodiversity identified during the Survey to assist with management plans.

Physical collections are deposited at Minnesota repositories, primarily at the University of Minnesota's J.F. Bell Museum of Natural History and at the Science Museum of Minnesota, St. Paul. As part of a larger network of museums and herbaria, these cooperators are essential to the documentation and sharing of MBS results. MBS and museum staff meet periodically to address curatorial, data management, and interpretive needs. MBS also delivers data through an international organization, NatureServe, and also shares data with cooperators at colleges and universities.

Project Completed: 06/30/2017

FINAL REPORT

Minnesota's Biodiversity Atlas for Enhanced Natural Resource Management
Subd. 03d \$340,000 TF

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Appropriation Language

\$340,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the Bell Museum of Natural History to create a publicly accessible, online tool and repository that will electronically integrate over 600,000 existing biodiversity records, 300,000 existing images, and future data and associated imagery pertaining to Minnesota wildlife, plant, and fungi species in order to enhance research, guide field surveys, and inform conservation planning. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Biodiversity Atlas project aimed to digitally capture, integrate and disseminate data on Minnesota's plant and animal diversity and distributions, with a focus on specimens held by the Bell Museum, the state's official museum of natural history. The result of this work, the Minnesota Biodiversity Atlas (<http://bellatlas.umn.edu/>), makes the majority of these data specimen data available in one easily-accessible resource for the first time. The new Atlas includes data from over 326,000 specimens of nearly 9000 taxa (species and subspecies) collected from throughout Minnesota by museum curators and state biologists over the last 140 years. Importantly, this project has made georeference data (precise latitude and longitude coordinates) of nearly 223,000 Minnesota specimens available in an integrated platform that allows simultaneous mapping of specimens from distinct groups (e.g., birds and plants) interactively within the Atlas or with the user's own application of choice. The Minnesota Biodiversity Atlas also provides access to a massive archive of specimen images (currently over 135,000), particularly of plants, allowing direct access for identification, collection of phenology and other data, and label verification. In addition to being served directly through the Atlas to agency partners and the public, all of these specimen data, along with all of the Bell Museum's specimen data from other parts of the world, are now served directly to global biodiversity data resources including the National Science Foundation-funded iDigBio and the Global Biodiversity Information Facility, which are critical resources for managers and research scientists around the world. The Minnesota Biodiversity Atlas is now a key resource providing critical data to resource managers and scientists both in Minnesota and globally. Future development of the Atlas will integrate additional specimen data from collections throughout Minnesota, as well as observational data collected by state agency partners and others, creating an even more powerful management tool and a permanent archive for these critical data.

PROJECT RESULTS USE AND DISSEMINATION

The primary result of this work was production of the Minnesota Biodiversity Atlas (<http://bellatlas.umn.edu/>), an online resource interactively serving data on specimen records of Minnesota plants and animals to agency partners, the public, and scientists and managers worldwide. This Atlas is the primary means of disseminating data on Minnesota's biodiversity. Bell Museum curators have promoted use of this resource by: 1) interaction with and training of agency partners in use of the Atlas; 2) interviews with the media, including two radio interviews and at least two print interviews; 3) training of participants in the Minnesota Master Naturalists program in specimen data capture (through a related project, Mapping Change, within the Zooniverse citizen science platform) and use of the Atlas, and 4) promotion of the Atlas through electronic exhibits within the newly-opened Bell Museum.

Project Completed: 06/30/2018

FINAL REPORT

Updating the National Wetland Inventory for Minnesota - Phase V

Subd. 03e \$1,500,000 TF

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Appropriation Language

\$1,500,000 the first year is from the trust fund to the commissioner of natural resources to continue to update and enhance wetland inventory maps for Minnesota. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Updating the National Wetland Inventory (NWI) is a key component of the State's strategy to ensure healthy wetlands and clean water for Minnesota. This effort is a multi-agency collaborative under leadership of the Minnesota Department of Natural Resources. These data are intended to replace the original 1980s NWI data. The NWI data provide a baseline for assessing the effectiveness of wetland policies and management actions. These data are used at all levels of government, as well as by private industry and non-profit organizations for wetland regulation and management, land use, conservation planning, environmental impact assessment, and natural resource inventories. The update project is being conducted in phases with data released for each region as it is finalized.

In this fifth phase of the overall effort, we provided updated wetland inventory maps for 20,385 square miles of northeastern Minnesota covering 15 counties in central and northern MN. With the completion of this phase, updated NWI data is now available for about 80% of the state.

The updated NWI were mapped in accordance with federal wetland mapping guidance. This update used spring aerial imagery acquired in 2013 and 2014, summer imagery acquired in 2015, and lidar elevation data as well as other ancillary data. Quality assurance of the data included visual inspection, automated checks for attribute validity and consistency, as well as a formal accuracy assessment based on an independent field data. Further details on the methods employed can be found in the technical procedures document for this project located on the project website (http://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html).

PROJECT RESULTS USE AND DISSEMINATION

All wetland map data and aerial imagery are available free of charge to the public. The data have been made available through the Minnesota Geospatial Commons (<https://gisdata.mn.gov/>) as well as through an online wetland viewer. A new wetland finder application will be deployed this fall to replace the previous wetland viewer. A copy of the data has also been provided to the US Fish and Wildlife Service for inclusion in the national wetland database.

Use of the NWI data is being promoted through a variety of channels. The DNR will be giving presentations about the NWI data at both the Minnesota Water Resources Conference and the Minnesota GIS/LIS Conference. We are also developing a communications plan to identify audiences, key messages, and various communications mechanisms (e.g. presentations, press release, websites, social media, etc.). The DNR's communications effort will be timed to coincide with the release of the full statewide NWI update, which we expect in December 2018.

Project Completed: 06/30/2018

[FINAL REPORT](#)

[Technical Procedures for Updating the NWI for MN](#)

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Creating a Statewide Wetland Bird Survey

Subd. 03f \$146,000 TF

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Appropriation Language

\$146,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Audubon Minnesota to develop a statewide wetland bird monitoring program to enable long-term monitoring of the status of wetland birds and the health of their wetland habitats. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

We have successfully developed and implemented the Minnesota Statewide Marshbird survey over the course of this grant. We set out to achieve a coordinated and sustainable approach to marshbird monitoring using both paid and volunteer surveyors. The first two years of data collection were fully executed as presented in the proposed work plan. We also conducted a third "bonus" field season in 2018 using minimal management oversight and limited staff involvement to see how long-term management and implementation could work going forward. The overall goals of this project were met and in most cases exceeded. Some highlights include:

- Engaging and retaining approximately 35 volunteers throughout the duration of this effort.
- Surveying a total of 73 routes (over 776 survey points) throughout MN in 2016-2017.
- Successfully collecting statistically rigorous data (defined as n>25 observations) on 9 of our 20 focal species
 - 4 primary species: American Bittern, Pied-billed Grebe, Sora and Virginia Rail.
 - 5 secondary species: Marsh Wren, Sandhill Crane, Swamp Sparrow, Wilson's Snipe and Yellow-headed Blackbird.
- Evaluating species-specific wetland habitat associations at multiple spatial scales.
- Assessing the sensitivity of marshbird occupancy (nine species) and abundance (three species) to anthropogenic disturbance variables (developed land, agriculture).

- Determining the strength of association between marshbird occupancy (nine species) and abundance (three species) with ecoregion (Aspen Parklands, Boreal Hardwood, Prairie Parkland and Boreal Harwood Transition).
- Currently working on the publication of this project and analysis for a peer reviewed, scientific journal.

Audubon continues to participate in the Great Lakes regional partnership focused on marshbirds and their habitat, with this project leading the way in analysis and adding to the overall dataset. This report highlights some of the results and recommendations of the statewide marshbird survey effort.

PROJECT RESULTS USE AND DISSEMINATION

The results of this analysis are currently being drafted for submission to a scientific, peer reviewed journal. We will distribute the final accepted paper to the ENRTF for their records upon completion (anticipated in fall 2018) and highlight the write up on the Audubon MN website.

Project Completed: 06/30/2018

[**FINAL REPORT**](#)

Endangered Bats, White-Nose Syndrome, and Forest Habitat - RESEARCH

Subd. 03i \$1,250,000 TF

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Appropriation Language

\$1,250,000 the first year is from the trust fund to the commissioner of natural resources in cooperation with the University of Minnesota and the United States Forest Service to survey and radio-track endangered bats to define and understand summer forest habitat use in order to minimize forestry impacts and mitigate white-nose syndrome disease impacts. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The Northern long-eared bat's (NLEB) listing as threatened under the federal Endangered Species Act prompted the DNR to undertake this project. The federal listing was in response to the impact of White Nose Syndrome (WNS) on bats throughout North America. WNS was detected in Minnesota in 2016, and NLEB hibernating in the Soudan mine subsequently declined drastically. The project first (Activity 1) compiled historic data to identify past distribution of NLEB. We next (Activity 2) deployed acoustic detectors throughout the forested region of Minnesota and found NLEB at over half of the detector sites. Bats most common in southern Minnesota were NLEB, big brown bat, red bat, little brown bat, and silver-haired bat. In northern Minnesota, NLEB, little brown bat, and silver-haired bat were most common.

In Activity 3, we used radiotelemetry to locate bat roost trees. We captured 1,202 bats, with little brown bat (37%), big brown bat (31%), and NLEB (17%) most common. Pregnant females were captured into the third week of July, with lactating females more common after the last week of June. Juveniles were captured from the 3rd week of June to the end of July. We tracked 83 female NLEB to 238 roost trees. Surprisingly, almost 80% of the time a roost tree was used for only 1 night before switching to a different roost tree, which meant females carried young to a different roost tree often. Maternity roost home range size for female NLEB was about 18 acres.

In Activity 4, we found that NLEB females roosted in 27 different tree species, with 90% of roosts in deciduous tree species and 10% in conifer species. Most roost trees were in upland forests. Aspen trees were used most in northern Minnesota, maple and aspen trees in central Minnesota, and oak in southern Minnesota. Female NLEB preferred roost trees surrounded by mature forest. Roost tree habitat in northern Minnesota is broadly distributed. In southern Minnesota, female NLEB selected a wider range of roost trees than in the north, probably reflecting the greater presence of agriculture and development. We mapped areas of Minnesota that should be suitable habitat for female NLEB while raising young, based on distribution of NLEB in Minnesota and forest characteristics.

Results of this project benefit Minnesota because we have identified roost tree habitat for NLEB that is critical for successful reproduction. We have identified when female NLEB are pregnant and lactating, and shown that young must be carried from one roost to another. The data collected in this project will enable development of management strategies to help recover the NLEB population, and can also be used for management of other bat species.

PROJECT RESULTS USE AND DISSEMINATION

Over the 3 years of this project we disseminated information to several outlets as listed in the project work plan. Site level reports and annual reports have already been shared with LCCMR and with Resource Management Agencies. Technical Reports, and additional peer-reviewed papers that will be written based on data collected in this project will be used in to develop future management actions for the Northern long-eared bat, and other bat species that could be listed in the future in response to White Nose Syndrome. NLEB roost tree locations have been entered into the DNR's Natural Heritage Information System. The results of this project are serving a critical role in the development of the Lake States Forest Bat Habitat Conservation Plan, a collaborative effort involving the states of Minnesota, Wisconsin, and Michigan that will provide the basis for bat conservation efforts in the three states. A full list of reports can be found in the final report.

Project Completed: 06/30/2018

FINAL REPORT

Summary of 2016 Northern Long-eared Bat Research in MN

Summary of 2017 Bat Research in MN: Technical Report 2017

Histocial northern long-eared bat occurrence in MN based on acoustic surveys: Technical Report 2018

Assessing Contaminants in Minnesota Loons and Pelicans-Phase III

Subd. 03j \$141,000 TF

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Appropriation Language

\$141,000 the first year is from the trust fund to the commissioner of natural resources to continue to assess the potential impact of petroleum, dispersants, and heavy metal contaminants from the Deepwater Horizon oil spill in the Gulf of Mexico on the wintering habitat of Minnesota's common loons and white pelicans using radiotelemetry, geolocators, and contaminant analysis.

OVERALL PROJECT OUTCOME AND RESULTS

The Deepwater Horizon oil spill in the Gulf of Mexico in 2010 exposed Minnesota-origin loons and white pelicans to direct mortality and to cancer-causing pollutants called Polycyclic Aromatic Hydrocarbons (PAH) and Diocetyl

Sodium Sulfosuccinate (DOSS). This study used radiotelemetry to study migration patterns of juvenile loons and to determine the extent of PAH and DOSS contaminants in live adult loons, loons found dead, and unhatched loon eggs.

Radiotelemetry efforts showed that juvenile loons migrate to the Gulf of Mexico in their first fall and then migrate to the northern Atlantic region offshore from Canada for their second summer and to the northeastern states and Ontario in their second year. They returned to the Gulf of Mexico each winter. Surviving birds wintered in the Gulf of Mexico where petroleum contaminants had settled offshore from Alabama and Florida. The subadult loons were expected to return to Minnesota for the first time in spring of 2017 but the last transmitter quit working in March of 2017.

A total of 17 of 22 juvenile loons marked with transmitters perished in their first two years and demonstrated that this species experiences high mortality in the first couple years of life.

Contaminant analyses revealed that 18 of 42 blood, feather, and fat samples from loons contained petroleum contaminants. Four of 29 unhatched loon eggs also contained PAH contaminants.

PROJECT RESULTS USE AND DISSEMINATION

The telemetry and contaminant data collected in this study have been incorporated with the results of previous research to validate and justify a claim to the US Fish and Wildlife Service for \$6 million in remediation funds from the BP settlement to carry out long term restoration efforts for loon and pelican conservation in Minnesota. This would be the first of up to five three-year claims for loon and pelican remediation funds for Minnesota.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Movement and Seasonal Habitat Use of Minnesota Elk - RESEARCH

Subd. 03k \$200,000 TF

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Appropriation Language

\$200,000 the first year is from the trust fund to the commissioner of natural resources to collect biological information about Minnesota elk, including movements and habitat use to enable long-term, sustainable management. This appropriation is contingent on a \$50,000 match from state or nonstate sources. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The results of this study represent some of the first scientific knowledge of elk in Minnesota. By monitoring 20 adult female elk for 2 years, we were able to characterize the extent to which the 4 subgroups of elk in northwestern Minnesota utilize the landscape. Additionally, we identified habitats preferred by elk across seasons. Annual home ranges of elk were large, ranging from 71 km² and 112 km². Seasonal home ranges for elk varied little during our study, with an average size of 48.5 km². Elk primarily selected for forested habitats, particularly on Wildlife Management Areas. Elk utilized open areas in close proximity to forested cover, including agricultural crops such as legumes and cereal grains, and fallow fields. Based on the movements of GPS-collared elk, female elk

do not interact with other females outside of their distinctive subgroups. Elk in northwestern Minnesota are non-migratory and maintained home ranges in the same general areas across the 2 years we monitored them. Our results provide specific information about the locations and movements of elk in Minnesota and habitats preferred by the species. This knowledge will enable managers to direct management to improve habitats most likely to be used by elk. Such efforts will improve the condition of elk and aid in minimizing elk-human conflicts.

Project Completed: 06/30/2018

FINAL REPORT

Space Use and Habitat Selection by Female Elk: Paper

Genetic and Camera Techniques to Estimate Carnivore Populations - RESEARCH

Subd. 03I \$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 - Duluth for the Natural Resources Research Institute to use genetic sampling and remote cameras to improve monitoring of distributions and estimate population sizes of carnivore species.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota has 20 carnivore species, 3 of which are very rare. Current monitoring methods of summer scent station surveys, winter track surveys, and population modelling could be complemented by camera traps and genetic DNA analysis. We used camera traps to obtain 3,400 images of carnivores over 12,000 camera-nights. American marten, fisher, short-tailed weasel, wolf, red fox, and gray fox were most frequently photographed. Occupancy analysis showed habitats used by each of these species. Mark-recapture estimation of population size was not possible. Camera traps could include significant public involvement, as is being done by the Wisconsin DNR. A second outcome of camera trap data is testing a Random Encounter Model to determine if population densities can be estimated without identifying individuals.

We implemented sampling protocols to obtain hairs non-invasively from weasels and larger carnivores. Hair collection was less efficient than camera traps. Wolf scat collection in snow was unpredictable. However, DNA analysis identified individuals in the collected samples. Hair and scat collection is technically feasible but logistically difficult to implement.

A consistent conclusion from genetic sampling protocols is that the cost to obtain and analyze genetic samples, at present, would make it difficult to implement a mark/recapture population estimate for management on a large spatial scale. We did not fully expend the ENRTF funding because genetics collaborators were fully occupied with their own research. One tangible outcome of this project is that a genetic collaborator with time to do the analysis is critical.

The Minnesota Carnivore website has descriptions, pictures from the camera trap project, and historical harvest data in Minnesota and adjoining jurisdictions. The website will be updated periodically to provide new information—it is the only Minnesota-specific Carnivore website available. In addition, we will finish 4 Technical Reports and a peer-reviewed paper on occupancy modelling in Fall 2018.

PROJECT RESULTS USE AND DISSEMINATION

1. Technical reports summarizing the entire project.
 - a. **Camera Trapping:** Moen, R. and B. Houck. 2018. Monitoring Carnivore Populations in Northeast Minnesota with Camera Traps. NRRI Technical Report No. NRRI/TR-2018/44. University of Minnesota Duluth.
 - b. **Weasel tube hair snares:** Houck, B. and R. Moen. 2018. Use of Tube Hair Snares to Detect Weasels in Minnesota. NRRI Technical Report No. NRRI/TR-2018/45. University of Minnesota Duluth.
 - c. **Cable-Restraint hair snares:** Houck, B. and R. Moen. 2018. Use of Single-Capture Hair Snares to Detect Carnivores in Minnesota. NRRI Technical Report No. NRRI/TR-2018/43. University of Minnesota Duluth.
 - d. **Wolf Scat Collection and Genetic Analysis:** Moen, R. 2018. Genetic Analysis of Wolf Scats Collected from Snow. NRRI Technical Report No. NRRI/TR-2018/51. University of Minnesota Duluth.
2. Occupancy modelling manuscript. Houck, B. and R. Moen. 2018. Occupancy modelling of carnivores in northeastern Minnesota from camera trap data. Manuscript to be submitted for peer review.
3. The Minnesota Carnivore website is currently located at <https://champ.d.umn.edu/mc>. It is being relocated to <https://www.nrri.umn.edu/mc>.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Historical northern long-eared bat occurrence in MN based on acoustic surveys: Technical Report 2018](#)

Digitization of Historic Gullions Ruffed Grouse Research

Subd. 03n \$75,000 TF

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Appropriation Language

\$75,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Central Lakes College to preserve the Gordon Gullion ruffed grouse data sets as permanent digital data files in order to improve accessibility to the information and inform forest wildlife conservation policies and practices.

OVERALL PROJECT OUTCOME AND RESULTS

Dr. Gordon W. Gullion is recognized as one of the world's foremost authorities on ruffed grouse. Dr. Gullion began his study of ruffed grouse ecology and habitat management in 1958 at the Cloquet Forestry Center, the Mille Lacs Wildlife Management Area and a privately owned Crow Wing Study Area.

More than 69,000 individual data records from his work exist on hard copy data cards today. These data document ruffed grouse habitat use throughout the year, food habits, reproductive success and mortality factors that provided the very foundation of ruffed grouse (and many other species) habitat and population management throughout much of the Great Lakes region.

Unfortunately, with Dr. Gullion's sudden death in 1991, and the deterioration of the data cards, this information was at a point where it may have been lost forever – and with it an important chapter in the history of wildlife conservation in Minnesota - without conversion of the data to a more permanent medium. This project set out to

transcribe 20,000 of these historic data cards into digital format and to develop of a data retrieval system that enables users to easily and efficiently navigate and retrieve data for specific analytical tasks from this electronic dataset. To assess this, a subset of Dr. Gullion's uncompleted manuscripts were to be completed using the data retrieval system to test its effectiveness.

Approximately 21,500 records were transcribed and archived in a digital database (MySQL). Data from MySQL files are easily exported into many analysis and spreadsheet programs, including MS Excel that increases accessibility to the data. Two of Dr. Gullion's manuscripts were reviewed using the archived data to determine the utility of the database. Additional funding provided by the Ruffed Grouse Society will allow digital transcription of the remaining 47,500 data cards. In addition, every data card will also be scanned front and back and a pdf version of each included in the database.

PROJECT RESULTS USE AND DISSEMINATION

Work will continue under Ruffed Grouse Society funding to continue to modify the digital database for ease of access as new card types and the remaining data cards are included. Upon the completion of transcription and scanning, the original data cards, files cabinets, maps, and any other materials from Dr. Gullion's collection currently housed at Central Lakes College will be returned to the Cloquet Forestry Center. The Center will also likely be the primary depository of the transcribed data and pdf images. Additional repository sites may include Central Lakes College, Minnesota Department of Natural Resources and the University of Minnesota. Archived materials in these collections will be available for electronic dissemination to anyone requesting the information.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Effects of Grazing Versus Fire for Prairie Management - RESEARCH

Subd. 03o \$414,000 TF

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Appropriation Language

\$414,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to compare the effects of conservation grazing and prescribed fire on tallgrass prairie plants and pollinators in Minnesota in order to inform and improve land management practices. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Without disturbance, Minnesota's tallgrass prairies would transition to woodland and forest. Current management includes prescribed fire and conservation grazing to maintain prairie plant communities, with the assumption that pollinator communities will also benefit. While effects of fire on northern tallgrass prairie are well-documented, information has been lacking on effects of conservation grazing on vegetation and insects in Minnesota. To address this knowledge gap we evaluated vegetation, bees, and butterflies on burned or grazed remnant prairies in western Minnesota. Quantitative assessments of plant, bee and butterfly communities were based on randomly placed transects at each site; species lists were augmented by directed searches of the sites.

Of 328 plant species identified, 52 were found only on grazed sites and 57 only on burned sites. On a scale from 0 (weeds) to 10 (species found only in undisturbed remnant prairie), burned sites averaged 4.1 and grazed sites 3.7, which suggests that the grazed sites were a bit weedier than the burned sites.

Of 40 butterfly species observed, 30 were seen at both burned and grazed sites. Nine of the 40 species are reliant on native prairie. In general, species that were seen at more sites were also more abundant. Common species tended to be more abundant at burned sites and rarer species tended to be more abundant at grazed sites. To date, 69 species have been identified from over 7,200 collected bees; a few taxonomically challenging specimens are as yet unidentified. Of conservation interest are the 11 species of bumble bees, three of which are listed as “vulnerable” by the IUCN (*Bombus fervidus*, *B. pensylvanicus*, and *B. terricola*).

Burning and grazing favored varying communities of plants, bees, and butterflies, suggesting that each management type has a role in maintaining Minnesota’s prairie ecosystems. Results of our research are providing land managers with information necessary for them to be effective stewards of prairie plant communities and the pollinators that depend on them.

Project Completed: 06/30/2018

[FINAL REPORT](#)

[Field Protocols](#)

[Prairie Vegetation and Insect Monitoring Workshop Handout](#)

Foundational Dataset Characterizing Historic Forest Disturbance Impacts

Subd. 03q \$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 to quantify forest disturbance impacts over the past forty years on water quality, wildlife demographics, and wood fiber supply in order to identify management strategies that better respond to disturbance impacts and improve and sustain forest resources. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Forest disturbance (arising from harvesting, fire, land conversion, etc.) has a fundamental impact on the health and resilience of multiple forest resources including water quality, wildlife habitat, and wood resources, among others. Recently the United States Geological Survey made a revolutionary decision by allowing open access to a historic archive of Landsat satellite data dating back to 1972, providing a new opportunity to assess historic forest disturbance (type, timing, and patterns). The objective of this project was to utilize the historical satellite images to characterize >40 years of Minnesota forest trends and disturbance patterns, and provide spatial mapping resources for a variety of local forest management and research applications. After the necessary processing to compile the Landsat imagery in a way that would allow the data to be comparable through time, we created models to produce annual (1973-2015) state-wide maps of canopy cover. These maps allow for the characterization of forest resources at a given point in time, as well as the monitoring of forest change and recovery trends, providing a valuable and versatile dataset for a variety of Minnesota users. For the second part of this project, we focused on the Laurentian Mixed Forest Province, which contains much of the public and forested

lands of Minnesota, where we utilized additional Landsat data to map the most recent abrupt disturbance events over time. We further enhanced the disturbance map by classifying the disturbance agent (harvest, land conversion, fire, wind, flooding), as well as providing information about the year, duration, and magnitude of each event. Currently we are working with several collaborators to input our mapping products to address a variety of forest management, wildlife habitat, and water quality assessment applications.

PROJECT RESULTS USE AND DISSEMINATION

Our initial publication from this project, entitled “Extracting the full value of the Landsat archive: Inter-sensor harmonization for the mapping of Minnesota forest canopy cover (1973–2015)” was published in Remote Sensing and Environment in March 2018, and is already providing a valuable resource for fellow researchers through our approach for incorporating rarely integrated early Landsat MSS imagery to time series analyses for the creation of >40 years of annual forest attribute mapping. While only recently published, the paper has already received 4 citations in peer reviewed publications and boasts 423 reads on research focused social media platform. We were invited to present this work through a webinar for the USDA Forest Service’s Forest Inventory and Analyses National Research Techniques Band (recording available at: <https://usfs.adobeconnect.com/prjhzov1f5fi/>), and continue to utilize the valuable state-wide data set presented in this publication for our disturbance mapping efforts and various forest, wildlife, and water resources applications.

We have worked with, and continue to work with, several collaborators to provide our canopy cover and disturbance mapping products for a variety of forest management, wildlife habitat, and water quality assessment applications. In addition to providing mapping resources to UMN moose biologists to assess habitat use and movement, we are also currently working with wildlife researchers from UMN-Duluth to incorporate our canopy cover and disturbance mapping products in a project assessing the impacts of harvest intensities and the quantity and spatial arrangement of retained tree canopy on avian and small mammal communities across a chronosequence of harvest ages. We have also provided initial harvest maps to contractors working with the MN PCA, to incorporate into a watershed planning tool for assessing forestry best management practices and impacts on water quality.

We have presented our work to a variety of research groups, local managers, and state and federal agencies throughout the project time period, and we continue to disseminate our results and mapping products to a variety of audiences to ensure that our products can provide vital additions to existing projects and management planning needs. We also continue to explore additional applications of the data and are working to compile manuscripts related to utilizing the disturbance products to assess various forest ecology and resource management questions and issues.

Project Completed: 06/30/2018

[FINAL REPORT](#)

[Extracting the full value of the Landsat archive: Publication](#)

Hydrologic Effects of Contemporary Forest Practices in Minnesota - RESEARCH

Subd. 03r \$150,000 TF

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Appropriation Language

\$150,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to install hydrologic monitoring stations to collect water quantity and quality data from lands managed for timber

production to better understand the relationship between harvest practices and water resources and related responses to changing climate and other disturbance factors in order to inform forest management practices. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

In forested landscapes, runoff amount and timing and sediment concentration and load are major water quality concerns. Previous studies on the effects of forest harvesting practices on water resources in Minnesota and throughout the Lake States region were conducted decades ago and their results have been widely applied beyond the conditions under which they were conducted. To facilitate effective, science-based forest management decisions, water quantity and quality information associated with contemporary forest harvesting practices is needed. To increase data on the hydrologic effects of contemporary forest management, we monitored stream discharge and water quality from early August 2016 to July 2018 at two river locations along the West Swan River in St. Louis county – one upstream and one downstream of ~100-acre growing season timber harvest. Average streamflow was approximately two times greater at the downstream site than the upstream site during the pre-harvest phase and increased to three times greater during the monitored post-harvest period. At the upstream site, average (\pm standard deviation) total suspended solids (TSS) concentrations remained relatively constant throughout the study (pre-harvest: 18.53 ± 21.49 mg/L; post-harvest: 19.81 ± 12.16 mg/L) whereas TSS concentrations at the downstream site very slightly increased from 22.13 ± 14.73 mg/L in the pre-harvest phase to 25.56 ± 24.85 mg/L in the post-harvest period.

Overall, this two-year data collection project quantified the variability of river flow and water quality as Total Suspended Solids concentrations. The variation water quality with approximately one year of pre- and post- timber harvest data showed slight differences that, for the most part, remain within the overall variability of pre-harvest conditions. Meaning that while the harvest had a nominal effect, this was seen only very local in space and near in time to the harvest. This relatively short case study provides data that is otherwise uncollected in this region. The results highlight the need to collect further data within the region and state to quantify the larger spatial effects of timber harvesting on water quality. In particular, additional efforts are needed to determine how site-level timber harvest effects scale up in space and factor into water quality planning at the watershed and/or hydrologic unit scale (e.g. in the Total Maximum Daily Load or One Watershed One Plan assessment and planning efforts).

PROJECT RESULTS USE AND DISSEMINATION

In the granting period, preliminary results of this project have been presented in 7 formal talks given by Dr. Karwan and Dr. Rose, as listed below. In addition to formal presentations, information learned from this project has been incorporated into teaching and broader conversation with forest management professionals by Dr. Karwan. First, Dr. Karwan provides forest hydrology instruction to silviculturists in the U.S.D.A. Forest Service National Advanced Silviculture Program every summer in Cloquet, MN. Lessons learned from this project, including working in mid-sized rivers and examining the effects of harvesting beyond small watersheds, are discussed as a part of this program. Second, information generated as a result of this project has been shared by Dr. Karwan as an invited participant to two groups affiliated with the State of Minnesota: (1) a 2018 panel convened to inform the research direction of the Minnesota Forest Resources Council, and (2) in meetings with a Technical Advisory Committee to the Minnesota Pollution Control Agency's team working to represent forestry Best Management Practices in hydrologic model scenarios (HSPF – SAM). Finally, work on this project formed the basis of an internship experience for two female high school students in Dr. Karwan's lab through the YWCA Minneapolis Girls Inc. Eureka! Program – a multi-year program for girls focused on STEM. In June – July 2018, two students assisted with water quality sample processing and traveled to the field site associated with this project. This experience formed a 4-week internship in which the high-school students experienced a STEM job first-hand and learned about both work in STEM fields and a university setting.

Upon completion of this project, we now have additional data and results to present. We are looking forward to doing this through venues that bring together scientists with forest and landscape managers, such as the annual Sustainable Forests Education Cooperative (SFEC) Forestry and Wildlife Research Review and the regional meetings of the National Council of Air and Stream Improvement, a timber industry group, which take places in the Great

Lakes region in the spring/summer of odd years. Furthermore, data from this project can be incorporated into graduate research and further work on the watershed functioning of northern MN forests.

Project Completed: 06/30/2018

FINAL REPORT

Habitat Mitigation for Goblin Fern Conservation

Subd. 03s \$61,000 TF

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Appropriation Language

\$61,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Leech Lake Band of Ojibwe to examine goblin fern populations, a threatened species in Minnesota, in relation to habitat degradation and to develop long-term habitat mitigation and species conservation strategies. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Goblin fern (*Botrychium mormo*) is a tiny, cryptic species of fern from the Great Lakes region of North America. The species once occurred throughout rich sugar maple and basswood forests of Minnesota, Michigan, and Wisconsin, but in recent times has become exceedingly rare and vulnerable throughout the entirety of its historic range. The primary goals of this project were to (1) evaluate habitat conditions and environmental factors influencing the decline of goblin fern populations; (2) quantify projected population extirpation rates for all recorded populations across Leech Lake Reservation, including Chippewa National Forest.

1. Habitat conditions were assessed by the degree of worm damage at each location and assigned an IERAT rank of 1-5 (1 = non-wormed, 5 = extremely wormed). Each site was also assigned a habitat ranking of 1-5 (1 = prime, 5 = non-extant); which directly correlates with the probability of goblin fern presence/absence at each location.
2. Our estimates of Minnesota goblin fern extirpation are consistent with previous publications; in fact our estimates indicate a significant increase in extirpation rates when compared to older publications addressing habitat issues and concerns.

Though startling, our study provides current published information about the loss of critical habitat, and subsequent decrease in occurrence and abundance of this state threatened species across its native range within Minnesota. With exception to the driftless area in southeastern Minnesota, there are no earthworm species native to the state, especially the rich maple and basswood forests of northern Minnesota. Contrary to long held belief, earthworms, especially those known as “crawlers”, cause irreparable damage to the forest floor and soil. As a result, much of the vital habitat required for the survival of goblin fern has become seriously degraded and fragmented across the north woods of Minnesota.

PROJECT RESULTS USE AND DISSEMINATION

Our abstract was submitted for peer review in June 2018. Upon receiving comment, review and revisions were made to the abstract, which was submitted in July 2018, and ultimately accepted for publication. The published article has been disseminated amongst select individuals within Minnesota Department of Natural Resources, Chippewa National Forest, Superior National Forest, and Ottawa National Forest for the purpose of developing and implementing improved habitat conservation measures. Additionally, all data collected from the project were shared with the USFS, Chippewa National Forest for the purposes of updating database records.

Project Completed: 06/30/2018

FINAL REPORT

Invasive earthworm damage predicts occupancy of a threatened forest fern: Publication

Subd. 04 Water Resources

A Novel Biofilm Technology for Water Nutrient Removal - RESEARCH

Subd. 04b \$281,000 TF

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Appropriation Language

\$281,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to develop a simulated lichen biofilm system that can be used to remove pollutants and recycle nutrients from storm water runoff and polluted lakes, ponds, and lagoons. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Nutrient pollutants such as nitrogen and phosphorus from urban and agricultural fields is the leading cause of water quality issues in Minnesota. We proposed a novel biofilm technology to remove nutrients such as nitrogen and phosphorus from water, based on a concept of a “simulated lichen biofilm”, mimicking the natural symbiotic lichen ecosystem, for efficiently removing and recovering nutrients and pollutants, by introducing a supporting matrix, binding filamentous fungal strains and microalgae. Different strain combinations, types of wastewater, reactor designs, and operational parameters were investigated. After laboratory scale experiments, the pilot demonstration was tested at the Sarita Wetland close to Saint Paul Campus of UMN and the pond next to the Frank and Sims Yard Waste Collection Site in East Saint Paul. Based on the results from the prototype model testing using a rotating paddle wheel design in Sarita wetland, we can conclude that the biofilm can be operated between 96-120 h with P removal efficiency of 80 %, N removal efficiency of about 66.2% and COD removal efficiency of about 74%, and needs replacement of biofilm for the next batch of operation. More future work is needed to address some technical challenges as it is applied in the field, including the competition from local microalgae in the wastewater, very effective in heavily polluted water while not effective with much diluted water nutrient pollution, and the biofilm as a food attraction to many insects, leading to the disintegration of biofilm. The technology developed from this project will contribute to a solution for both rural and urban communities to handle water sites polluted by nutrients. When communities can effectively manage their nutrient pollution in water systems, public health and the environment are adequately protected while the community has the management structure in place over the long-term.

PROJECT RESULTS USE AND DISSEMINATION

Even though a final applicable solution is still in needs of more research and development, we have presented our research in many national and local conferences, several publications either in press or in submission. We published three journal articles and made a list of presentations to disseminate our research results and the Environment and Natural Resources Trust Fund was acknowledged at each of the presentation and paper publications. We also reached large amount of undergraduate students and high school teachers via the teaching module developed from this project. The project generates some excitement from both the scientific community

and industry. The technology developed from this project, together with the information obtained from the techno-economic analysis, can be beneficial to local communities to eventually find a solution for nutrient pollution issues. Besides the academic dissemination, a video of showcasing the pilot-scale testing system at Sarita Wetland will be posted on the group website for general public access. Below are the list of papers and publications and we are preparing for another two manuscripts for peer-reviewed publication.

Project Completed: 06/30/2018

FINAL REPORT

Biological Consequences of Septic Pollution in Minnesota Lakes - RESEARCH

Subd. 04c \$364,000 TF

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Appropriation Language

\$364,000 the first year is from the trust fund to the Board of Trustees of the Minnesota State Colleges and Universities system for St. Cloud State University to assess the presence of possible sources of contaminants of emerging concern in Minnesota lakes in order to determine their effects on fish health, understand the potential contribution from septic systems, and inform options for remediation and prevention to protect Minnesota lakes from these contaminants in the future. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

All activities proposed for the current study have been completed. The addition of a fifth lake and expansion from 16 to 20 study sites has provided a wealth of chemical and biological data that provide multiple avenues for further analysis and study. Pore-water sampling at all 20 lake sites has been completed and the samples have been analyzed for the presence of Contaminants of Emerging Concern (CECs). In addition, composite surface water samples from all five lakes were collected and analyzed. Composite pore-water samples were also collected and analyzed. Synoptic sampling of septic seepage flow into ground water was completed in the final year of the study. The chemical analysis of all samples has been completed and included pore-water, surface water, composite samples and laboratory water samples for confirmatory water chemistry. In total, well over 1,000 analyses were conducted to assess the presence and quantify the concentrations of CECs in Minnesota waters. These analyses revealed several key findings. First, CECs are ubiquitous in pore-water samples. Second, concentrations of CECs are higher in sites closer to lakeshore septic systems. Third, in addition to household-source signatures (i.e., CECs most likely used in households and as personal care products), some pore-waters also contain agricultural signatures (i.e., presence of pesticides in pore-water). Fourth, CECs are also ubiquitous in lake surface water -likely as result of incoming ground water flow.

The biological consequences of CEC exposures were evaluated using a combination of field and laboratory assessments. Native sunfish (*Lepomis macrochirus*) were captured near twenty field sites in which pore- and surface water chemistry was assessed for the presence of Contaminants of Emerging Concern (CECs) (Activities 1 and 2). In addition, hatchery-reared sunfish were exposed to mixtures of CECs derived from the pore-water measurements. We also exposed larval and adult fathead minnows (*Pimephales promelas*) in the laboratory to pore water (larvae only) and CEC mixtures. These analyses revealed several key findings. First, male fish taken from septic seepage-influenced lake sites and male fish exposed in the laboratory responded by producing the egg-yolk protein vitellogenin – a well-established biomarker of exposure to estrogenic CECs. Second, larval fathead

minnows exposed to either pore water collected from field sites or to a comparable mixture of CECs were less likely to survive than control larvae. Third, higher concentration CEC mixtures, matching those observed in lake pore-water produced subtle adverse biological effects. The biological findings identify CECs as a source of concern for the health and sustainability of Minnesota fish populations in lakes impacted by septic seepage.

PROJECT RESULTS USE AND DISSEMINATION

One peer-reviewed manuscript has been published, and two additional manuscripts are in preparation. In addition, results of the current study were disseminated widely in a series of presentations at regional and international scientific conferences:

- March 2016 – Society for Environmental Toxicology & Chemistry chapter meeting in Madison, WI
- November 2016 - Society for Environmental Toxicology & Chemistry world congress in Orlando, FL
- February 2017 - Fish & Wildlife Conference in Lincoln, NE
- March 2017 – MN Wastewater Conference, Brooklyn Park, MN
- March 2017 - Society for Environmental Toxicology & Chemistry chapter meeting in Minneapolis, MN
- April 2017 – Thesis defense (Les Warren) at St. Cloud State University
- September 2017 – Seminar (Megan Guyader) at St. Cloud State University
- November 2017 - Society for Environmental Toxicology & Chemistry North America meeting in Minneapolis, MN (two presentations)

Project Completed: 06/30/2018

FINAL REPORT

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Appropriation Language

\$505,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to develop a new nanocomposite material made from biomass that is designed to adsorb phosphorus, nitrogen, and pesticides from storm water and drain tile runoff discharge for recycling back to agricultural lands. This appropriation is subject to Minnesota Statutes, section 116P.10.

