

M.L. 2010 Projects Completed in 2013-2014

M.L. 2010 Projects

MN Laws 2010, Chapter 362, Section 2 (beginning July 1, 2010)

NOTE: Below are shore abstracts for projects funding during the 2010 Legislative Session and ending during 2013-2014. The final date of completion for these projects is listed at the end of the abstract. Final Reports for all completed projects are available at <http://www.lccmr.leg.mn/projects/2010-index.html> or by contacting the LCCMR office.

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- 03a County Geologic Atlases and Related Hydrogeologic Research
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- 03g Quantifying Carbon Burial in Wetlands - RESEARCH
- 03i Ecosystem Services in Agricultural Watersheds
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- 05b Managing Mineland Sulfate Release in Saint Louis River Basin - RESEARCH
- 05c Ecological Impacts of Effluent in Surface Waters and Fish - RESEARCH
- 05e Assessing Septic System Discharge to Lakes - RESEARCH
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- 06d Bioacoustic Traps for Management of Round Goby - RESEARCH

Subd. 07 Renewable Energy

- 07a Algae for Fuels Pilot Project
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- 08a Minnesota Conservation Apprenticeship Academy
- 08b Engaging Students in Environmental Stewardship through Adventure Learning
- 08d Urban Wilderness Youth Outdoor Education
- 08e Get Outside - Urban Woodland for Kids
- 08f Expanding Outdoor Classrooms at Minnesota Schools
- 08g Integrating Environmental and Outdoor Education in Grades 7-12

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08i Fishing: Cross Cultural Gateway to Environmental Education
08j Minnesota WolfLink

Subd. 03 Natural Resource Data and Information

County Geologic Atlases and Related Hydrogeologic Research

Subd. 03a \$1,130,000

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Appropriation Language

\$1,130,000 is from the trust fund to the Board of Regents of the University of Minnesota for the Geologic Survey to initiate and continue the production of county geologic atlases, establish hydrologic properties necessary to water management, and investigate the use of geochemical data in water management. This appropriation represents a continuing effort to complete the county geologic atlases throughout the state. This appropriation is available until June 30, 2013, 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 1982 that is being conducted jointly by the University of Minnesota's Minnesota Geological Survey and the Minnesota Department of Natural Resources (DNR). The program collects information on the geology of Minnesota to create maps and reports depicting the characteristics and pollution sensitivity of Minnesota's ground-water resources. County Geologic Atlases are used in planning and environmental protection efforts at all levels of government and by businesses to ensure sound planning, management, and protection of land and water resources. The Minnesota Geological Survey will use this appropriation to:

- Initiate geologic atlases for Sherburne and Morrison counties;
- Continue work on county geologic atlases already in progress;
- Make collected data available in a digital format;
- Investigate the hydrologic properties of the St. Lawrence Formation in southeastern Minnesota;
- Evaluate methods for investigating groundwater flow pathways in urban areas, using Rochester, MN as the test area.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Geological Survey maps sediment and rock because these materials control where water can enter the subsurface (recharge), where and how much water can reside in the ground (aquifers), where the water re-emerges (discharge), and at what rates this movement occurs. This information is essential to managing the quality of our water and the quantity that can be sustainably pumped. This project completed geologic atlases for Sherburne and Morrison counties, and contributed to atlas work in Anoka, Wright, Hennepin, Hubbard, Becker, Wadena, St. Louis, and Lake counties. Information about the geology is gleaned from the records of domestic wells, and from drilling conducted for this project. In Sherburne County we used 14,450 wells and 5 cores and in Morrison County we used 6,400 wells and 21 cores, and soil borings and geophysical surveys. From the data we created maps of the geology immediately beneath the soil; the aquifers within the glacial sediment; and the shape,

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elevation, and rock types of the bedrock surface. These maps and data support monitoring, wellhead protection, water appropriation, clean-ups, and supply management.