OVERALL PROJECT OUTCOME AND RESULTS

The effective production of food and fiber relies on fertilizers to provide plant nutrients and pesticides to control weeds, insects, and plant diseases that interfere with the yield and marketability of crops. In the fields, these do an important job, but when they run off into surface or groundwater they can pose a threat to water quality and raise environmental issues. The impact of pesticides on water quality is a technically complex subject. Phosphorus, from fertilizers, is often the limiting nutrient in aquatic ecosystems and the main culprit in eutrophication. Once these chemicals enter our waters it is virtually impossible to remove them. The objective of this research was to determine if an engineered hydrochar, fabricated from inexpensive agricultural residues, would remove phosphorous, nitrates and pesticides from agricultural drainage waters. Our early research indicated that certain metals could be incorporated into chars to remove phosphorus and nitrates from dilute solutions. Subsequently, many experiments were performed with a wide range of biomass from corn stover to manures and with various potential activating metals.

Significant outcomes:

- Lanthanum (a transition metal) modified corn stover hydrochars have best phosphorus removal capacity in range of 25-45 mg of P/gram char from a 50ppm solution
- Zinc chloride modified bio-hydrochar sorbs nitrates comparably to activated carbon

- Lanthanum modified bio-hydrochar can simultaneously remove phosphorous and glyphosate from dilute solution
- Chars will sorb pesticides if first subjected to post-thermal heat treatment (PTT) in an oxygen-free atmosphere
- Dry biomass, like cornstover, can be converted directly by PTT to a biochar that will remove pesticides

These results provide a path forward in preserving the quality of our water resources by reducing the phosphorous, nitrates and pesticides that migrate to waterways through daintiles. The information generated here forms the basis for field trials leading ultimately to preservation of our aquatic ecosystems.

PROJECT RESULTS USE AND DISSEMINATION

The University has expanded the scope of the original provisional patent to include broader claims. The new provisional patent is: U.S. Provisional Application No. 62/718,705 Title: METHOD FOR REMOVING PHOSPHORUS COMPOUNDS FROM AN AQUEOUS MEDIUM, on August 14, 2018. This technology was developed with trust funds from our LCCMR project and any future revenues will be shared as required.

Project Completed: 06/30/2018 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

Southeastern Minnesota Cover Crop and Soil Health Initiatives Subd. 04e \$253,000 TF

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Appropriation Language

\$253,000 the first year is from the trust fund to the Board of Water and Soil Resources to promote cover crops as a means of protecting soil and water quality in southeastern Minnesota through training and education for local practitioners, economic analysis of implementation, and on-farm demonstration sites. This effort must be coordinated with the University of Minnesota Forever Green Initiative. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

This project was very important in keeping the momentum going for cover crop and soil health awareness in Southeastern Minnesota. In 2014 when BWSR applied for the LCCMR grant, very limited outreach and awareness of implementing cover crops was occurring in Southeast Minnesota as well as Statewide. Over the last 4 years, the work of this project has helped keep cover crops and soil health on the forefront of innovative conservation in Minnesota. This project was successful in establishing cover crop demonstration sites, providing education and outreach through workshops and field days, and completing an economic analysis report of cover crops. The following includes the major accomplishments of this project:

Field Days: This project lead or assisted in sponsoring 9 different field days through the course of this project, which was the target goal for the project. A total of 575 people attended these field days.

Workshops: A total of 832 people attended 11 workshops that were sponsored by this project, which exceeded our initial goal of 6 workshops.

Cover Crop Demonstration Sites: This project worked with 13 landowners to implement 2098 acres of cover crops over 2 years. These sites represented farmers from across the focus area using different farming methods and cover crop seed mixes

Soil Health Sampling and Method/Protocol Development: This project was important in working with our partners at USDA-NRCS and local SWCD staff to develop a sampling protocol for collecting soil samples for soil health analysis. Soil tests were collected at each of the landowner demonstration sites.

Cover Crop Economic Analysis: A report on the economics of cover crops based on data from the landowner demonstration sites was developed.

Partnership Development: This project was instrumental in bringing University of Minnesota, Federal, State, and local partners together to coordinate and ensure project success.

PROJECT RESULTS USE AND DISSEMINATION

This project provided dissemination of information regarding soil health, cover crops, and alternative crops through the many workshops and field days that were outlined above. This project utilized the U of M Soil Health website, as well as many other local sources, to provide information about upcoming workshops and field days.

See web link: <https://extension.umn.edu/soil-and-water/soil-management-and-health> .

Specific new information that was developed and disseminated through this project include:

- Cover Crop Economics Report by Dr. Bill Lazarus, U of M Applied Economics:
- Updates to U of M Cover Crop Economics Spreadsheet tools,
- Soil health testing results were supplied to each of the 13 cooperators,
- Project updates on BWSR's website, such as this BWSR Snap Shot article:
<http://www.bwsr.state.mn.us/news/webnews/december2016/1.pdf>

Through this project over the last 3 years, BWSR has learned a lot about the positive impacts of soil health, the pros, cons, and risks of implementing cover crops into a farming operation, and what types of information farmers and local conservation practitioners are looking for. This project was instrumental in providing a basis for BWSR adopting cover crops as practice for our grant programs, helping provide insight into the development of the new BWSR/University of Minnesota joint venture with the Office for Soil Health, and was a precursor to a recently awarded Conservation Innovation Grant from the USDA-NRCS focusing on soil health metrics. BWSR is confident that the momentum created by this project will help move the State of Minnesota forward in developing new strategies for soil health that will lead to greater adoption of cover crops and other soil health practices.

Project Completed: 06/30/2018

FINAL REPORT

Shoreview Water Consumption and Groundwater Awareness Project

Subd. 04i \$54,000 TF

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Appropriation Language

\$54,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the city of Shoreview to provide biweekly water consumption data to at least 400 residential households for a two-year period to determine whether additional groundwater can be conserved with greater awareness of consumption data. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The City of Shoreview is a suburb of approximately 26,000 people in the northeast metro area of the Twin Cities. Like many metropolitan municipalities, Shoreview supplies drinking water to residents and businesses via groundwater wells instead of surface water resources. Recent attention concerning the sustainability of groundwater resources in Minnesota is well documented and could pose a serious threat to future availability. Because of this threat, Shoreview decided to implement new initiatives to encourage water conservation in an attempt to conserve water resources. In 2015 the City applied for an LCCMR grant. Originally, Shoreview intended to use the grant to start reading water meters monthly, as opposed to quarterly, while also implementing a program called Know-Your-Flow that would provide a group of 400 resident volunteers with an at-home wireless Badger meter reader that displayed water use instantly inside the home. The goal of the increased meter reading frequency paired with the instant meter readers was to increase resident awareness of how much water was being used in their homes on a more frequent basis. The hope was that if water use were brought to the attention of residents more often, it could encourage conservation behaviors.

In March of 2016, city staff amended the grant to add an additional water conservation program, the behavioral water efficiency software company WaterSmart Software (WaterSmart), to the project. WaterSmart is a software platform that gathers publicly available data on water consumption, property and home metrics such as lot size and number of bedrooms, as well as climate data in order to provide individualized mailed “water reports” that compare each participant’s use to average and reduced water users within Shoreview. Sample email and print water reports are included with the supplemental attachments to this report. WaterSmart also provides residents with an online portal through which to view and update their property information in order to get a more accurate comparison. Shoreview continues to bill for water service on a quarterly basis. But, with now reading all water meters monthly, access to the online portal allows residents to keep up to date on their water use patterns between billings. The City added the WaterSmart program with the same hypothesis that increased water use awareness could lead to water conservation practices.

In order to test the hypothesis, the City and WaterSmart began a study that examined the effects of resident access to the WaterSmart online portal and mailed water reports on their water usage. A sample of single family residences in Shoreview were excluded from the program and labeled the “control group”. All other single family residences, including the 400 Know-Your-Flow volunteers, were given access to WaterSmart’s online portal and started receiving mailed water reports on their individual use. Over the course of 18 months, data on water use for both the control group and the group with WaterSmart access has been collected. Figures showing the difference in water use between the two groups are available in the supplemental attachment to this report. Based on the study, the City saved 4.1 million gallons of treated groundwater between January 2017 and June 2018. Four million gallons translates to an approximate 1% savings in total water use across Shoreview. The savings can be attributed to access to the WaterSmart program. This was determined by evaluating the amount of water used by the control group residents compared to residents who were given access to WaterSmart tools and outreach.

The initial results are encouraging because they suggest that increasing the amount and frequency of access to a resident’s water usage can lead them to conserve more water. Because of current conversations surrounding groundwater resource availability and conservation, and the fact that many Minnesotans are serviced by groundwater, the results of this project could be significant. If providing residents with more frequent access to their water use data can encourage conservation, other water suppliers could use similar techniques to achieve similar results. This would benefit Minnesota and Minnesotans by helping to preserve valuable groundwater resources while also helping shape environmental stewardship behavior in both children and adults.

PROJECT RESULTS USE AND DISSEMINATION

Outreach on Shoreview’s water conservation programs funded through this grant included press releases at the start of the project announcing both the Know-Your-Flow program and then the WaterSmart program. It should be noted that the exception to all dissemination activities in this section is the WaterSmart control group. They did not receive any mailings or other outreach described separate from press releases and city-wide newsletter articles. To start the programs, each eligible residence was mailed a welcome letter and instructional materials. The Know-Your-Flow group also received a Badger meter reader device. No other outreach was done for the Know-Your-Flow program as the City changed directions and began focusing on WaterSmart because the program

could be offered to more residents. For the WaterSmart program, eligible participants were sent a pre-launch survey along with their welcome letter. A sample of this survey is included in the supplemental materials for this report. The survey asked residents about their thoughts on Shoreview's water utility as well as their level of satisfaction and understanding. A summary of the pre-launch survey results is also included in the supplemental materials. As the program progressed, all single family residences in Shoreview who were not part of the control group received periodic individualized water reports at a rate of approximately 4 per year. These residents also had access to their online water conservation portal, specific to their residence. Examples showing the interface for the portal on both mobile and desktop devices are included in the supplemental materials. In addition to individual outreach, the City also published articles about the program in two editions of the ShoreViews community newsletter, mailed to all residents. City-wide outreach was limited due to the presence of the control group that excluded some from the program.

After a year's worth of portal access and water reports, all eligible residences were sent another, this time post-launch, survey. That survey and a presentation of the results are included in the supplemental materials for this report. Based on the surveys, residents in Shoreview had overwhelmingly positive things to say about their levels of satisfaction with their water utility, and they felt as though they understood their water use. In the second survey, a comparison was done between the pre-launch and post-launch survey results. Changes in results between the two surveys were attributed to WaterSmart access because the program was the only change made between the first and second surveys. Post-launch survey results showed that 88% of residents were satisfied or very satisfied with the value of water services in Shoreview, and 91% felt that the City helped them better understand their water use. These percentages had increased from 79% and 78% respectively since the pre-launch survey, highlighting the value of Shoreview's WaterSmart program for residents.

City staff has given several presentations to other municipalities and natural resource management groups in Minnesota about the WaterSmart program and preliminary results from the efficiency study. Based on these meetings, several other groups have expressed interest in WaterSmart and similar programs. The City has not yet shared the results of the project efficiency study with residents because the control group is still in effect and not all residents can opt-in to the program. Staff currently plans to continue the study through summer of 2019 and then start broader outreach on the value of WaterSmart and increasing knowledge and accountability in residential water use. The City is also currently considering making the online portal available to irrigation and commercial accounts as well as residential. Shoreview finds great value in all water conservation programs implemented through this grant, and has quantified over 4 million gallons saved to date. Staff plans to continue with WaterSmart portal and water report access through summer 2019 for those that are currently eligible. After the study is complete, Shoreview hopes to allow portal access to all residents so that outreach on the program can be more uniform.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Subd. 05 Environmental Education

Connecting Students with Watersheds through Hands-On Learning

Subd. 05b \$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 Minnesota Trout Unlimited to provide hands-on learning focused on water quality, groundwater, aquatic life, and watershed health stewardship. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Youth are increasingly becoming disconnected from the natural environment we live in. This lack of connection follows students into adulthood and impacts their ability to make well informed decisions about their environment. Most environmental education programming fails to adequately reinforce ongoing lessons through real-life applications outdoors. To remedy this, the program used field days to reconnect students with water, aquatic life, groundwater systems, and watersheds by getting them outdoors and providing hands-on learning experiences. Students were also exposed to outdoor recreation to encourage lifelong, tangible connections to aquatic ecosystems.

The program also utilized the Trout in the Classroom curriculum, which placed aquariums in classrooms so students could actively follow the development of trout from egg to juvenile. During this process, monitoring and scientific discovery took place and it was used as a spring board for fieldtrips to streams and as a focal point for reinforcing learning about watersheds, water quality and ecology. Fall field days preceded the fish rearing component of Trout in the Classroom and raised fish were released by students as part of spring field days. More than 2,000 students from 49 classrooms participated in these hands-on field days outdoors. This year-long program combined field studies and classroom visits, allowing students to apply the principles learned outdoors with realistic applications. Another 5,000 students in these schools participated in other aspects of the program. More than 2,000 students were encouraged to develop lifelong, tangible connections to aquatic ecosystems through school day introductions to fishing skills and fishing. Students and families were offered fishing clinics and mentorship opportunities outside of school.

Minnesota will benefit from students' increased awareness of their role in sustaining healthy aquatic ecosystems, especially as they carry a sense of stewardship forward into adulthood.

PROJECT RESULTS USE AND DISSEMINATION

Press advisories were issued for most field days and for three student summits. Many field days, and all summits, received good television coverage. Many newspapers also reported on the program. Minnesota Trout Unlimited highlighted this education program each year at the Great Waters Fly Fishing Expo in St. Paul, and featured an article on its accomplishments in each issue of its statewide newspaper (5,000 to 8,000 copies were distributed three times each year).

Project Completed: 06/30/2018

[FINAL REPORT](#)

Zumbro River Watershed Recreational Learning Stewardship Sites

Subd. 05c \$300,000 TF

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Appropriation Language

\$300,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Zumbro Watershed Partnership to develop at least six recreational and educational sites on the Zumbro River with water quality demonstration elements and interpretative signage designed to encourage adoption of water protection practices. No more than 15 percent of this appropriation may be spent on site and construction consultation, planning, and design. Any plantings or restoration activities conducted with this appropriation must use native plant species according to the Board of Water and Soil Resources' native vegetation establishment and enhancement guidelines. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The Zumbro River and its tributaries flow through mostly private lands. Consequently, we have a population disconnected from this shared natural resource and relatively uninformed about its ecology, water quality challenges, flooding issues, and recreational uses. The ultimate goals of the Recreational Learning Sites were to reconnect citizens to this resource and encourage citizens to invest in its conservation. The Zumbro Watershed Partnership (ZWP) cooperated with local and state governments and non-profit organizations, including the Minnesota DNR, the Conservation Corps of Minnesota and Iowa and the University of Minnesota Extension, to enhance recreational access to the Zumbro River at eleven existing sites in six communities across four counties. Through a series of engagement events, we worked with communities to address local needs; for example, we built canoe landings in Pine Island, fire pits in Wanamingo and a hiking trail in Oronoco. These and other sites received natural plantings, stone benches, picnic tables and other amenities. Enhancements were intended to make the river more inviting. A series of permanent education kiosks were distributed among sites in each community. Education kiosks provided basic information about watershed science, ecology, land use history, recreation and actionable ways to improve water quality and mitigate flooding. This project benefited Minnesotans by enhancing the Zumbro River State Water Trail and community parks with regional significance, such as the Douglas Trail Head in Pine Island. Though substantial community engagement, this project benefited ecosystem management by focusing local governments and citizens on how they can improve public lands and waters. It also benefited ecosystems by planting trees, forbs and grasses native to Minnesota. This project provided concise and regionally-specific information about the Zumbro Watershed that can be the basis for productive engagement among informed citizens, governments and organizations.

PROJECT RESULTS USE AND DISSEMINATION

The recreation focused panels and the map panels that georeferenced other Recreational Learning Sites are the best tools that the ZWP created for dissemination. Many are placed in locations where visitors are likely to traverse. Beyond that, the ZWP continues to promote this project with Facebook posts and by maintaining a specific page for this project, easily accessed through our homepage (<http://zumbrowatershed.org>)

Project Completed: 06/30/2018

[FINAL REPORT](#)

Splash Screen: SciGirls Exploring Watersheds Using Mobile Technologies

Subd. 05d \$147,000 TF

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Appropriation Language

\$147,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Twin Cities Public Television to deliver an experiential, project-based educational program using mobile technologies to empower at least 200 middle school students in 4-H programs to engage in understanding and protecting local water resources.

OVERALL PROJECT OUTCOME AND RESULTS

Splash Screen: Students Engaging Local Watersheds Using Mobile Technologies environmental education pilot was designed to foster stewardship of water resources in middle school youth living in urban Minnesota communities. Ran in partnership with urban 4H clubs in the Twin Cities and Duluth, the project combined Place Based Education (project based learning experienced outside the classroom alongside community experts) with Mobile Learning, or education that uses portable technology, to teach about watersheds.

Project goals were for participating youth to:

- understand the importance of water resources in their community;
- be able to describe the major features of their local watershed;
- develop a basic understanding of some ways that humans can help and/or hurt this important resource;
- become acquainted with storm water runoff and what people can do to prevent it; and
- experience environmental advocacy first-hand by developing a public information campaign to share with their peers, family, and community, educating them about their watershed.

A total of 20 educators in Duluth and St. Paul were trained in: Splash Screen hands-on curriculum (Project Wet activities); place-based education, including working with community experts; and mobile technology. Bi-monthly webinars were held to provide updates and hear feedback from sites. Additionally, TPT and 4H held in-person meetings for educators prior to implementation for updates and technology distribution.

Two 4-H programs in Duluth and eleven in the Twin Cities implemented the Splash Screen curriculum during the spring and summer of 2016, reaching 107 youth participants with 25 hours of hands on learning per student. Summative Evaluation of Splash Screen was conducted by the Science Museum of Minnesota's Evaluation and Research in Learning group and measured the overall impact of the project on the educators and youth compared to project outcomes. The evaluation was guided by four questions, three aligned with project outcomes for educators and one aligned with project outcomes for youth. Project evaluation results, which showed that overall the project was more successful at addressing educator outcomes than it was at addressing youth outcomes, will guide TPT and 4H as the project staff plans scale-up of the program for youth. (See Splash Screen Summative Evaluation for an overview of the project evaluation.)

PROJECT RESULTS USE AND DISSEMINATION

On Saturday, October 8, 2016, Twin Cities PBS hosted a Splash Screen event at the station for project participants to share their watershed media project with family, friends, and community members. Youth presented a total of 9 final projects from 5 project sites, sharing their media-rich projects and discussing the importance of urban watersheds health for Minnesota communities.

In addition, SciGirls staff presented at TIES 2016 Education Technology Conference on Monday, December 12, 2017, in downtown Minneapolis. The session, titled Splash Screen: Engaging Local Watersheds Using Mobile Technologies, was attended by approximately 50 teachers, technology integrationists, and other education professionals from the formal education sector.

Here is a description of our offering:

Combine Place Based Education (project based learning experienced outside the classroom alongside community experts) with Mobile Learning to teach about watersheds. You will be given apps and other resources for environmental education, technology integration strategies and lessons learned from the pilot and evaluation done by the Science Museum of Museum. Splash Screen is a pilot project created by Twin Cities PBS in partnership

with Urban 4H with funding provide by the Minnesota Environment and Natural Resources Trust Fund, that is designed to foster environmental stewardship of water resources in youth living in urban Minnesota communities. While our project is now officially closed, TPT and Urban 4H are looking for funding opportunities to provide scale-up of the pilot program.

Project Completed: 06/30/2016

FINAL REPORT

Splash Screen Summative Evaluation

Mississippi Water Journey Camps

Subd. 05e \$25,000 TF

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Appropriation Language

\$25,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to design and pilot two week-long summer camps for youth ages 6 to 11 focused around clean water and the Mississippi River and designed to get children outdoors exploring and engaged with the natural environment and creating educational materials to help their communities protect water quality.

OVERALL PROJECT OUTCOME AND RESULTS

Mississippi River Water Journey Camps get children ages 6-11 outdoors exploring water connections between the built and natural environment, doing wetland plantings, and teaching the public about water systems and how to improve water quality. The grant funded development of a toolkit and first year support for two one-week summer camps: “Water Journey: Drink” and “Water Journey: Rain,” held twice each at the Institute on the Environment, at St. Paul Campus, University of Minnesota as part of the University Recreation & Wellness Summer Youth Program. The camps adapt an existing arts/science adventure approach called Earth System Journey that engages youth with the infrastructure connecting daily water use to what happens at the other end of the pipes, in order to make conservation lessons relevant to students’ experience. This reflects environmental education needs for place-based education, bridging actions with impacts, getting kids outdoors, and engaging learners as real-world contributors.

The project goals were achieved. The evaluation report shows increased camper water system knowledge, stewardship attitudes and skills. This impacted 55 campers in summer 2016, with estimated 128-224 more campers reached in the coming four years of camp that the toolkit makes possible. While future camps are funded through camp tuition, support from the Institute on the Environment will continue. The project successfully demonstrated a model for formal and informal educators and increased public awareness of water issues and education methods. Outreach deliverables include a website, video, GIS story maps, summer art/science exhibit, and numerous educator and public presentations including at the 2016 EcoExperience. Inspired by this project, three education grants have been proposed including one in northern Minnesota, with one awarded so far. The model supports emerging approaches for integrated water management and education across public works and natural resource management organizations. Learn more and see all reports at <http://waterjourneycamps.blogspot.com>.

PROJECT RESULTS USE AND DISSEMINATION

A key outcome for Water Journey Camps is continuation of the program without LCCMR grant support in the summer for 2017, when 44 new children participated in four week-long camps that closely followed the model established in 2016. Another 3 years of camps are planned. In 2017, revenues from camp fees paid by each child, along with scholarships for low-income children, offset most of the costs, including staff pay, field trips, transportation and expendable art supplies like papers and beads. The bulk of art, science and photography supplies purchased in 2016, with LCCMR funds, were used again in 2017. The art and science “kit” should serve Water Journey Camps for at least 3 more years. Water Journey Camps is now a well-established and sustainable program that will ultimately reach more than 200 campers over 5 years.

Another outcome of Water Journey Camps is learning gains made by the campers themselves. The Evaluation Report details results of pre and post-camp surveys filled out by the children, with help from counselors for the youngest children. This survey data indicates gains in awareness of how we use water, knowledge of where water comes from and importance of water stewardship. In end-of-camp reflection on their experience, campers indicated more comfort with and interest in STEM projects, as they enjoyed 1) water quality testing and analysis, 2) learning about and planting plants and 3) crafting questions for professionals working in water systems. The art projects and mapping experiences were highlights for many campers. The Youth Program leaders offered informal feedback that parents were pleased with what their children learned. Water Journey Camps were the favorite of several children who enrolled in multiple camps at the University of Minnesota.

A Toolkit is now available on the Water Journey Camps website, aimed at serving teachers and informal educators interested in the approach to learning about water in a particular place or using specific projects. The Toolkit is itself an outcome of the grant. It is flexible enough to allow for replication of the entire overall concept of Water Journey Camps, the use of one or more of the projects in a class period or field trip, or the addition of a new element - such as story maps, photography, planting or tracking pipes – in an existing lesson. The website and materials available have been or will be shared with hundreds of educators through conference presentations and networking sessions as well as web and social media outreach done by IonE. The conferences include the Minnesota Association for Environmental Education (MAEE) meetings in 2016 and 2017, the Minnesota Educator’s Academy annually in October as well as the Upper Midwest Association for Campus Sustainability (UMACS) in Pella, Iowa in late September, 2017, and on a national stage at the Association for Advancement of Sustainability in Higher Education (AASHE) annual conference in October, 2017. AASHE invited Beth Mercer-Taylor to serve on its first panel on K-12 sustainability summer programs supported by campus sustainability units.

As a key partner, the Institute on the Environment (IonE) gained the unexpected benefit of expansion into new water and K-12 programming as a result of Water Journey Camps. IonE’s provision of significant staff support, no-cost space and a beautiful public gallery space for display of camp maps, art and science projects made more IonE staff and faculty keenly aware of the power of an art, science and storytelling approach to learning about water. The energy of the campers and their learning about water systems inspired the staff and faculty as well as many visitors attending meetings and events at IonE. In the last week of June, 2017, immediately after the camps were completed, over 100 educators saw the Water Journey Camp displays, including nearly 60 attending the Climate Generation Summer Institute at IonE and 45 attending a national workshop on Sustainability & Diversity in Higher Education at IonE. Water Journey Camps contributed to IonE staff and faculty expanding their engagement in water related and K-12 programming, including:

1. a new stewardship project starting in fall, 2017 at Sarita Conservation Area;
2. an partnership between IonE and the “Water Bar” where flights of local tap waters are served to students and community partners;
3. placement of 5 high school interns from the City of St. Paul Right Track program at IonE in summer 2017, including 3 assisting with Water Journey Camps;
4. hosting the Climate Generation Summer Institute for educators.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Mississippi River Water Journey Camps Toolkit Guidance Document](#)

[Mississippi River Water Journey Camps Evaluation Report](#)

Subd. 07 Air Quality, Climate Change, and Renewable Energy

Reducing Emissions from Open Burning through Biomass Gasification

Subd. 07b \$268,000 TF

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Appropriation Language

\$268,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota in cooperation with the Department of Natural Resources to characterize and promote distributed biomass gasification of wood waste as a means for producing renewable and sustainable energy in rural areas through a demonstration at the Department of Natural Resources regional office facility in New Ulm.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota forests produce 2.4 million tons of wood waste per year, a significant portion of which is burned in open piles or in large-scale gasification facilities to generate heat and power. However, open burning wastes energy and emits harmful pollutants while large-scale power generation facilities rely on transporting fuel long distances. This project demonstrated that a small-scale distributed gasifier-generator system could produce heat and power for remote rural areas while reducing harmful pollution. In laboratory tests conducted at the University of Minnesota, the research team found that small-scale gasification emitted fewer pollutants like nitrogen oxides (NOx), soot, and carbon monoxide per amount of wood consumed than open burning and comparable emissions to large-scale wood energy operations. Further, due to clean engine combustion and production of biochar, small-scale gasification was found to achieve the lowest lifecycle greenhouse gas emissions compared to open burning, large-scale gasification and wood decomposition.

In the second phase of the project, the gasifier generator system was packaged into a weatherproof container and installed at the Minnesota Department of Natural Resources Southern Regional Office in New Ulm, MN. There it supplemented the facility's installed photovoltaic solar array on winter mornings, offsetting 10-15 kW of utility purchased power used to operate geothermal heat pumps. The system's performance at DNR supports small-scale gasification's potential for use in remote applications like state park facilities. Although promising when operational, excessive DNR staff time was required to regularly start and maintain the system, and prepare dry fuel. Other operational deficiencies included internal clogging and equipment failures. To be viable for further deployment, additional development work must be done to realize a more reliable and automated system. Ultimately, this project proved that small-scale distributed biomass gasification, if improved, could be an environmentally and economically favorable alternative to open burning and large-scale gasification.

PROJECT RESULTS USE AND DISSEMINATION

To disseminate the results of the gasifier-generator emissions analysis, a graduate thesis explaining all elements of the project was completed. In addition, a paper emphasizing the applications and merits of distributed small-scale gasification using waste biomass was submitted to the journal Biomass and Bioenergy. Several tours were held at the DNR facility to showcase the gasifier offsetting the facility's electricity costs and to discuss the benefits and challenges of biomass gasification technology. Finally, power output data from the gasifier operating during winter months was published to the DNR's Energy Smart website <http://www.dnr.state.mn.us/energysmart/>.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Building Deconstruction to Reduce Greenhouse Gas Emissions and Solid Waste
Subd. 07c \$1,000,000 TF

Part 1 - \$845,000

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Part 2 - \$155,000

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Appropriation Language

\$845,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Better Futures Minnesota in cooperation with the Northwest Indian Opportunities Industrialization Center and \$155,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota - Duluth for the Natural Resources Research Institute to develop and test a model for implementing building deconstruction and material reuse as a competitive alternative to demolition for the purpose of reducing greenhouse gas emissions, reducing landfill waste, and providing job training. The project report must quantify and document greenhouse gas emissions reductions resulting from specific deconstruction techniques and materials reuses.

Part 1 - OVERALL PROJECT OUTCOME AND RESULTS

This project promoted building deconstruction as an alternative to demolition. The project also developed viable techniques for reducing greenhouse gas emissions and diverting significant amounts of reusable and recyclable building materials from landfills. Construction and demolition debris is the second largest component of our waste stream; only 20-30 percent is recycled. Deconstruction is the systematic disassembly of a building, with the purpose of recovering materials for reuse or manufacturing into new products. Overall, material reuse reduces the industry's consumption of virgin materials, helps preserve natural resources, and protects the environment from pollution related to extraction, processing, and disposal of raw materials.

The partners exceeded nearly all the expectations related to this project:

1. 29 LCCMR-eligible properties were deconstructed.
2. 303 unemployed people were trained and/or employed. 18 FTE positions were created.
3. The partners compiled environmental impact data for the projects. Over 2,600 tons of building material was diverted from landfills. For projects in the Twin Cities, more than 85% of the waste was diverted and 5% of the materials were reused. It was difficult to achieve these diversion rates in Greater Minnesota due to the lack of building material recycling facilities.
4. The environmental benefits generated by deconstruction compared to traditional demolition are significant. The practice of dumping a building into a landfill emits, on average, 248 metric tons of CO₂ for each property demolished. Better Futures' deconstruction work emitted on average just 51 metric tons of CO₂.

5. This project averted the emission of 5,288 metric tons of CO₂. This decrease in CO₂ emissions is equivalent to taking 1,114 cars off the road for one year. The social cost of this carbon offset is \$190,548.

These activities and accomplishments confirmed the multiple benefits of building deconstruction. This approach for building removal reduces the release of harmful toxins and gasses to our air, water and land. Deconstruction also creates meaningful employment with opportunities for advancement in numerous industries. This process also preserves a wide range of fixtures and other materials that are in demand for reuse or repurposing. But significant challenges hinder the financial viability of deconstruction since the current cost of demolition is artificially low. The existing price for demolition does not reflect the true environmental, health, economic, and social cost of burying material in landfills. The solution, based on the testing, work, and research completed under this grant is to adopt building material stewardship policies statewide.

Part 1 - PROJECT RESULTS USE AND DISSEMINATION

Throughout the grant period, the partners were consistently engaged in promoting the practice of deconstruction and material reuse. Over time, the visibility of workers taking a part a building generated the most publicity and heightened the level of interest among the public. The actual work helped to highlight the futility and wastefulness of demolition and showcased a practical way to significantly reduce trips to a landfill. Homeowners emerged as the prime drivers for deconstruction of privately owned buildings. Accordingly, the partner's revised its messages and materials to address a homeowners' demands and concerns about demolition. An added advantage is homeowners secure a tax deduction for the materials donated to the partners. This tax benefit helps with making the case for deconstruction.

Part 2 - OVERALL PROJECT OUTCOME AND RESULTS

NRRI partnered with Better Futures MN and Northwest Indian Community Development Center to promote building deconstruction as an alternative to demolition. Deconstruction is the systematic disassembly of a building, with the purpose of recovering materials for reuse or manufacturing into new products. This partnership hopes to bring awareness to Minnesotans that building deconstruction is a reliable way to manage our natural resources used for construction, and reduce the environmental impact and costs associated with disposal of demolition wastes.

NRRI activities during the project period:

1. Assisted with the development of safe, cost-effective methods for the removal of materials to retain maximum value of items harvested. As an aid to the partners, a final report was generated by NRRI that covers a list of potential end uses for materials and suggests some methods for determining value for the various materials that were harvested during the project period.
2. Provided training to participants from Better Futures and NWICDC to select quality materials, practice safety in the wood shop, build indoor/outdoor benches, and suggested methods to determine value of the items built. Participants learned additional skills to make themselves more marketable to future employers.
3. Assisted with the promotion of building deconstruction across the state of Minnesota by participating in the assembly and presentation of several case studies with examples of the benefits of deconstruction; shared the case studies during meetings with county officials, at regional Green Building meetings, and at two conventions in Minneapolis and Duluth.
4. Provided input to Ecotone Partners, who developed a tool for calculating yield and environmental impact of materials harvested from deconstruction. Reports produced using the tool provide information on greenhouse gas reduction, energy savings, reduced landfill use, and materials reused.

Part 2 - PROJECT RESULTS USE AND DISSEMINATION

Over the course of the project, NRRI was consistently promoting deconstruction and material reuse by engaging the public during public tours at our facility in Duluth. A display was constructed from harvested materials that highlighted the value and the environmental impact of diverting materials from the landfill and reusing or converting them into usable commodities. NRRI engaged others through the use of social media to promote activities that the partners were involved with. Media events connected to specific projects in St. Louis County

helped to showcase the positive impact offered through deconstruction by highlighting local job creation, landfill diversion, and the lack of material recycling and reuse in greater Minnesota.

Project Completed: 06/30/2018

FINAL REPORT

Subd. 08 Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Prioritizing Future Management of North Shore Trout Streams

Subd. 08a \$416,000 TF

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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.

OVERALL PROJECT OUTCOME AND RESULTS

Since the last report we have used the stream temperature data collected by NRRI and DNR to develop models predicting the presence of groundwater and the presence of cold water in North Shore streams. Two different models were developed predicting: 1) presence/absence of cold-water features; 2) actual mean July mean, minimum and maximum July temperature. We then used a “weight of evidence” approach from these model predictions to predict the tributaries with a high probability of encountering a cold-water feature. Maps were developed to depict the location of these cold-water tributaries and reaches with cold-water features; a database was developed showing the location of sampled streams along with their status with respect to 1) observation of cold-water features; 2) existence of cold-water tributaries; 3) no cold-water features. In addition, we created stream temperature models for several tributaries, and used them to project future changes in stream temperature and studied the potential for mitigating temperature changes with increased riparian shading. Throughout this project a member of the angling community was embedded in the project planning meetings, participated in project meetings in which data and models were evaluated, provided perspectives on data and outreach products, and has assisted in the development of management recommendations. This individual will be assisting with further outreach to the angling community throughout the coming spring (2019).

Overall Project Outcomes

Water temperature is generally considered one of the primary physical habitat parameters determining the suitability of stream habitat for fish species, but climate change is threatening these cold-water habitats. The primary goal of this project was to provide the information to ensure that restoration and management are targeted at stream reaches essential to ensuring long-term sustainability of cold-water fisheries. Project goals were: (1) collect temperature data and map the locations of thermal refuges in “top tier” North Shore trout streams; (2) determine the environmental characteristics (flow, geology, and land use / land cover) associated with cold-water refuges, and predict areas most resilient to climate change; and (3) recommend actions to protect / manage these cold-water features. We developed an inventory and database of cold water tributaries and features

in North shore streams based on manual surveys (n = 121 stream reaches; of which 83 were found to contain cold-water features), and continuous monitoring (n = 36 locations); developed empirical models predicting the probability of encountering a cold-water tributary or a reach with a cold-water feature; assessed the relative influence of climate versus riparian shading on stream temperature; developed management recommendations to promote the persistence of cold-water habitat under future climate conditions. Fishery personnel were involved throughout the project development and execution to help assess results and develop recommendations. Recommendations for future data needs included: depth to bedrock, extent of bedrock fracturing, more detailed map of Quaternary Geology. Additional temperature monitoring is recommended to include locations within and outside cold-water features. Management actions focused on restoring or enhancing riparian vegetation near high value streams with narrow channels, streams in smaller subcatchments, and, where groundwater seeps enter warmer channels, maintaining tree cover to preserve lower groundwater temperatures. Data will be posted on a public website for distribution (<https://data.nrri.umn.edu/data/>).

PROJECT RESULTS USE AND DISSEMINATION

MN Trout Unlimited personnel have been involved in all aspects of this project, starting with the study design, development of sampling methods, site selection, data analysis / interpretation, and information dissemination. MN DNR staff were consulted extensively in site selection; data from MN DNR temperature surveys have been incorporated into modeling efforts. Personnel from the Minnesota Spring Survey were also consulted periodically to exchange site selection information.

We have given periodic talks to fishing organizations, attended fishing expos, and will meet with fishing organizations and DNR staff during the coming winter to further disseminate results and discuss recommendations. PI Johnson and student Jonathan Utecht made a presentation to the Arrowhead Fly Fishers group on February 16, 2015 to invite volunteers; they also attended two additional events at the Nemadji Water Fest in Carlton County (March 12th) and the Great Waters Fly Fishing Expo (March 19-20) in St. Paul. Informal interactions between project personnel and the angling community occurred at MN Trout Unlimited and MN Steelhead Association meetings throughout the project.

Project Completed: 06/30/2018

FINAL REPORT

Preserving and Protecting Minnesota Native Orchid Species

Subd. 08c \$167,000 TF

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Appropriation Language

\$167,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the Minnesota Landscape Arboretum for propagation and cultivation research to enable long-term conservation of at least 15 selected species of the 48 native orchid species in Minnesota. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota is home to 48 species of native orchids, 20% of which are on the state endangered species list. Even “common” orchids are generally regarded as rare. These plants are charismatic state treasures that evoke the imagination of Minnesota residents and people around the world. Orchid hunting – both photographing and

poaching – has increased the threat to these plants while , in turn, increasing conservation efforts. Beyond poaching, orchids have a more complex relationship to their environment than many other plant species and are easily affected by local disturbances, especially those that change local groundwater levels and flows. The Native Orchid Conservation Program (NOCP) at the Minnesota Landscape Arboretum (MLA) follows a vision unique to the U.S.: to conserve the genetics of all Minnesota orchid species and bring as many as possible to MLA to display. Building a seedbank for 15 of the state’s species was the initial objective and research to develop propagation techniques for all species is on-going. Some species have known growth-from-seed techniques; for most, however, that knowledge is unknown. As both conservation and propagation of seed efforts continue, the goal is to share information in order to encourage obtaining orchids for personal gardens through sustainable seed-produced orchids, rather than poached transplants (which have a high failure rate). Displaying these orchids is vital and will accomplish two goals: 1) show visitors the beauty of these treasured plants – plants they might otherwise never see due to the remote habitats they often occupy, and, 2) educate people about the importance of protecting these species and about their known successful propagation techniques.

While the NOCP and MLA are committed to long-term orchid conservation, success was achieved quickly within the project’s first phase, banking more species than expected. Through this process, it became clear that: there is untapped enthusiasm throughout Minnesota for orchid conservation, finding some species in the wild remains difficult, and there may be lower population numbers than expected for even the “common” species. We created a diverse genetic bank for nearly 1/3 of Minnesota’s species, covering much of the state, and have worked with nearly 2/3 of Minnesota’s species to research, establish, or further propagation. This advanced our work, allowing us to display some of our new orchids already, to the delight of MLA visitors. Our data will increase understanding of how these species are distributed across the state and provide locations of vital populations identified for conservation. Ultimately, as we bank seed and establish propagation techniques for each species and pair this work with an increased understanding of how each species lives in its natural environments we will better equip ourselves and others to keep these treasures on Minnesota landscapes for years to come.

PROJECT RESULTS USE AND DISSEMINATION

Over the course of the granting period the public visibility of the Native Orchid Conservation Program increased steadily. With articles in magazines/newspapers, a story on MPR and social media posts, we engaged the public in multiple ways and the success bred interest across the state. The result was that we had people from around the state contacting us with offers to help, information about orchid populations in need, and requests to have us bank seeds on private landowners’ lands. This reaction from around the state was unexpected this early in the program and demonstrates both a real need for this kind of program and general support among Minnesotans. As we continue to establish this program and develop our strategy to educate visitors and the public, this broad base of support will allow us to continue to reach the farthest corners of the state. This kind of reach will allow us to share our work and Minnesota’s orchids with people who may not be able to visit the Arboretum and, interestingly, will also allow us to share our plant treasures with people around the world.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Conservation Assistance Acceleration Project

Subd. 08d \$1,000,000 TF

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Appropriation Language

\$1,000,000 the first year is from the trust fund to the Board of Water and Soil Resources for the final phase of a pilot program to provide grants to soil and water conservation districts and other units of local and state government for employment of staff to provide technical assistance to secure enrollment and retention of private lands in federal and state conservation programs. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

This project has come to a close exceeding expectations and should be credited with stemming the loss of conservation acres in this state enrolled in the CRP program. This project has allowed the much needed local staff commitment to follow through on federal program assistance at a time when federal agencies have reduced staffing and cut budgets shifting workload to anyone left able to do the job all under tight deadline and ever changing program requirements. The existing SWCD structure in this state along with the expanded partnership at the local level with Pheasant Forever to hire, train, and support upwards of 40 full time equivalent staff positions in 53 county offices has made this all a reality. It will never be known the status of conservation acres in this state had this project not been in place, but it can be said with confidence that we would have lost acres at a higher rate. Project totals for the project period are 11,521 landowner contacts and 167,500 ac. enrolled in conservation. See Attachment C for result totals. For the first time in a while, MN did actually have a net gain conservation acres as can be seen in the updated Conservation Lands Summary. Specifically CRP grew by 70,000 ac. in the past year although is slated for some significant reductions again on Oct. 1, 2018. The future of this effort will continue under diverse funding sources to maintain the 40 fte's and more of an emphasis is currently on the ongoing CREP initiative, not approaching 10,000ac. in enrollment.

PROJECT RESULTS USE AND DISSEMINATION

The MN Conservation Lands Summary can be found at:

http://www.bwsr.state.mn.us/easements/CLS_Statewide_Summary_August_2018.pdf and was recently updated 8/17/2018

Project Completed: 06/30/2018

[FINAL REPORT](#)

Metro Conservation Corridors Phase VIII - Prairie, Forest, and Savanna Restoration Greater Metropolitan Area Subd. 08e \$276,000 TF

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Appropriation Language

\$276,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Friends of the Mississippi River for Phase VIII of the Metro Conservation Corridors partnership to conduct restoration activities on at least 195 acres of forest and savanna and at least 60 acres of prairie to preserve and increase wildlife habitat in the metropolitan area, as defined under Minnesota Statutes, section 473.121, subdivision 2, and portions of the surrounding counties. Expenditures are limited to the identified project corridor areas as defined in the work plan. A list of proposed restorations must be provided as part of the required work plan. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Friends of the Mississippi River improved 260 acres of forest, savanna and prairie habitat at six sites in the Twin Cities Metro Area. The sites are situated within the Mississippi River flyway, a corridor that is vital for migratory birds. Site restoration improved habitat connectivity for wildlife dispersal and enhanced the quality of habitat for native pollinators and Species of Greatest Conservation Need. Prairie restorations returned deep-rooted plant species to sites along the Mississippi River that help retain and filter water runoff. Removal of invasive woody plant species from forested sites re-established healthier woodlands, allowing native plant species to thrive. Prairie restoration activities took place on 198 acres and included removal of non-native species, seeding of native plants, prescribed burns and mowing. At Spring Lake Park Reserve's east prairie restoration, 41 of 69 species of native plants were detected, achieving a very diverse prairie. At the small two-acre Ole Olson prairie, 25 species of prairie plants replaced turfgrass, creating habitat for diverse pollinator populations. At Grey Cloud Dunes SNA, we had originally planned to burn 10 acres of prairie, but an unplanned wildfire in April 2018 burned 90 acres. While more than what was planned, the burn did help rejuvenate the prairie and maintain the area free of woody encroachment.

Forest restoration activities took place on 62 acres and included removal of invasive woody plants, treatments with herbicide, native plant seeding, hand-pulling invasive plants, and prescribed burns. At Hampton Woods WMA, where native woodland wildflowers were once sparse under the buckthorn canopy, they now proliferate following buckthorn removal. At Old Mill Park, a prescribed burn on the savanna in spring 2018, resulted in native prairie species returning to dominate the site with about 90% cover. The state-threatened kittentail population (*Besseyia bullii*) population remains stable at the site.

PROJECT RESULTS USE AND DISSEMINATION

The restoration projects received regular coverage over the three years, particularly in Friends of the Mississippi Rivers' outreach through newsletters and social media. We also received some good coverage in print media and on television.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Metro Conservation Corridors Phase VIII - Enhancing Restoration Techniques for Improved Climate Resilience and Pollinator Conservation

Subd. 08f \$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 Great River Greening for Phase VIII of the Metro Conservation Corridors partnership to pilot and evaluate innovative restoration techniques aimed at improving the resilience of bur oak communities to changing climate conditions and enhancing prairie management to benefit pollinators with the help and engagement of citizen volunteers. Expenditures on restoration efforts are limited to the identified project corridor areas as defined in the work plan. A list of proposed restorations must be provided as part of the required work plan. This appropriation is available until June 30, 2018, by which point the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Greening and our partners Xerces, Maplewood Nature Center, and U of MN, advanced prairie and oak woodland restoration practices for vegetation and pollinators in multi-faceted fashion. We implemented quality restorations and enhancements, and gathered 12,000 data points, analysis of which is already guiding restoration, pollinator, and engagement practices. Improvements include a successful climate-resilient approach to oak restoration; using conservation haying to benefit prairie plants and pollinators; refining our approach to pollinator refugia, overwintering and nesting needs during restoration; improving student knowledge of native plants and pollinators; implementing citizen science practices for valuable data collection and outdoor citizen engagement; increasing our understanding of native pollinators' macro- and micro- floral resource needs; improving pollinator habitat along trails; and documenting the federally endangered rusty-patched bumble bee. This program further accomplished 32 acres restored, including 6,000 bur oaks, 12,000 pollinator plants, and 45,000 milkweed seeds getting into the ground.

PROJECT RESULTS USE AND DISSEMINATION

Dissemination of the results is also multi-faceted and robust, underway and promising to continue beyond the grant period. This includes the publication of a bee monitoring guide for citizen science, and five presentation-ready reports; five social media outreach avenues reaching thousands; eight conference presentations reaching over 400 professionals; partnering with five local government land-owning units; and active engagement of over 1,500 citizens, including 841 K-12 students, 45 Master Naturalists, 200 citizen scientists, and 235 restoration volunteers.

Project Completed: 06/30/2018

[FINAL REPORT](#)

Shoreland Protection for the Lower St. Croix River

Subd. 08j \$190,000 TF

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Appropriation Language

\$190,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the St. Croix River Association to provide technical assistance to landowners, local governments, realtors, and developers on shoreland conservation and protection of the lower St. Croix River. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The Lower St. Croix Wild and Scenic River (LSCWSR) is federally designated and state managed; it is about 52 miles long, and ¼ mile wide, and was the focus of this project. This heavily visited National Park is a high-quality fishery, offers spectacular natural views and has high recreational value. Development pressure has been constant. An insufficient understanding of the river's unique protection status has led to conflicts and weakening of adherence to established rules designed to protect bluffs and shoreland.

The St. Croix River Association (SCRA) has worked to protect, improve and restore natural vegetation adjacent to the St. Croix River through educational workshops, resource creation, and strategic outreach to realtors, local governments, and landowners in the Riverway. Over 5,000 landowners received information about Riverway regulations and over 500 realtors attended workshops or presentations about Riverway protections, native plants, raingardens and scenic easements. SCRA presented at more than 35 city council meetings for ten local

governments in the Lower Riverway and provided six training opportunities for over 170 local officials. The most significant resources created were The Landowner's Guide to the Lower St. Croix Riverway, Best Practices for Zoning Applications in the Riverway, and a video about the Lower St. Croix River.

Development pressure remains constant, but SCRA has seen immense improvement in the collaboration between cities, landowners, and realtors to prioritize water quality and habitat as a result of this project. The resources created will continue to educate landowners about best practices and protections on the Lower St. Croix River, and are available online on SCRA's website and at city halls, realty offices, watershed groups, the National Park Service, and the MN DNR.

Minnesotans are now able to easily access information about the Lower St. Croix River's history, significance, and protections. Whether they live on the St. Croix, have considered purchasing property there, or simply enjoy visiting the Riverway, Minnesotans will know the story of the Riverway and the importance of upholding its unique protections. The results of this project reflect the power of education, collaboration, and communication between diverse stakeholders to work together to protect the river they love.

PROJECT RESULTS USE AND DISSEMINATION

Materials Created

- The Landowner's Guide to the Lower St. Croix Riverway
- Best Practices for Zoning Applications in the Lower Riverway
- 3-minute animated video about Riverway history, significance, and regulations
- Safe Harbor Earth Tone Color List
- Riverway GIS layer hosted publicly

Outreach and Dissemination:

- Over 3,000 copies of the Landowner's Guide to the Lower St. Croix Riverway have been disseminated to landowners either directly or through local governments and realtors.
- 1,000 copies of the Lower Riverway panel cards were distributed to businesses along the River
- Over 50 presentations were given to landowners, realtors, and local governments about Riverway history, significance, protections, and best practices for landowner stewardship

Project Completed: 06/30/2018

[FINAL REPORT](#)

Redwood and Renville Counties Outdoor Recreation and Conservation Master Plan

Subd. 08k \$75,000 TF

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Appropriation Language

\$75,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Renville County in cooperation with Redwood County to develop a joint outdoor recreation and conservation master plan to guide future development and protect cultural, historical, and natural resources in the Minnesota River Valley.

OVERALL PROJECT OUTCOME AND RESULTS

The development of a Minnesota River Valley Recreation and Conservation Master Plan is complete and all deliverables in the contract with the consultant have been delivered. The development of this plan has resulted in a solid direction to advance the interests of improving the recreation and conservation opportunities in the valley. Once adopted by the Counties, this plan provides a prioritized list of action items to begin immediate implementation. This will hopefully result in an increased use and respect for the incredible resource that is shared by Renville and Redwood Counties.

The Master Planning process resulted in a large collection of public opinion from both local residents as well as those outside of the area. Our public meetings had many local residents and averaged an attendance of around 35 people per meeting. Our online survey collected 382 usable surveys from 42 different counties in Minnesota. The data collected from the public was necessary to create this plan, but will also provide many benefits for other efforts in the area for years to come.

The Master Plan is a catalyst for future conversation about how to invest in the Valley for ways to increase the value and benefits of valley resources for those who live in or visit the area. The shared vision in this plan creates a picture of what the Valley can become in the future.

PROJECT RESULTS USE AND DISSEMINATION

All outcomes have been completed with some amendments being made to Outcome 6. Throughout the course of this project it became clear that providing detailed cost estimates was overly ambitious and beyond the scope of this project. Strategies for prioritizing land use decisions and long term funding opportunities and project management were completed. We held one more public meeting than stated with an additional meeting to present the final plan to the public. Final Master Plan was printed and sent to the counties in June 2017 along with digital copies of all files created by consultant throughout this project.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Minnesota River Valley Recreation and Conservation Master Plan](#)

Subd. 09 Land Acquisition for Habitat and Recreation

Metro Conservation Corridors Phase VIII - Coordination and Mapping and Conservation Easements

Subd. 09e \$515,000 TF

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Appropriation Language

\$515,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Minnesota Land Trust for Phase VIII of the Metro Conservation Corridors partnership to provide coordination and mapping for the partnership and to acquire permanent conservation easements on at least 120 acres of strategic ecological landscapes to protect priority natural areas in the metropolitan area, as defined under Minnesota Statutes, section 473.121, subdivision 2, and portions of the surrounding counties. A list of proposed easement acquisitions must be provided as part of the required work plan. 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. Up to \$40,000 may be used for coordination and mapping for the Metro Conservation Corridors. All conservation

easements must be perpetual and have a natural resource management plan. A list of proposed easement acquisitions must be provided as part of the required work plan. This appropriation is available June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

In this eighth phase of the Metro Conservation Corridors the Minnesota Land Trust (MLT) sought to protect 120 acres of critical habitat through conservation easements within designated Metro conservation corridors. To facilitate this outcome, MLT implemented a competitive RFP process (a revision of the MMAPLE framework developed for the ENRTF-funded Avon Hills program in Stearns County) to solicit bids from interested landowners within areas of high biological value targeted for the program. A framework for scoring and prioritizing bids was developed for the Metro Corridors program that placed emphasis on a set of ecological criteria (size of habitat to be protected, condition of the habitat, and ecological/protection context within which the parcel lies) and cost. Along with their proposal for inclusion into the program, landowners identified the funding level necessary for their participation.

The Land Trust utilized an array of strategies to effectively target landowners within priority areas, ranging from direct mail to face-to-face meetings and web-based methods (Facebook and web postings). Subcontracts were entered into with Anoka Conservation District, Isanti SWCD, Sherburne SWCD, and Washington Conservation District to conduct landowner outreach within priority areas.

Three properties were projected under this phase of the program. In total, 158 acres of high-quality habitat were protected through conservation easement, including 14,152 linear feet of undeveloped shoreland. This ENRTF grant leveraged \$71,850 through landowner donation of easement value and support provided by partners toward the costs of easement project development and acquisition, equivalent to roughly 14% of the overall project budget. Though a large portion of project funding was left unspent MLT was able to exceed protection deliverables while efficiently utilizing state funds to secure conservation easements on strategically-located parcels containing high-quality habitat which buffered, or connected to, protected habitat complexes.

PROJECT RESULTS USE AND DISSEMINATION

MLT also convened and led quarterly meetings of the MeCC partnership to review project accomplishments, share information related to each respective partner's conservation work across the MeCC program area, and to strategically plan and coordinate conservation activities.

The MeCC web-based project database upgrade work was completed by the DNR during Spring 2016. A web-based map for public use can be accessed on the DNR's website at: <http://www.dnr.state.mn.us/metroconservationcorridors/index.html>. An upgrade to the MeCC web-based project database was completed under Phase VI was used and the MeCC corridor map was revised and posted for public use in early 2017.

Project Completed: 06/30/2018

FINAL REPORT

Metro Conservation Corridors Phase VIII - Wildlife Management Area Acquisition
Subd. 09h \$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 Phase VIII of the Metro Conservation Corridors partnership to acquire in fee at least 82 acres along the lower reaches of the Vermillion River in Dakota County within the Gores Pool Wildlife Management Area. Land acquired with this appropriation must be sufficiently improved to meet at least minimum management standards. This appropriation may not be used to purchase habitable residential structures, unless expressly approved in the work plan. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

The DNR, in partnership with Dakota County, acquired 169.59 acres of high quality habitat along the lower reaches of the Vermillion River on April 27, 2016. The acquisition consists of several disjoint parcels that are inholdings within the Gores Pool Wildlife Management Area (WMA) and the Vermillion River Complex. This was a high-priority acquisition for the Department of Natural Resources as the area is classified as an Outstanding Regionally Significant Ecological Area for documented colonial waterbird nesting and red shouldered hawks. The property includes more than one mile of river shoreline, high value wetlands and floodplain forest (red oak- sugar maple- basswood forest; silver maple floodplain forest) important for waterfowl, beaver and mink, whitetail deer and numerous other species including non-game species of special concern. Bald eagles and common snapping turtles are present; lake sturgeon and blue sucker occur in Mississippi River Pool 3 nearby. The acquisition reduced the WMA boundary by approximately one mile and resolves potential for boundary dispute.

PROJECT RESULTS USE AND DISSEMINATION

This parcel will soon be designated as part of the statewide WMA system (anticipated in August, 2016). This process involves publishing a designation order in the State Registrar, and a news release announcing this and other recently acquired WMA lands. The news release will mention the use of Environment and Natural Resource Trust Fund for the acquisition.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Multi-benefit Watershed Scale Conservation on North Central Lakes

Subd. 09j \$950,000 TF

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Appropriation Language

\$950,000 the first year is from the trust fund to the Board of Water and Soil Resources to secure permanent

conservation easements on at least 480 acres of high-quality habitat in Crow Wing and Cass Counties. Of this amount, up to \$65,000 must be deposited in a conservation easement stewardship account; and \$54,000 is for an agreement with the Leech Lake Area Watershed Foundation in cooperation with Crow Wing County Soil and Water Conservation District and Cass County Soil and Water Conservation District. Deposits into the conservation easement stewardship account must be made upon closing on conservation easements or at a time otherwise approved in the work plan. A list of proposed easement acquisitions must be provided as part of the required work plan. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Land conservation is a critical tool in the water plans of Crow Wing and Cass County. Limiting development within the watershed has multiple benefits that extend far beyond water quality protection. Science and geographic information system studies were used to strategically identify and prioritize the most significant lake watersheds on which to focus conservation efforts. This pilot project acquired five conservation easements protecting approximately 218 acres and 1,750 feet of strategic shoreland and forestland within the watersheds of priority recreational lakes in Cass and Crow Wing counties.

The focus was on 8 strategic “tullibee-refuge lakes” that are near 75% protection and where additional protection in the watershed can measurably move the needle of protection towards or to full 75% protection. These included notable lakes such as Ten Mile, Roosevelt, Thunder, Washburn, and the Whitefish Chain of Lakes –some of Minnesota’s premier recreational lakes.

BWSR’s RIM Reserve easement program has been a successful tool to protect environmentally sensitive land and water quality throughout agricultural regions of the state. In recent years, BWSR has received increasing requests from soil and water conservation districts for BWSR to make available a RIM tool in the forested region of the state.

Geographic data and existing technical criteria were used to identify parcels that would provide the highest conservation protection investment with a goal of 75% watershed protection. Leech Lake Area Watershed Foundation focused on landowner recruitment including presentations at targeted lake association meetings, direct mail, landowner visit’s and a workshop. Applications were ranked based on the scoring criteria. Approved applications were integrated into the standard BWSR RIM process using soil and water conservation districts (SWCDs) as local agents teamed up with easement acquisition expertise of BWSR staff. Long –term monitoring and enforcement will be provided by BWSR in partnership with the SWCDs.

PROJECT RESULTS USE AND DISSEMINATION

Landowner outreach was conducted to provide information to landowners on the opportunity for conservation easements to protect land and preserve water quality. A press release announced two workshops which were hosted in May 2016 at the Crooked Lake Town Hall (Outing, MN) and the Ideal Town Hall (Pequot Lakes, MN).

Project Completed: 06/30/2018

[FINAL REPORT](#)

Conservation Easement Assessment and Valuation System Development

Subd. 09k \$250,000 TF

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Appropriation Language

\$250,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to assess the effectiveness of existing conservation easements acquired through state expenditures at achieving their intended outcomes of public value and ecological benefits and to develop a standardized, objective conservation easement valuation system for guiding future state investments in conservation easements to ensure the proposed environmental benefits are being achieved in a cost-effective manner. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

OVERALL PROJECT OUTCOME AND RESULTS

Our research sought to address a problem that conservation practitioners and the LCCMR face; how do we know that a proposed easement acquisition is a good use of resources? What benefits does it provide, and is it the best parcel to provide those benefits? We set out to understand existing approaches, and create a tool to complement their strengths and improve conservation targeting.

After researching the methods state agencies and NGOs use to prioritize acquisitions in the state, we designed a tool to complement existing approaches in two ways. First, we observed that existing systems all use a rubric to score proposed acquisitions on a parcel-by-parcel basis. Detailed local knowledge gathered in site visits is important for decision-making, however, it is impossible to gather site-level data for the entire state. Valuable parcels will be missed without a statewide, landscape-level perspective. To complement existing rubrics, our approach scored over 300,000 privately held, undeveloped parcels to provide the context of how a proposed acquisition compares to all other parcels in the state.

Second, our approach created 11 environmental benefit metrics, designed to complement those used in existing prioritization systems. Our metrics combine spatial data to map not just where high quality natural resources are, but also where the public would benefit the most from conservation. For example, our bird watching metric considers where experts have identified as important bird habitat, and where the public actually goes to engage in bird watching. The resulting metric recognizes both important habitat, and where bird watchers go, but gives the highest scores to locations where both occur.

Our research provides conservation practitioners with the data and tools to quickly assess the environmental benefits of a parcel, and how those benefits compare to hundreds of thousands of other parcels in the state. By assessing all of the parcels in the state, practitioners will be able to identify the best parcel to meet their objectives and cost-effectively provide multiple benefits to all Minnesotans

PROJECT RESULTS USE AND DISSEMINATION

We have been presented this research to conservation practitioners at organizations including:

- UMN Natural Resources Research Institute (they agree to include our metrics in their spatial data atlas)
- The Nature Conservancy Freshwater and Land teams
- Lessard-Sams Outdoor Heritage Council working group on impact assessment
- BWSR
- DNR Easement stewardship working group
- Authors of the MN Gulf nutrient reduction strategy
- Minnesota Land Trust

We will continue to communicate with these groups to ensure they are able to make the most of our research products.

In addition to traditional outreach through presentations, we also produced a professionally developed website (pebat.umn.edu), with a particular focus on explaining our methods in a simple, non-technical way. While the site has online been online for a month, it has had 100 visits and 25 downloads of the tool. We will continue to track

visits and downloads. Furthermore, will also be publishing an article on the UMN Institute on the Environment site that publicizes the research products from this project. It will be produced in the same style as the post we used to publicize the manuscript that was produced in activity 1 of this project: <http://environment.umn.edu/news/new-study-conservation-investments-working-harder-minnesotans/>

Project Completed: 06/30/2018

[FINAL REPORT](#)

Subd. 10 Emerging Issues Account

Emerging Issues Account

Subd. 10 \$1,000,000 TF

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Appropriation Language

\$1,000,000 the first year is from the trust fund to an emerging issues account authorized in Minnesota Statutes, section 116P.08, subdivision 4, paragraph (d).

Sub-Project 01: Avian Influenza distribution, evolution, and impacts on ring-billed and herring gulls in Minnesota

Project Completed: 06/30/2017

Sub-Project 01: Avian Influenza distribution, evolution, and impacts on ring-billed and herring gulls in Minnesota - \$213,443 TF

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OVERALL PROJECT OUTCOME AND RESULTS

In summary, this project provided novel and important information regarding the avian influenza prevalence and viral shedding routes in Minnesota ring-billed gulls and the genetic characteristics of the influenza A viruses detected. We addressed a gap in influenza A virus surveillance by sampling 1346 ring-billed gulls (*Larus delawarensis*) during Spring and Fall migrations and at three breeding sites in 2017 across Minnesota. Results indicated noticeable age-cohort dynamics in AI virus prevalence within ring-billed gulls in Minnesota. Immunologically naïve juveniles represented the cohort with the highest prevalence rate (57.8%). Regardless of age, more gulls had AI virus detected in oropharyngeal than in cloacal swabs.

Our results varied among colony sites and seasons, but a consistent finding was that juvenile and hatch year birds had higher avian influenza virus prevalence than adults. Furthermore, swabs from the oropharynx and cloaca demonstrated a significant difference in avian influenza virus prevalence. Oropharyngeal swab testing yielded true avian influenza virus prevalence estimates of 23.55%, versus 10.64% for cloacal swab testing. These results suggest, as other studies have shown, that gulls more commonly shed avian influenza virus via the oropharyngeal

route which may facilitate transmission to other species and have implications for surveillance strategies. Although our results indicate that gulls shed virus predominately through the oropharyngeal cavity it is important to consider the apparent prevalence bias of sampling only the oral cavity. If only oral cavities were sampled, our estimates of sample prevalence would have been negatively biased by 2.5% considering all sampled birds together. Using this approach, avian influenza virus detection would have been missed in 34 birds. This negative bias would have been highest at 6.4% if we conditioned the analysis on local birds, resulting in 86 missed detections. The negative bias would have been negligible for adults at < 1% yet would still result in 12 missed detections. This example supports the practice of swabbing both oropharyngeal and cloacal cavities for avian influenza virus surveillance efforts in gulls. If funding is limited, then oropharyngeal and cloacal swabs should be taken and pooled into one tube.

During our study, we identified only two H5 avian influenza viruses that were detected by subtype specific rRT-PCR and neither was confirmed as highly pathogenic avian influenza virus by gene sequencing. We further analyzed all swabs that tested positive for avian influenza virus with Ct values < 30 and subjected them to whole genome sequencing to further characterize the viruses detected and found H13N6, H13N8, and H13N2 viruses. Analyses of these genes showed that there was apparently no virus movement between wild gulls and domestic poultry in Minnesota in the time period studied.

The high AI virus prevalence within ring-billed gulls, particularly in immunologically naïve birds, warrants further targeted surveillance efforts of ring-billed gulls and other closely related species. Sequence analyses completed on the viral genes identified, suggest that our data group separately from highly pathogenic H5NX avian influenza viruses that devastated Minnesota poultry in 2015 which is interesting and suggests that gulls are not part of the poultry transmission cycle (see Figure 2 as an example). Additional analyses will be conducted and we look forward to further research using the data generated from this successfully completed project.

Subproject 01 Completed: 06/30/2018

[FINAL REPORT](#)

Subd. 11 Administration and Contract Agreement Reimbursement

Contract Agreement Reimbursement

Subd. 11b \$135,000 TF

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Appropriation Language

\$135,000 the first year is from the trust fund to the commissioner of natural resources at the direction of the Legislative-Citizen Commission on Minnesota Resources for expenses incurred for contract agreement reimbursement for the agreements specified in this section. The commissioner shall provide documentation to the Legislative-Citizen Commission on Minnesota Resources on the expenditure of these funds.

OVERALL PROJECT OUTCOME AND RESULTS

This appropriation was used to support the ENRTF contract management program, which ensured that ENRTF grantees expended grant funds in compliance with state law, session law, approved work plans, and Office of Grants Management grants policies.

The DNR Grants Unit managed 59 grants active in FY 2016. In FY 2017, the Grants Unit managed 67 active grants. Between 7/1/2015 when the services began and 06/30/2017 when they ended, the DNR Grants Unit:

- Made 270 reimbursements to grantees totaling \$6,186,311.59
- Prepared and executed 21 ML 2016 grant agreements
- Published 6 editions of the quarterly newsletter for all grantees
- Billed 976 hours at the FY 2016 professional services rate of \$59.00/hr
- Billed 1,245 hours at the FY 2017 professional services rate of \$62.00/hr
- Monitored all grants in compliance with Office of Grants Management policies.

PROJECT RESULTS USE AND DISSEMINATION

Project personnel were in frequent contact with appropriation recipients and LCCMR staff. Information was disseminated through manuals, training sessions, orientations, meetings, memos, letters, emails, newsletter, and phone.

Project Completed: 06/30/2017

[FINAL REPORT](#)

3. M.L. 2014 Projects Completed
January 15, 2017 – January 15, 2019
MN Laws 2014, Chapter 226, Section 2

M.L. 2014 Projects

[MN Laws 2014, Chapter 226](#), Section 2 (beginning July 1, 2014)

[MN Laws 2014, Chapter 312](#), Article 12, Section 8 (beginning July 1, 2014)

Subd. 03 Water Resources

Solar Driven Destruction of Pesticides, Pharmaceuticals, Contaminants in Water - RESEARCH

Subd. 03a \$291,000 TF

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Appropriation Language

\$291,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to quantify the solar-driven destruction of contaminants reacting with dissolved organic matter to optimize water treatment methods and guide reuse. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Pesticides, pharmaceuticals, and agricultural nutrients serve important functions in crop production and the treatment of disease. However, these chemicals become pollutants when discharged into surface waters through wastewater, storm water, and agricultural runoff. There are natural processes, though, that help break down and remove these pollutants from water. One such process is the role that sunlight interacting with dissolved organic matter naturally present in surface water from decaying plant materials and algae has in transforming these contaminants. Researchers at the University of Minnesota are using this appropriation to better understand the role this interaction between sunlight and dissolved organic matter has in affecting the fate of water pollutants in order to optimize water treatment methods and guide effective water reuse.

OVERALL PROJECT OUTCOME AND RESULTS

Urban stormwater, agricultural runoff, and municipal wastewater effluent transport pesticides, pharmaceuticals, and other trace organic compounds to aquatic systems. Once in the environment, these compounds are considered pollutants because they may have adverse ecological effects on non-target organisms. It may be possible to use or design wetland systems to take advantage of natural processes to maintain pollutant concentrations below harmful levels. Chemical reactions initiated by sunlight, also called photochemical reactions, are particularly important in degrading these pollutants. The organic matter (produced by the breakdown of plant material or from algae) dissolved in the water absorbs sunlight, and this process reactivates intermediates that breakdown pollutants.

In this work a method was developed to relate the amount of reactive intermediates produced to the source and composition of the organic matter. This allows prediction of how fast pollutants will be broken down by sunlight in surface waters impacted by stormwater runoff or wastewater effluents. Stormwater, wetland surface water, and municipal effluent samples were collected seasonally from Fall 2014 to Spring 2016 throughout the Minneapolis-St. Paul metro area and greater Minnesota. The efficiency of reactive intermediate formation was experimentally measured using chemical probes, and the composition of the organic matter was assessed using light absorbance

and fluorescence measurements and high-resolution mass spectrometry. Trends show that organic matter with low capacity to absorb light also has high efficiencies of reactive species formation. The relationship between reactive species formation efficiency and organic matter composition appears to be highly influenced by the content of the organic derived from plants. From this work, a model was developed to aid in the design of treatment wetlands to achieve pollutant removal by allowing an appropriate amount of time for sunlight exposure. In addition, an empirical multiple linear regression model using both chemical information about the organic matter and descriptors of the surrounding landscape was developed to aid in the prediction of reactive species formation in surface waters across regional scales. This will allow prediction of contaminant degradation via sunlight-driven reactions in a broad range of surface waters in Minnesota.

PROJECT RESULTS USE AND DISSEMINATION

This work has been presented at two sessions of the Environmental Chemistry Division of the American Chemical Society in March 2017 (both submitted with this report). This work has also been presented at poster sessions of the Minnesota Water Resources Conference (October 2016), the Conference on the Environment (November 2016), and the Year of Water Action Forum (March 2017; poster submitted with this report). One manuscript presenting the results of this work has been accepted for publication (July 2017; manuscript submitted with this report) and additional manuscripts are in preparation. Additional opportunities are being pursued to develop a pilot-scale treatment wetland to assess the accuracy and applicability of the models developed from this study.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Poster Presentation Graphic](#)

Methods to Protect Beneficial Bacteria from Contaminants to Preserve Water Quality - RESEARCH

Subd. 03b \$279,000 TF

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Appropriation Language

\$279,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to research how and why bacteria that provide ecological functions humans depend on for water quality are affected by exposure to certain man-made perfluorinated chemicals entering the wastewater treatment system in order to identify methods that can be implemented to protect those bacterial functions from being degraded. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Many types of bacteria perform critical ecological functions, such as cycling carbon and other nutrients, which enable life to exist. In fact, humans harness these types of bacteria in certain engineered systems, such as wastewater treatment plants and landfills, to provide various benefits such as protecting surface waters from excess nitrogen, decomposing solid waste, and treating wastewater. Unfortunately, the environments within these systems where the beneficial bacteria live are also environments that receive a complex array of synthetic chemicals that can negatively affect bacterial function, particularly when present in mixtures. One such class of chemicals that find their way into these systems is perfluorinated chemicals, which research has suggested can cause other co-contaminants to be more toxic to bacteria. Researchers at the University of Minnesota are using this appropriation to research how and why these beneficial bacteria are affected by exposure to perfluorinated

chemicals entering the wastewater treatment system in order to help develop and engineer methods to better protect and enhance the important ecological functions these bacteria provide.

OVERALL PROJECT OUTCOME AND RESULTS

We studied the effect of common pollutants, perfluorinated alkyl substances or perfluorinated substances (PFCs), on bacteria. PFCs are found throughout the environment from concentrations of 0.00001 mg/L in rivers to 10 mg/L at heavily polluted sites. Because humans rely on bacteria for nutrient cycling and waste degradation, it is important to understand whether PFCs affect bacteria. We studied PFCs with known health impacts, those containing 7-8 fully fluorinated carbons, along with shorter, 4- and 6-carbon “replacement” PFCs. We discovered that PFCs with 3-8 fully fluorinated carbons increased the permeability of bacterial membranes at high (mg/L) concentrations. We observed that these compounds deposited into model bacterial membranes and changed their fluidity at concentrations of 0.1 to 50 mg/L. This is significant because bacterial membranes form semi-permeable barriers; it is the semi-permeable nature of membranes that enable bacteria to communicate with one another and control metabolism. Increased membrane fluidity and permeability in bacteria induced by PFC exposure could have impacts on the bacterial functions that humans rely on.

Perhaps not surprisingly, we also discovered that PFCs with 3-8 fully fluorinated carbons altered the bacterial response to the external chemical signal used for bacteria-to-bacteria communication. This occurred at PFC concentrations of 0.01 to 50 mg/L. Finally, exposure to high (50 mg/L) concentrations of PFCs with 7-8 fully fluorinated carbons and PFC-containing aqueous film-forming foam changed microbial metabolism, decreasing the amount of carbon degraded to methane. The presence of a co-contaminant lessened this effect, likely as a result of the co-contaminant displacing the PFCs from the bacterial surface. This research indicates microbial metabolism is not likely to be affected by PFCs unless these compounds are present at high concentrations, such as at fire-fighting training sites. Nevertheless, the effects of PFCs on bacterial membranes and bacteria-to-bacteria communication at lower concentrations could cause unanticipated impacts.

PROJECT RESULTS USE AND DISSEMINATION

Three peer-reviewed manuscripts are expected to be published from this work; these will be submitted to the LCCMR when accepted for publication. Multiple presentations about the research have been given at both regional and national/international conferences.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Triclosan Impacts on Wastewater Treatment - RESEARCH

Subd. 03c \$380,000 TF

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Appropriation Language

\$380,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to assess the role of the commercially used antibacterial agent triclosan in creating antibiotic resistant bacteria during the municipal wastewater treatment process. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

As people use antibiotics and products containing antibacterial substances the bacteria that are resistant to the effects of these products survive and reproduce, thus creating a selection for antibiotic resistant bacteria. Many of these bacteria and the antibacterial substances ultimately make their way into the waste stream and are mixed together and concentrated at wastewater treatment plants, where they interact and can create further selection for organisms with antibiotic resistance to multiple antibacterial substances resulting in what are commonly known as "super bugs". If these antibiotic resistant organisms are not entirely removed during the wastewater treatment process, these organisms then are released into the environment where they can eventually affect humans and other species. One antimicrobial substance of particular concern is triclosan, which is present in numerous personal care products, because it has been shown to help select for organisms that show antibiotic resistance not just to triclosan but also to a multitude of other antibiotics. Researchers at the University of Minnesota are using this appropriation to improve understanding of the role of triclosan in selecting for antibiotic resistant bacteria during the municipal wastewater treatment process.

OVERALL PROJECT OUTCOME AND RESULTS

Laboratory-scale sequencing batch reactors were constructed and operated in triplicate at four different concentrations of triclosan (0 µg/L, 1 µg/L, 5 µg/L, and 15 µg/L). After six weeks of operation, biomass was harvested and used for 12 discrete sequencing batch reactors (SBRs) and operated them for a total of six weeks. Chemical analysis of the biomass for triclosan concentrations confirmed that the cultures were grown over the expected range of triclosan concentrations. Metagenomic DNA was extracted and purified from the biomass from these laboratory-scale cultures. Bacterial community composition was characterized by PCR of 16S rRNA genes followed by DNA sequencing using Illumina MiSeq. Results demonstrated that bacterial community composition shifted in a statistically significant fashion in response to higher triclosan doses. Direct DNA sequencing of metagenomic DNA demonstrated that only a few antibiotic resistance genes were overrepresented in the cultures with high triclosan concentrations compared to those with low triclosan concentrations. Specifically, *tet(R)* and *tet(A)* genes were overrepresented in the 5 µg/L triclosan treatment; *tet(R)*, *tet(A)*, *tet(X)*, *msrE*, and *sul1* were overrepresented in the 15 µg/L triclosan treatments. No statistical difference was observed for more than 2,100 other antibiotic resistance genes. Metagenomic DNA was also directly cloned and introduced into *E. coli* to select for functional antibiotic resistance genes. Each of the resulting clone libraries averaged 20,000 clones, the equivalent of more than 1300 bacterial genomes. All libraries were selected for genes conferring resistance to a panel of antibiotics. Sequence analysis indicated that the enzymes encoded by the resistance genes ranged from 57 to 100 percent identical to the closest matching proteins in the GenBank database. Many of these genes were found adjacent to each other on single DNA molecules. Two clones contained multiple resistance genes on integrons in arrangements that have not been previously reported in the literature.

PROJECT RESULTS USE AND DISSEMINATION

Results from this project have been presented at Microbe 2016, the annual meeting of the American Society for Microbiology and at the Functional Metagenomics 2016 conference in Inderøy, Norway. Manuscripts are currently being written for publication in the peer-reviewed archival literature.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Evaluation of Wastewater Nitrogen and Estrogen Treatment Options - RESEARCH

Subd. 03d \$500,000 TF

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Appropriation Language

\$500,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to examine the performance of new wastewater contaminant treatment options under Minnesota weather conditions in order to understand how to improve wastewater treatment of nitrogen and estrogenic compounds, decrease costs and energy use, and safeguard aquatic species. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Wastewater treatment plants discharge effluent that contains contaminants of emerging concern, such as estrogens. Estrogens have been shown to cause ecological effects such as fish feminization and fish population collapses. Presently the treatment and discharge of estrogens into the environment via wastewater treatment is not regulated. However, it has been found that the extent of estrogen discharge from wastewater treatment correlates with how and how well nitrogen, which currently is regulated and will likely be more so in the future, is removed during the treatment process. Thus more effective nitrogen removal processes have the potential to also ensure more effective removal of estrogens. Researchers at the University of Minnesota are using this appropriation to determine how different nitrogen removal processes perform under a variety of weather conditions with respect to how well they remove both nitrogen and estrogenic compounds in order to help improve wastewater treatment of nitrogen and estrogenic compounds.

OVERALL PROJECT OUTCOME AND RESULTS

Wastewater treatment plants (WWTPs) discharge effluent that contains contaminants of emerging concern (CECs), including estrogens. These estrogens have caused ecological damage, such as fish feminization, with unknown long-term consequences. The most important estrogen exiting WWTPs is a chemical called estrone. In this project we studied how different treatment systems performed with respect to estrone degradation and how temperature effected degradation. We also studied how fish vulnerability changed seasonally. Finally, we combined these laboratory efforts with models of fish population dynamics to extrapolate the results.

We determined that the technology used by a treatment plant is likely to have an impact on the estrogenicity of WWTP effluent, with some technologies performing very well and others failing to remove estrone. In addition, natural seasonal fluctuations in temperature and expected fluctuations in estrone concentration can cause negative changes in exposed fish. Mathematical models were used to expand this research to whole river systems and showed that the impacts of estrone on fish populations varied depending on the characteristics of the environment. Impacts were expected to be low in systems in which fish were limited by food and high in systems in which fish were limited by predators. Therefore, fish populations in Minnesota rivers are likely to vary in their response to wastewater estrone. The cost of various wastewater improvements were calculated, which could be compared to the value associated with recreational fishing.