The deep bedrock aquifers in southeastern Minnesota are in most places not yet significantly impacted by pollution and presumed to be protected by low permeability overlying geologic layers, called aquitards. Even though aquitards are an important control on recharge and contaminant transport, their hydrologic characteristics are poorly understood compared to aquifers. This subproject investigated the St. Lawrence Formation through existing data, new data on fracturing, and by constructing an instrumented borehole to test the water-bearing characteristics. We learned that the St. Lawrence acts to retard vertical water flow where it is buried by more than 50 feet of overlying rock, but fails to do so in more shallow settings. Parts of the formation convey water horizontally in either setting.

A third subproject traced ground water movement in the Rochester area by examining the chemistry of the water. We learned that flow patterns are changing, apparently in response to high capacity pumping.

PROJECT RESULTS USE AND DISSEMINATION

County geologic atlases are distributed in print and digital formats. The digital format allows us to include all the data that support the maps and the ability to change the maps or create new ones. The products are available from the MGS web site (<http://www.mngs.umn.edu/index.html>). We also conduct post-project workshops in the map area to familiarize users with the products and their applications. The products are also distributed to libraries. Products of the Morrison County Geologic Atlas have been applied to finding new municipal water supplies in Little Falls and Motley. We expect both these atlases will be applied to understanding the widespread distribution of nitrate in ground water in this part of Minnesota. Additional funding from DNR has allowed us to continue to collect data from the instrumented borehole constructed for the St. Lawrence subproject. This additional data will be combined with what we have in a formal MGS Report of Investigations. The Rochester study is likely to improve computer simulations of water flow and influence decisions about the distribution and pumping rates of the wells that supply the city.

Project Publication:

Hydrogeologic Properties of the St. Lawrence Aquitard, Southeastern Minnesota (PDF - 1.87 GB)

Project completed: 6/30/2014

Updating the Minnesota Wetlands Inventory: Phase 2

Subd. 03b \$1,100,000

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Appropriation Language

\$1,100,000 is from the trust fund to the commissioner of natural resources to continue the update of wetland inventory maps for Minnesota. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

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The National Wetland Inventory, a program initiated in the 1970s, is an important tool used at all levels of government and by private industry and non-profit organizations for wetland regulation and management, land use and conservation planning, environmental impact assessment, and natural resource inventories. The data behind the National Wetlands Inventory for Minnesota is now considerably out-of-date and a multi-phase, multi-agency collaborative effort coordinated by the Minnesota Department of Natural Resources is underway to update the data for the whole state. This appropriation is being used to conduct the second phase of this effort, which involves updating wetland maps for 13 counties in east-central Minnesota surrounding the greater Twin Cities metropolitan area, evaluating imagery sources and mapping technologies for use in future mapping of agricultural regions of the state, and acquiring additional data needed to update wetland maps for southern Minnesota.

OVERALL PROJECT OUTCOME AND RESULTS

Updated wetland maps were created for 13 counties in east-central Minnesota (7,150 square miles), encompassing the Twin Cities metropolitan area. Wetlands in Minnesota were originally mapped by the U.S. Fish and Wildlife Service in the early 1980's as part of the National Wetlands Inventory (NWI). Although still widely used for land use planning, wetland permit screening and natural resource management, the original maps have grown increasingly out-of-date due to landscape alterations over the years. The data created for this project marks the first significant update to the NWI in Minnesota.

The new maps are much more accurate, capture more detail, and provide more information than the original maps. Besides showing the location, size, and type of each wetland, the updated map data includes information on the wetland's landscape position and hydrologic characteristics, which can be useful in assessing the benefits provided, such as water quality improvement, flood storage, and fish and wildlife habitat. Updating the NWI is a key component of the State's strategy to monitor and assess wetlands in support of efforts to assure healthy wetlands and clean water for Minnesota. The DNR is planning to complete the NWI update for the entire state by 2020.

Accomplishments for this project phase also include acquiring high-resolution, spring leaf-off digital aerial imagery for 23,900 square miles of southern Minnesota, acquiring field validation data for southern Minnesota, and developing wetland mapping procedures for the agricultural region of Minnesota.