Overall, this research showed that low energy treatment systems do exist that are capable of excellent estrone removal, which should be considered so that multiple ecological benefits can be reaped as treatment plants upgrade. Nevertheless, modeling results suggest that the impacts of estrone vary at the population scale based on river characteristics. Therefore, the impact of estrogens at the fishery scale should be evaluated for a given river of interest.

PROJECT RESULTS USE AND DISSEMINATION

Information from this project has been shared broadly and multiple peer-reviewed manuscripts have been published from this work and submitted to the LCCMR.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Individual Based Models for the fathead minnow *Pimephales promelas* and the walleye *Sander vitreus*: Report](#)
[Add-my-pet procedure for fathead minnow *Pimephales promelas* and the walleye *Sander vitreus*: Report](#)
[Thermal modulation of anthropogenic estrogen exposure on a freshwater fish at two life stages: Publication](#)
[Temperature modulates estrone degradation and biological effects of exposure in fathead minnows: Publication](#)
[Estrone biodegradation in laboratory-scale systems designed for total nitrogen removal from wastewater: Publication](#)

Antibiotics and Antibiotic Resistance Genes in Minnesota Lakes - RESEARCH

Subd. 03e \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to quantify the relationship between antibiotics and antibiotic-resistant bacteria in Minnesota lakes to determine if improved wastewater treatment is necessary to protect human and aquatic health. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Through various means, human produced chemicals can make their way into surface waters where they can have adverse effects on the function of ecological communities. Of particular concern are antibiotics and other antimicrobial substances because they have the potential to create increased antibiotic resistance. While there is a background level of naturally occurring antibiotic resistance in the natural world, elevated or persistent levels caused by human activities have the potential to harm human, animal, and overall ecosystem health. Researchers at the University of Minnesota are using this appropriation to quantify and compare the levels within lakes of naturally occurring antibiotic compounds versus those resulting from human actions to delineate the role of each in creating antibiotic resistant bacteria and determine the extent to which improved wastewater treatment could contribute to controlling the amount of antibiotics and antibiotic resistant genes within the environment.

OVERALL PROJECT OUTCOME AND RESULTS

Antibiotics are substances that stop the growth of or kill bacteria. Animal agriculture and human medicine are the largest consumers of antibiotics worldwide. A fraction of the antibiotic administered is excreted in its original form through urine and/or feces. These residues reach aquatic environments through the discharge of wastewater effluent or drainage and surface runoff from agricultural fields to which manure has been applied. The presence of antibiotics in the environment are of concern, because these chemicals may select for and proliferate the occurrence of antibiotic resistance genes (ARGs). ARGs allow bacteria to survive in the presence of an antibiotic. Heavy metals are also known to co-select for ARGs. The World Health Organization has identified antibiotic resistance as one of the major threats to global health. The increase in the prevalence of antibiotic resistant infections, coupled with the decrease in the development of new antibiotics, emphasize the need for new strategies to better understand antibiotic resistance.

The goal of the project is to quantify the current and historical levels of selected human and veterinary antibiotic compounds and genes that code for their resistance in lake sediments. Sediment cores collected for three anthropogenically-impacted Minnesota lakes (Lake Pepin, Duluth Harbor, and Lake Winona) and a control lake in Superior National Forest (Little Wilson Lake) were radiometrically dated. The twenty antibiotics included in this

study have a mixture of human and/or agricultural uses, some are known natural products, and they span several of the major classifications (sulfonamides, fluoroquinolones, tetracyclines, macrolides).

Sediment cores were successful at capturing the usage trends of ten antibiotics. The initial appearance of antibiotics in the sediment core generally agreed with the FDA approval date, which provided further confidence in the dating of the sediment cores and the ability of sediment cores to capture antibiotic usage trends. Ofloxacin, trimethoprim, sulfapyridine, and sulfamethazine were the only antibiotics to be detected in all three anthropogenically-impacted studied lakes with levels up to 91.7, 2.5, 13.1, and 5 ng g⁻¹, respectively. Human-use antibiotics were detected more frequently and at higher concentrations than antibiotics used for veterinary medicine. Also, the degree of antibiotic pollution appeared to be a function of treated wastewater impact. Lake Winona was the most heavily wastewater impacted lake in the study (approximately 63% of the inflow is treated wastewater effluent) and had the highest concentrations and greatest number of antibiotics detected. Treated municipal wastewater is likely the primary contributor to antibiotic pollution in the studied lakes.

The abundance of 48 antibiotic, metal, and antibiotic-associated resistance genes were quantified in the sediment cores with detected levels ranging from 103 to 108 gene copies per gram. Most ARGs included in this study, however, were not consistently quantifiable throughout the sediment cores. Similar concentrations of blaSHV, cadA, copA, int11, and mexB were measured amongst the sediment cores, but Lake Winona had higher levels of sul3 and tet(A) compared to the other lakes. ARGs levels did not appear to be a function of sediment core depth, and thus the measured levels are at or close to natural, indigenous background levels of the studied genes. Also, (unlike the antibiotics studied) ARG abundance did not appear to be a function of agricultural activity or degree of wastewater impact. Therefore, ARG abundance in the studied lakes is likely not influenced by antibiotic usage, but rather may be influenced by the presence of heavy metals that are known to co-select for ARGs.

PROJECT RESULTS USE AND DISSEMINATION

This project led to the production of chapters in the PhD dissertations of both Kyle Sandberg and Jill Kerrigan. Manuscripts will be submitted to the journals Science of the Total Environment and Environment Science and Technology Letters. Copies of manuscripts will be provided upon publication. The results of this work have been presented at least nine times at national and local conferences.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Impacts of Estrogen Exposure on Minnesota's Shallow Lake Wildlife - RESEARCH
Subd. 03f \$136,000 TF

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Appropriation Language

\$136,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the University of St. Thomas to use biological samples already gathered from shallow lakes across Minnesota to determine the environmental estrogen exposure impacts on aquatic wildlife in shallow lakes for enhanced land and lake management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Endocrine-disrupting contaminants such as environmental estrogens have been found and studied in large lakes and streams and shown to exist at concentrations that have adverse effects on wildlife. However, very little is known about the sources and effects of environmental estrogens in small, shallow lakes. Preliminary data suggests that these compounds are present in shallow lakes and have an effect on the survival and reproduction of wildlife. Researchers at the University of St. Thomas are using this appropriation to determine the extent to which aquatic wildlife in shallow lakes are being exposed to environmental estrogens, the land-use practices that correlate with exposure, and the amount of detrimental impact that exposure creates in order to enhance land and water management practices.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota's shallow lakes play an important role in the ecosystem by providing clean water, recharging groundwater stores, and sequestering chemical and soil runoff. These lakes also benefit citizens, both by providing opportunities for recreation (e.g., fishing, swimming) and by providing economic value as a site for various commercial ventures (e.g., summer camps, fisheries). Endocrine-disrupting contaminants, including environmental estrogens (EEs) are present in Minnesota's larger lakes and streams at concentrations which have adverse impacts on wildlife. However, very little is known about the sources and effects of EEs in small, shallow lakes. Importantly, the use of surrounding land and associated lake management practices may influence or exacerbate the effects of contaminants in these systems. By developing an assay that allows us to look at levels of EE exposure in the painted turtle, we have found that lakes across Minnesota have widely different chemical makeup, and that turtles in these lakes show different levels of exposure. By examining the brains of these animals, we have discovered that the size of certain structures related to reproduction is highly correlated with EE exposure. We are now examining the relationship between land-use practices in lake watersheds and the chemical makeup of these lakes.

PROJECT RESULTS USE AND DISSEMINATION

We presented work resulting from our efforts to develop a species-specific measure for VTG in painted turtles at the Midwest Regional Chapter meeting of the Society for Environmental Toxicology and Chemistry in April, 2017. We presented work that describes the relationship between VTG levels and brain structure at the North American Society for Environmental Toxicology and Chemistry annual meeting in November, 2017.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Watershed-Scale Monitoring of Long-Term Best Management Practice Effectiveness - RESEARCH

Subd. 03g \$900,000 TF

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Appropriation Language

\$900,000 the second year is from the trust fund to the Science Museum of Minnesota for the St. Croix Watershed Research Station to evaluate the effectiveness of best management practices in reducing sediment and nutrient loads at watershed scales over long time periods. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Minnesota has widespread water quality impairments due to nonpoint-source pollution generated by agricultural, urban, and other human-altered lands. Mitigation of these impairments requires implementing best management practices (BMPs) that are designed to limit soil erosion and nutrient transport from lands to receiving waters. Long-term data sets of water quality and land-use history are needed to tease apart the many factors that affect water quality. In particular, data sets that span periods before and after BMP implementation are needed to determine BMP effectiveness. However, such data sets are lacking because water quality monitoring of our lakes and rivers did not begin until well after humans altered the landscape. To fill this data gap, Researchers at the Science Museum of Minnesota's St. Croix Watershed Research Station are using this appropriation to construct long-term historical water quality records through analysis of lake sediments in order to enable better determination of the effectiveness of BMPs on improving water quality.

OVERALL PROJECT OUTCOME AND RESULTS

Nonpoint-source pollution (NPS) by sediment and nutrients represents the greatest human impact to Minnesota surface waters, especially in agricultural regions, yet monitoring records are too short to demonstrate the magnitude of the impact or potential benefits of best-management practices (BMPs). To fill this knowledge gap, our project used sediment cores, land-use compilations, and watershed modeling to reconstruct the long-term record of how land use has contributed to sediment and nutrient pollution in our rivers and lakes, and whether BMPs have been effective in reducing this pollution. Watershed erosion gradually fills in lakes over time, and so lake-sediment accumulation provides a record of watershed-scale erosion rates and changes.

We first re-analyzed statewide data from 142 lakes in our extensive lake-core archive. We then selected 14 lakes from the southern half of Minnesota for intensive analysis, collected 57 sediment cores from these lakes, and analyzed over 4,000 samples from these cores to determine the accumulation rates of sediment and phosphorus over the past 150 years. Radioisotope analysis determined the sediment age and source, whether from fields or stream channels. The results confirm that sediment erosion increased from the time of settlement in concert with increased cropland and the subsequent replacement of hay and small grains by corn and soybean row crops. In our intensive study lakes, sediment accumulation increased 2-10 (average 6) times over natural (pre-settlement) rates, and phosphorus accumulation increased 2-8 (average 5) times over natural rates. Radioisotopic fingerprinting indicated most of the lake sediment originated from fields, which is in contrast to our larger rivers such as the Minnesota, where bluffs and stream banks are the major erosion sources. Watershed modeling linked soil erosion to lake-sediment accumulation and confirmed that while BMPs produce beneficial results, they are overwhelmed by increases in row-crop acreage. We conclude that Minnesota needs to look beyond conventional BMPs towards putting more perennials in our croplands to achieve substantial water-quality improvement.

PROJECT RESULTS USE AND DISSEMINATION

Presentations have been given to the following groups in the Twin Cities and in out-state Minnesota: Clean Water Council; "Moving the Needle" taskforce to follow up on Governor Dayton's Water Summit; Working Lands group, as organized by BWSR; Greater Blue Earth River Basin Alliance; Chippewa Watershed "10% Project"; Isaac Walton League (joint meeting for southern Minnesota chapters); Lake Pepin Legacy Alliance; Friends of the Mississippi River; Upper Mississippi River Conservation Alliance (in partnership with the U.S. Fish and Wildlife Service); Friends of the Star Prairie Land Preservation Trust; Great Lakes Protection Commission (national meeting). A special session is planned for this year's Minnesota Water Conference on "The Need for and Potential of Creating Markets for BMPs" where project results will be discussed. Finally, a series of fact sheets will summarize the main components of the project for water-resource managers and an educated lay audience.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Protection of State's Confined Drinking Water Aquifers - RESEARCH

Subd. 03h \$394,000 TF

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Appropriation Language

\$394,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to test methods of defining properties of confined drinking water aquifers in order to improve water management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

The groundwater contained in confined glacial aquifers provides clean drinking water to many Minnesota residents. An important factor affecting the long-term sustainability of these aquifers is how water infiltrates through clayey deposits of overlying glacial till, which act as barriers to contaminants but also limit water flow and aquifer recharge. Very little is actually known about the properties and infiltration of water through till, which hinders the ability to accurately define the sustainability of these aquifers. The United States Geological Survey is using this appropriation to test methods for assessing and defining the hydrologic properties of glacial till in order to understand the role it plays in the long-term sustainability of groundwater.

OVERALL PROJECT OUTCOME AND RESULTS

Confined (or buried) aquifers overlain by till confining units provide drinking water to thousands of Minnesota residents. These till confining units are typically conceptualized as having very low potential for transmitting water. Thus, buried aquifers are thought to be less susceptible to surface contamination, but may recharge very slowly and may be prone to unsustainable groundwater withdrawals. This study was completed to give insight to the susceptibility and sustainability of the groundwater resources being withdrawn from confined aquifer systems in Minnesota. A combination of hydrologic field measurements, geochemical analyses, and modeling techniques were used to quantify the variability of hydrologic properties and flux of water through till confining units to buried aquifers at two representative sites in Minnesota. Glacial deposits of the Des Moines Lobe were characterized in Litchfield, Minnesota and glacial deposits of the Superior Lobe were characterized in Cromwell, Minnesota. A conceptual understanding emerges from the field measurements at the two sites that till "layers" in the glacial deposits of the Des Moines and Superior Lobes in Minnesota are not really continuous layers, but rather a complex series of sediment mixtures with differing abilities to transmit water. The hydrologic field measurements and geochemical analysis demonstrated large variations in till confining unit properties over relatively small vertical and horizontal distances, underscoring the challenges of assessing the susceptibility and sustainability of groundwater resources in confined aquifer systems.

Many waters in Minnesota are under threat of nutrient contamination from anthropogenic activities such as row-crop agriculture. This study provided some evidence that till confining units may be effective at reducing the susceptibility of buried aquifers to nitrate contamination, but may be a source of phosphorus. Data from Litchfield show that chloride is present in elevated concentrations where nitrate is not, despite abundant agriculture in the surrounding area. This suggests that denitrification may be occurring within the till; previous studies have demonstrated denitrification in Des Moines lobe tills (Simpkins and Parkin, 1993; Parkin and Simpkins, 1995). Phosphorus, though present at depth, particularly in Cromwell, is likely geologic rather than anthropogenic in origin.

The conceptual modeling demonstrates the importance of having accurate information, about the hydrogeologic setting (particularly about the vertical hydraulic conductivity of overlying till, the areal extent of the buried aquifer, and the lateral connectivity of the buried aquifer to other aquifers) when evaluating the sustainability of pumping water from confined aquifer systems. Over long periods of time, pumping-induced hydraulic gradients can be established in buried aquifer systems and, even in low hydraulic conductivity tills, these gradients could induce

flow that affects surface-water resources. The source of water entering a buried aquifer that is being pumped can be highly variable, depending on the overlying till vertical hydraulic conductivities and the lateral connectivity of buried aquifer to adjacent till and aquifers. A sensitivity analysis demonstrated that the simulation of the source of water to wells is most sensitive to the vertical hydraulic conductivity of the overlying till, the areal extent of the aquifer, and the connectivity of the horizontal hydraulic conductivity of geologic materials adjacent to the aquifer.

PROJECT RESULTS USE AND DISSEMINATION

As the result of this project, 4 publications were produced and 1 in preparation. A total of 9 presentations were given to audiences; 5 presentations at professional meetings and 4 public presentations.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Minnesota Geological Survey Report](#)

[MDH Cromwell Well Aquifer Test](#)

[MDH Litchfield Well Aquifer Test](#)

Watershed Water Budgets for Managing Minnesota's Groundwater - RESEARCH

Subd. 03i \$129,000 TF

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Web: <http://mn.water.usgs.gov/index.html>

Appropriation Language

\$129,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to create a pilot study to calculate complete watershed water budgets for two counties in Minnesota for enhanced groundwater management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Effective groundwater management requires accurate knowledge about the water budget, which is the amount of water stored within the system in aquifers and the amount of water flowing through the overall hydrologic system including water flowing at the surface, water flowing from above ground down into aquifers, and water flowing between aquifers below the surface. While groundwater storage can be generally well understood and there is good knowledge about surface water flow, there is not usually a strong understanding about the water flowing down from the surface to aquifers and below the surface between different aquifers. The United States Geological Survey is using this appropriation to pilot a method intended to better calculate the groundwater flow component of the hydrologic system in order to provide information that will improve knowledge about water sustainability and the interaction between surface and ground water. The method will be piloted in watersheds in St. Louis and Goodhue counties.

OVERALL PROJECT OUTCOME AND RESULTS

A new visual mapping technique that illustrates the relative and cumulative streamflow contributions from across a large watershed was developed for two pilot areas in Minnesota: Cannon River and St. Louis River. Both areas were selected because of mining-related activities. For the Cannon River, for the surficial sand mining, and for the St. Louis River, for the ongoing iron ore mining of the Mesabi Iron Range. Each large watershed (Cannon, St. Louis) was sub-divided into a series of much smaller sub-watersheds (Cannon: 153; St. Louis: 353). For each sub-watershed, the estimated groundwater (as baseflow) and surface runoff fluxes flowing into all surface-water

features was summed under different typical conditions, such as drought or flood conditions. Downstream sub-watersheds aggregate upstream surface-water flows in addition to baseflow and surface runoff directly from the sub-watershed. These maps, termed as streamflow distribution maps, can help illustrate sub-watersheds that are vulnerable due to either groundwater or surface-water appropriations, particularly under drought conditions. For each pilot watershed, a series of the streamflow distribution maps were developed at selected flow regimes: extreme drought conditions, drought conditions, an average condition, and a flood condition. Each pilot watershed is displayed as a single map sheet with the four flow regimes as separate panels for ease of comparison. The selected streamflow distribution maps illustrate streamflow contributions from different parts of the watershed for typical conditions, not necessarily the contribution for any particular time. These maps will provide a tool for State cooperators, such as the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency, for proactive water management and water-use sustainability. Furthermore, by highlighting the sub-watersheds in terms of surface-water flows, the streamflows can be evaluated in the context of meeting specific ecological flows under different flow regimes and potentially assist with decisions regarding groundwater and surface-water appropriations.

PROJECT RESULTS USE AND DISSEMINATION

The new visual mapping technique will be summarized in a U.S. Geological Survey Scientific Investigations Map (SIM). The SIM series includes map sheets and an accompanying report to discuss the methodology for creating the map products. In the case of this study, the SIM will include the following: (1) separate map sheets for each watershed (Cannon River, St. Louis River) that includes four panels of selected flow regimes: extreme drought, drought, mean flow, and flood; (2) the accompanying report with included tables and figures that support the map construction; (3) three separate model archives related to the mapping work. The web locations for the Scientific Investigations Map and model archives will be included with the final report, expected to be completed by November 2017. With this final workplan update/progress report, a complete draft of the SIM and the accompanying map sheets has been included. By the requirement of U.S. Geological Survey guidelines, all materials used in the construction of these maps will be made available through public webpage (<https://www.usgs.gov/>) upon release of the final SIM report.

The U.S. Geological Survey also organized two phone calls during the project timeline to interface with key partners from the Minnesota Department of Natural Resources (MNDNR) and the Minnesota Pollution Control Agency (MPCA). These meetings were meant to ensure that the mapping products produced from the project would meet their needs, and the USGS project team did adapt some of the final products to make the maps more useful. Keen interest was shown in the final products, and upon release of the final Scientific Investigations Map, the lead project managers (Erik Smith and Chris Sanocki) will be meeting again with key MNDNR and MPCA to develop next steps for other watersheds in the State.

Project Completed: 06/30/2017

FINAL REPORT

Streamflow Distribution Maps Report

Cannon River drainage basin Soil-Water-Balance model data set

St. Louis River drainage basin Soil-Water-Balance model data set

Identifying Causes of Exceptionally High Mercury in Fish - RESEARCH

Subd. 03j \$743,000 TF

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Appropriation Language

\$743,000 the second year is from the trust fund to the commissioner of the Pollution Control Agency to quantify the probable causes of high mercury levels in fish within the Roseau River and two tributaries of the Red River of the North by comparing mercury movements within watersheds to understand the drivers of mercury biomagnifications in the food web of rivers with similarly high mercury levels and to guide further mercury reduction initiatives. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Most mercury in Minnesota waters is deposited from the atmosphere as a byproduct of burning coal and other compounds. Once in the environment, mercury can convert to a form called methylmercury where it bioaccumulates up the food chain from microscopic plants and animals to fish and then to humans and wildlife that consume the fish. The first step in solving the problem of mercury in fish is reducing the sources of mercury entering waters. Significant efforts are underway to reduce the amount of mercury released from human sources such as smokestacks and wastewater discharge, which will address the majority of the mercury entering the environment. However, there are a percentage of watersheds where mercury appears to have enhanced concentrations due to factors that are particular to the ecology of a watershed and not mainly driven by the amount of mercury entering the watershed. The Minnesota Pollution Control Agency is using this appropriation to better understand the probable causes of high mercury levels in fish in watersheds where atmospheric deposition alone does not account for the high mercury levels in order to determine what additional measures beyond source reduction can be taken to reduce mercury levels in those watersheds.

OVERALL PROJECT OUTCOME AND RESULTS

This study investigated probable causes of higher mercury levels in fish in certain mercury-impaired Minnesota rivers. We hypothesized that these high fish-mercury concentrations are caused by increased efficiency of mercury transmission to fish. To evaluate this, we measured mercury flow through the watershed, conversion of mercury to methylmercury, and accumulation of methylmercury in the riverine food web. The first two processes determine mercury availability to the food web, while the structure of the food web also determines mercury in fish. The project focused on the Roseau River, in the Red River Basin, with comparison measurements in six other rivers. Also in the Red River Basin, Thief River was chosen for its similarity and proximity and the Mustinka River because of its relatively low fish-mercury levels. The other rivers had high mercury levels in fish, similar to Roseau, but differed in watershed land cover and water chemistry. Data collection for this project is complete, but data analysis will continue.

Mustinka had the lowest methylmercury levels, and the lowest rates of conversion of inorganic mercury to methylmercury (methylation). Roseau and Thief Rivers had the highest methylmercury levels in water and biota, showing increasing methylmercury in the food web from upstream to downstream locations.

Although analysis of results will continue over the next several years, the preliminary results seem to indicate the dominant cause of high mercury in the food webs differ among the rivers and even within rivers. Organic carbon has a predominant role in transporting mercury, but inhibiting uptake by the food web. For instance, methylmercury levels in Vermilion River fish were similar to Roseau River, but levels in the water were much lower in Vermilion. Lake Vermilion appears to retain mercury before water flows to the Vermilion River; however, low organic carbon in the river allows more methylmercury available for uptake by the biota.

PROJECT RESULTS USE AND DISSEMINATION

Six presentations were completed by June 30, 2017, two poster presentations at the International Conference on Mercury as a Global Pollutant and four presentations at various scientific conferences. Three manuscripts are proposed for publication. When the data are compiled, analyzed, and reported, completed publications will be shared with LCCMR.

Project Completed: 06/30/2017

FINAL REPORT

Reducing Lake Quality Impairments through Citizen Action

Subd. 03k \$59,000 TF

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Appropriation Language

\$59,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Freshwater Society to train lake associations and other stakeholder groups to develop lake management plans and to implement science-based, citizen-led water quality improvement projects on impaired lakes in west central Minnesota. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Many lakes in Minnesota are classified as "impaired" for aquatic recreation and aquatic life as the result of nonpoint source pollution. These impairments can be addressed by the citizens that live by and have a vested interest in these water bodies, but there is often a lack of knowledge and resources to take effective action. The Freshwater Society is using this appropriation to train citizen groups in lake ecology and management in order to guide them in implementing water quality improvement projects for their local water bodies.

OVERALL PROJECT OUTCOME AND RESULTS

Since 2000, more than 400 lake associations have participated in the Healthy Lakes and Rivers Partnership (HLRP) program founded by Don Hickman of the Initiative Foundation and now run by Freshwater Society. HLRP is a program designed to help lake associations across the state identify and work towards the priorities they have for their water body, one county at a time. The round of HLRP funded through LCCMR allowed for collaboration with Otter Tail Soil and Water Conservation District, with specific attention focused on helping to align lake plans with County Water Plans so that local efforts could help to achieve county water quality goals.

In the last year and a half, four lake associations from Otter Tail County participated in a 2-day training covering the importance of lake planning, engaged in a Freshwater Society-led participatory planning process to define lake-specific and community-identified goals and strategies, drafted and finalized a Lake Management Plan specific to their lake (copies included in report), and began implementing those plans. These groups now have in their hands documents which detail specific stresses, threats, and opportunities for their lakes generated by RMB Laboratories, a clear indication of the shared vision of the community, and a 2-5 year action plan with steps they identified to help them realize these goals. Additionally, each group understands the resources that are out there to help them along the way, and has received \$5,000 of seed funds to get them started from West Central Initiative.

The four participatory planning sessions engaged a total of 184 lake residents from the county, and countless volunteer hours from the boards of the four lake associations to produce their own lake management plan for lakes representing hundreds of Minnesotans who have clear, community-identified goals and action plans to improve the health of their lakes.

PROJECT RESULTS USE AND DISSEMINATION

As a requirement for the final distribution of funds from West Central Initiative, all groups needed to send their final Lake Management Plans to East Otter Tail Soil and Water Conservation District. The groups are also planning to distribute the final versions to their member residents and local elected officials in one way or another. This may include a mailing of a portion of the plan, loading the final copy to the website, or providing a small supply to volunteer leaders within the association. Additionally, the Project Manager sent final plans to West Central Initiative so they could see how the funding was going to be used. Freshwater Society will also keep copies of the plan on file to be given to other interested persons upon request.

A blog post describing the project and outcomes will be published by Freshwater Society in coming months, and the project website will be updated to reflect the closure of the project and goals identified by the groups. Each lake association has been asked to check in with updates so that we may share how LCCMR funding has contributed to the success of community-led efforts to improve local water resources.

Project Completed: 06/30/2017

FINAL REPORT

[Lake Management Plan for Lake Six](#)

[Lake Management Plan for Big McDonald Lake](#)

[Lake Management Plan for Wall Lake](#)

[Lake Management Plan for Lake Lida](#)

Rainwater Reuse and Valuation Investigation

Subd. 03I \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to design, install, and monitor a rainwater reuse system for use in evaporative chiller systems and identify other potential applications for rainwater reuse systems.

Project Overview

Rainfall runoff in urban areas contributes to localized flooding and washes contaminants and excess nutrients downstream affecting water quality. Systems to mitigate these problems can be challenging to implement in urban areas due to existing infrastructure and competing demands for land use. However, one option is to find alternative applications for the excess rainwater and use it replace the potable water that is currently being used for certain purposes. Researchers at the University of Minnesota are using this appropriation to evaluate alternative uses for captured rainwater. In particular the project will design and install a rainwater reuse system for integration into evaporative chiller systems, which are common in large buildings and currently account for a significant portion of summer water usage at these sites, and examine other potential reuses for rainwater, such as for toilet flushing and industrial processes.

OVERALL PROJECT OUTCOME AND RESULTS

This project evaluated rain water as a source for evaporative chillers and process water. Rain water has low dissolved solids and is better suited as process feed water than groundwater derived waters. The project

investigated the utility of capturing high purity water that would otherwise contribute to excessive runoff, localized flooding, and downstream nutrient and contaminant transport.

Harvested rain water was run through an evaporative concentrator simulating operation of commercial evaporative chiller systems. In contrast to conventional systems which required complete replacement of the system water after 3 to 4 cycles the rain water fed systems could run more than 30 cycles without replacement. After 30 cycles of evaporation the accumulated dissolved solids were still not precipitating minerals, especially calcite. In conventional systems mineral deposits must be prevented by the addition of chemicals and/or removed by acid washes in addition to frequent water replacement.

Based on the much smaller volume of feed water required with rain water, estimates of the seasonal chiller demand, roof area, rain fall rates, and storage volume can be made with a spreadsheet tool developed as part of this project. The required volume of water can be as little as 10% of the volume of ground water derived drinking water required for current systems. The costs of a roof water capture and treatment system is partially offset by savings on potable drinking water and to a larger extent by reducing the cost of other storm water retention and detention systems.

As part of a literature review other potential ways rain water can advantageously replace potable water were investigated ranging from toilet flushing, laundry, industrial processes, and anywhere the naturally dilute nature of rain water is an advantage. Traditional plumbing codes and definitions of gray water need to be updated to consider the relative cleanliness of roof run-off. In fact, many regions of the world where there is limited fresh water collect rain water as their sole drinking water source.

Unfortunately, a demonstration system designed for the UM campus could not be constructed within the project timelines, leaving a significant portion the grant funds unspent.

PROJECT RESULTS USE AND DISSEMINATION

Results were provided as a future addendum to the Minnesota Storm Water Manual in coordination with UM Extension Service. A journal article covering the potential for rain water reuse in commercial evaporative chiller systems is in review. We are working with local watershed districts, engineers, and architects to identify potential sites for rain water reuse systems in commercial settings. Presentations of this work have been made to the Mississippi Watershed Management Organization in Minneapolis and the Capital Region Watershed District in St. Paul.

Presently rain water is being used at the 17th Ave Residence Hall where roof runoff is stored for reuse in toilet flushing and at the Landcare Building where a cistern stores storm water for irrigation. Results from these systems show that rain water quality declines rapidly from pure rain water to roof runoff to street level runoff. Finding ways to capture the cleanest fractions of rain water for reuse this water instead of simply dumping it to the river is critical. Options for rain water reuse are particularly important where underground conditions limit infiltration of storm water and dense urban areas where there is no room for conventional storm water management systems. We have been in discussion with local storm water professionals and consulting firms about the use of rain water. Of particular interest are retail settings, like large shopping centers, that produce detrimental amounts of storm runoff but are resistant to giving up parking space for storm water management. These same retail areas use large evaporative chillers systems that consume significant ground water resources. In addition, rain water has great potential as feed for industrial process water. In particular, rain water can be easily polished through filtration and reverse osmosis to produce high purity water.

Project Completed: 06/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

Measuring Hydrologic Benefits from Glacial Ridge habitat Restoration - RESEARCH
Subd. 03m \$168,000 TF

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Appropriation Language

\$168,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Red Lake Watershed District and the United States Geological Survey for completion of the analysis of flooding and water-quality benefits resulting from wetland and prairie restorations at Glacial Ridge National Wildlife Refuge.

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 complete 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 ditchflow 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 ditchflow 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 ditchflow from storms decreased, ditchflow recessions lengthened, and baseflow 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 baseflow 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 workplan. 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: 06/30/2017 [Extended in M.L. 2015, Chapter 76]

[FINAL REPORT](#)

Subd. 04 Aquatic and Terrestrial Invasive Species

Blocking Bighead, Silver, and Other Invasive Carp by Optimizing Lock and Dams - RESEARCH

Subd. 04a \$854,000 TF

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Appropriation Language

\$854,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to collaborate with the United States Army Corps of Engineers to develop ways, including new technologies, to modify the operations of Lock and Dam Numbers 2 to 8 to optimize their ability to impede invasive carp movement into the Minnesota, St. Croix, and Mississippi Rivers. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Invasive carp species, including silver carp and bighead carp, are migrating north up the Mississippi River and pose threats to the native fish and aquatic ecosystems of Minnesota rivers and lakes where they can become established. While individual carp have been found in Minnesota, it is not presently believed that there are established breeding populations in the state. Nevertheless, the only current impediments to the upstream travel of carp into Minnesota waterways are the various lock and dam systems located between the Iowa border and the Twin Cities and these systems do not create a constant barrier to carp passage. Researchers at the University of Minnesota, in cooperation with the U.S. Army Corps of Engineers, are using this appropriation to develop and test ways to modify and optimize the operations of the existing lock and dam systems in order to enhance their ability

to deter and block carp passage without detrimentally affecting native fish or current lock and dam function. These efforts have the potential to delay or even prevent statewide invasion by invasive carp in Minnesota via the Mississippi River.

OVERALL PROJECT OUTCOME AND RESULTS

We successfully collaborated with the United States Army Corps of Engineers (USACE) and developed new ways and technologies to impede the upstream movement of invasive (bigheaded) carp through their locks and dams in the Mississippi River. Further, these approaches have now been implemented at Lock and Dam #8, which is the southernmost Lock and Dam in Minnesota and has thus been our focus. At this structure, dam spillway gate operating protocols were adjusted by the USACE to optimize their ability to stop carp and speakers added to the lock gates to deter carp with few effects on native fish. This is the first structure in the world to be so modified and our calculations suggest it now stops twice as many carp as it once did (well over 90%). Tentative plans for similar modifications to Lock and Dams #2 and #5 (the other most promising structures in Minnesota) have also been presented to the USACE for future deployment at their discretion. This progress was possible because we met all four objectives of this project: 1) we added speakers to Lock and Dam #1; 2) we quantified and published how well bigheaded carp swim (and thus what flows might stop them); 3) we developed and tested several new acoustic systems in the laboratory and field that stop carp but do not affect native fish ; and 4) we developed new solutions for the gates at Lock and Dam #2-8 and provided specific data (specific solutions) for Locks and Dams #5 and #2, the most promising structures of these.

PROJECT RESULTS USE AND DISSEMINATION

Our findings were disseminated via several dozen presentations to both professional scientific and lay groups across both the state and country, as well as four peer-review publications in high quality international journals. The speakers we installed at Lock and Dam #8 are still operating where they stop carp and have inspired the USACE and USFWS to mount similar speaker systems elsewhere while the DNR funded studies of their performance. Meanwhile, the published data we generated on silver and bigheaded carp swimming performance serves as the foundation of computational models to guide changes in gate operations to stop carp. In addition, the sound systems we identified as having special promise for stopping carp are now being considered for installation as part of a proof-of-concept project in both Minnesota (ENRTF, USFWS) and either Illinois or Kentucky (USFWS). Finally, our computational models are guiding gate operations that are presently both stopping carp and reducing scour at Lock and Dam #8. There is active interest by the USFWS to deploy our work downstream to further protect our state and region.

Project Completed: 06/30/2017

FINAL REPORT

Bubble Curtain Deflection Screen Diverts the Movement of both Asian and Common Carp

Silver, bighead, and common carp orient to acoustic particle motion when avoiding a complex sound

Swimming performance of adult bighead carp and silver carp

Bioacoustics to Detect, Deter and Eliminate Silver Carp - RESEARCH

Subd. 04b \$262,000 TF

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Appropriation Language

\$262,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota-Duluth to develop bioacoustics technology for detection and early warning systems, capture and elimination methods, and deterrent systems for silver carp. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Silver carp are migrating north up the Mississippi River and pose threats to the native fish and aquatic ecosystems of Minnesota rivers and lakes where they can become established. Additionally, the unique jumping ability of silver carp also places recreational boaters in danger of being injured during collisions with airborne fish. However, it is believed that this jumping ability could potentially be exploited as a weakness to help detect, manage, and control silver carp populations. Researchers at the University of Minnesota - Duluth, in cooperation with the U.S. Geological Survey, are using this appropriation to develop bioacoustics technologies that use sound to stimulate silver carp jumping in order to assist with strategies for detection, capture, and deterrence.

OVERALL PROJECT OUTCOME AND RESULTS

The project examined various emerging technologies to detect and deter the upstream migration of invasive bigheaded carp into Minnesota. Both silver and bighead carp were found to have an aversion to broad band sound and the project focused on how to exploit this weakness. An early detection buoy was developed that stimulates silver carp jumping with sound to allow managers to locate fish. The hearing sensitivities of the fishes were examined and found to have higher frequency hearing than previously reported. Broadband sound was successful in deterring fish and also preventing them from entering a small channel. Fish were successfully herded by broadband sound in the wild, suggesting that sound could be used to increase capture rates. We have also noted that long sound exposure may cause transient hearing losses in fishes so the sound deterrence must be balanced against potential hearing loss. In summary, broadband sound induces aversive behavior in silver and bighead carp however further study is needed to address the duration of its effectiveness.

PROJECT RESULTS USE AND DISSEMINATION

Presentations have been made at state, regional and national scientific meeting to disseminate the data and five publications were produced.

Project Completed: 06/30/2017

FINAL REPORT

[Acoustical deterrence of Silver Carp: Publication](#)

[Characterization and management implications of silver carp: Publication](#)

[Reexamining the frequency range of hearing in silver and bighead carp: Publication](#)

[Acoustic deterrence of bighead carp to a broadband sound stimulus: Publication](#)

[Management implications of broadband sound in modulating wild silver carp behavior: Publication](#)

[Potential implications of acoustic stimuli as non-physical barrier to silver carp and bighead carp: Publication](#)

Biosurveillance and Biocontrol of Emerald Ash Borer - Phase 2

Subd. 04d \$447,000 TF

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Appropriation Language

\$447,000 the second year is from the trust fund to the commissioner of agriculture in cooperation with the University of Minnesota to continue to monitor ash tree and emerald ash borer populations and expand the biological control implementation for emerald ash borer management. This appropriation is available until June 30, 2017, 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 Lake states and is currently advancing into Minnesota where it threatens the nearly 1 billion ash trees that occur throughout the state - the second most in 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. Biological control - the use of a natural enemy of a species from its native habitat to help with control of that species - is currently the only promising long-term management strategy for EAB. The Minnesota Department of Agriculture is using this appropriation to continue to implement and assess the effectiveness of a biocontrol method for EAB in Minnesota that involves the use of tiny, stingless wasps that are parasitoids of EAB.

OVERALL PROJECT OUTCOME AND RESULTS

Emerald ash borer (EAB) populations have grown slower than expected in the Twin Cities metro region. To date, the insect has not spread as quickly in Minnesota as in other states. We were able to characterize this growth phase well with the continuing study on the infestation core commenced in Phase I of this project. Using annual branch sampling, we showed that after a decade of EAB presence in the Twin Cities metro region, half of the trees in the core area still did not exhibit easily-detectable levels of EAB, and canopy conditions remained quite good. We expect that EAB mortality due to extreme cold during the winter of 2013-2014 helped slow population growth. This slow growth continued to buy the state valuable time for implementing biological control and engaging the public in the fight against this insect, two other important strategies funded by this project. An astounding total of 450,000 larval and egg parasitoids were released at 33 sites during Phases 1 and 2 of this project. We are pleased that we documented established, reproducing populations of biological control agents at 5 sites in 2 counties. To document this, both larval parasitoids and the egg parasitoids were recovered with methods involving debarking ash branches and trunks, bark sifting, yellow pan traps and larval dissection. We also documented a native parasitoid, *Atanycolus simplex*, which can also attack EAB. We engaged a total of 128 citizen scientists using the biosurveillance program with smokey winged beetle bandit wasps, and collected more than two dozen species of buprestid beetles brought back to the nests by these wasps. We recovered ten species of *Agrilus* (in addition to EAB), providing important survey information on what other potential damaging wood borers in this family are present in the state. *Agrilus coxalis* is killing oaks in California, for example, but we have not found it in Minnesota to date.

PROJECT RESULTS USE AND DISSEMINATION

Our newly updated EAB management guidelines will be a valuable resource for people planning for or actively managing EAB. We incorporated findings from the project titled Improving EAB Detection in addition to Phase 1 and Phase 2 of our project. These guidelines provide information regarding EAB identification and reporting, detection methods and their relative efficiencies, recommended management tactics, including biocontrol, based on the infestation and site specifics. The guidelines will soon be available on MDA's EAB webpages

[\(https://www.mda.state.mn.us/emeraldashborer/\)](https://www.mda.state.mn.us/emeraldashborer/).

We will build upon our accomplishments and learning with Phase 3: Assessment and Citizen Engagement.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[UMN Wasp Watcher Training Materials](#)

[UMN Wasp Watcher 2015 Field Report](#)

[UMN Wasp Watcher 2016 Field Report](#)

[UMN Wasp Watcher Pamphlet](#)

[MDA EAB Management Guidelines](#)

[MDA EAB Biocontrol Fact Sheet](#)

[MDA Biological Control of EAB: Bark sifting for *Oobius agrili*](#)

Mountain Pine Beetle Invasive Threat to Minnesota's Pines

Subd. 04e \$250,000 TF

Subd. 04e1 - \$175,000 TF

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Subd. 04e2 - \$75,000 TF

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Appropriation Language

\$175,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota and \$75,000 the second year is from the trust fund to the commissioner of agriculture to survey for the presence and characterize the potential risk of the invasive mountain pine beetle to Minnesota's pine forests to inform early detection and rapid response. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Native to the western United States and Canada, mountain pine beetle is considered the most devastating forest insect in North America. Trees usually die as a result of infestation and an unprecedented outbreak in the west is currently decimating pine forests there. While mountain pine beetle is not presently believed to reside in Minnesota, there are risks posed by an expanding species range resulting from warming climate and the potential for accidental introduction via lumber imports from infested areas. It is estimated that Minnesota currently has about 200 million trees that would be susceptible to mountain pine beetle if it should become established here and loss of those trees would threaten wildlife habitat, water quality protection, and recreation. Researchers at the University of Minnesota and the Minnesota Department of Agriculture are using this appropriation to survey state locations for the presence of mountain pine beetle and to characterize the risk posed by the insect to Minnesota pine species. If detected early enough isolated populations of mountain pine beetle may be possible to control and a better understanding of how Minnesota's particular pine species might react to the insect would guide future management response strategies.

U of M Project: OVERALL PROJECT OUTCOME AND RESULTS

Native to the western United States and Canada, mountain pine beetle is the most devastating forest insect in North America, impacting almost 125 million acres of western mature pine forests to date. Mountain pine beetle reproduces under the bark in the water conducting tissues of many species of pines. During outbreaks, mountain pine beetles must kill their trees in order to reproduce and prefer live, vigorous, large-diameter trees. Minnesota is at risk of invasion from mountain pine beetle via two different routes. First, populations reproducing in Alberta,

Canada could spread through a corridor of jack pine stretching across Canada's boreal forest into northern Minnesota. Second, green pine logs imported from western states could inadvertently bring this insect to the Midwest.

This project, in partnership with the Minnesota Department of Agriculture, had two objectives. First, pine stands in several areas of the state were surveyed for the presence of this insect. No populations were detected to date (see MDA update). Second, we exposed logs of pine species common in Minnesota, such as red pine, jack pine, white pine, and Scots pine, to the nearest known mountain pine beetle populations in the Black Hills of South Dakota, to gain baseline data on the risk to Minnesota's species of pines.

We found that mountain pine beetles were able to tunnel into cut logs of Minnesota's pines, attract mates, and lay eggs. The eggs were fertile, and insects could complete their development. The insects were cold hardy and the data suggest they could survive Minnesota's winters if established here. Development times in Minnesota's pines were slightly faster than those in historical western pine hosts, which was surprising. These results indicate that we should continue to take the threat of range expansion of mountain pine beetle seriously.

U of M Project: PROJECT RESULTS USE AND DISSEMINATION

During the course of this project, the MDA enacted an exterior state quarantine for pine logs with bark on them from western states, and the project manager met with DNR officials to discuss management/silvicultural responses to mountain pine beetle should the insect arrive in the state. This project fostered collaborations with five partner state and federal agencies, three universities, trained a PhD student who received a faculty position, and engaged several dozens of undergraduate university students by incorporating this project into classroom education such as redesigned laboratory practical exercises. In one instance, we hosted an undergraduate student from a different state who flew to Minnesota to conduct her internship on this project (at no cost to the project). If you are a student seeking to help with one of the most serious pending challenges in North America, the state of Minnesota is a great place to come! This research project has resulted in five peer-reviewed publications to date, with others currently in review, along with several presentations at various scientific conferences.

MDA Project: OVERALL PROJECT OUTCOME AND RESULTS

Mountain pine beetle (MPB), is native to western North America, where periodic outbreaks are a normal part of its ecology; in recent years, however, MPB has experienced the largest population explosion ever recorded and has caused the mortality of approximately 125 million acres of coniferous forest in North America. There is concern that MPB may reach Minnesota and cause similar devastation. Adult beetles have been shown to attack many different species of healthy pines including some that are found in Minnesota.

Mountain pine beetle has been detected in Minnesota two times in recent past: in 2012 in lodgepole pine from Montana for log cabins and furniture building and in 2014 in pine firewood from Wyoming for retail sale. In both cases, the insects were dead; however, this demonstrated the existence of a pathway across the plains for MPB to enter Minnesota. Interviews with wood product businesses in Minnesota indicated past instances where western pine had been imported as well. As a result, the MDA began conducting a detection survey in 2014 to determine if low-level populations of MPB are present. Lindgren funnel traps baited with pheromone lures were checked at sites near businesses such as log home and furniture builders and sawmills for 3 consecutive field seasons. Twenty five sites were chosen and 5 traps per site were monitored bi-weekly throughout the field season. Trap catches were screened for presence of mountain pine beetle. Subsamples of captures were also kept to better characterize the community of potential predators, parasitoids, and other associates already present in Minnesota. A total of 2150 trap checks were conducted from 2014-2016, fortunately no mountain pine beetle were detected. Estimating the arrival of MPB is difficult, thus monitoring is an important part of informing land managers so that management of isolated, endemic populations may be attempted.

MDA Project: PROJECT RESULTS USE AND DISSEMINATION

Dissemination of information from the monitoring portion of this mountain pine beetle project was ongoing through the entire three years 2014-2017. Staff participated in a variety of events with an emphasis on MPB. Our presence at trade shows, conferences, and community events provided unique and valuable opportunities to

interact with different audiences in-person. We attended more than 20 events, where we interacted with over 13,000 people. At these events we specifically focused on invasive pest and pathogens. Three of the most trafficked events attended include the Minneapolis Home and Garden Show, whose audiences included families, gardeners, and outdoors enthusiasts; the Minneapolis/St. Paul RV and Camping Show, whose audiences included outdoors enthusiasts, families, and firewood users; and a Minnesota Twins Plaza Day, whose audiences included homeowners. Information and materials related to MPB were displayed and distributed to event visitors. Materials produced for events included updated flyers, wallet-sized identification cards, display boxes, brochures and fact sheets. In addition, web pages focused on MPB and related surveys were added and updated as part of a larger, ongoing development project aimed at improving user experience. Cooperators, the public and the forest industry were also engaged and updated via phone, email, and through personal encounters in the field. Information and data was also continually updated throughout the project on the MDA MPB webpage: <https://www.mda.state.mn.us/plants/insects/mpb.aspx>

Project Completed: 06/30/2017

FINAL REPORT - Aukema - (Subd. 04e1)

Colonization behaviors of mountain pine beetle - (Subd. 04e1)

Stimulating Curiosity and Engagement with Insects - (Subd. 04e1)

Cold tolerance of mountain pine beetle among novel eastern pines - (Subd. 04e1)

Sexing live mountain pine beetles - (Subd. 04e1)

FINAL REPORT - Abrahamson - (Subd. 04e2)

Mountain Pine Beetle Fact Sheet - (Subd. 04e2)

Brown Marmorated Stink Bug Monitoring and Biocontrol Evaluation

Subd. 04f \$266,000 TF

Subd. 04f1 - \$167,000 TF

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Subd. 04f2 - \$99,000 TF

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Appropriation Language

\$99,000 the second year is from the trust fund to the commissioner of agriculture and \$167,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to monitor for brown marmorated stink bugs to identify problem areas, target biocontrol efforts, and evaluate the suitability of candidate biological control

agents for use in Minnesota. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Brown marmorated stink bug is a terrestrial invasive species in Minnesota that was first discovered in 2010 and has been expanding its range since. It is a generalist plant pest that attacks more than 300 species of plants in natural, agricultural, and horticultural settings and is known for its unpleasant odor, large numbers, and propensity for home invasion. Proactive management approaches are available and in development that can be used to slow and potentially control brown marmorated stink bug populations. Researchers at the Minnesota Department of Agriculture and the University of Minnesota are using this appropriation to establish a state framework for monitoring and biological control of brown marmorated stink bug; efforts will focus on identifying new infestations and potential problem locations and evaluating and implementing biological control options.

U of M: OVERALL PROJECT OUTCOME AND RESULTS

The brown marmorated stink bug (BMSB), a pest of numerous crops and nuisance household invader, continues to spread and increase in abundance in Minnesota. Biological control offered by tiny parasitic wasps that attack BMSB eggs is a promising tactic for sustainable management of this pest. This project aimed to evaluate and identify appropriate biological control agents for use against BMSB in Minnesota before the pest reaches damaging levels. This work was performed as a successful collaboration with USDA. In particular, we used laboratory methods for quantifying the temperatures at which insects freeze and die to examine the ability of the candidate biological control agents to survive cold winter conditions. Methods were developed to measure the response to cold temperature of several populations of two species of parasitic wasps of BMSB. Among these, the samurai wasp is the primary species of interest for biological control releases and is already known to occur in parts of the USA. Results indicated that the samurai wasp likely to survive cold winter conditions of much of Minnesota and is better able to survive exposure to cold than BMSB. Furthermore, results of a broader modeling effort showed a south to north gradient of climatic suitability for the samurai wasp in Minnesota ranging from high to marginal suitability. Therefore, based on comparison of specific cold hardiness parameters and more complex modeling, the samurai wasp is likely to survive if introduced to Minnesota, and could provide for more sustainable management of BMSB than the current use of insecticides. In addition, this project prepared the State for implementation of biological control against BMSB by identifying and optimizing cold storage methods and conditions for mass production of the samurai wasp for biological control releases against BMSB.

U of M: PROJECT RESULTS USE AND DISSEMINATION

Results of this project were disseminated to scientific and grower audiences. For scientific audiences, results on the ability of biological control agents for BMSB were published in scientific article (Nystrom Santacruz et al. 2017, <https://doi.org/10.1016/j.biocontrol.2017.01.004>) and publication of additional results related to cold storage and mass production of the samurai wasp will be published soon. In addition, research was disseminated through multiple oral presentations at conferences of the Entomological Society of America and seminars at the U of MN. To reach audience of growers and the general public, results of this research have been included in several extension presentations to growers and crop consultants. Furthermore, the research stimulated attention and interviews by local media (<http://www.startribune.com/local/262464751.html?page=1&c=y> and <http://kstp.com/article/stories/S3469363.shtml?cat=26>). While working on this project, it was observed that there was a general lack of accessible information on the biology and management of BMSB and other stink bugs for crop and land managers. Therefore, we wrote and published an extension-friendly article on these topics in the Journal of IPM (Koch et al. 2017, <https://doi.org/10.1093/jipm/pmx004>), which also received considerable media attention.

MDA Project: OVERALL PROJECT OUTCOME AND RESULTS

Brown marmorated stink bug (BMSB) was first discovered in Minnesota in 2010. BMSB is a generalist that will feed on 300+ species of plants in natural and agricultural settings. Due to its large size and unpleasant odor, BMSB is also a nuisance home invader during the winter months. Based on experience with BMSB in other areas of the country, BMSB is expected to first become a household nuisance and then become a significant plant pest. MDA aimed to monitor BMSB to help track where problem areas are developing.

When MDA started this project in 2014, BMSB had been identified in 11 counties and has now been identified in 18. The goal of this project was to create a network of survey sites and place pheromone baited mini-tedder traps to detect BMSB and alert stakeholders to allow for targeted management. Traps were placed in the spring, serviced throughout the summer and removed in late October or early November 2014- 2016 and spring of 2017. Over the course of the monitoring project, MDA placed and serviced 690 mini-tedder traps throughout the state. Trap catches were low the first two years of the project with one adult captured in 2014 and 2 captured in 2015. MDA did respond to increasing reports of BMSB throughout the state despite low trap catches these years. Most of these reports were of single insects that were likely brought into the state from elsewhere. In the fall of 2016, MDA trapped 200 adult BMSB and 47 nymphs between 9 locations in the metropolitan area.

The increase in reports of BMSB and trap catches, including nymphs, indicates growing activity in the metro area which this project was able to document. This information provides an opportunity to proactively focus biocontrol efforts in this area and provides an opportunity to avoid reactive use of insecticides by growers.

MDA Project: PROJECT RESULTS USE AND DISSEMINATION

Dissemination of information and data about BMSB has been ongoing throughout this entire project. Presentations were given at Minnesota Fruit and Vegetable Growers Association annual meetings, the Minnesota Organic Conference, the Minnesota Apple Growers Association annual meeting, and Forest Pest First Detector Trainings. Growers were engaged and updated via phone, email, special mailings such as the Minnesota Department of Agriculture's Plant Pest Insider, and through personal encounters in the field.

Throughout the project, the MDA has maintained online maps regarding the status of BMSB

- Current BMSB activity: <https://www.mda.state.mn.us/plants/insects/stinkbug.aspx>
- Activity in past years: <http://www.mda.state.mn.us/plants/insects/stinkbug/bmsbmonitoring.aspx>

Project Completed: 06/30/2017

[FINAL REPORT - Koch: \(Subd. 04f1\)](#)

[Identification, Biology, Impacts, and Management of Stink Bugs: Publication \(Subd. 04f1\)](#)

[Cold tolerance of *Trissolcus japonicus* and *T. cultratus*: Publication \(Subd. 04f1\)](#)

[FINAL REPORT - Abrahamson: \(Subd. 04f2\)](#)

[BMSB Fact Sheet - Abrahamson: \(Subd. 04f2\)](#)

[BMSB MDA Presentation - Abrahamson: \(Subd. 04f2\)](#)

Subd. 05 Foundational Natural Resource Data and Information

Update Statewide Land Cover Use Map

Subd. 05a \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to update Minnesota's land cover data at moderate spatial resolution statewide and at high resolution for selected areas,

distribute products, and provide training. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Land and water conservation efforts require accurate information about land cover and land use. Minnesota's land cover and land use data has not been updated since 2000 and so does not reflect changes since that time resulting from growth and development, agricultural production, or landscape cover. Researchers at the University of Minnesota are using this appropriation to conduct a statewide update and enhancement of land cover and land use data and make it freely available online for use by government and non-government organizations involved in land and water conservation.

OVERALL PROJECT OUTCOME AND RESULTS

Conservation and management of Minnesota's natural resources require significant investments of time and money by many state/local agencies and stakeholder groups. The three components of success in such projects (define problem sources, target and track changes) begin with accurate quantification of land cover via Geographic Information System (GIS) or geospatial data. This project updated the statewide land cover data and freely distributed it to all stakeholders. We acquired 130 Landsat satellite images for all of Minnesota for three broad seasons: Spring 2014, Summer 13-14 and Fall 13-14. The Landsat images were preprocessed according to current standards, including cloud correction, mosaicking, and subsetting. We acquired and preprocessed statewide lidar data. Preprocessing included developing Digital Elevation Models, Digital Surface Models, Normalized Digital Surface Models, and Normalized Digital Terrain Models. The imagery and lidar data were classified using an Object-Based Image Analysis (OBIA) approach, wherein the image pixels were aggregated into homogeneous "objects" that have parameters such as spectral values, size, shape, texture, and context. These variables were used in an OBIA classification framework incorporating a Cognition Language ruleset and the Random Forest algorithm to map each object into one of several classes: Forest (and sub-types), Urban (and sub-types), Wetland (and sub-types), Grassland, Extraction, and Agriculture. We produced statewide geospatial land cover/use data for 2013-2014, with higher resolution data for the Twin Cities Metro Area, Duluth, and Rochester. The classified maps have very high accuracy.

PROJECT RESULTS USE AND DISSEMINATION

All of the project data have been posted to the Minnesota Geospatial Commons (<https://gisdata.mn.gov/dataset/base-landcover-minnesota>), the Data Repository for the University of Minnesota (<https://conservancy.umn.edu/handle/11299/181555>), and the UMN Remote Sensing and Geospatial Analysis Laboratory (<https://rs.umn.edu/datalayers>) websites. A full project report has been provided separately. We have announced the availability of the data using several methods: via email, in person, in presentations at the MN GIS/LIS conference, and other communications. We regularly receive positive comments from users of the data. Scientific journal articles are in preparation.

Project Completed: 06/30/2017

FINAL REPORT

State Spring Inventory for Resource Management and Protection
Subd. 05b \$200,000 TF

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Appropriation Language

\$200,000 the second year is from the trust fund to the commissioner of natural resources to develop necessary protocols, processes, and definitions of springs along with limited field testing of inventory procedures in priority areas to enable a systematic inventory of springs statewide needed to maintain spring flows and protect groundwater-dependent resources. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Natural springs occur throughout Minnesota and provide critical services for the state, such as creating trout streams and cool water fisheries, sustaining base flows in streams, creating unique ecological habitats, and maintaining the integrity of aquatic ecosystems against invasive species. In order to protect springs and the groundwater-dependent resources that depend on them, though, it is important to understand spring locations and status - information that is currently lacking in many areas of the state. The Department of Natural Resources is using this appropriation to establish a foundation and plan to systematically inventory, assess, and monitor spring resources throughout the state.

OVERALL PROJECT OUTCOME AND RESULTS

The purpose of this project was to initiate a systematic inventory of springs statewide. This inventory should help create awareness of and appreciation for this resource so spring flows can be maintained and groundwater-dependent resources can be protected. This phase of the inventory focused on developing protocols and methods for field work and data compilation along with limited field testing of inventory procedures. Major project objectives included the development of 1) a spring inventory guidance document to provide documentation of methods and guidance for other researchers; 2) a spring inventory database built on a web-based geographic information system (GIS) platform that can be used in the field with a computer tablet with GPS and cell phone data capabilities; 3) a web-based reporting application that citizens can use to submit spring locations with smartphones or other mobile devices; and to 4) expand the known set of spring locations through paper and digital records review and a limited amount of fieldwork.

All of these objectives were accomplished. Important sections of the guidance document include a spring classification system and key data to collect in the field. The document also describes data flow/data verification methods for entering data into the database from historical documents, field entry of data with the tablet, and data processing of citizen submittals through the citizen reporting application. The custom GIS database allows the project team to upload data directly to a server from the field with a cell phone data link. Important data include: spring location, estimated flow rate, photos, and physical/chemical information. The citizen reporting application provides similar but more limited capabilities.

To date, the spring inventory team has uploaded approximately 500 locations to the inventory database with the tablet system. Approximately 100 possible spring locations have been submitted through the citizen reporting application and targeted mailings with self-addressed, postal paid postcards. These efforts, in addition to migration of existing data from an older database and extensive document review, have created an inventory that currently contains approximately 6,000 locations.

PROJECT RESULTS USE AND DISSEMINATION

The long-term strategy is to establish the Spring Inventory at DNR as an ongoing hydrologic cycle database on the same basis as the existing DNR stream gaging, groundwater level monitoring, climatology, and related hydrologic cycle databases.

This data can be accessed through the following link:

http://www.dnr.state.mn.us/waters/groundwater_section/springs/msi.html. Data can be downloaded from the Minnesota Geospatial Commons: <https://gisdata.mn.gov/dataset/env-mn-springs-inventory>.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[MDNR Minnesota Spring Inventory Guidance Document](#)
[Legacy Data in the Minnesota Spring Inventory](#)

Drainage Records Modernization and Statewide Geographic Information System Database
Subd. 05c \$230,000 TF

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Appropriation Language

\$230,000 the second year is from the trust fund to the Board of Water and Soil Resources to develop a template and Web-based geographic information system (GIS) database portal to facilitate statewide modernization of public drainage records under Minnesota Statutes, chapter 103E, and integrate new specifications into existing drainage records modernization guidelines. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

There are currently more than 21,000 miles of drainage ditches and many thousands of miles of subsurface tile located throughout Minnesota and overseen by over 100 different local drainage authorities. Historically public records of these drainage systems have been maintained primarily in hard copy following differing protocols depending on local requirements. However, this antiquated approach limits the usability and accessibility of public drainage records creating various challenges for drainage management efforts. Modernizing drainage records involves creating and cataloguing electronic copies of the records. While many drainage authorities have begun at least some level of modernization, there is still much work to be done. The Board of Water and Soil Resources is using this appropriation to establish a standardized information system to house public drainage records in a consistent manner that integrates the data with overall statewide GIS data. The system will facilitate increased accessibility and usability to drainage records and benefit water planning, modeling, and management efforts.

OVERALL PROJECT OUTCOME AND RESULTS

Approximately 100 counties and watershed districts serve as public drainage authorities (DA) under Chapter 103E drainage law. Their public drainage system administration encompasses more than 21,000 miles of drainage ditches and many thousands of miles of subsurface tile. Historically, their drainage system records have been maintained primarily in hard copy forms using production methods and materials of the time. Many of these records are over a century old and are becoming faded and fragile. Drainage records modernization (DRM) typically begins with creation and cataloguing of electronic copies (scans) of drainage system records. Advanced levels of DRM includes creation of associated geographic information systems (GIS) data layers.

This project included the development of a DRM GIS Database Template along with data standards, and access via a web-based data portal for M.S. Chapter 103E public drainage system hydrographic information (drainage system location, type, alignment, dimensions, profile, and road crossings) on the Minnesota GeoCommons which is administered by the Minnesota Geospatial Information Office (MnGeo). The database Template is available upon request to BWSR by interested drainage authorities statewide through the GeoCommons (<https://gisdata.mn.gov/organization/us-mn-state-bwsr>). Template use requires that the drainage authority upload drainage system hydrographic information on a yearly basis. If a DA desires to receive competitive DRM cost-share, it will be required to use the Template.

This project also included the updating of the Drainage Records Modernization Guidelines first published in 2008 by the BWSR, which is available on the BWSR website.

http://www.bwsr.state.mn.us/drainage/drainage_records_guidelines.pdf

The GIS database template creation and the Drainage Records Modernization Guidelines update were accomplished in coordination with MnGeo and their subcontractor, Houston Engineering, Inc., in consultation with 3 focus groups and a diverse project advisory committee.

PROJECT RESULTS USE AND DISSEMINATION

To date the GIS database template and updated Drainage Records Modernization Guidelines have been shared at the Minnesota GIS/LIS Consortium Conference (8/16), the fall meeting of the Minnesota Association of Drainage Inspectors (MADI) (10/16), the annual meeting of the Minnesota Association of Watershed Districts (MAWD) (10/16), the annual meeting of Association of Minnesota Counties (AMC) (specifically the AMC Ag and Rural Development Committee) (12/16), and the Minnesota Association of Soil and Water Conservation Districts (12/16). Plans are being made to continue outreach in 2017. Presently drainage records modernization cost share is before the Minnesota Legislature in the form of a LCCMR appropriation. The outcome of that effort will help establish the form of future DRM outreach.

At present 3 drainage authorities have requested the DRM GIS Database Template. One of those has uploaded drainage system hydrographic information to the GeoCommons.

Project Completed: 06/30/2016

[FINAL REPORT](#)

[Drainage Records Modernization Guidelines](#)

Assessing Species Vulnerability to Climate Change Using Phenology

Subd. 05e \$175,000 TF

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Appropriation Language

\$175,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to compile and use historical datasets to assess change over time in the ecology of Minnesota species, identify vulnerable species, and inform management strategies for climate change. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

There is a critical need to understand how our natural resources are already responding to climate change in order to develop tools for projecting natural resource responses into the future and to devise plans for actions that can be taken in reaction to observed and predicted changes. Phenology - the timing of seasonal biological events such as budburst, flowering, bird migration, and leaf coloring - provides a tested indicator of climate change response by plants and animals. A rich source of phenology datasets exists independently throughout the state, but these datasets are not compiled in a centralized manner. Furthermore, ongoing collection of phenology data is a cost efficient task that, done in an organized manner, can continue to provide valuable long-term evidence of climate change response. Researchers at the University of Minnesota are using this appropriation to compile and analyze historical phenology datasets and to establish a statewide network to collect future phenology data. This information will be helpful in identifying plant and animal species vulnerable to climate change and enhancing

adaptive management strategies, such as for maintaining forest productivity, supporting plant pollination and reproduction, and supporting efforts to maintain the integrity of wildlife and fisheries populations.

OVERALL PROJECT OUTCOME AND RESULTS

Understanding how natural resources are responding to climate change and developing tools for projecting responses into the future represent critical needs for environment and natural resource management in Minnesota. Phenology, the timing of biological events such as budburst, flowering and bird migration, provides an excellent and tested indicator of climate change response. The objectives of this project included: identify species vulnerable to climate change, develop a network of observers to monitor phenology into the future, provide data to natural resource managers for developing adaptive strategies that sustain environmental quality in a changing climate. To achieve these objectives we analyzed historical records of phenology to understand past trends and trained citizen scientists to collect new data to test models and provide continued monitoring into the future. In total we digitized over 44,595 historical observations from around the state of Minnesota. We performed >25 statewide training seminars (~800 participants) and created online training materials and a website. The number of observers entering phenological data into Nature's Notebook went from 140 in 2015 to 1150 today. Minnesota now has the second most phenology observers by state, only surpassed by California. Observers come from all parts of the state (n=108 Northwest MN, 193 Northeastern MN, 59 Central MN, 85 Southern MN, and 703 in the Twin-cities Metro area). The growth in new observations has increased between 22-51% per year since the start of the project. Combining historical and current datasets yielded a total of 865,816 phenological observations. Our work is significant as one of the largest regional datasets documenting change in nature's cycles and seasons. The data is publicly available for natural resource managers and scientists to use in decision-making. Examining phenological trends through time, we've found a number of species that show earlier spring phenology and later fall phenology as predicted under climate change. Among notable animals, Sandhill Crane, Northern White Shoveler, American White Pelican and Eastern Towhee are arriving significantly earlier. For plants, apple, bur oak, American elm, quaking aspen, beaked hazel and red pine all show significantly earlier budburst. For many of these, events are happening 7-9 days earlier in than in the 1940s. On-going analyses in a Ph.D. thesis will highlight species that could be at risk in a changing climate and thus guide policy and decision-making.

PROJECT RESULTS USE AND DISSEMINATION

We created and made available an online, searchable database and visualization tool of historical data (<https://mnpn.usanpn.org/datasets>). This dataset has been downloaded 20 times to date. New data collected by citizen observers is publicly available through Nature's Notebook, a program of the USA-NPN (<https://www.usanpn.org/results/data>). Training videos and workshop materials are freely available via the Minnesota Phenology Network website. As described in our activity report and abstract, we conducted >25 presentations and workshops to ~ 800 people over the course of the project. We manage a Facebook page (Minnesota Phenology Network) on which we share results and create online community.

Project Completed: 06/30/2017

FINAL REPORT

Minnesota Breeding Bird Atlas - Final Phase

Subd. 05f \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Audubon Minnesota to complete a statewide survey of Minnesota's breeding bird distributions through final analysis, preparation, and dissemination of information collected on an ongoing basis since 2008 on breeding birds in the state. The completed atlas must be available for download from the Internet free of charge. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

A state Breeding Bird Atlas is a comprehensive systematic field survey of the occurrence, distribution, diversity, and breeding status of bird species within every region of a state. Atlases are mainly used to set conservation priorities, develop conservation plans, and guide habitat protection, restoration, and management efforts - in addition to being useful for recreational bird watching. Minnesota is one of only seven states in the country that has yet to complete a Breeding Bird Atlas. Audubon Minnesota and the Natural Resources Research Institute at the University of Minnesota - Duluth will use this appropriation to complete the Minnesota Breeding Bird Atlas. This phase involves analyzing and synthesizing over 350,000 observations collected since this effort began in 2008 and producing and disseminating related information products.

OVERALL PROJECT OUTCOME AND RESULTS

The Final Phase of the Minnesota Breeding Bird Atlas (MNBBA) analyzed field data collected during the five year atlas project and developed a website presenting the results. The MNBBA was a comprehensive, statewide survey on the breeding distribution for all bird species in Minnesota. Initiated in July 2008, it was a collaborative effort among Audubon Minnesota, the Minnesota Department of Natural Resources, the U.S. Fish and Wildlife Service, the Minnesota Ornithologists' Union, and the University of Minnesota's Natural Resources and Research Institute. The atlas encompassed 5 field seasons (2009-2013), involved nearly 700 volunteers and survey staff in data collection, and cataloged the distribution and relative abundance of 249 breeding species statewide down to the 1/4 township level. Similar initiatives have been conducted by states and provinces throughout North America. Specific project outcomes since July 2014 included: 1) a technical review of the 380,707 records collected during the atlas to insure data integrity; 2) development of 160 predictive distribution models that linked the distribution and abundance of breeding species with data on climate, habitat, and landscape context; 3) analysis of habitat associations for 130 of the most common species; 4) preparation of accounts for each of the 249 species that summarized their life history, conservation status, Minnesota distribution since the late nineteenth century, breeding habitat, and population abundance; and 5) development of a website (mnbirdatlas.org) that presents results for each species, including an interactive map that enables users to conduct a variety of geographic and ecological searches of the MNBBA data.

These data will be invaluable to conservation planning efforts by local, state, and federal agencies as well as non-governmental organizations as they plan and implement efforts that affect Minnesota's natural resources. As a historical record, the MNBBA also provides baseline data to monitor future changes in avian distribution and abundance.

PROJECT RESULTS USE AND DISSEMINATION

All project results, analyses, and interpretation will be displayed on the newly developed website no later than October 30, 2017 (mnbirdatlas.org). Audubon Minnesota will publicize the site's launch. In the interim, all data collected during the atlas continue to be displayed on the website that has serviced the project since the beginning, mnbb.org. Data collected by MNBBA volunteers and point count data collected by the Natural Resources Research Institute will also be displayed and housed by the Midwest Avian Data Center (<http://data.pointblue.org/partners/mwadc/>), a regional node of the Avian Knowledge Network (<http://www.avianknowledge.net>). A Data Sharing Agreement between Audubon Minnesota and the Avian Knowledge Network (AKN) outlines procedures for individuals interested in acquiring full or partial downloads of the original data. Users of the (<https://mnbirdatlas.org/>) website who wish to acquire data are directed to the AKN website. These same data also will be made available to the University of Minnesota's Minnesota Biodiversity Atlas maintained by the Bell Museum of Natural History.

Project Completed: 06/30/2017

FINAL REPORT

Sandhill Crane Populations and Management in Minnesota - RESEARCH

Subd. 05h \$250,000 TF

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Appropriation Language

\$250,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to delineate population boundaries, habitat use relative to crop depredation, and migration patterns and survival of Minnesota's two populations of sandhill cranes, Mid-continent and Eastern. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Sandhill cranes have expanded their range in Minnesota and elsewhere and as populations have expanded several states, including Minnesota, have initiated sandhill crane hunting seasons and other states are considering doing the same. Partially this is in response to increasing complaints of crop degradation by sandhill cranes. Despite expanding populations, though, sandhill cranes remain a species of management concern and current information on population distribution and migration patterns of sandhill cranes in Minnesota is insufficient for projecting the impact of hunting or for making informed management decisions. Researchers at the University of Minnesota are using this appropriation to conduct a survey to better understand population distributions, movement patterns, habitat usage, and survival of sandhill cranes in Minnesota in order to inform harvest and management strategies that will minimize conflict with agricultural interests.

OVERALL PROJECT OUTCOME AND RESULTS

Sandhill cranes are an important part of Minnesota's natural heritage, and although they have expanded their breeding range in Minnesota, they remain a species of management concern. Minnesota supports two populations of sandhill cranes– the Mid-continent Population that breeds and migrates through northwestern Minnesota, and the Eastern Population that breeds and migrates throughout much of the remainder of the state. We affixed GPS-cell transmitters to 55 sandhill cranes during 2014 and 2015 near the presumed boundary between breeding Mid-Continent and Eastern Population cranes in Minnesota and monitored their seasonal (i.e., migratory) and local movements to (1) determine whether Mid-Continent and Eastern Population cranes breeding in Minnesota overlap in breeding or autumn staging distributions, and if so, identify regions of overlap, (2) quantify habitat-use patterns, especially related to crop depredation, and (3) estimate annual survival rate of Minnesota sandhill cranes:

1. We identified areas of overlap between breeding populations in northwestern Minnesota, near the historical range boundary of Mid-Continent cranes, suggesting that Eastern Population cranes have expanded their distribution significantly northwest. Furthermore, cranes from both populations used fall staging areas in northwestern Minnesota in the current zone where recreational harvest of Mid-Continent Population cranes was allowed beginning in 2010, indicating at least some overlap of populations during Minnesota's crane hunting season. In addition, some cranes used migration routes associated with both populations, providing potential for population mixing outside of their breeding ranges.
2. At the local scale, adult and juvenile cranes used crops during both crepuscular and mid-day periods during spring (the peak period of crop depredation), with juvenile cranes exhibiting a stronger preference for crops during crepuscular periods, suggesting that juvenile cranes are more likely to engage in crop

depredation than adults. However, juvenile cranes exhibited considerable individual variation in their use of agricultural landscapes.

3. Finally, our estimates of annual survival rate of Minnesota cranes are consistent with other published estimates of crane survival rate, although because we had difficulty distinguishing mortality from transmitter failure, the uncertainty in our estimates is large.

Our study provides current information about the population affiliation of Minnesota sandhill cranes, and indicates that the recent dramatic growth in abundance of cranes in Minnesota is largely a consequence of an increase in the number and distribution of Eastern Population sandhill cranes in the state. There is overlap in the distribution of these two populations both on the breeding grounds, and to a lesser extent, during staging, migration, and winter, potentially complicating local management options. Conflicts caused by spring crop depredation are likely disproportionately due to juvenile cranes, and efforts to mitigate crop damage are likely to be most effective if targeted at cranes engaging in depredation, rather than at the entire population through hunting or other means. Generally high annual survival rates likely contribute to a growing Minnesota sandhill crane population, especially Eastern Population cranes.

PROJECT RESULTS USE AND DISSEMINATION

We presented our research results via four oral presentations and two poster presentations at professional conferences (the Annual Meeting of the Minnesota Chapter of The Wildlife Society, the Midwest Fish and Wildlife Conference, and the North American Crane Workshop). We presented two invited talks to the Minnesota Department of Natural Resources (the Waterfowl Committee and the Northwest Regional Wildlife meeting). We presented four invited talks in general public scientific settings (Brainerd Lakes Audubon Society, Minnesota Prairie Chicken Society, Maplewood Nature Center, and the Minnesota Waterfowl Association), and a public seminar at the University of Minnesota (Natural Resource Science and Management Graduate Seminar Series). We also gave a presentation to five kindergarten classes in the Mounds View School district. We currently have one manuscript accepted for publication and in press at the Wildlife Society Bulletin. We also digitally archived the data and programming code required to reproduce the analysis for this publication at the Data Repository for the University of Minnesota, which is part of the University Digital Conservancy. This research project was featured in articles in the following Minnesota newspapers and magazines:

1. Minnesota Study Focuses on Sandhill Cranes. Grand Forks Herald. Brad Dokken. May 17, 2015.
2. Crane Set Record, Prompt Research at Sherburne NWR. Saint Cloud Times. Ann Wessel. November 2, 2015.
3. The Resilience of Sandhill Cranes. Minnesota Conservation Volunteer. Carroll Henderson. March-April edition, 2016.
4. Study's Aim: Shed Light on State's Sandhill Cranes. Outdoor News. Joe Albert. July 22, 2016.

Project Completed: 06/30/2017

FINAL REPORT

Imperiled Prairie Butterfly Conservation, Research and Breeding Program - RESEARCH

Subd. 05j \$625,000 TF

Subd. 05j1 - \$380,000 TF

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Subd. 05j2 - \$245,000 TF

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Appropriation Language

\$380,000 the second year is from the trust fund to the Minnesota Zoological Garden and \$245,000 the second year is from the trust fund to the commissioner of natural resources to prevent the extirpation and possible extinction of imperiled native Minnesota butterfly species through breeding, genetics and mortality research, inventory, monitoring, and public education. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

With only 1% of Minnesota's native prairie remaining, many prairie plant and animal species have dramatically declined. Of the 12 butterfly species native to Minnesota prairies, two species, the Poweshiek skipperling and the Dakota skipper, have already largely disappeared from the state and are proposed for listing under the U.S. Endangered Species Act despite being historically among the most common prairie butterflies and having their historic ranges concentrated in Minnesota. The Minnesota Zoo and the Minnesota Department of Natural Resources are using this appropriation to conduct efforts aimed at preventing the extirpation and possible extinction of these butterfly species in Minnesota. Efforts will include expansion of both a butterfly research and conservation breeding program and ongoing butterfly survey and monitoring programs. Because of the ecological role of butterflies as pollinators and a food source for wildlife, analysis should also reveal important information about the greater prairie ecosystem and guide actions to be taken to protect it.

MN Zoo Project: OVERALL PROJECT OUTCOME AND RESULTS

Many of Minnesota's prairie butterflies are declining. Due to ENRTF support, the Minnesota Zoo's Prairie Butterfly Conservation Program has dramatically expanded the first and only conservation rearing and breeding programs for Minnesota's imperiled prairie butterflies. We developed new rearing and breeding techniques, and increased the Zoo's conservation population of U.S. Threatened (Minnesota Endangered) Dakota skippers from 44 adults in 2014 to over 375 adults in 2017. This expansion allowed for the beginning of a multi-year reintroduction program in 2017 when 200 Zoo-reared Dakota skippers were released to reestablish a lost Minnesota population. A new augmentation program is also underway to support some of the last United States populations of the Endangered Poweshiek skipperling.

The causes of these butterfly declines are not fully understood, many factors likely contributed, and some of those threats may still exist. The ENRTF provided critical funding though to begin understanding the potential role of insecticide drift into prairies. We produced foundational data on the extent, composition, and timing of pesticides drifting into critical habitats for these protected species. The findings inform hypotheses about what may have contributed to declines of these butterflies and have spurred additional research recommendations. We are working with other agencies and parties to advance risk assessments and proper habitat management and to reduce drift exposure.

The ENRTF supported foundational Dakota skipper and Poweshiek skipperling population genetics research, filling critical knowledge gaps that inform management of these butterflies at both in the Zoo and in the wild. These studies are being published in peer-reviewed scientific literature.

We developed new outreach about butterflies, prairies, and what the public can do to help. Thanks to the ENRTF, we published two popular pamphlets in both English and Spanish, and these have been distributed free to nearly 10,000 people at the Minnesota Zoo and at other events.

MN Zoo Project: PROJECT RESULTS USE AND DISSEMINATION

We have developed a large network of collaborators across local, state, national, and international levels. We hold frequent conference calls with several recovery and threat assessment working groups for both Poweshiek skipperling and Dakota skipper, and have attended and/or hosted several multi-day meetings and conferences for these species. We present our results to these working groups and other permitting agencies, and prepare detailed annual reports. Our results informs the actions and recommendations of the working groups. The foundational husbandry protocols we developed have also helped Winnipeg's Assiniboine Park Zoo launch a parallel and collaborative prairie butterfly conservation rearing and breeding program. Scientific products of our ENRTF-supported work will be submitted for peer-reviewed publication.