PROJECT RESULTS USE AND DISSEMINATION

Imagery acquired for this project is available to the public through the Minnesota Geospatial Information Office (MnGeo): http://www.mngeo.state.mn.us/chouse/wms/geo_image_server.html. The MnGeo imagery service receives about one million page requests per month for the southern Minnesota imagery. This is the first publicly available leaf-off imagery data for southern Minnesota since 1991.

The updated wetland map data are available through an interactive mapping application on the DNR's website at: <http://www.dnr.state.mn.us/eco/wetlands/map.html>. The data can also be downloaded, free of charge, for use in geographic information system applications through the DNR's data deli at: <http://deli.dnr.state.mn.us/>. The data will eventually be incorporated into the national "Wetland Mapper" application maintained by the U.S. Fish and Wildlife Service.

The wetland mapping procedures and accuracy results for the 13-county updated NWI data are presented and discussed in a manuscript that has been submitted to the journal *Wetlands*, a publication of the Society of Wetland Scientists (SWS). Information from this project was also presented at the SWS annual conference in Duluth, MN in 2013. In addition, a press release was distributed regarding the updated NWI data and the story was published on several online news websites.

Researchers at the University of Minnesota Remote Sensing and Geospatial Analysis Laboratory conducted an extensive study of the effects of digital elevation model (DEM) preprocessing and mapping methods on the accuracy of wetlands maps in three different physiographic regions of Minnesota. This research covered two study sites in agricultural areas including the Minnesota River Headwaters (Big Stone County) and Swan Lake (Niccollet County) as well as a comparison site from northern Minnesota (St. Louis and Carlton Counties). The results of this

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effort were compiled and submitted for publication in several peer-reviewed scientific journals along with results from the earlier phase of the NWI update project. Three hard copies and one electronic copy of these publications have been submitted with the final report to LCCMR. There have also been numerous presentations at professional conferences.

Project Publications:

- Influence of Multi-Source and Multi-Temporal Remotely Sensed and Ancillary Data on the Accuracy of Random Forest Classification of Wetlands in Northern Minnesota (PDF - 2.7 MB)
- Comparison of Flow Direction Algorithms in the Application of the CTI for Mapping Wetlands in Minnesota (PDF - 15.3 MB)
- The Effects of Data Selection and Thematic Detail on the Accuracy of High Spatial Resolution Wetland Classifications (PDF - 0.2 MB)
- A semi-automated, multi-source data fusion update of a wetland inventory for east-central Minnesota, USA (PDF - 1.4 MB)
- Wetland Mapping in the Upper Midwest United States: An Object-Based Approach Integrating Lidar and Imagery Data (PDF - 1 MB)

Project completed: 6/30/2014

Mitigating Pollinator Decline in Minnesota

Subd. 03e \$297,000

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RESEARCH

Appropriation Language

\$297,000 is from the trust fund to the Board of Regents of the University of Minnesota to assess the role of insecticides in pollinator health in order to help mitigate pollinator decline. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

A class of insecticides known as systemic neonicotinyl insecticides have been identified as a potential factor in recently observed declines in pollinators - the beneficial insects that carry pollen from plant to plant - including the phenomenon amongst honeybees known as Colony Collapse Disorder. But only preliminary investigation into this potential link has been completed to date. This appropriation is enabling the University of Minnesota's Department of Entomology to conduct additional research needed to determine what impacts systemic neonicotinyl insecticides may be having on the health, behavior, and mortality of honeybees and other pollinators. Findings could be used to help mitigate pollinator decline and identify alternative approaches for managing pest insects.

OVERALL PROJECT OUTCOME AND RESULTS

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The commonly used systemic neonicotinyl class of insecticides (imidacloprid, thiamethoxam, clothianidin, and dinotefuran) is implicated in bee decline since insecticide residues accumulate in pollen and nectar. These residues can kill foraging bees and decrease pollination, seeds, and fruits of native plants and crops.