Thanks to the programmatic expansions supported by the ENRTF, the plight of prairies and their butterflies have become much more visible and publicly known. We have presented to dozens of general public audiences (thousands of people in total), and at several University undergraduate and graduate-level courses and seminars. At least nine newspaper, radio, and television stories have been produced about the prairie butterfly conservation efforts supported by the ENRTF since 2014, including four new newspaper, radio, and television stories associated with the Dakota skipper reintroduction program in the summer of 2017.

Minnesota Zoo Facebook Live streaming event from the Hole-in-the-Mountain Prairie Preserve (<https://www.facebook.com/mnzoo/videos/10155374215493788/>) featuring Prairie Butterfly Conservation Program manager Dr. Erik Runquist, the Minnesota DNR's Dr. Robert Dana (project lead on this joint ENRTF for Activity 3), and staff from The Nature Conservancy and the US Fish and Wildlife Service. Viewed nearly 11,000 times, the video provided a live look at the Dakota skipper reintroduction effort, the history of the ENRTF-supported Prairie Butterfly Conservation Program, and the partnerships involved. Additional Minnesota Zoo social media and blog posts were presented throughout the summer of 2017 highlighting the reintroduction effort, our "Plant For Pollinators" campaign, and the re-introduction of the Butterfly Brew Dakota Skipper Endangered Reserve promotion through Fair State Brewing Cooperative.

MN DNR Project: OVERALL PROJECT OUTCOME AND RESULTS

This project was a collaboration with the Minnesota Zoo to find the cause or causes of the recent precipitous declines of two prairie-dependent skipper butterflies, the Poweshiek skipperling and the Dakota skipper, and to restore both to a level of abundance that will assure their survival. These declines have prompted the U.S. Fish & Wildlife Service to list the Poweshiek skipperling as endangered and the Dakota skipper as threatened. The MN DNR was responsible for one of the project's component activities—surveying sites throughout MN's prairie region that historically supported these two butterflies as well as sites with appropriate habitat that had never been previously surveyed.

The goals of this survey were to determine if there were extant populations of these two species in Minnesota, to initiate monitoring of any populations found, and to survey for 11 additional butterfly species that are prairie-dependent or highly associated with native prairie in MN to determine whether they also show evidence of decline from historical levels. Surveys were conducted from July 1 through early September in 2014 and from early June through early September in 2015 and 2016.

A total of 63 sites throughout western Minnesota were surveyed one or more times, 44 in 2014, 51 in 2015, and 52 in 2016. Seven of the target species were not observed: Dusted skipper, Garita skipperling, Uhler's arctic, Iowa skipper, Ottoe skipper, Assiniboia skipper, and most significantly, Poweshiek skipperling, adding to the probability that this federally endangered species is extirpated in Minnesota. One population of the federally threatened Dakota skipper was confirmed to remain, and this population probably declined over the three survey years. Only two populations of the Pawnee skipper were located, one in same site as the Dakota skipper. Other species found were Gorgone checkerspot, Prairie ringlet, Melissa blue, and Regal fritillary. The results indicate a sharp decline from historical levels for Gorgone in the south half of the surveyed region and probable but weaker declines for the blue and the ringlet. Only the Regal fritillary appears to be resisting the trend.

MN DNR Project: PROJECT RESULTS USE AND DISSEMINATION

Two presentations: one to the annual Day of Insects symposium at Iowa State University in 2015, one to a workshop organized by the MN Zoo with the University of Minnesota on the possibility that insecticide contamination is a contributor to the declines. Interviews with reporters, one with the Fargo Forum newspaper, one with a MN Public Radio reporter resulting in some media coverage. Participation in a meeting organized by USFWS with land managers to discuss management strategies in the Felton Prairie. Presentation to the Clay County Board on the Dakota skipper presence in the Felton Prairie. The County owns the prime Dakota skipper habitat in the Felton prairie, and the presentation, along with ones by USFWS staff and other DNR staff, was to update them on the biological significance of the site. Annual reports to DNR Div. of Parks and Trails, Scientific & Natural Areas Program, The Nature Conservancy, the town of Fertile, MN, Clay County, USFWS, Morris Wetland District, The MN Zoo has made many presentations in which this survey work has been given some exposure.

Project Completed: 06/30/2017

[FINAL REPORT - Runquist: \(Subd. 05j1\)](#)

[Prairie Butterfly Conservation Program Annual Report - Runquist: \(Subd. 05j1\)](#)

[Plan for the Controlled Propagation, Augmentation, and Reintroduction of Dakota Skipper - Runquist: \(Subd. 05j1\)](#)

[MN Zoo Butterfly Brochure \(ENG\): \(Subd. 05j1\)](#)

[MN Zoo Butterfly Brochure \(SPA\): \(Subd. 05j1\)](#)

[MN Plant for Pollinators Brochure \(ENG\): \(Subd. 05j1\)](#)

[MN Plant for Pollinators Brochure \(SPA\): \(Subd. 05j1\)](#)

[FINAL REPORT - Dana: \(Subd. 05j2\)](#)

Conserving Minnesota's Native Freshwater Mussels - RESEARCH

Subd. 05k \$350,000 TF

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Appropriation Language

\$350,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota in cooperation with Macalester College to document native freshwater mussel abundance and distribution, quantify environmental conditions necessary to conserve Minnesota's native freshwater mussels, and conduct outreach to local organizations and the public. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

Project Overview

Though they are a relatively unnoticed group of species, native freshwater mussels are a critical part of river ecosystems because they provide a variety of important functions including improved water clarity, enhanced streambed stability, reduced downstream transport of contaminants, and creation of habitat for other aquatic life. However, mussel populations in Minnesota have declined in recent decades as a result of habitat destruction, pollution, land-use change, over-harvesting, and the introduction of exotic species. Researchers at the University of Minnesota are using this appropriation to conduct surveying and analysis to better understand mussel abundance, distribution, and interactions with habitats in order to guide efforts to preserve and restore native mussel populations and maintain the ecosystem services they provide.

OVERALL PROJECT OUTCOME AND RESULTS

Native freshwater mussels are a valuable part of Minnesota river ecosystems. Mussels can improve water clarity, enhance streambed stability, and create habitat for other aquatic organisms. Freshwater mussels are filter feeders that live within river bottom sediment and are sensitive to environmental changes including increased sediment loads, higher flood flows, or lower base flows. We investigated the interactions between mussels and their habitat using a combination of fieldwork in the Minnesota and the St. Croix watersheds and laboratory experiments in the Outdoor StreamLab and flumes at St. Anthony Falls Laboratory. We re-visited field sites previously sampled by MN DNR and evaluated mussel population change in abundance, diversity, life history traits and disturbance tolerance across a gradient of suspended sediment loads and agricultural impacts. We also evaluated growth rates and mussel energy stores (glycogen) within these watersheds. In general, as agricultural impacts (and sediment loads) increased, mussel abundance and diversity decreased, but growth rates and mussel energy stores increased, likely due to increased food availability from agricultural nutrient inputs. In addition, as agricultural impacts increased, mussel communities shifted toward more disturbance tolerant, opportunistic communities. In the laboratory, we evaluated mussel response to flow, suspended sediment, and streambed stability. Mussels did not stop feeding under high flows with increased sediment loads, and there was no measurable impact on mussel energy stores. However, mussels did increase their waste excretion behaviors. During flooding, when bed sediment was mobile, mussels anchored in place until flood waters receded. These experiments provide important evidence about how adult mussels respond to changing hydrology and sediment loads. However, sediment effects could not be isolated in the field and multiple stressors (hydrologic changes, sediment, nutrients, other pollutants, etc.) can affect sensitive mussel species and/or sensitive phases of the mussel life cycle. This research informs mussel conservation and re-introduction efforts.

PROJECT RESULTS USE AND DISSEMINATION

Through this project, we advocated cleaner and healthier Minnesota waters by studying the environmental conditions necessary to conserve and promote a diverse and sustainable native mussel population. This project impacted 1) the greater scientific community through the development of five peer-reviewed publications and presentations at scientific conferences (state, regional, and national); 2) water resources and wildlife professionals working towards freshwater mussel conservation through the dissemination of results, and 3) the general public through public engagement strategies designed to illustrate ecosystem services provided by freshwater mussels and the linkages between mussels and clean water. In addition, this project provided training for the next generation of water resource professionals by incorporating twelve undergraduate student researchers in field, laboratory, and engagement activities.

Project Completed: 06/30/2018

[FINAL REPORT](#)

[Issue Nine: Winter 2018 - Open Rivers: Rethinking Water, Place & Community](#)

[Issue Four: Fall 2016 - Open Rivers: Rethinking the Mississippi](#)

Impacts of Forest Quality on Declining Minnesota Moose - RESEARCH

Subd. 05I \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota in

cooperation with the Department of Natural Resources to link regional patterns of moose abundance through time to the distribution of food and cover and determine if this distribution affects the diet and survival of individual moose. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Moose, one of Minnesota's prized wildlife species, are dying at much higher rates in Minnesota than elsewhere in North America. Recently observed increases in mortality rates amongst some moose in northeastern Minnesota have led to concern that the population there may be entering a decline like that seen in the northwestern part of the state, where moose populations fell from over 4,000 to fewer than 100 in less than 20 years. Additionally the specific causes of increased mortality amongst individual moose remain under investigation. Scientists at the University of Minnesota are using this appropriation to examine the role of habitat quality and landscape change and how it impacts moose diet, body condition, and mortality risk, specifically the role of forest age, structure, and composition in distribution of food and cover. Knowledge gained will be used by federal, state, and local natural resource agencies to identify appropriate management and habitat needs and actions that can be taken to help slow or prevent continued population declines in northeastern Minnesota of this iconic, keystone species.

OVERALL PROJECT OUTCOME AND RESULTS

We examined characteristics of land cover and forage quality that could be affecting the declining Minnesota moose population at multiple spatial and temporal scales. At a broad spatial scale, we found that the landscape of NE Minnesota has changed over 18 years, both in the composition (e.g., more coniferous and less mixed-wood forest) and arrangement (e.g., decreased fragmentation of coniferous forest and increased fragmentation of mixed-wood forest) of forested land-cover types. At the scale of the moose survey unit (2.8 x 5 miles), some of these changes appear to be related to moose population dynamics. Specifically, moose tended to have higher population growth rates in cooler areas and in survey units that had more young and mixed-wood forest, less coniferous and deciduous forests, and less fragmented forested wetlands. We found that, during summer, moose are in fact altering their behavior to seek out mixed-wood forest at the hottest times of the day, and because we found that forage availability differs both by cover type and by location in moose range, these decisions may be affecting diet. Further, because the diets of animals that died were different from those of live animals, we suspect that the availability of high-preference foods may be critical. Because several independent sources of data all point in a similar direction, we recommend a large-scale, long-term experiment to explicitly test how different combinations of land cover and food availability may be affecting moose habitat use and population dynamics. Specifically, we suggest working with forest managers to harvest blocks of forest stands to manipulate overstory and understory features that appear to be important to moose. Monitoring the success of these manipulations with collared animals and camera traps over a 5-10 year period could help determine how to best manage forest landscapes for a healthy moose population.

PROJECT RESULTS USE AND DISSEMINATION

This research has been presented 15 times at national or international research conferences or invited seminar series. The research team has worked with the Bell Museum to contribute information related to the moose diorama and also provided an extensive interview to the "Access Minnesota" radio show. Three scientific articles have been published so far, and the research team is working with MNDNR and tribal biologists to discuss the results and implications of this work. Finally, 12 undergraduate students, five graduate students, and three postdoctoral researchers received training as part of this project; results from this research have been added into teaching materials in two required Fisheries, Wildlife, and Conservation Biology courses at UMN.

Project Completed: 06/30/2017

FINAL REPORT

Habitat functional response mitigates reduced foraging opportunity: Publication

Combinations of Abiotic Factors Differentially Alter Production of Plant Secondary Metabolites: Publication

Used-Habitat calibrations plots: Publication

Moose Decline and Air Temperatures in Northeastern Minnesota - RESEARCH
Subd. 05m \$600,000 TF

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Appropriation Language

\$600,000 the second year is from the trust fund to the commissioner of natural resources in cooperation with the University of Minnesota to study the physiology and behavior of adult moose and effects of female condition on calf production and survival to determine the impact of air temperature on moose population performance and decline. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Moose, one of Minnesota's prized wildlife species, are dying at much higher rates in Minnesota than elsewhere in North America. Recently observed increases in mortality rates amongst some moose in northeastern Minnesota have led to concern that the population there may be entering a decline like that seen in the northwestern part of the state, where moose populations fell from over 4,000 to fewer than 100 in less than 20 years. Additionally the specific causes of increased mortality amongst individual moose remain under investigation. Scientists at the Minnesota Department of Natural Resources are using this appropriation to help understand how air temperature affects moose habitat use and behavior, reproductive success, and survival in order to determine if, when, and how moose are able to successfully modulate internal body temperature. Knowledge gained will be used by federal, state, and local natural resource agencies to identify appropriate management and habitat needs and actions that can be taken to help slow or prevent continued population declines in northeastern Minnesota of this iconic, keystone species.

OVERALL PROJECT OUTCOME AND RESULTS

We used GPS collars, mortality implant transmitters (MITs), which continuously record internal body temperatures, and samples of moose urine voided in snow to study moose in northeastern Minnesota, a population that recently experienced significant declines.

Annual mortality rates of adult moose were 12–19% during 2013–2016, higher than the 8–12% rates reported in stable moose populations elsewhere in North America. The main causes of death for 57 moose were wolf predation (32%), parasites (30%), bacterial infections (21%), and other health issues (17%). MIT temperatures were 37.55–42.10°C in 25 moose; more MITs will be recovered later. Average daily MIT temperature increased 0.0009°C for every 1 degree increase in average daily air temperature. Twenty-three moose had 0.2–11% of internal temperatures considered above normal (i.e. $\geq 39.2^{\circ}\text{C}$). Habitat types used when an animal was hot compared to what was available was significantly different in some moose during summer.

The average pregnancy rate was similar to the North American average (83%). For GPS-collared calves born in 2013–2014 and unmarked calves (with collared mothers) born in 2015–2016 survival to 30 days of age was 58.4% and ~65%, respectively. By early spring survival declined to 34.1% and 33–40%, respectively. For 57 calf mortalities wolf predation consistently was the primary cause of death (66.7%), and bear predation was next (15.8%). Hiding cover was a dominant attribute at calving sites compared to pre-calving sites, whereas canopy closure and forage availability were greater at peak-lactation sites, indicating that balancing security and nutritional requirements influenced habitat selection over time.

Ratios of urinary urea nitrogen to creatinine ≥ 3.5 indicated more severe nutritional restriction during winters 2013, 2016, and 2017 compared to 2014 and 2015. Annual incidences of severe nutritional restriction were correlated with estimates of population size ($r = -0.863$), calf production ($r = -0.922$), and winter survival of adult moose ($r = -0.860$), indicating that winter undernutrition is playing a role in the poor population performance. Our results will improve understanding of if, when, and how moose are able to successfully modulate their internal body temperature, which can inform strategies for conserving the population, especially through habitat management.

PROJECT RESULTS USE AND DISSEMINATION

For the moose research projects supported by this funding we have produced 8 peer-reviewed publications, 4 manuscripts currently in review, and several more to come with final analyses of the data. There have been 15 DNR agency reports written, and they are available from our wildlife publications website (<http://www.dnr.state.mn.us/publications/wildlife/index.html>). Agency staff and graduate students have given 117 presentations at professional conferences of all levels—state to international—other meetings with professional biologists, and to all manner of public audiences, from school groups to sporting and nature groups to a veterans group.

During these 3 years the lead investigators, Drs. DelGiudice and Carstensen, have participated in 38 interviews with journalists from television, radio, and print outlets, and there have been more than 175 additional instances of media coverage about our research. Media outlets included all major newspapers in Minnesota and 2 adjacent states, many smaller newspapers, the Washington Times, National Geographic, public and commercial radio stations in Minnesota, and public, network, and cable television stations in Minnesota. Furthermore, we have posted information on our DNR moose research website (<http://www.dnr.state.mn.us/moose/index.html>) throughout the project, and our results will be used to inform public stakeholder groups and DNR decisions about moose conservation.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Expansion of Minnesota Wildflowers Online Botanical Reference

Subd. 05n \$150,000 TF

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Appropriation Language

\$150,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Minnesota Wildflowers Information to accelerate field work for surveying and imaging of plant species and publication of species profiles to a plant identification reference Web site available to the public and land managers. Images acquired and information compiled using these funds are for purposes of public information available on a Web site. If the organization is no longer able to maintain the Web site, the organization shall work with the state and the University of Minnesota Bell Museum of Natural History to ensure the materials remain publicly available on the Web. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

The average Minnesotan and even most natural resource managers are not skilled in plant identification, yet the ability to positively identify plants is crucial to a number of conservation activities, including identifying areas that need protection, recognizing new or existing invasive species, monitoring restoration projects, and delineating wetlands. The Minnesota Wildflowers project attempts to fill this need with a free web-based field guide ultimately aimed at providing profiles for each of the over 2,100 vascular plant species in Minnesota. Minnesota Wildflowers Information is using this appropriation to continue to update and expand the information contained on its online field guide by doubling the number of new species profiled. Information will be freely available to the public, students, and natural resource professionals as a learning reference and to assist in plant identification.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota Wildflowers, an online field guide to the plants of Minnesota, was launched in 2007 by an amateur botanist who grew frustrated with the lack of information and quality imagery specific to Minnesota's flora. The task of systematically seeking out specific plants, photographing the identifying characteristics, describing each species in non-technical terms, and publishing on the web was undertaken with the goal of becoming a comprehensive reference for all of Minnesota's 2100+ plants.

The need for such a reference, especially targeted to non-botanists, has been evident by the number and type of users of the website, virtually anyone asking such questions as: What is that plant? Is it native or a weed? How to distinguish it from similar plants? These users include natural resource managers, restoration specialists, educators from elementary school through university level, citizen scientists, native plant advocates, gardeners and the general public. In 2014 when ENRTF funding began, 799 species (mostly forbs) had been published and the average traffic during peak season was 2,000 visits and 10,000 web pages viewed per day.

During the 3-year funding period, the 2-member team traveled 35,000 miles visiting locations in 64 Minnesota counties, photographed 1200 plant species, 500 of which had not previously been photographed. This field work resulted in significantly increased coverage. As of June 30, 2017, 1337 species have been published (over 60% of all Minnesota plant species) including trees/shrubs, grass-like plants and ferns. More than 220 species profiles were updated with improved images and information. Traffic has more than doubled with over 5,000 visits and nearly 23,000 pages viewed per day during 2017 peak season. 468,000 unique users were served in 2016 and numbers continue rising. This clearly shows the website is a valued resource and the more species covered, the more valuable it becomes.

PROJECT RESULTS USE AND DISSEMINATION

While word-of-mouth and Google searches are the source of much traffic, our web statistics show the single highest usage comes from the State of Minnesota, which includes multiple state agencies as well as the University of Minnesota. Our plant images are in high demand for other educational and outreach purposes, including interpretive signs, PowerPoint presentations, and invasive species fact sheets. Our field work puts us in contact with many state parks, nature centers and educational institutions across the state where we promote the project to their staff and visitors. During the past 3 years we partnered with the DNR State Parks and Trails on their wildflower geocaching program, were profiled in the Minnesota Conservation Volunteer magazine, and gave presentations about the project to the Minnesota Native Plant Society, the Minnesota Wetlands Professionals Association, the Minnesota Landscape Arboretum, Master Naturalists, Master Gardeners, Wild Ones and several garden clubs.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Subd. 06 Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Understanding Systemic Insecticides as Protection Strategy for Bees - RESEARCH

Subd. 06b \$326,000 TF

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Appropriation Language

\$326,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to continue research on how native bee and honey bee colonies are impacted by systemic, neonicotinyl insecticides in pollen and nectar of plants growing in fields and landscapes. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

A class of insecticides known as systemic neonicotinyl insecticides has been identified as a potential factor in recently observed declines in pollinators, including the phenomenon amongst honeybees known as Colony Collapse Disorder. Previous research examining the effects of neonicotinyl insecticides on lab colonies of bumblebees found that exposure to these insecticides at various levels increased queen bee mortality and detrimentally altered bee behavior and production. Researchers at the University of Minnesota are using this appropriation to continue this research aimed at quantifying levels of insecticide residues in pollen and nectar of plants treated with systemic insecticides to determine how exposure to these residues affects bee colony health. This phase expands the research to conduct studies in the field in a natural setting.

OVERALL PROJECT OUTCOME AND RESULTS

Our objectives were to understand how to protect pollinators. We wanted to understand if bees were affected when feeding on pollen from ornamental plants that were treated with imidacloprid, a neonicotinoid insecticide. Neonicotinoids are systemic and are applied to the soil or injected into trees. Both native bees, *Bombus impatiens*, and managed bees, *Apis mellifera*, are affected in similar ways by imidacloprid. The imidacloprid dose in flower pollen that kills bees is 40 ppb and below 25 ppb imidacloprid causes sublethal effects on behavior.

Objective 1-1, 1-2, 1-3.. Determine imidacloprid residue in leaves, flowers, soil, and pollen from a soil drench and trunk injection.

We studied imidacloprid residue in linden trees, bee friendly flowers, blueberries, and greenhouse plants grown to be installed in the landscape. Also, we investigated the effects on the EPA NOEL or sub-lethal limit of imidacloprid (20 ppb) on bumblebee colony health in the field.

Our data showed that trunk injections of imidacloprid caused very high levels of imidacloprid in flowers and pollen that would kill foraging bees. Soil drenches produced lower amounts in flower that are below the EPA sublethal level. However, dogwoods growing under the trees to which a soil drench was applied contained sufficient imidacloprid residue to kill a foraging bee. These same flowers would not kill a house sparrow that fed on the dogwood berries. However, recent papers say these sublethal levels will affect bird movement and feeding. Bee friendly plants in landscapes did not accumulate enough residue after 1 application to kill a foraging bee. However, greenhouse applications to flowering baskets and pots resulted in sufficient residues to kill foraging bees.

Objective 2-1. Determine the impacts of these imidacloprid residues on colony health of native bumblebee.

A tier 3 EPA research field study with replicate plots was performed on the St Paul UM Campus. The bumblebee colonies were free flying and were fed 20 ppb imidacloprid in sugar syrup. The EPA NOEL (Not Effective Adverse Level or sub lethal dose) is 25 ppb imidacloprid. The bees in the treated colonies showed decreased movement, decreased sugar consumption, decreased brood, decreased queen production, and decreased hygienic behavior. Bumblebee colonies are negatively affected by 20 ppb imidacloprid. So the NOEL identified by the EPA in March 2016 as 25 ppb is incorrect.

Our residue data and our bumblebee study tells us that imidacloprid residue in flowers from a trunk injection or flowering plants growing under trees treated with soil drenches or greenhouse treated flowering plants would contain sufficient residue to kill or negatively affect native bumblebee colonies.

PROJECT RESULTS USE AND DISSEMINATION

Dissemination: Objective 1-4. Share the research results through outreach with talks, workshops, pollinator website, and interviews.

We talked to the public and other researchers about the effects of pesticides on bees, the data from this research, and what municipalities and consumers could do in their green space to conserve bees. We held 3 workshops at the MN Landscape Arboretum, produced 2 websites on native bee conservation, spoke about the research in 10 talks/yr, and gave over 6 interviews/yr to radio, television, and print media.

Imidacloprid residue in plant parts after a standard imidacloprid EPA approved label rate application

Species/application type	Applied	Leaves (ppb)	Soil (ppb)	Flowers (ppb)	Pollen (ppb)	Sub-Lethal <25 ppb	Lethal >40 ppb
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Ratio of imidacloprid in whole flowers to pollen

13 EPA docs submitted by industry					25% of residue in flowers		
Prairie petunia, Ruella humilis	300 mg			1,100	267		X
Yellow bells, Tecoma stans	300 mg			109	109		X

Landscape trees: Imidacloprid residue

Objective 1-1. Determine imidacloprid residue in pollen and nectar of basswood (linden) trees from a soil drench and trunk injection.

		Yr 1					
Linden 20 in DBH, soil drench	48 g	Yr1 July: 727	July:15,430	34	9	X	
		Aug: 1,023	Aug: 5,956	No flow	No flow		
		Yr2 July 706	Yr 2	81	20	X	
		Aug: 429	July:1,634	No flow	No flow		
			Aug: 534				
Linden 8 in DBH, soil drench	14 g	July: 13,675	July: 290	34	9	X	
		Aug: 25,250	Aug: 385	No flow	No flow		
Linden 8 in DBH, trunk injection	3 g	July: 848	July: 14	1,340	335		X
		Aug: 36,283	Aug: 14	No flow	No flow		

Landscape trees: Imidacloprid residue

Objective 1-2. Determine imidacloprid residue in native plants around imidacloprid-treated trees

Dogwoods under soil drench		July: 21,061	Aug: 16,787	762			
				Fruit: 425 will not kill house sparrows eating fruit	190		X

Landscape Bee plants: Imidacloprid residue

Objective 1-3. Determine imidacloprid residue in pollen and nectar of native flowers and blueberry from imidacloprid soil drenches.

Agastace foeniculum, anise hyssop	25 g	561	94	24	X
Asclepias currassavica, tropical milkweed	25 g	132	87	22	X
Commercial blueberries Collaboration with Koppert			residue in 5/6 flower samples (220, 136, 42, 10, 12 ppb), mean 84 ppb	Bumblee bee colonies in these fields declined.	X

Greenhouse Bee plants: Imidacloprid residue

Objective 1-3. Determine if greenhouse grown plants in hanging baskets contained sufficient residue to harm foraging bees.

Prairie petunia, Ruella humilis	120 mg	July: 14,400 Aug: 2,086	July: 1,100 Aug: 502	July: 267 Aug: 126	X X
Million bells, Calibrachoa	200 mg	July: 67,266 Aug: 34,166	July: 1,972 Aug: 333	July: 615 Aug: 83	X X

Greenhouse Bee plants: Imidacloprid residue

Objective 1-3. Determine if greenhouse grown plants in pots contained sufficient residue to harm foraging bees.

Agastace foeniculum, anise hyssop	300 mg		1,973	493	X
Asclepias currassavica, tropical milkweed	300 mg		1,568	392	X
Yellow bells, Tecoma stans	300 mg		106	106	X
Canola	300 mg		4,144	1,036	X
Rose Consumer label	300 mg		1,175	293	X
Rose Greenhouse label	240 mg		812	203	X

Landscape experiment on bumblebees at 20 ppb imidacloprid below EPA NOEL of 25 ppb Objective 2-1.

Determine the impacts of these imidacloprid residues on colony health of native bumblebee.

Imidacloprid at the EPA sublethal rate of 20 ppb caused fewer queens to be produced, lower nest weight, and less hygienic behavior compared to controls.

Project Completed: 06/30/2017

[**FINAL REPORT**](#)

Prairie Sustainability through Seed Storage, Beneficial Microbes, and Adaptation - RESEARCH

Subd. 06c \$600,000 TF

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Appropriation Language

\$600,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to collect and preserve germplasm of plants throughout Minnesota's prairie region, study the microbial effects that promote plant health, analyze local adaptation, and evaluate the adaptive capacity of prairie plant populations. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Healthy prairies contribute numerous benefits, such as providing habitat for wildlife and pollinators, maintaining and improving water quality, stabilizing roadsides, and providing a sustainable source of materials for bioenergy production and other products. Since European settlement the once vast expanses of Minnesota prairie covering 18 million acres have been reduced to small remnants totaling about 235,000 acres. With this decline has also come a drastic reduction in the genetic diversity of the various species typical of Minnesota prairies. This has resulted in inbreeding of remnant species populations, which reduces the robustness of plants and can result in yet further population decline. Researchers at the University of Minnesota are using this appropriation for efforts aimed at protecting the long-term health and sustainability of remaining prairie in the state by collecting prairie plant genetic material for long-term preservation, collecting and studying microbes that promote prairie plant health, and examining the capacity for prairie plants to adapt to changing conditions. Information and resources derived from this effort will contribute to improving restoration techniques and ensuring healthy prairies into the future.

OVERALL PROJECT OUTCOME AND RESULTS

The once vast MN prairie harboring tremendous genetic diversity has been drastically diminished. Society's increasing recognition of the multifarious benefits MN prairie provides has generated demand for scientifically based prairie conservation and restoration. Accordingly, this project undertook to:

- preserve seeds of 40 plant species from sites throughout MN's prairie region,
- identify microbes that promote prairie plant health,
- discover the scale of local adaptation for prairie plant species, and
- predict the rate of future adaptation of prairie plant populations.

Outcomes:

We obtained genetically representative collections from over 330 populations of 64 plant species native to MN prairie. To ensure lasting viability of these seeds, many are stored at the USDA National Center for Genetic Resources Preservation in Fort Collins, CO.

We characterized microbial communities on prairie plants, isolating and identifying over 2500 strains from prairie clover. Graduate student DeMers presented these findings at a national scientific meeting. We conducted an experiment to determine whether microbes benefit host plants that originate from the same site more than they benefit host plants from different sites; analysis is ongoing.

We established 3 field experiments to clarify the extent to which plants survive and reproduce more when they are planted near their site of origin. This study focuses on 6 prairie species, each sampled from 12 sites. Monitoring of survival and growth of plants is proceeding, as is analysis of this dataset.

To assess the genetic variation available to support adaptation, we established foundation plantings of little bluestem, in preparation for estimating the adaptive capacity of two populations.

PROJECT RESULTS USE AND DISSEMINATION

In accomplishing these goals, we have advanced:

1. Relationships with professional native-seed collectors and with several student groups at rural MN university campuses.
2. Scientific training of 10 undergraduates at 3 Minnesota university campuses, 7 technicians, 3 graduate students, and 2 post-doctoral associates and engagement of over 60 community volunteers and over 400 others.
3. Discussions with users and producers of native seed, aiming to increase source-identified seed available for prairie restorations in Minnesota.

This Project has expanded the diversity and volume of local, source-identified seeds and microbes from Minnesota prairies and has collected and analyzed data that will support restoration of MN prairie. All aspects of this project are being continued through new funding from the ENRTF.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Northeast Minnesota White Cedar Restoration - Phase 2

Subd. 06d \$335,000 TF

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Appropriation Language

\$335,000 the second year is from the trust fund to the Board of Water and Soil Resources to continue an assessment of the decline of northern white cedar plant communities in northeast Minnesota, demonstrate restoration techniques, and provide cedar restoration training to local units of government. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Northern white cedar wetland plant communities provide unique ecological, economic, and wetland functions, including high value timber, long-term carbon storage, winter refuge for deer and other wildlife, wildlife habitat, and thermal buffering for brook trout streams. However, these plant communities have been declining in Minnesota for decades mostly as a result of development impacts. The Minnesota Board of Water and Soil Resources is using this appropriation to continue efforts aimed at improving the quantity and quality of white cedar wetland plant communities in Minnesota. Efforts will include assessing existing white cedar communities to prioritize sites for restoration and then providing training and demonstration of restoration and re-vegetation techniques for local natural resource managers.

OVERALL PROJECT OUTCOME AND RESULTS

Project Background: Northern white cedar (*Thuja occidentalis*) has been declining in Minnesota for decades. White cedar provides ecologically diverse plant communities and critical wildlife habitat and wetland functions. (Phase 2).

Project Goals:

1. Reverse decline of white cedar plant communities in Minnesota.
2. Complete two hydrologic restorations of white cedar plant communities and develop recommendations for restorations.

Methods: Board of Water and Soil Resources (BWSR) established 2 white cedar hydrologic restorations in Itasca and Lake Counties. Engineering designs were developed to restore natural groundwater flows where forest roads had impacted white cedar stands. A training video was developed for land managers. Dr. Rod Chimner evaluated the effectiveness of the hydrologic restorations plus the phase 1 vegetative restorations of northern white cedar plant communities.

Results:

1. Hydrologic Restoration:
Goal: Restore 2 sites where roads had impacted white cedar plant communities.
Results: Two experimental methods of hydrologic restoration were completed in Itasca and Lake Counties.
2. Monitor seven phase one white cedar restoration sites:
Results: 7 sites established in Beltrami, Koochiching, St. Louis and Lake County were monitored.
3. Develop recommendations for white cedar restoration and evaluate additional sites:
Results:
 - o Recommendations for white cedar restoration were developed.
 - o 75 additional restoration sites were evaluated by SWCDs.
 - o Northern white cedar has limited ability to replace black ash stands due to high water levels.
 - o White cedar restoration video developed and disseminated.

Project Findings:

- e. Many white cedar swamps are degraded and need restoration.
- f. Major disturbances were roads, ditches and herbivory.
- g. After two years, the largest single factor affecting northern white cedar survival was hydrology.
- h. Light levels (shading) plays a role in cedar regeneration.
- i. After one season, the hydrologic restoration of two forest roads were successful, restoring hydrologic flow conditions.

Project Significance: Northern White cedar provides unique functions including:

- o Thermal winter cover for white tailed deer
- o Critical habitat for pine marten, bear, fish, songbirds
- o Provides thermal buffering for cold water fisheries (brook trout streams)

PROJECT RESULTS USE AND DISSEMINATION

Presentations were given at a scientific conference, to other various interested organizations and project stakeholders (Voyageurs National Park, MN DNR, MN DOT, St. Louis County Highway Department, Superior National Forest, U of M, NRRI, Michigan Tech). A 30 minute radio interview was conducted at KTWH, Two Harbors. Scheduled to present project results to the Minnesota Forest Resources Council and Forestry Committee in International Falls.

Collaboration with the Itasca Community Television (ICTV) to capture video and photography of all stages of construction of hydrologic construction sites. Footage has been edited and training videos have been created. The videos have been distributed to multiple stakeholders, including BWSR, DNR, MPCA and County Forestry Offices, U of M and Federal Agencies. Videos will be made available on the BWSR web page (<https://spaces.hightail.com/space/wYWZBy450n>).

Work with staff from the Superior National Forest to set up field reviews of potential sites that the Forest Service would like to restore hydrology and white cedar plant communities, by utilizing this project's findings. Work is continuing in reaching out to foresters from County Land and Forestry Departments, DNR Foresters, U.S. Forest Service to build avenues for disseminating project findings and generate interest in for white cedar restoration.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Northeast Minnesota White Cedar Plant Community Restoration: Phase I & II Technical Report

Southeast Minnesota Watershed Protection Plan

Subd. 06e \$200,000 TF

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Appropriation Language

\$200,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with The Nature Conservancy to provide a framework and plans for the protection and stewardship of unimpaired waters in southeast Minnesota. The result will be a template for watershed protection in Minnesota. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Often times water conservation efforts are directed toward impaired waters. However, it is much more cost-effective to protect habitat and water resources before they become degraded. The Nature Conservancy is using this appropriation to create a broader, long-term, watershed-based framework for proactively protecting habitat and water resources in southeast MN, specifically the Cannon River and Zumbro River watersheds, before they become degraded. Information will help guide efforts for assessing and prioritizing conservation efforts in southeast MN and provide a framework for other watersheds in the state to replicate.

OVERALL PROJECT OUTCOME AND RESULTS

Despite extensive watershed planning in Minnesota, much of the efforts to date have focused on the restoration of impaired waters. Many watersheds in Minnesota have relatively healthy, unimpaired minor watersheds or sub-watersheds. These watersheds often have considerable private ownership with upland habitat, perennial vegetation or compatible land use that is resulting in clean, unimpaired waters. Yet, these landowners with existing habitat on their properties can be overlooked for conservation assistance for water quality purposes.

This project completed healthy watershed plans or Landscape Stewardship Plans (LSPs) for the Cannon and Zumbro Rivers in Southeastern Minnesota. The LSPs for the watersheds included several GIS analyses identifying ecosystem services of natural communities and priority habitat complexes within a watershed context. This information was used to prioritize Conservation Opportunity Areas (COAs) within each watershed. The plans identified a combined 589,396 priority acres out of 1,849,500 acres studied across 11 COAs encompassing minor watersheds. Four COAs were selected within the Cannon River covering 277,196 acres or roughly 30% of the watershed. Seven smaller COAs were identified within the Zumbro River watershed covering 312,200 acres or 34% of the watershed. These COAs provide guidance on protecting and restoring the most important watersheds and identified properties within them to meet multiple watershed conservation goals including water quality, upland and aquatic habitat and recreation.

The project resulted in 20 property-wide stewardship plans covering 3,000 acres listing a range of management practices for unique zones on each property. In addition to the stewardship plans 20 Conservation Action Plans (CAP) for 168 acres were developed. The CAPs can be used to apply for and implement state and federal cost-share programs for activities like prescribed fire, invasive species control and tree thinning for forest stand improvement. The 2014 Clean Water Accountability Act and subsequent Nonpoint Funding Prioritization Plan directed state agencies to target restoration activities to those impaired waters that are closest to meeting Minnesota water quality standards and to protect those high - quality unimpaired waters at greatest risk of becoming impaired. The

watershed planning approach utilized in this project prioritizes functional landscapes for healthy watershed protection as an important component to the Watershed Restoration and Protection Strategies and One Water One Plans developed by state and local partnerships. To date watershed planning has focused on the more costly aspect of restoring highly degraded waters, not those in need of protection to prevent impairment. By focusing limited technical and financial resources on intact functional landscapes and the clean waters they support, costly restoration can be avoided and ecosystem services can be maintained. This project provides an actionable plan for the Cannon and Zumbro Rivers and a process for other watersheds to achieve the goals of the Clean Water Accountability Act and Nonpoint Funding Prioritization Plan.

PROJECT RESULTS USE AND DISSEMINATION

Plans along with supplemental materials have been prepared to disseminate the most important content of the LSPs to relevant stakeholders and conservation planners. Landscape Stewardship Planning is being recognized as a valuable resource in watershed based plans in SE Minnesota, including the Cannon and Zumbro Watersheds. Both LSPs have been incorporated by reference into the corresponding Watershed Restoration and Protections Strategies (WRAPS) documents for the Cannon and Zumbro Watersheds. The Cannon River Watershed is now beginning the process of adopting a One Watershed One Plan (1W1P), and the technical committee has already been given a presentation on the LSP. The contributions of key partners and stakeholders in developing the plans will also increase their dissemination, as future partners recognize their own contributions and “buy in” to the process.

While the LSPs themselves are targeted at a more technical audience for use in conservation planning, the goals and themes of good stewardship of natural communities for watershed protection have been distributed to a general audience through landowner field days held in the Cannon River Watershed.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Landscape Stewardship Planning Document](#)

[Brochure - Cannon River Watershed](#)

[Overview - Cannon River Watershed](#)

[Landscape Stewardship Plan - Cannon River Watershed](#)

[Brochure - Zumbro River Watershed](#)

[Overview - Zumbro River Watershed](#)

[Landscape Stewardship Plan - Zumbro River Watershed](#)

Upland and Shoreline Restoration in Greater Metropolitan Area

Subd. 06f \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Great River Greening to restore and enhance upland, shoreline, and approximately 150 acres of forests, woodlands, savanna, and prairie and to provide related educational opportunities for volunteers in the greater metropolitan area. A list of proposed restorations and enhancements must be provided as part of the required

work plan. This appropriation is available until June 30, 2017, 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 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 continues the efforts of the Metro Conservation Corridors (MeCC) partnership, an ongoing effort by a partnership of state and non-profit organizations, to conduct strategic and coordinated land conservation 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. Great River Greening is using this appropriation to restore approximately 150 acres of permanently protected forest, woodland, savanna, and prairie habitat while engaging hundreds of volunteers in the stewardship of the metropolitan area's remaining natural areas.

OVERALL PROJECT OUTCOME AND RESULTS

Along with partners and volunteers, Great River Greening completed twelve restoration projects to reduce habitat fragmentation, enhance habitat quality, and reconnect habitat corridors. With Trust Funds and leveraged matching funds, Greening conducted restoration and enhancement efforts on ecological corridors and ecological cores on 291 acres of prairie, oak savanna, woodland, wetland, and riparian habitats. In addition, Great River Greening created community connections, engaging and educating a total of 892 volunteers at five project sites. At these restoration events, volunteers performed habitat restoration techniques, participated in a roving presentation by an ecologist, learned about the larger restoration process at the site, and gained insight on how to transfer knowledge gained to a project at home or in their local community.

Great River Greening produced the following results:

1. Completed a management plan for Westwood Hills Nature Center (WHNC) in St. Louis Park, to “enhance the diversity and resilience of the plant communities at WHNC to increase their value as both wildlife habitat and to enhance their utility as outdoor classrooms.”
2. Restored/enhanced 135.5 acres of upland habitat with Trust Funds (target = 147 acres), which included 0.6 miles of shoreline (target = 0.26 miles), at an average cost of \$1902 per acre. Restored/enhanced an additional 155.5 acres with leveraged matching funds for a total of 291 acres of habitat restored/enhanced (target = 247 acres).
3. Engaged 892 volunteers in meaningful restoration projects with environmental education from Greening ecologists (target = 300 volunteers). 294 of 892 volunteers were youth, age 17 or under.
4. Leveraged \$114,885 in non-state funds and \$189,419 in state funds, for a total of \$304,304 leveraged matching funds for habitat restoration/enhancement, volunteer events, and management plan development.

Summary Table: Trust Fund Deliverables by Parcel

Parcel Name	City	County	Habitat Acres	Shoreline miles	Volunteers
Katherine Abbott Park Phase II	Mahtomedi	Washington	10	0.0	106
Carver Park Reserve	Victoria	Carver	16	0.0	51
Allemansratt Park Phases I, II, III	Lindstrom	Chisago	23	0.0	0
Trout Brook Nature Preserve Phase II	St. Paul	Ramsey	2	0.0	524
Lilydale Bluffs	St. Paul	Ramsey	0	0.0	0
Accelerated Migration Technique	Cottage Grove	Washington	3	0.0	0

Prescribed Grazing/Haying, at a) Central Corridor b) Pilot Knob Hill Westwood Hills	a) Cottage Grove b) Mendota Heights	a) Washington b) Dakota	34	0.0	63
Nature Center Phase I, II	St. Louis Park	Hennepin	25	0.1	148
Wolsfeld Woods SNA	Long Lake	Hennepin	11	0.5	0
Dodge Nature Center II	West St. Paul	Dakota	8	0.0	0
Bur Oak Research: Central Corridor, Allemansrätt Park, Otter Lake, Fish Creek Open Space	Cottage Grove, Maplewood, Lindstrom, White Bear Lake	Chisago, Ramsey, Washington	3	0.0	0
Fish Creek Open Space	Maplewood	Ramsey	0.5	0.0	0
TOTALS			135.5	0.6	892

PROJECT RESULTS USE AND DISSEMINATION

Greening is in active partnership with landowners, other land managers, service providers, conservation peers, and volunteers resulting in a dynamic and timely exchange of information and results.

Volunteer event descriptions acknowledging Trust Fund contributions and qualitative results were emailed to Greening's e-subscribers in July 2014, February 2015, July 2015, spring 2016, fall 2016 and spring 2017 in advance of spring and fall volunteer event seasons; over the course of the grant, the number of subscribers increased from approximately 5,000 to over 8,500. Information about Metro Conservation Corridors is on the Great River Greening website at <https://www.greatrivergreening.org/category/mccorridor/>; over the course of the grant, visits to the website increased from 1,100 to over 1,500 visits per month. In addition, Greening's Facebook and Twitter pages have featured the Pilot Knob Grazing Monitoring project, the Accelerated Migration/ White Oak Ecotype Study at Central Corridor, Allemansratt Wilderness Park, Trout Brook, Westwood Hills, and Carver Park. In March 2017, 150 attendees convened to attend The Best Practices for Pollinators in the Real World Summit, for Minnesota Counties, Municipalities, Leaders. During the conference, Washington County Parks presented on Innovative Management Approaches, highlighting the South Washington conservation haying project. In addition, five press articles from the Pioneer Press, Star Tribune, and Lillie News disseminated information about Pilot Knob Hill, publicizing its addition to the National Register of Historic Places and the prescribed grazing project.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Prairie, Forest, and Savanna Restoration in Greater Metropolitan Area

Subd. 06g \$200,000 TF

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Appropriation Language

\$200,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Friends of the Mississippi River to restore approximately 150 acres of prairie, forests, and oak savanna in the greater metropolitan area. A list of proposed restorations and enhancements must be provided as part of the required work plan. This appropriation is available until June 30, 2017, 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 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 continues the efforts of the Metro Conservation Corridors (MeCC) partnership, an ongoing effort by a partnership of state and non-profit organizations, to conduct strategic and coordinated land conservation 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. Friends of the Mississippi River is using this appropriation to restore approximately 150 acres of permanently protected prairie, forest, and oak savanna habitat in the metropolitan area.

OVERALL PROJECT OUTCOME AND RESULTS

Friends of the Mississippi River worked to enhance 150 acres of prairie and 82.5 acres of woodland for a total of 232.5 acres at six properties in the Twin Cities metropolitan area: Hastings Sand Coulee Scientific and Natural Area (SNA), Orvin Ole Olson Park in Minneapolis, Pine Bend Bluffs Natural Area in Rosemount, a Ravenna Township conservation easement property, River Oaks Park in Cottage Grove and Rosemount Wildlife Preserve. We enhanced an additional 46 acres of prairie and 44.5 acres of woodland using non-state match. All of the project sites are within the designated Metro Conservation Corridors, a planning tool that shows connectivity among parks and natural areas.

All management activities were based on an established Natural Resource Management Plan for the site. Each of the projects were directed at improving the ecological health and wildlife value of the site by improving the abundance and diversity of native plant species. All of the sites were degraded by non-native plants that displaced the native plants and the wildlife that depend on them. Restoration techniques and activities included prescribed burning, control and eradication of non-native invasive plant species, native woody plant removal from prairies, seed collection, and seeding and plant installation. Such practices increase the resilience of the native plant community so that it can better sustain itself and provide better wildlife habitat. This project also enabled matching funds to be used to engage dozens of volunteers in these restoration efforts.

PROJECT RESULTS USE AND DISSEMINATION

FMR disseminated information about the project sites and the ENRTF primarily through two means. We published a couple of short articles about stewardship events at our project sites in our electronic newsletter that included information about ENRTF. In addition, during volunteer events, FMR discussed the project and the source of funding. The Environment and Natural Resources Trust Fund was also named as a funder in FMR's 2016 annual report.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Nutrient Capture Through Water Management and Biomass Harvesting

Subd. 06h \$300,000 TF

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Appropriation Language

\$300,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Red River Basin Commission to evaluate the potential capture of excess nutrients using cattails grown and harvested within shallow flood reservoirs for bioenergy use. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Excess nutrients are among the most common impairments of water resources in the Red River Basin, as well as the rest of Minnesota. About 80% of the land use in the Red River Basin is for agricultural cropland and over 90% of phosphorus and nitrogen found in rivers and streams in the area originate from nonpoint sources, such as cropland. Excess nutrients are also one of the most difficult impairments to correct. The Red River Basin Commission is attempting to help correct this problem by using this appropriation to develop and evaluate an innovative, multipurpose method to use cattails and other vegetation within existing flood storage reservoirs to capture and reduce nutrient loads from runoff originating from mostly non-point sources and then use the harvested vegetation for purposes including bioenergy production and fertilizer. If effective this technique could be implemented in multiple locations in the Red River Basin and in other agricultural regions of the state to assist in reducing nutrient loads in waterways.

OVERALL PROJECT OUTCOME AND RESULTS

This project evaluated the potential for capturing nutrient runoff from nonpoint sources by utilizing cattails or other vegetation within existing shallow flood storage reservoirs. Utilizing the North Ottawa (NO) Project in the Bois de Sioux Watershed District(BDS). Over 80% of the phosphorus and nitrogen (nutrient) loads that are being discharged downstream are coming from nonpoint runoff mostly from agricultural fields. This project developed and evaluated a new methodology for capturing and reducing the nutrient loads coming off agricultural dominated watersheds. This technique provides a new and effective “tool” for addressing nutrient reductions.

The project provides water quality improvements downstream of the impoundment which is then passed on to the rivers and streams of this project including the Red River. As the desire for reductions in phosphorus and nitrogen have led to increased regulation in the state of Minnesota these types of projects will only assist in meeting these regulations and offering another layer of reduction. The data that has been collected is submitted to EQUIS.

The desired outcome is to capture and remove 50- 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. The interior dikes were constructed for the management of water within the 1920 acre impoundment in 160 acre treatment cells. The four-160 acre Pool B cells will give us the ability to hold water for differing time periods and to manage vegetation differently within these cells to maximize nutrient capture.

In 2016, the RRBC harvested cattail biomass from the NO Impoundment and utilized the harvested material as a green manure on agricultural land within the upstream drainage area. Using conventional forage chopping equipment resulted in a 4.76 tons per acre biomass yield. Nutrient analysis of the harvested biomass equated to 48 lbs. nitrogen and 6.6 lbs. phosphorus captured per acre harvested (10 acres) resulting in 480 lbs of Nitrogen and 66 lbs of Phosphorus removed from the system . By scaling up the harvesting, capture and removal of 50 - 100 percent of the phosphorus and nitrogen nutrients is feasible.

Ongoing monitoring is critical to and allows an accurate determination of when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits. Management strategies included drawdown timing and velocity, water retention time for settling nutrients, and optimizing vegetation for nutrient reduction.

PROJECT RESULTS USE AND DISSEMINATION

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin. The RRBC is presently working closely with the Bois de Sioux Watershed District Managers and Administrative staff to provide all the information and outcomes from the work being done at their North Ottawa Impoundment. The BDS has established a project team specific to this effort to look at future tasks and work that could be evaluated at the impoundment site.

The marketing materials, handouts and videos produced will be distributed as a part of our larger basin outreach strategy. These materials will also be showcased at our upcoming Ex Officio board meeting and annual conferences. The final documents will also be posted on our website. Manitoba is also doing research with cattail bio mass and nutrient reduction but on a much smaller scale than North Ottawa. They are extremely interested in the results and continued data that will come out of this project. The RRBC and our partners have done more than 5 tours of North Ottawa since the beginning of this project in 2014.

RRBC Staff have presented too many entities as part of the RRBC's larger outreach strategy around the basin about this effort and conclusions and recommendations for the future. We are diligently working to communicate the excellent data that has come out of this effort to other entities to garner future financial support to continue monitoring for the foreseeable future. This would allow an opportunity to understand the system and the uncontrollable variables that impact the functioning of this impoundment and how that translates into water quality benefits. It will also speak to the longevity of these types of projects and the life of nutrient capture in impoundments. We will be able to use this information and apply to projects of this nature and hopefully one day be provide quantitative data in proposed retention/detention project cost benefit ratios.

Project Completed: 06/30/2018

[**FINAL REPORT**](#)

[**Cattail Nutrient Removal: Handout**](#)

[**Feeding Green Cattails: Handout**](#)

[**Harvesting Cattails: Handout**](#)

Subd. 07 Land Acquisition, Habitat, and Recreation

Scientific and Natural Area Acquisition, Restoration, Improvement and Citizen Engagement

Subd. 07a \$2,540,000 TF

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Appropriation Language

\$2,540,000 the second year is from the trust fund to the commissioner of natural resources to acquire lands with high-quality native plant communities and rare features to be established as scientific and natural areas as provided in Minnesota Statutes, section 86A.05, subdivision 5, restore and improve parts of scientific and natural areas, and provide technical assistance and outreach. A list of proposed acquisitions must be provided as part of the required work program. Land acquired with this appropriation must be sufficiently improved to meet at least minimum management standards, as determined by the commissioner of natural resources. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Minnesota's Scientific and Natural Areas (SNA) Program is an effort to preserve and perpetuate the state's ecological diversity and ensure that no single rare feature is lost from any region of the state. This includes landforms, fossil remains, plant and animal communities, rare and endangered species, and other unique biotic or geological features. These sites play an important role in scientific study, public education, and outdoor recreation. The Minnesota Department of Natural Resources is using this appropriation to permanently protect approximately 240 acres of high quality habitat with rare species and unique natural resources of statewide significance; to restore approximately 770 acres of existing SNAs to conserve the rare features they protect; and to monitor existing SNAs to gauge, improve, and verify that site specific conservation values are protected and achieved. The project includes engagement activities for local communities to help build a network of people to be involved with their local SNAs.

OVERALL PROJECT OUTCOME AND RESULTS

Four parcels totaling 395 acres (238 acres pro-rated to this appropriation) were acquired and designated as SNA: two parcels totaling 286 acres (225 prorated acres) became the new **Brownsville Bluff SNA** (Houston Co); 37 acre (10 prorated acres) new **Crystal Spring SNA** (Washington Co); and 72 acre (4 pro-rated acres) new **Lawrence Creek SNA** (Chisago Co).

Habitat restoration and enhancement project activities on over 1100 acres were completed including: construction of a 31-acre deer enclosure for a woodland restoration project; invasive species treatment on 442 acres at 46 SNAs; prescribed burns on 687 acres at 14 SNAs and prescribed haying on 120 acres at 2 SNAs; and site development work at 38 SNAs, plus new interpretive signs for 8 SNAs. Adaptive Management Plans were written for 9 SNAs and staff collaborated on 9 partner-led projects. Ecological inventory/monitoring of key species/features was completed on 16 SNAs to inform or evaluate restoration and enhancement projects. The SNA Facebook page achieved over 4,150 page likes. The SNA Flickr social media channel was launched with 42 members sharing over 675 high quality photos. Nature Notes e-newsletter was delivered to over 3,900 subscribers. Improvements to the SNA webpage included improved usability on mobile device, fully revised and Visiting Guidelines section of the SNA webpage and new/enhanced site descriptions. A series of three native lady's-slippers posters were developed (2000 each) and distributed to promote SNAs and Minnesota's native wildflowers. About 180 educational and natural resource management events were held involving over 1670 people. One or more volunteer site stewards help monitor and care for 131 SNAs (79% of SNAs – with a total of 165 site stewards). Regular communications are made with the stewards and SNA staff have provided site stewards (and other volunteers) with personal protective equipment to use during SNA events.

PROJECT RESULTS USE AND DISSEMINATION

The SNA program uses multiple media to engage the people of Minnesota in SNAs and to inform them about work done with support from ENRTF. The extent of outreach supported by this appropriation include the following. The SNA Facebook (<https://www.facebook.com/MinnesotaSNAs>) page has achieved over 4,150 page likes by June 2017. The SNA Flickr (https://www.flickr.com/groups/minnesota_snas/) social media channel was launched in February 2015; the site allows high quality photo sharing and with 42 members sharing over 675 photos. The 16th (Winter 2015) issue of the Nature Notes e-newsletter (<http://www.dnr.state.mn.us/snas/enews.html>) was delivered to over 3,900 subscribers. Improvements to the SNA webpage (<http://www.dnr.state.mn.us/snas/index.html>) include conversion of slideshows for each site from Flash to Javascript in order to improve usability on mobile device and the Visiting Guidelines section of the SNA webpage was fully revised and new/enhanced site descriptions have been written. Acquisitions acquired with this ENRTF appropriation are also featured on the website: Brownsville Bluff (<http://www.dnr.state.mn.us/snas/detail.html?id=sna02067>), Crystal Spring (<http://www.dnr.state.mn.us/snas/detail.html?id=sna02068>), and Lawrence Creek (<http://www.dnr.state.mn.us/snas/detail.html?id=sna02065>). A series of three native lady's-slippers posters were designed, printed (2000 each), and mostly distributed in order to promote SNAs ("Visit the Wild Places") and Minnesota's native wildflowers. Data and feedback were obtained from people seeking the first released copies of the 1st poster.

Project Completed: 06/30/2017

FINAL REPORT

Martin County Park and Natural Area Acquisition

Subd. 07e \$435,000 TF

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Appropriation Language

\$435,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Fox Lake Conservation League, Inc. and Martin County to acquire approximately 40 acres in Martin County, including a ten-acre prairie remnant to be owned and managed by Martin County as part of its park system. A vegetation management plan must be developed and implemented and public access must be provided to the native prairie remnant. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

After years of discussions, some of the most diverse riparian, mesic, and dry hillside native prairie containing the only identified remnant population of Prairie Bush Clover in Martin County is available for permanent protection. Martin County is using this appropriation to acquire and permanently protect approximately 40 acres, including 10 acres of remnant prairie. The land will be turned into a county park providing recreational opportunities for local residents and educational opportunities for area students.

OVERALL PROJECT OUTCOME AND RESULTS

The primary goal of this project was to permanently protect Martin County's only known Prairie Bush Clover population, the ten-acre prairie remnant and a thirty-acre buffer. Adding this piece of native prairie habitat to the Perch Lake, Timberlane, Bright Lake and Cedar-Hanson County Parks which include native riparian forest habitats seemed the best way to protect it.

After a failed attempt to enroll the prairie remnant in the Prairie Bank program, several years went by before the landowner decided he may be willing to sell it as land prices rose to record highs. His asking price was four hundred thousand dollars for the forty that held the prairie remnant. He stated, "it is hilly, but grows good crops," and nearby cropland had just sold for 20% more than he was asking. So, we put together an application to the LCCMR outlining the value of probably the highest quality dry hillside and mesic prairie remnant remaining in Martin County, pointing out its proximity to the Martin County West School in Trimont, its value to students and the public. Wind energy generating towers were claiming similar positions on nearby hilltops.

Since starting to work with the landowner, new requirements that capped the amount that could be paid per acre for land acquisitions, appraisal requirements, a landowner request for payments to be made over three years, requiring a one-year project extension, were issues that delayed progress but were overcome.

A prairie plan was developed which includes a vegetation management plan and an infrastructure plan. An access, parking area and approximately 1,700 feet of trail were installed. Mechanical and chemical invasive species removal continues and prairie restoration work including weed control has been done and will continue for several years as the prairie remnant buffer is expanded. Handicap parking is adjacent to and at the same level as the trail. To benefit all Minnesotans, the entire trail up to and including the overlook is expected to be handicap accessible.

Once transplants and seeded plants become established in the clump plantings adjacent to the trail, signage will be installed to identify plant species. Our project suggests that we protect and buffer the best!

PROJECT RESULTS USE AND DISSEMINATION

The Martin County Park Board provided project leadership throughout the grant period, at monthly meetings, visited the site several times, and reported to the County Board and the community. The FLCL Board discussed priorities and project progress at monthly meetings and provided information to the public. The Martin SWCD featured the project with articles and photos, in the January and June editions of the "Conservation Update" and talked about the project on their weekly radio program throughout the grant period and offered visits to the site for "First Rite of Spring" celebrations as well as at other times of the year. Project information was offered at other public meetings, including the County Board, Martin SWCD, Water Plan Advisory Committee, and Martin County Conservation Club. Many photos of the site are available. Check the Martin SWCD website: www.martinswcd.net and the FLCL website: www.foxlakeconservation.com

Project Completed: 06/30/2018 [Extended in M.L. 2016, Chapter 186]

FINAL REPORT

Minnesota River Water Trailhead and Landing in Morton

Subd. 07f \$198,000 TF

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Appropriation Language

\$198,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the city of Morton to transform a municipal parcel from a compost site into a Minnesota River water trailhead and landing and to design and build interpretative trails around the landing complex. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Morton, Minnesota is home to many unique natural, cultural, and historic sites, including sites from the US-Dakota War and some of the oldest exposed rock, called Morton Gneiss, on the planet. The City of Morton is using this appropriation to develop a municipal site along the Minnesota River in Morton to be converted into a public canoe landing and campground and a trail connection between the Minnesota River State Water Trail and natural and cultural sites in the area including the Morton Outcrop Scientific and Natural Area. The project will provide increased recreational opportunities and amenities for users and provide a natural classroom for students to learn about the river.

OVERALL PROJECT OUTCOME AND RESULTS

The Charles Eastman Canoe Landing in Morton Minnesota, located on the Minnesota River has been completed. The project began with the removal of buckthorn and other invasive species on the entire site by a Conservation Corp of Minnesota work crew.

A picnic shelter/outdoor classroom was constructed on the rock outcropping overlooking the river. In order to make this portion of the project fully accessible, a new road was constructed from the existing city street, a dedicated parking area was paved, and a bathroom area and a sidewalk to the shelter was constructed.

Several large granite blocks, mined in Morton, were moved to the site and arranged to create an amphitheater classroom.

Three primitive campsites, each with a crushed granite base and a fire ring, were constructed.

Trails, internal to the site, interconnect the canoe loading/unloading area with the canoe landing ramp, to the campsites, and to the shelter/classroom were constructed.

A cement plank canoe landing was installed on the riverbank.

A parking area was constructed.

The parking area, the trails connecting the parking area to the shelter, the camping sites, and to the river landing site were constructed by removing invasive plants and putting down a layer of crushed granite, a vegetation barrier, and an additional layer of crushed granite.

Interpretative, informational, and directional signage was designed, created, and installed. This signage includes a sign, conforming to Minnesota Historical Society standards for markers, that describes the life of Charles Eastman. An important element of the signage is a tasteful but prominent sign, visible from the river, announcing the landing site to paddlers.

This entire project was designed and completed not only to provide a canoe landing and trailhead, but to serve as a model for other communities along the Minnesota River State Water Trail as to how those communities can create a welcoming landing and wayside for paddlers and other recreational users of the Minnesota River.

PROJECT RESULTS USE AND DISSEMINATION

The public has been informed of this project through local news media including coverage of a well-attended dedication event in September of 2016. Speakers at this event included the Chairman of the Lower Sioux Tribal Community, the Regional DNR Supervisor, and a member of the LCCMR.

The Minnesota Department of Natural Resources has been formally asked to include this landing, trailhead, and campsite on the official Minnesota State Water Trail maps for this section of the Minnesota River.

A two-county tourism promotion organization, the Tatanka Bluffs Corridor Committee, has been asked and will feature pictures of the trailhead site in its upcoming 2017 visitors guide.

The Morton Chamber of Commerce has included promotion of the site on its web site/Facebook page.

All dissemination efforts, including the main entrance sign, prominently cite the Environment and Natural Resources Trust Fund and the LCCMR as the source of funding to complete this project.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Subd. 08 Air Quality, Climate Change, and Renewable Energy

Solar Cell Materials from Sulfur and Common Metals - RESEARCH

Subd. 08a \$494,000 TF

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Appropriation Language

\$494,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to develop solar cell materials using nontoxic and common metals combined with sulfur. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Sustainable energy production is a major challenge facing our society. Solar energy is renewable and is a viable and attractive option. However, there are obstacles to widespread use. Current technology is expensive, making it difficult for businesses and homeowners to implement, and solar cells are commonly made using toxic and rare elements or using processes that require large amounts of energy. To become commonplace, solar cells must be inexpensive and robust, and they must be made of abundant, cheap, nontoxic materials. Researchers at the University of Minnesota are using this appropriation to develop and test an innovative, more energy and time-efficient method for producing thin film solar cells made of sulfur and common metals instead of the more toxic and rare elements currently used in most cases.

OVERALL PROJECT OUTCOME AND RESULTS

We successfully synthesized the proposed transition metal sulfide materials with controlled composition. Preparing materials without impurities, which essential for success since impurities in the thin film of light absorbing material will cause solar cells to fail, was particularly challenging. We identified which synthetic variables are most important for preventing impurities. In addition, we can successfully control particle size, which is important for making high quality thin films of these materials. We developed a reproducible protocol for preparing thin films of the particles. We examined effects of annealing conditions (sulfur partial pressure, heating rate, heating time, pre-annealing compaction, the nature of the molybdenum layer beneath the CZTS particles, and more) on the CZTS films and were able to identify ideal conditions for the necessary annealing step. A particularly exciting outcome was the development of a protocol for removing impurities from the thin films. During the annealing step, impurities often form even when the thin films are prepared using pure material. To solve this problem, we developed a selective etching method that effectively removes those impurities ("Selective Etching of Light Absorber Substrates", Application No. 62/328,851, which was filed April 28, 2016 but did not proceed to patent status).

Our biggest outcome expected was a fundamental advance in our ability to make high quality thin films of photovoltaic quality CZTS, and we did succeed in that regard. High quality thin films are required for the fabrication of high performing solar cells. In addition, we developed a green synthetic method for the controlled production of CZTS nanoparticles and can prepare high quality, microcrystalline thin films on conductive substrates using the microwave synthesis method. Unfortunately, we did not realize our final goal, which was to make a prototype solar cell fabricated using the aforementioned materials.

PROJECT RESULTS USE AND DISSEMINATION

We have published three papers in the peer-reviewed literature describing our results and two additional papers that are currently in review with scientific journals.

Unfortunately, Application No. 62/328,851, which was filed April 28, 2016, did not proceed to patent status. Our technology would have been used in the production of both copper indium gallium disulfide (CIGS) and copper zinc tin sulfide (CZTS) thin film solar cells. The changing solar cell market landscape and continued significant dominance of silicon solar cells over CIGS and CZTS devalued our technology despite its green advantages. Silicon solar cells now dominate over 90% of the solar cell market. Moreover, the provisional patent application was returned with objections and to narrow the claims. Continuing the patent application for these reasons did not make economic sense.

Project Completed: 06/30/2017

FINAL REPORT

Synthesis of nanocrystals and formation of polycrystalline: Publication

Controlling (CZTS) phase in microwave solvothermal synthesis: Publication

Chemically Deposited CdS Buffer: Publication

Innovative Groundwater-Enhanced Geothermal Heat Pump Study

Subd. 08b \$196,000 TF

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Appropriation Language

\$196,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to analyze and validate a new geothermal pump method and technology that will reduce heat pump costs and improve performance and predictability. This appropriation is subject to Minnesota Statutes, section 116P.10.

Project Overview

Space and water heating and cooling consume 48% of all energy used in an average U.S. residence, and usually that energy is supplied by natural gas or fossil-fuel derived electricity. Geothermal heat pumps can reduce energy requirements for heating and cooling by up to 75%. However, traditional geothermal heat pumps are expensive and their performance is difficult to predict before installation. Researchers at the University of Minnesota are using this appropriation to develop, test, and demonstrate a novel geothermal heat pump technology that utilizes the heat exchange of groundwater flow to be more efficient, less space intensive, and less costly than current conventional geothermal systems. The technology has the potential to make geothermal heat pump systems have a faster payback period, resulting in more widespread use, and give geothermal a larger role in renewable energy production.

OVERALL PROJECT OUTCOME AND RESULTS

The objective of this project was to provide extensive numerical modeling and lab demonstration of a novel geothermal/groundsource heat pump (GHP) that was previously-devised and underwent initial modeling at the University of Minnesota.

GHP's can reduce energy requirements for heating/cooling, which account for approx. 48% of average US residential energy usage, by 75%. However, traditional GHPs are expensive, and their performance is difficult to predict before installation. Our novel, groundwater-enhanced GHP method/technology should substantially reduce GHP costs while improving performance and predictability by taking advantage of the thermal transport properties of groundwater in a closed-loop fashion so that no groundwater is used and no contaminants are introduced to the subsurface.

This project sought to determine whether the groundwater-enhanced GHP was technically feasible through a combination of detailed numerical simulation and simple lab tests. For the numerical modeling, we used the codes COMSOL and OpenGeoSystem to simulate operation of our GHP in a geologic environment, specifically examining heat transfer between the GHP and groundwater over a variety of temperatures and fluid flow rates. For lab testing, we constructed a simple, simulated GHP environment and a basic version of our novel heat exchanger, permitting the performance of this exchanger to be tested and compared against conventional GHP units. Our

numerical and lab results indicated that under a broad range of conditions, our novel GHP performs very effectively, with the practical result that fewer boreholes – as little as 1/5th to 1/10th – would be needed in real-world GHP installations using this approach as compared to conventional technologies. As boreholes are up to 50% of the cost of GHP installations, our method/technology should make GHP's more economically viable.

To follow this project and demonstrate commercial viability of the groundwater-enhanced GHP, we must next demonstrate the technology in a series of full field tests. To that end, we have several pending grant proposals submitted or in process, and we have engaged a local engineering firm to construct these field studies. Our ultimate objective is to increase the use of GHP's in MN and beyond, decreasing emissions and energy costs related to heating and cooling.

PROJECT RESULTS USE AND DISSEMINATION

To date, dissemination of project results has been limited in order to ensure that the design and performance of the novel groundwater-enhanced GHP remain confidential prior to filing of a patent application. As noted in the workplan, an intellectual property disclosure was submitted to the UMN Office for Technology Commercialization prior to initiation of this project.

Once a patent application has been submitted, we intend to submit our research for publication in a peer-reviewed journal.

Project Completed: 06/30/2017 [Extended in M.L. 2016, Chapter 186]

[FINAL REPORT](#)

Demonstrating Innovative Technologies to Fully Utilize Wastewater Resources - RESEARCH

Subd. 08c \$1,000,000 TF

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Appropriation Language

\$1,000,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to demonstrate innovative technologies to utilize and treat wastewater streams for conversion of treatment by-products to biofuels. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Each year Minnesota municipal wastewater treatment plants generate large amounts of oily scum, concentrated liquid called centrate, and sludge. These waste streams are disposed of either in landfills or by burning or subjected to additional treatment. However, new technologies have shown potential to capture resource values from these waste products while lowering the treatment costs for these waste streams. Researchers at the University of Minnesota are using this appropriation to demonstrate the feasibility and effectiveness of several technologies that implemented together in a wastewater treatment system could improve wastewater treatment while generating valuable biofuel byproducts. Expected benefits of the technologies include reduced landfill contributions, reduced fossil fuel use, cost savings and revenue generation for wastewater treatment plants, and reduced air and water pollution.

OVERALL PROJECT OUTCOME AND RESULTS

Minnesota municipal wastewater treatment plants (MWTP) generate large amounts of oily scum, concentrated liquid (also called “centrate”), and sludge each year. These waste streams are either used as landfill (scum) and direct burning (sludge), or subjected to additional treatment (centrate). The goal of the project was to demonstrate the feasibility and effectiveness of implementing innovative technologies in municipal wastewater treatment plants. Three main activities were carried out during the project: (1) Processes have been developed to convert wastewater scum to biodiesel meeting the relevant ASTM standards, (2) Processes have been developed for sustainable growth of microalgae on centrate and full utilization of nutrients in the centrate stream, and (3) new processes have been developed thermochemically convert sludge to high value energy and materials. During the research, the processes were evaluated for effectiveness and efficiency. Pilot scale systems for designed and fabricated for scum to biodiesel conversion, mass cultivation of microalgae on centrate supplemented by glycerol, and microwave assisted conversion of sludge to bioenergy and biomaterials. Four graduate students and four research scientists were involved and trained during the project. One patent for scum to biodiesel production was filed and one propitiatory technology for fast microwave assisted pyrolysis has been licensed to a company. More than 30 papers have been published on peer-reviewed journals. More than 10 presentations have been presented in state, national, and international meetings. Demonstration of the pilot systems has been given to Superior Process Technology, Resynergi Inc., Minnesga Inc., LZL Engineering, eVende, Metro Council Environmental Service. Media interviews have been given to Minnesota Daily, Channel 5, and Channel 11. The outcome of the project has significant impacts on Minnesota’s renewable energy production, environment conservation and protection, and economy and jobs. The new technologies can be implemented in mid to large size municipal wastewater treatment plants in Minnesota and elsewhere, producing significant amounts of renewable energy for internal use or to be distributed to the market, resulting in significant savings for waste management and disposal, generating considerable revenues.

PROJECT RESULTS USE AND DISSEMINATION

1. The research activities were used to train students and junior researchers. Research findings were used to enhance classroom teaching materials
2. Research findings were published in peer-reviewed papers (>30), presented in state, national, and international meetings (>10)
3. One patent was filed and one propitiatory technology has been approved and licensed to a US company
4. The technologies developed from the project have been demonstrated to various stakeholders
5. The project was reported by local newspapers and TV stations

Project Completed: 06/30/2017

[FINAL REPORT](#)

Transitioning Minnesota Farms to Local Energy

Subd. 08d \$500,000 TF

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Appropriation Language

\$500,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the West Central Research and Outreach Center in Morris to develop clean energy strategies for Minnesota farms in order to reduce fossil fuel energy use and increase local energy production. Any installation of infrastructure or improvements must be at the University of Minnesota West Central Research and Outreach Center. This

appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Production agriculture's dependence on fossil fuel energy carries significant economic and ecological risks. The energy consumed within livestock facilities alone is the equivalent consumption of several large cities, and agriculture currently contributes approximately 14% of the total greenhouse gas emissions in the state. As consumers increasingly demand low carbon footprint products, adoption of clean energy systems in crop and livestock production would position Minnesota's agricultural sector with a competitive advantage. While Minnesota farmers have historically adopted technology to more efficiently use resources and optimize production, implementation of clean energy technologies on farms has been slow to date and farmers continue to opt for conventional fossil-based energy. In response to this, researchers at the University of Minnesota West Central Research and Outreach Center are using this appropriation to develop, test, and evaluate options for clean energy systems for modern swine production facilities and conduct associated outreach to increase adoption of clean energy systems at these facilities.

OVERALL PROJECT OUTCOME AND RESULTS

Agriculture production requires large amounts of fossil energy. The use of fossil energy for agriculture impacts the environment, air, water, and economy. The goal of this project was to provide swine producers with research-based information enabling the transition to clean, locally-produced energy. The project was organized into four tasks.

The first task was to design clean energy systems for modern swine facilities.

- Energy consumption was audited at six commercial swine production facilities and the West Central Research and Outreach Center (WCROC).
- Facilities included breed-to-wean, nursery, and finishing buildings.
- Energy consumption data enabled rankings of energy loads for each phase of production.
- Results, for example, indicated that heat lamps for piglets used on average 49% of the electrical energy consumed in a farrowing facility. Producers would benefit by upgrading to energy efficient heating for piglets.
- An engineering firm analyzed several energy efficiency measures (EEM) appropriate for swine production to reduce energy consumption.
- Return on Investments (ROI) were calculated for each EEM.

Task two involved field testing of a clean energy system.

- A 27 kW solar PV system was installed and tested on the WCROC swine finishing facility.
- The system provided all energy consumed within the facility generating 30,000 kWhr per year.
- Solar PV system ROIs were modeled for commercial swine facilities. Installation costs are declining but incentives are still needed to achieve simple paybacks under 10 to 15 years.

Life Cycle Assessment (LCA) was employed in Task 3.

- LCA was used to analyze the amount of fossil energy consumed and carbon dioxide emitted during swine production. Energy improvements were also modeled.
- Results indicated the Global Warming Potential (GWP) emissions in the broader swine lifecycle were highest for feed production, which accounted for almost 60% percent of fossil energy and 50% of greenhouse gas emissions.
- Producers have management control on roughly 25% of the fossil energy consumed.
- On-farm renewable energy systems can significantly lower fossil energy use on farms.

Task 4 involved dissemination of results and education which is described below.

PROJECT RESULTS USE AND DISSEMINATION

The Midwest Farm Energy Conference was hosted at the WCROC in June 2017. Approximately 90 farmers and other guests participated in the event. Swine energy workshops were conducted in other regions of the State. Energy information was provided to producers, who in total, market over 3 million pigs per year and represent

over 90% of the State's annual production. In addition, energy curriculum was developed for agriculture and science educators teaching secondary and post-secondary technical students. The curriculum is being made available on-line. Additional materials including conference video and slide presentations can be accessed at <https://wcroc.cfans.umn.edu/research-programs/renewable-energy>.

Project Completed: 06/30/2017

FINAL REPORT

Task 1: Designing Clean Energy Systems

Task 2: Field Testing of Clean Energy Systems

Task 3: Life Cycle Assessment (LCA)

Task 4: Dissemination of results and education

Life Cycle Energy of Renewably Produced Nitrogen Fertilizers

Subd. 08e \$250,000 TF

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Appropriation Language

\$250,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the West Central Research and Outreach Center in Morris to calculate fossil fuel energy savings and greenhouse gas reductions resulting from the use of local renewable energy technologies, including biomass gasification, anaerobic digestion, and hydroelectricity to produce fertilizer. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Minnesota supports over 14 million acres of cropland in grain production. Almost 600,000 tons of synthetic nitrogen fertilizers are needed annually to maintain productivity on this land, which requires the equivalent of 3,000,000 barrels of oil and costs farmers over \$400 million dollars per year. This amount of fossil fuel use results in a significant amount of greenhouse gas emissions, while the absence of fossil energy resources in the state means that these synthetic nitrogen fertilizers must be imported into Minnesota from other states and overseas. In response to this, researchers at the University of Minnesota West Central Research and Outreach Center are using this appropriation to conduct modeling and analysis of the viability of options for using different renewable energy technologies that could be implemented in Minnesota for generating nitrogen fertilizer. Findings have the potential to help reduce agricultural energy related production costs and make rural communities more energy independent.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota landscape supports over 14 million acres of grain production, requiring almost 600,000 tons of nitrogen fertilizers and costing over \$400 million annually. Producing this fertilizer consumes the equivalent of 3,000,000 barrels of oil, which is a significant use of fossil fuels resulting in a considerable amount of greenhouse gas emissions. Minnesota has renewable technologies that are capable of the constant energy generation needed to produce ammonia, which would promote economic development, spur job creation in rural areas and improve the overall sustainability of agriculture. This project examined the viability of developing these baseload renewable energy sources for ammonia production.

Using life-cycle assessment and techno-economic modeling, the research examined ammonia production with three renewable energy options; gasification, anaerobic digestion and hydroelectric systems. The findings indicate that from both a technical and environmental standpoint, these renewable production systems can produce renewable ammonia fertilizer. However, the present economics make investing in renewable ammonia production unfeasible at this time. The current and continued low price of natural gas prices suggests that low cost fossil-based ammonia is a more economical option at this point. Past shortages and price spikes in ammonia fertilizers indicate that the economics and need for the systems might re-appear under different conditions. Yet, it is unlikely that these renewable ammonia systems would be viable in the short term without a significant consumer or other regulatory demand. Ammonia fertilizer is critical to Minnesota's agriculture and the information from this study is available should alternative ammonia production need to be implemented on short notice.

PROJECT RESULTS USE AND DISSEMINATION

The project used two main paths to disseminate scientific, technology, and economic information. The first was in-person via presentations to the wide variety of stakeholders interested in ammonia, agriculture, sustainability and rural development. Many of these interactions are during facility tours of the West Central Research and Outreach Center's agricultural renewable energy facilities and production systems. However, team members have given a variety of presentation and talks on renewable ammonia production and renewable energy to the chemical engineering and ammonia energy interests. This is in addition to general discussions on farming energy inputs and improving farming sustainability that we normally have at conferences, in classrooms, and at farming events. The international members of the team have broadened the in-person dissemination beyond the Midwest. The other main focus of dissemination is print and online media. Both can be used for reaching audiences that are not able to physically visit or meet with us at conferences. These formats also allow for informing audiences with a wide range of skills and interests. For the more academic audiences, we are developing a technical paper that will be published in an academic journal. The findings of the study are being written up as an internally published white-paper document for those interested in the practical finding from the work. Smaller summaries were developed as a handout for general audiences. All of these documents are or will be available on the project's website at <https://wcroc.cfans.umn.edu/green-nh3-lifecycle>. The site also has links to other ammonia, agriculture, and research topics being studied by the West Central Research and Outreach Center and University of Minnesota Researchers.