Neonicotinyls are applied in numerous methods (seeds, soil drenches, and tree trunk injections). Of the 442 million acres of U.S. cropland, 143 acres are treated with over 2 million pounds of neonicotinyl insecticides. In Minnesota in 2009, 46,766 pounds of imidacloprid and 19,347 pounds of clothianidin were applied.

These research objectives were to understand the effects of imidacloprid residues on bee health. This research found that a standard, label rate of imidacloprid applied to soil of potted plants produced imidacloprid residues of 1973 ppb in mint and 1568 ppb in milkweed flowers. A residue in flowers of 185 ppb imidacloprid kills a bee.

Research on greenhouse colonies of bumblebees showed that 20-100 ppb imidacloprid or clothianidin provided in sugar syrup for 11 weeks increased queen mortality and decreased consumption, sugar syrup storage, colony weight, and male production. Consequently, 20 ppb had detrimental effects on bumblebees and will reduce pollination of native plants. Research on field colonies of honey bees showed that only 33% of the imidacloprid was stored in colony cells. At 200 ppb there was less brood, fewer returning foragers, and higher amounts of distorted wing virus, which can cause colony death.

This research demonstrated that applications of imidacloprid and clothianidin insecticides to soil result in high residues in nectar and pollen that will kill bees. Studies on bees showed how colonies died from these insecticides.

An 11 part website for outreach education in Minnesota on pollinator conservation was developed.

PROJECT RESULTS USE AND DISSEMINATION

The purpose of the research was to supply data to protect pollinators to ensure future seeds and fruits for wildlife and people. These research data are very important to groups trying to understand the impact of systemic, neonicotinyl insecticides on bee colonies and individual foragers. These data are used by bee keepers, advocacy groups, state agencies, and the US EPA for discussion on whether neonicotinyl insecticides are affecting bee health and whether their use needs to be restricted. In June 2013 The European Union's Food Safety Authority (EFSA) has restricted the use of neonicotinyl insecticides for 2 years on all flowering plants that bees utilize. The reports and discussion are on the LCCMR sponsored "Pollinator Conservation" website. This is a remarkable proactive decision to ensure the safety of pollinators.

An 11 part website on bee pollinator conservation was developed for outreach education in Minnesota. The website contains research results, manuscripts, workshop, bulletin on insecticides and bees, bulletin on pollinator conservation, and poster on bee plants. We will produce 4 manuscripts from these data and 3 are already in final form and available on the website.

These research data have been requested by groups that need to understand more about the risk of neonicotinyl insecticides to bees: US EPA, Center for Food Safety, PANNA (Pesticide Action Network), Xerces Society for Invertebrate Conservation, Washington State Department of Agriculture, Pesticide Research Institute, MN Honey Producers, Boulder County Bee Keepers, and Colorado State Beekeepers. The lab was interviewed by TV and radio many times: MN Public Radio (3), Harvest Public Media, Iowa Public Radio, WCCO, Kare 11 News, KSTP, Pioneer Press, Star Tribune, and the Minnesota State Fair. Krischik has provided her research results to the US EPA twice: an online slide show webinar to EPA scientists and a visit to UM by the US EPA Administrator for the Office of Chemical Safety and Pollution Prevention (OCSPP). Krischik's expertise from this research has made her a reviewer for 2 white papers from the Xerces Society of Invertebrate Conservation and another from the Friends of the Earth as well as peer reviewer on related scientific manuscripts.

Project completed: 06/30/2013

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Science and Innovation from Soudan Underground Mine State Park

Subd. 03f \$545,000

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RESEARCH

Appropriation Language

\$545,000 is from the trust fund to the Board of Regents of the University of Minnesota to characterize unique microbes discovered in the Soudan Underground Mine State Park and investigate the potential application in bioenergy and bioremediation. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

The Soudan Iron Mine near Ely, Minnesota is no longer an active mine and is now part of a state park, as well as the home to a state-of-the-art physics laboratory at the bottom of the mine. The mine has also recently been discovered to contain an extreme environment in the form of an ancient and very salty brine bubbling up from deep below the Earth's surface through holes drilled when the mine was active. Strange microorganisms - part of an ecosystem never before characterized by science - have been found living in the brine. Scientists from the University of Minnesota will use this appropriation to:

- Study this unique ecosystem and its organisms;
- Examine the potential of using the microorganisms for applications in medicine, energy production, and other areas;
- Develop a program to educate mine visitors about the brine ecosystem and its organisms.