Project Completed: 06/30/2017

[FINAL REPORT](#)

[Renewable Hydrogen Energy Pilot Program](#)

[Modeling Anaerobic Digestion Based Ammonia Production](#)

[Gasification-Based Ammonia Ethanol Production Model](#)

Clean Water and Renewable Energy from Beet Processing Wastewater and Manure - RESEARCH

Subd. 08f \$400,000 TF

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Appropriation Language

\$400,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the Southern Research and Outreach Center in Waseca to research the cofermentation of sugar beet processing wastewater and swine manure for hydrogen and methane production and to install and evaluate a pilot-scale

system. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Minnesota ranks #2 in hog production and #1 in sugar beet production in the U.S., generating about 11 million tons of pig manure and over one million tons of sugar processing wastes annually. Presently there are not cost-effective methods available to deal with these waste streams other than land application, which usually results in nutrient runoff into ground and surface water resources. Better treatment of these waste streams is necessary, but treatment alone is not only expensive but usually fails to capture resource values contained within these waste streams that could be put to other uses. Additionally, these two waste streams together contain complimentary nutrients needed for biological processes such as fermentation and anaerobic digestion. Researchers at the University of Minnesota Southern Research and Outreach Center are using this appropriation to develop, test, and evaluate technologies that utilize these two different agricultural waste streams containing complementary nutrients to produce value-added byproducts in the forms of bioenergy and fertilizer while reducing the negative impact of both waste streams on water quality.

OVERALL PROJECT OUTCOME AND RESULTS

This project has developed a novel treatment system to co-treat swine manure with sugar beet processing wastewater and produce biohydrogen, biomethane, and a slow release fertilizer (struvite). Overall outcomes and results can be summarized in four parts:

1. A continuous biohydrogen and biomethane production process, taking swine manure with sugar beet processing wastewater as feedstock, has been investigated in a two-stage anaerobic sequencing batch reactor (ASBR) system. Three significant operational parameters (pH, hydraulic retention time (HRT), and total solids level (TS) of the swine manure) were identified and the optimal condition was determined to be pH 5.3, HRT 16.5h, and TS 0.78% for the biohydrogen stage with highest yield at 1.52 mol-H₂/mol glucose, while pH 6.9 and HRT 51h was determined for the highest biomethane yield of 0.21 g-CH₄/g-COD-feed;
2. A wet-scrubbing biogas purification system for cleaning both biohydrogen and biomethane gases was investigated with optimal gas flow rate at 0.84L/min and 1.32L/min, with 0.3M and 0.2M NaOH solution, 6 min and 9 min replacing interval, respectively, to achieve complete CO₂ removal;
3. A struvite precipitation reactor system with pH 9.0, Mg²⁺/PO₄³⁻ molar ratio at 1.5, air flow at 2 LPM for 30 mins determined for efficient struvite formation of 650 mg per liter upstream waste;
4. An integrated system including the above three units has achieved a daily production of 7.8L/d H₂, 28.3L/d CH₄, and 1.95g/d struvite, with removal efficiency of TS, COD, TN and TP at 49.6, 76.5%, 65.8% and 76.8%, respectively, with a negative net energy gain due to the small system size and relatively high running cost.

A pilot scale system with 1000-gallon daily loading was estimated to have a positive energy gain of 630 kWh/d and the payback period for its capital and running cost will be nearly 2 years not considering maintenance cost.

PROJECT RESULTS USE AND DISSEMINATION

Results produced from this project has been incorporated in teaching material for courses: BBE 4733/5733 – Renewable Energy Technologies at Department of Bioproducts and Biosystems Engineering, University of Minnesota, lectured by Xiao Wu, 2015-2016; BE 461 – Bioprocessing Engineering at Department of Biological Engineering, University of Idaho, lectured by Xiao Wu, 2017.

An oral presentation has been made at ASABE 110th Annual International Meeting, with paper#: #1701057, at Spokane, Washington. July 16-19, 2017. Presenters: Wu, S., S. Deng, J. Zhu. Title: Hydrogen and methane production from swine manure and sugar beet wastewater by a two-step ASBR system.

Dissemination of this project will continue with publishing refereed and non-refereed articles, talking to people in the concerned industries and the stakeholders, developing teaching materials in college and graduate levels,

demonstration of the complete system for co-treating swine manure and sugar processing waste molasses and education of stake holders and general public, etc.

Project Completed: 06/30/2017

FINAL REPORT

Journal of Integrative Agriculture Paper Publication

Next Generation Large-Scale Septic Tank Systems - RESEARCH

Subd. 08g \$258,000 TF

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Appropriation Language

\$258,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to develop a dual utility large-scale septic tank system designed for nutrient recuperation, bioenergy generation, and environmental protection using a bio-electrochemical system. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Septic tank systems aim to treat sewage generated by homes and facilities that do not have access to centralized wastewater treatment plants. Currently 25% of the U.S. population relies on these systems as their primary means of wastewater treatment. However, the treatment capabilities of these systems are limited and so byproducts can contribute to degradation of water resources and other environmental problems and the systems emit instead of collect powerful greenhouse gases such as methane. Additionally, the systems are actually an untapped source for recovering nutrients for other uses. Researchers at the University of Minnesota are using this appropriation to develop, test, and evaluate technologies to improve large-scale septic systems to be more effective and capable of capturing valuable nutrients from the waste stream and generating bioenergy. The technologies could be integrated into existing septic tank systems and the information will be helpful to wastewater professionals in designing next generation septic systems.

OVERALL PROJECT OUTCOME AND RESULTS

Septic systems treat sewage generated from homes and mid-sized facilities that do not have access to centralized wastewater treatment plants. They are effective in retaining and degrading organic matters in the sewage, however, the tanks do not substantially decrease phosphorus nutrients in effluent. The nutrients may enter surrounding aquatic environment and have a negative impact in water bodies such as lakes and rivers. To overcome the limitation, we developed a novel septic system that is better at removing phosphorus and organic matter than conventional septic tanks by using a "microbial electrolytic cell" which uses electricity to promote biological reactions inside the tank. Different reactor designs, sizes and operational parameters were investigated, i.e., from laboratory scale to pilot scale. Laboratory scale experiments were carried out at the University of Minnesota - Department of Bioproducts and Biosystems Engineering and the pilot scale was tested at the Saint Paul Municipal Wastewater Treatment Plant of Metropolitan Council Environmental Services. A preliminary techno-economic assessment showed that around one third additional installation cost is needed to implement this technology, and this enables 50%-90% of the phosphorus removal from the sewage, compared to the conventional septic system. The collaboration with the Metropolitan Council Environmental Services led to the development of a new technology that can help communities effectively manage their wastewater treatment

systems and improve public health and the environment. The technology developed from this project, together with the information obtained from the techno-economic analysis, could be useful to thousands of rural communities and help decision-making process of trying the novel tank configuration. When communities effectively manage their wastewater treatment systems, public health and the environment are adequately protected while the community has the management structure in place over the long-term.

PROJECT RESULTS USE AND DISSEMINATION

The technology developed from this project, together with the information obtained from the techno-economic analysis, can be beneficial to Minnesota septic tank users, which account for about 20%-25% of its population. Besides the academic dissemination, a video of showcasing the pilot-scale testing system was posted in our website (<http://bohu.cfans.umn.edu/>) and youtube (<https://z.umn.edu/lccmr-video>) for general public access. Important and practical results from this project will also be disseminated in relevant workshops or in Onsite Sewage Treatment Program of UMN. During the study, project information, results, and major achievements have been disseminated through multiple ways. While we are preparing another two manuscripts for peer-reviewed publication, one paper was published. Four oral presentations were made in 2014 and 2016 AIChE conferences, and in 2015 and 2016 ASABE AIM conferences. Two posters were also presented in the Department of Bioproducts and Biosystems Engineering Showcase.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Subd. 09 Environmental Education

Minnesota Conservation Apprenticeship Academy

Subd. 09a \$392,000 TF

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Appropriation Language

\$392,000 the second year is from the trust fund to the Board of Water and Soil Resources in cooperation with Conservation Corps Minnesota to continue a program to train and mentor future conservation professionals by providing apprenticeship service opportunities with soil and water conservation districts. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Many of the most experienced conservation practitioners at local soil and water conservation districts throughout the state are nearing retirement, and with their departure will go much of their practical, on-the-ground knowledge, experience, and skills. Meanwhile, college students seeking to be the next generation of conservation practitioners have knowledge of emerging technologies and other innovations that can improve and contribute to current conservation efforts. Through this appropriation the Minnesota Board of Soil and Water Resources will work with the Minnesota Conservation Corps to continue a program that places students in apprenticeship positions with county soil and water conservation district offices throughout the state. This unique program provides an opportunity for interns to gain valuable in-the-field experience from current practitioners while sharing their knowledge with those practitioners about the newest ideas and solutions for meeting today's natural resource challenges.

OVERALL PROJECT OUTCOME AND RESULTS

Future conservation leaders need to be familiar with Minnesota's widely varying land-use practices, water and soil resources, plant and animal habitats, and landowner concerns if we hope to maintain the capacity of local organizations to deliver conservation on the ground. While college graduates with conservation-related degrees are knowledgeable in technology, theory, and research methods, they still need to develop their on-the-ground skills. Communicating with landowners and implementing quality projects are vital to the success of conservation efforts and best learned from seasoned professionals. The Conservation Apprenticeship Academy transfers knowledge from experienced Soil and Water Conservation District professionals to the next generation of conservation managers. Real-world experience gained with Soil and Water Conservation Districts (SWCDs) during their busy season is experience that textbooks cannot convey.

This project funded the placement of 30 apprentices in 2015, 31 apprentices in 2016, and 32 apprentices for the first part of 2017. During this time the apprentices stabilized erosion on 916,318 square feet of slopes, planted 61,201 plants, trees, shrubs and seedlings, maintained 22.6 million square feet of restored areas, collected 3,505 water samples and impacted 2,451 people through environmental education and outreach.

In addition to these environmental benefits, the program also has a positive impact on students and conservation districts. 100% of apprentices indicated they felt more prepared to work in the conservation industry as a result of the program, and would recommend it to others. 95% of the Districts were satisfied with the work their apprentices completed, and 99% said they would participate in the program again. Managers also indicated that the work conducted by the apprentices increased the amount of conservation practices delivered by their districts during the program period.

PROJECT RESULTS USE AND DISSEMINATION

Information from the project has been disseminated through reports to LCCMR, newsletters by BWSR and through the Conservation Corps newsletter, website and annual report. Information was also used to recruit apprentices. Communication and outreach activities include the aforementioned reports, press releases, and electronic newsletters. Additionally, BWSR and Conservation Corps staff conducted outreach to SWCDs to find optimal matches between districts and apprentices. Through the course of their work, the apprentices conducted significant outreach to land owners and residents in topics ranging from easement protection to water quality education.

Project Completed: 06/30/2017

[FINAL REPORT](#)

Urban Environmental Education Engaging Students in Local Resources

Subd. 09c \$1,093,000 TF

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Appropriation Language

\$1,093,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Wilderness Inquiry for a collaborative partnership, including the National Park Service, Minneapolis Public Schools, and St. Paul Public Schools, to establish a metrowide system providing place-based environmental education experiences using existing, but underutilized, outdoor environmental resources serving over 15,000 middle and

high school students. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

There has been a sharp decline in participation in outdoor recreation and education amongst youth, particularly in urban areas. Some argue that youth who have meaningful outdoor education experiences are more likely to become engaged in environmental stewardship and invested in outdoor resources as adults. Wilderness Inquiry - in partnership with state and federal agencies, non-profits, and local school districts - is using this appropriation to expand an environmental education and recreation program that provides youth with hands-on educational and recreational experiences centered around the Mississippi River. Funds enable the program to offer experiential, place-based educational experiences to nearly 16,000 additional disadvantaged middle and high school students in Minneapolis, St. Paul, and six greater Minnesota school districts. Experiences will include hiking, canoeing, fishing, aquatic sampling, camping, and conservation-related summer employment.

OVERALL PROJECT OUTCOME AND RESULTS

Wilderness Inquiry undertook this project of connecting youth to natural spaces in response to an observation that fewer and fewer young people access and enjoy nature than previous generations. With the growth of the urban population, resource management agencies were not in a position to connect young people to the Mississippi River and its surrounding parks and waterways. Through extensive partnerships with land management entities, federal agencies, local non-profit organizations, and school districts, Wilderness Inquiry exceeded the outcomes of this project by serving more than 25,000 Minnesota youth and families in the Twin Cities metro area and across the state.

- Wilderness Inquiry connected more than 21,000 youth to place-based, outdoor learning through single-day events on the Mississippi River, Minnesota State Parks, St. Paul and Minneapolis Regional Parks, and more.
- 2,794 youth engaged in deeper learning by participating in 2-3 day camping experiences as well as yearlong outdoor clubs. These experiences offered students the opportunity to gain comfort and confidence being outdoors. Fire building and shelter building activities were especially popular on these trips.
- 1,207 youth experienced 4-5 day camping trips or 40+ hours of experiential, place-based learning. These trips included paddling in the Boundary Waters Canoe Area or Voyageurs National Park, hiking in Superior National Forest, or multi-day events in the metro area, exploring the history and ecosystem of the Mississippi River.
- 148 students who participated in multi-day overnight exchange experiences introducing urban and rural youth to each other and the natural resources of each respective area. Despite the project ending in June 2017, Wilderness Inquiry will continue this program due to its success and growth over three years.
- Wilderness Inquiry trained and hired over 50 licensed teachers to lead programs and design content for this project. These professional development opportunities for teachers resulted in hundreds of youth learning MN state-standard curricula through place-based outdoor opportunities. The teachers expressed that they will use the skills they learned and the content they designed in their classes for many years. Empowering educators to connect their students to outdoor learning is one of the greatest accomplishments of this project, and its impact is yet to be truly known.

PROJECT RESULTS USE AND DISSEMINATION

Wilderness Inquiry successfully evaluated and disseminated the outcomes of this project through partnership with the University of Minnesota Center for Applied Research and Educational Improvement. Final report briefs from 2014-2016 evaluations can be found online for the general public at <https://www.wildernessinquiry.org/current-news/research-results/uwca-evaluations/>. Results have been shared with the Wilderness Inquiry staff to ensure continued improvements to training and program models. These findings have been shared at conferences and with our local partners including Minnesota Department of Natural Resources, Minnesota Department of Education, Minneapolis Park & Recreation Board, St. Paul Parks and Recreation, and others. Our work continues to be shared by our national partners including Children & Nature Network, City Parks Alliance, National Park Service,

and National Summer Learning Association. In July 2017, Wilderness Inquiry was selected from a group of finalists to receive a national education award for excellence and innovation in summer learning programs, read more about the honor at <https://www.wildernessinquiry.org/current-news/news-notes/wilderness-inquiry-wins-major-award-national-summer-learning-association/>.

Project Completed: 06/30/2017

FINAL REPORT

Canoe Mobile Evaluation Brief 2016

Urban Wilderness Canoe Adventures Evaluation Brief 2015

Urban Wilderness Canoe Adventures Evaluation Brief 2014

Diversifying Involvement in the Natural Resources Community

Subd. 09d \$500,000 TF

Subd. 09d1 - \$416,000 TF

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Subd. 09d2 - \$84,000 TF

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Appropriation Language

\$416,000 the second year is from the trust fund to the commissioner of natural resources and \$84,000 is to the Board of Regents of the University of Minnesota to increase participation of under-represented communities in the natural resource professions and in outdoor recreation by means of targeted urban outreach and stronger linkages between Department of Natural Resources programs and academic offerings. This initiative must be coordinated with other environmental education appropriations in this subdivision. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Minnesota's natural resource professional workforce is much less diverse than its citizenry and many other professional fields. The benefits of a more diverse workforce are many, including the ability of organizations to increase innovation and creativity, attract higher qualified candidate pools, and ensure services that meet the diverse interests and needs of all citizens. The Department of Natural Resources and the University of Minnesota are using this appropriation to engage diverse urban youth, under-represented in the natural resources community, in natural resources education and developing outdoor recreational skills. Project efforts include connecting youth with close-to-home natural resource recreation and protection issues, a recruitment and retention program to introduce potential career opportunities, support and mentoring for those interested in pursuing natural resources college education and careers, and introductory experiences and internships in natural resources jobs.

DNR Project: OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Department of Natural Resources (DNR), Conservation Corps of Minnesota and Iowa (CCMI), University of Minnesota and US Forest Service (USFS) collaborated on a project targeting the lack of diversity in Minnesota's natural resource professional workforce. To increase involvement in our state's natural resource community, we engaged under-represented urban youth and their families in natural resource programming tailored to their interests and needs.

CCMI developed an employment and education program for high school youth from under-represented communities in the Twin Cities. Over three years, 220 youth received career and academic counseling as well as natural resource experiences. Of that group, 34 youth – “the Bridges Crew” participated in an intensive summer program working alongside DNR and other agency staff. Weekly enrichment days and in-the-field experiences engaged youth in the science of natural resources restoration and management. Their final three weeks were spent working in the Superior National Forest, funded by USFS. Youth evaluations revealed that this capstone experience cemented the bonding experience among crew and with the natural world and showed that 87% of youth had more awareness of and interest in natural resource and natural resource careers than at the start of the program.

DNR hired and mentored five student workers who researched issues and solutions to increasing diversity in natural resource activities and careers. Their work led to the production of career brochures and activities that are widely used by the agency and others to attract a more diverse workforce. These interns planned, organized crew projects and enrichment days. With DNR staff, they collaborated with partners to organize four annual events, marketed to and attended by under-represented communities, introducing over 1800 people per year to outdoor recreation. At these events, the interns shared information about careers and nearby opportunities to continue their outdoor adventures. A summary that outlines the program and lessons learned is available on CCMI's website.

DNR Project: PROJECT RESULTS USE AND DISSEMINATION

CCMI has created a Bridges page on their website that outlines the programs, goals and components of the Bridges Project (<http://www.conservationscorps.org/bridges>). Based on the work of project interns, the DNR produced a career guide and handouts that are aimed at attracting a more diverse workforce. The DNR has shared the career guide with all supervisors in the agency and will be posting them on their website for downloading. These materials are being used by our outreach staff and others, at career fairs and school visits throughout the state. A set of materials have been provided to college and career offices in Minneapolis and St. Paul high schools. The DNR continues to work with outside partners to continue our collaborations and accomplish new avenues to connect with new audiences. For instance, on Aug 12th we partnered with St. Paul Public Housing to have a nature bike ride, with residents enjoying the outdoors. CCMI, DNR and the US Forest Service will continue to collaborate on continuing components of the Bridges crew to the extent future funding will allow. Career engagement materials, activities and guidance documents will be shared with organizations we have work with throughout this project.

U of M Project: OVERALL PROJECT OUTCOME AND RESULTS

The lack of diversity in the natural resource workforce and its educational pipeline is problematic as the need accelerates for a qualified and diverse pool of professionals to replace the retiring generation. Many under-represented students are not aware of natural resources as an alternative to better-known science and engineering careers. To address this issue, the University, in coordination with the Conservation Corps of Minnesota (CCM) Department of Natural Resources (DNR), and US Forest Service (USFS) created a program for under-represented youth that bridged their natural resource work experience with university natural resource pathways and programs.

Overall, we engaged over 225 youth in campus activities in natural resources. During college and career days, youth toured labs and interacted with faculty and students. During summer enrichment days, 34 youth experienced a variety of research and management activities including assessment of invasive aquatics and water quality, bird banding, urban forestry, research at Cedar Creek Reserve and wetlands restoration. For many youth,

this was their first opportunity to handle a fish or a bird, or collect water quality and plant community data. Youth interacted with 8 different university faculty and numerous graduate students, learning about their career paths. Our staff and students valued this experience, as many are committed to enhancing the diversity of the next generation of natural resource professionals.

Post-program surveys showed that the youth gained awareness of and interest in natural resource education pathways and careers. However, our goal of enrolling as many of these youth as possible into the university's Post-Secondary Enrollment Option (PSEO) was less successful. Only two students were accepted into and participated in this highly competitive option. Focus of our work shifted to meet the needs of the youth recruited to work for CCM - counseling and mentoring students to pursue the whole range of college readiness options in high school. In conjunction with our project partners (DNR, CCM, USFS) we developed a collection of effective resource materials and engagement strategies that can be provided to high school youth in the coming years.

U of M Project: PROJECT RESULTS USE AND DISSEMINATION

Monthly meetings with project partners (DNR, CCM, Forest Service) allowed us to provide input to and share materials that were developed in addition to coordinating efforts.

We developed a composite summary flier outlining the three most relevant majors in natural resources at the University of Minnesota. We distributed those at youth events and also at various recruiting events used by us, CCM and the DNR to recruit youth to the CCM programs. We developed a Facebook group page to engage CCM youth and make them aware of opportunities; we shifted the group focus to alumni of the various youth programs with the aim to maintain a connection with opportunities after they left the corps.

We developed an extensive set of PSEO materials for distribution to youth and use by the CCM college and career counselor and crew leaders.

Supporting materials have been provided to our project partners (DNR, CCM, USFS) and we have a collection of programs and opportunities that can be provided to high school youth in the coming years. Internally, materials were shared with project participants and partners on a google drive. The materials are now deposited with the Conservation Corps and available from their website (<http://www.conservationcorps.org/bridges>).

Project Completed: 06/30/2017

FINAL REPORT - Bonsignore: (Subd. 09d1)

MN DNR Career Guide: (Subd. 09d1)

MN DNR Career Sheets: (Subd. 09d1)

FINAL REPORT - Newman: (Subd. 09d2)

Minnesota Pollinator Partnership

Subd. 09g \$100,000 TF

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Appropriation Language

\$100,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Pheasants Forever to complete 40 community pollinator education and habitat projects. This appropriation must

be coordinated with appropriations provided by the outdoor heritage fund. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

Project Overview

Pollinators play a key role in ecosystem function and in agriculture, including thousands of native plants and more than one hundred U.S. crops that either need or benefit from pollinators. However, pollinators are in dramatic decline in Minnesota and throughout the country. The causes of the decline are not completely understood, but identified factors include loss of nesting sites, fewer flowers, increased disease, and increased pesticide use. Fortunately, there are known actions that can be taken to help counteract some of these factors, such as adding diversity of flowering plants to the landscape in order to provide nectar and habitat for pollinators. Pheasants Forever is using this appropriation to pilot an education and habitat restoration program in 40 communities around the state that will involve 800 youth and 200 adults in learning about pollinators and their habitat and engaging them in conducting community pollinator projects that establish pollinator foraging habitat on a total of at least 40 acres.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Pollinator Partnership was created because species like domesticated honey bees and monarch butterflies are experiencing alarming declines in their populations, and pollinating insects are an essential component in global food production. Our objectives of this program were to educate youth groups and the general public in MN about the value of pollinating insect species and the habitat on which they rely on to survive, provide hands-on opportunities for youth groups and the general public in MN to establish pollinator habitat projects, establish quality pollinator habitat projects that provides foraging habitat for native pollinators, and to create a model that would aide other Pheasants Forever (PF) chapters, land managers, biologist and the general public in MN in the establishment and maintenance of future pollinator habitat projects.

During the last three years, PF staff worked with our volunteer chapters and partners to engage youth groups and community groups across MN to establish pollinator projects. Small grants were offered to Pheasants Forever Chapters and our partners to establish pollinator projects. In order to take advantage of the grants, PF chapters and partners had to engage a youth group and/or community group in the establishment of a pollinator projects. In addition, PF chapters and partners had to provide educational activities and/or curriculum to those youth groups and community groups they were working with to establish the project.

Since the program's inception, we have helped establish 43 projects on 137 acres. There have been 4,297 individuals who have participated in a pollinator partnership event, and those volunteers have donated over 4,500 hours of time planning, planting, and maintaining project sites. In addition, the program has been so successful that it helped us build a model that has been replicated across the entire country; and we have now completed youth pollinator projects in 20 other states.

PROJECT RESULTS USE AND DISSEMINATION

Information from this project has been used and disseminated in the following ways:

- The program and projects have been promoted at Pheasants Forever meetings (i.e. District Meetings, State Meeting, Pheasant Fest, Professional Meetings, Program Website, Newsletters, Videos, Flyers, Facebook, Twitter, Press Releases, and News Paper Articles).
- The program has helped produce program standards that are now used across the country to implement Youth Pollinator Projects. We now have projects in 20 states outside MN that follow the same protocols developed for the MN Pollinator Partnership.
- In order to determine the impacts on those involved in the MN Pollinator Partnership, we distributed a survey and conducted post survey interviews with Pheasants and Quail Forever volunteers and staff members. Sixty-seven adult Pheasant Forever and Quail Forever Chapters volunteers responded to the survey.

Information created from this program will continue to be disseminated through Pheasants Forever channels. We

plan to continue and grow this program across MN and the Midwest with the materials we have created through the MN Pollinator Partnership.

Project Completed: 06/30/2017

[FINAL REPORT](#)

4. M.L. 2013 Projects Completed
January 15, 2017 – January 15, 2019
MN Laws 2013, Chapter 52, Section 2

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/atlases.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/atlases.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 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 areas 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

Greg Hoch

MN DNR

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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](#)

**5. M.L. 2011-2012 Projects Completed
January 15, 2017 – January 15, 2019**

**MN Laws 2011, First Special Session, Chapter 2,
Article 3, Section 2**

and

MN Laws 2012, Chapter 264, Article 4, Section 2

M.L. 2011-12 Projects

[MN Laws 2011, 1st Special Session, Chapter 2](#), Article 3, Section 2 (beginning July 1, 2011)

[MN Laws 2012, Chp. 264](#), Article 4, Section 3 (beginning July 1, 2012)

MN Laws 2011, Chapter 52, 1st Special Session, Chapter 2, Article 3, Section 2

Subd. 04 Land, Habitat, and Recreation

Regional Park, Trail, and Connections Acquisition and Development Grants

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

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Appropriation Language

\$1,000,000 the first year and \$1,000,000 the second year are from the trust fund to the commissioner of natural resources to provide matching grants to local units of government for acquisition and development of regional parks, regional trails, and trail connections. The local match required for a grant to acquire a regional park or regional outdoor recreation area is two dollars of nonstate money for each three dollars of state money. This appropriation is available until June 30, 2014, by which time the project must be completed and final products delivered.

Project Overview

A vast network of locally managed parks and trails of regional or statewide significance exist outside the seven county Metropolitan area providing outdoor recreational opportunities for the public while preserving green space for wildlife habitat and other natural resource benefits. Through an existing grant program, the Minnesota Department of Natural Resources is using this appropriation to partner with local communities around the state to partially finance the acquisition and/or development of approximately 550 acres for new or expanded regional parks, regional trails, or trail connections outside the seven county Metro area.

OVERALL PROJECT OUTCOME AND RESULTS

The overall aim of this project is to partner with local communities in providing access to outdoor recreation opportunities. Connecting citizens with the outdoors through trail and park facilities enhances Minnesota's stewardship ethic and provides many social and health benefits. This is achieved through competitive, matching grants to local governments for land acquisition and improvements related to parks and trails through the Regional Park Grant Program, Regional Trail Grant Program, and Local Trail Connections Grant Program.

The Primary results of the project were:

- Two Regional Park Grants to Wright County for the acquisition of 186 acres for Bertram Chain of Lakes Regional Park. The park consists of 1,200 acres, including four undeveloped lakes (5.75 miles of lake shore and 1.5 miles of streams). This project expands a new regional park along the I-94 growth corridor.
- Four Regional Trail Grants. The City of Pine City to connect the Sunrise Prairie Trail to the Munger State Trail, the City of Paynesville to construct 2 miles of the Lake Koronis Trail, Itasca County to reconstruct 6.16 miles of the Mesabi and Itasca Trails and the City of St. Cloud to construct .8 miles of trail to connect Beaver Island Trail to River Bluffs Regional Park.

- Six Local Trail Connections grants to the cities of Monticello, Chanhassen, Two Harbors, Victoria and St. Michael and Sibley County providing important trail links within the communities to safety connect people to desirable locations.

PROJECT RESULTS USE AND DISSEMINATION

Information about these grants have been added to the DNR website, under the Regional Park Grant Program, Local Trail Connections Grant Program and the Regional Trail Grant Program.

Project Completed: 6/30/2017

[FINAL REPORT](#)

MN Laws 2012, Chp. 264, Art. 4, Sec. 3

Aquatic Invasive Species Cooperative Research Center; Appropriation - RESEARCH

Sec. 3 \$2,000,000 TF

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Appropriation Language

\$2,000,000 is appropriated in fiscal year 2013 from the environment and natural resources trust fund to the Board of Regents of the University of Minnesota to develop and implement an Aquatic Invasive Species Cooperative Research Center, including equipment and facility development. As a condition of receiving this appropriation, the University of Minnesota is requested to collaborate with the commissioner of natural resources in developing solutions to control aquatic invasive species. Money appropriated in this section may not be spent on activities unless they are directly related to and necessary for the purposes of this section. Money appropriated in this section must not be spent on indirect costs or other institutional overhead charges that are not directly related to and necessary for the purposes of this section. This is a onetime appropriation and is available until June 30, 2018.

Project Overview

The legislature granted the University of Minnesota \$2,000,000 from the LCCMR to start an Aquatic Invasive Species Cooperative Research Center to address and solve aquatic invasive species (AIS) problems in the state. The University will use this initial funding to establish the administrative structure for this center, establish and renovate its facilities, start studies of Asian carp biology designed to control this species, and develop work plans for the LCCMR to ensure continuing funding for the center. This three-year project is designed to stand alone while establishing a solid foundation for a second phase of operating funding being requested from the ENRTF for 2013-2019, and coordinating with ongoing zebra mussel work at the University which will be supported by the Clean Water Fund.

OVERALL PROJECT OUTCOME AND RESULTS

This project established a new research center at the University of Minnesota dedicated to developing sustainable solutions to the problems posed by aquatic invasive species (AIS) and developed a solution for bigheaded carp from Asia ("invasive carps"), two of the primary issues faced by our region. The Minnesota Aquatic Invasive Species Research Center (MAISRC) still exists at the University although it now has a new leadership, administrative structure, and vision. As part of this project, associate and scientific directors for MAISRC were hired; they then initiated the process of hiring the state's only zebra mussel and aquatic plant experts, acquired funding for a new research laboratory, renovated an extant laboratory, and established a communications plan. A memorandum of understanding with the DNR was created as well as an administrative structure that included boards dedicated to

self-governance, research, and strategic vision. In addition, research on invasive carp was conducted which identified a possible affordable and sustainable solution that does not cause collateral damage. This solution entails strategically adjusting gate openings in river locks and dams to prevent carp passage and adding sound systems to lock gates; it is now being implemented at Lock and Dam 8 with new ENRTF funding as well as a site in Kentucky by the U.S. Fish and Wildlife Service. This solution was enabled by new developments in molecular survey techniques (“eDNA”) also instigated by this study, which showed that, contrary to public fears, few invasive carp had reached Minnesota. Finally, this study showed that an important fish disease (VHS) is not in Minnesota water and that invasive carps use novel foods and social signals (pheromones) that could be deployed in control were they to enter Minnesota. All this information is publically available and in the hands of the DNR awaiting full implementation.

PROJECT RESULTS USE AND DISSEMINATION

The first invasive carp deterrent system in the world is now in place in southern Minnesota and is now being upgraded. The only known state-directed AIS research center is also up and running. Information about this research center and its solutions are being disseminated via a website, an e-newsletter and a Facebook account, as well as via both radio and TV coverage. Sorensen and colleagues have at 11 peer-reviewed scientific publications in high quality journals and several technical reports while other MAISRC investigators have also published others. eDNA survey results conducted by MAISRC were used by the DNR and USFWS to make decisions about invasive carp survey techniques while information on feeding attractants is now being considered for use by the U.S. Geological Survey in fish toxin design. Over 3 dozen public talks were given as part of this project.

Project Completed: 6/30/2018

[FINAL REPORT](#)

[Minnesota Aquatic Invasive Species Research Center: Strategic Plan 2015 - 2025](#)

[Why Some Wetland Plants are Invasive and How They Affect Restoration: Publication](#)

- **Spreadsheet of all research projects completed between January 1, 2017 and January 15, 2019.**

Environment and Natural Resources Trust Fund (ENRTF)
Research Projects completed between January 1, 2017 and December 31, 2018
Full abstracts are included in Section III. Completed Research Projects

Year	Subd.	Title	Organization	First Name	Last Name	Funding Amount
2012	Sec. 03	Aquatic Invasive Species Cooperative Research Center	U of MN - AIS Center	Peter	Sorensen	\$ 2,000,000
2013	04g	Moose Habitat Restoration in Northeastern Minnesota	U of MN - Duluth NRRI	Ron	Moen	\$ 200,000
2013	05b	Assessment of Natural Copper-Nickel Bedrocks on Water Quality	U of MN - NRRI	Stephen	Monson Geerts	\$ 585,000
2013	05e	Measuring Hydrologic Benefits from Glacial Ridge Habitat Restoration	Red Lake Watershed District	Myron	Jesme	\$ 400,000
2013	05f	Evaluation of Lake Superior Water Quality Health	U of MN - Duluth	Erik	Brown	\$ 600,000
2013	06a-02	AIS Research Center Sub-Project 02: Delaying the Spread of AIS: Monitoring the Abundance and Distribution of AIS Using New Molecular Tools so Techniques to Delay Their Spread can be Implemented	U of MN - AIS Center	Michael	Sadowsky	\$ 602,580
2013	06a-04	AIS Research Center Sub-Project 04: Common carp management using biocontrol and toxins	U of MN - AIS Center	Przemyslw	Bajer	\$ 413,247
2013	06a-05	AIS Research Center Sub-Project 05: Reducing and Controlling AIS: Developing and Evaluating New Techniques to Selectively Control Invasive Plants	U of MN - AIS Center	Ray	Newman	\$ 214,996
2013	06a-06	AIS Research Center Sub-Project 06: Determining Heterosporosis Threats to Inform Prevention, Management, and Controls	U of MN - AIS Center	Paul	Venturelli	\$ 111,889
2013	06a-11	AIS Research Center Sub-Project 11: Reducing and controlling AIS: Risk analysis to identify AIS control priorities and methods - Phase 2: Risk Analysis	U of MN - AIS Center	David	Andow	\$ 126,676
2013	06a-13	AIS Research Center Sub-Project 13: Eco-Epidemiological Model to Assess AIS Management	U of MN - MAISRC	Nicholas	Phelps	\$ 215,000
2014	03a	Solar Driven Destruction of Pesticides, Pharmaceuticals, Contaminants in Water	U of MN	William	Arnold	\$ 291,000
2014	03b	Methods to Protect Beneficial Bacteria from Contaminants to Preserve Water Quality	U of MN	Paige	Novak	\$ 279,000
2014	03c	Triclosan Impacts on Wastewater Treatment	U of MN	Timothy	LaPara	\$ 380,000
2014	03d	Evaluation of Wastewater Nitrogen and Estrogen Treatment Options	U of MN	Paige	Novak	\$ 500,000
2014	03e	Antibiotics and Antibiotic Resistance Genes in Minnesota Lakes	U of MN	William	Arnold	\$ 300,000

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Year	Subd.	Title	Organization	First Name	Last Name	Funding Amount
2014	03f	Impacts of Estrogen Exposure on Minnesota's Shallow Lake Wildlife	St. Thomas University	Kurt	Illig	\$ 136,000
2014	03g	Watershed-Scale Monitoring of Long-Term Best Management Practice Effectiveness	Science Museum of Minnesota	Daniel	Engstrom	\$ 900,000
2014	03h	Protection of State's Confined Drinking Water Aquifers	US Geological Survey	Jared	Trost	\$ 394,000
2014	03i	Watershed Water Budgets for Managing Minnesota's Groundwater	US Geological Survey	Erik	Smith	\$ 129,000
2014	03j	Identifying Causes of Exceptionally High Mercury in Fish	Minnesota Pollution Control Agency	Bruce	Monson	\$ 743,000
2014	03m	Measuring Hydrologic Benefits from Glacial Ridge Habitat Restoration	Red Lake Watershed District	Myron	Jesme	\$ 168,000
2014	04a	Blocking Bighead, Silver, and Other Invasive Carp by Optimizing Lock and Dams	U of MN	Peter	Sorensen	\$ 854,000
2014	04b	Bioacoustics to Detect, Deter and Eliminate Silver Carp	U of MN - Duluth	Allen	Mensing	\$ 262,000
2014	05h	Sandhill Crane Populations and Management in Minnesota	U of MN	David	Andersen	\$ 250,000
2014	05j1	Imperiled Prairie Butterfly Conservation, Research and Breeding Program	Minnesota Zoological Garden	Erik	Runquist	\$ 380,000
2014	05k	Conserving Minnesota's Native Freshwater Mussels	U of MN	Jessica	Kozarek	\$ 350,000
2014	05l	Impacts of Forest Quality on Declining Minnesota Moose	U of MN	James	Forester	\$ 300,000
2014	05m	Moose Decline and Air Temperatures in Northeastern Minnesota	MN DNR	Mike	Larson	\$ 600,000
2014	06b	Understanding Systemic Insecticides as Protection Strategy for Bees	U of MN	Vera	Krischik	\$ 326,000
2014	06c	Prairie Sustainability through Seed Storage, Beneficial Microbes, and Adaptation	U of MN	Ruth	Shaw	\$ 600,000
2014	08a	Solar Cell Materials from Sulfur and Common Metals	U of MN	Lee	Penn	\$ 494,000
2014	08c	Demonstrating Innovative Technologies to Fully Utilize Wastewater Resources	U of MN	Roger	Ruan	\$ 1,000,000
2014	08f	Clean Water and Renewable Energy from Beet Processing Wastewater and Manure	U of MN	Shaobo	Deng	\$ 400,000
2014	08g	Next Generation Large-Scale Septic Tank Systems	U of MN	Bo	Hu	\$ 258,000
2015	10	Avian Influenza distribution, evolution, and impacts on ring-billed and herring gulls in Minnesota	U of MN	Marie	Culhane	\$ 213,443
2015	03i	Endangered Bats, White-Nose Syndrome, and Forest Habitat	MN DNR	Richard	Baker	\$ 1,250,000

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Year	Subd.	Title	Organization	First Name	Last Name	Funding Amount
2015	03k	Movement and Seasonal Habitat Use of Minnesota Elk	MN DNR	Lou	Cornicelli	\$ 200,000
2015	03l	Genetic and Camera Techniques to Estimate Carnivore Populations	U of MN - Duluth NRRRI	Ron	Moen	\$ 200,000
2015	03o	Effects of Grazing Versus Fire for Prairie Management	U of MN - AIS Center	Susan	Galatowitsch	\$ 414,000
2015	03r	Hydrologic Effects of Contemporary Forest Practices in Minnesota	U of MN	Diana	Karwan	\$ 150,000
2015	04b	Biofilm Technology for Water Nutrient Removal	U of MN	Bo	Hu	\$ 281,000
2015	04c	Biological Consequences of Septic Pollution in Minnesota Lakes	St. Cloud State University	Heiko	Schoenfuss	\$ 364,000
2015	04d	Preventing Phosphorous from Entering Water Resources through Drain Tiles	U of MN	Kenneth	Valentas	\$ 505,000