OVERALL PROJECT OUTCOME AND RESULTS

The Soudan Iron Mine near Ely, MN is home to an extreme environment where microorganisms are thriving 2300 feet below the surface in an ancient, salty brine. Though mining operations have been closed for almost 50 years, the mine is now a State Park managed by Minnesota's Department of Natural Resources. Visitors can tour the mine, learning about the history of mining at Soudan and can also tour the state-of-the-art physics laboratory built at the bottom of the mine. Just a few hundred feet away from the physics laboratory, bubbling up from holes drilled in the last days of iron mining, is strange water - an incredibly salty brine that lacks any oxygen gas - and strange microorganisms (bacteria and other single-celled microbes) living in the water. Our work has resulted in the characterization of the level 27 brine with respect to its chemical makeup, the rate that the brine mixes with surface water, cultured and uncultured microbial communities living in the brine, and speciation of minerals found in the brine channel. We have also specifically cultured about two dozen microorganisms from the mine that produce potent anti-fungal compounds, several of which have been shown to have activity against fungal pathogens. We have also isolated several novel species of iron oxidizing and iron reducing bacteria, which we continue to characterize. Finally, we developed an interactive touchscreen display and presentation about subsurface microbiology and geochemistry, specifically highlighting our work from this project. The goal of this touchscreen display is to both educate citizens of Minnesota broadly about subsurface microbiology and highlight some of the most exciting results from our project in a way that is broadly accessible to non-scientists.

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Findings from this project formed the basis for a follow-up project begun in 2013 - "Harnessing Soudan Mine Microbes: Bioremediation, Bioenergy, and Biocontrol" - that is to exploring potential applications of using the microorganisms living in Soudan Iron Mine for removing metals from mine waters, producing biofuels, and developing a biocontrol for White-Nose Syndrome, which is decimating bat populations around the country.

PROJECT RESULTS USE AND DISSEMINATION

Project results have been disseminated through presentations made by students and investigators supported on this project. Co-Investigator Prof. Brandy Toner has presented research from our project at an international meeting in 2011 (Goldschmidt Conference, Prague, Czech Republic) and at a national meeting in 2012 (American Geophysical Union, San Francisco, CA). Prof. Jeff Gralnick presented some of the work supported by this project at the TEDxUMN 2012 event, students working on this project gave several poster presentations at national and local meetings (2 presentations in 2012, 4 presentations in 2013). Two scientific publications are currently in preparation (first authors Lindsey Briscoe from the Toner Lab and Benjamin Bonis from the Gralnick Lab) and one has been published in the open access journal of the American Society of Microbiology mBio (Summers, ZM, JA Gralnick and DR Bond. 2013. mBio. Cultivation of an obligate Fe(II)-oxidizing lithoautotrophic bacterium using electrodes. Jan 29;4(1)e00420-12.). Our project was also featured by several media outlets including the Northland's Newscenter, WCCO Channel 4 in the Twin Cities, MoBio's blog, and the University of Minnesota College of Biological Sciences.

Our specific outreach component for this project was to purchase, design and implement an interactive touch screen display for the Visitor's Center at the Soudan Underground Mine State Park. We purchased the equipment (computer, 42 inch touch screen display, mounting bracket, security cables) and have finished the first presentation featuring work from this project. The installation will take place before the mine reopens for visitors for the 2014 season.

Project completed: 06/30/2013

Quantifying Carbon Burial in Wetlands

Subd. 03g \$144,000

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RESEARCH

Appropriation Language

\$144,000 is from the trust fund to the Board of Regents of the University of Minnesota to determine the potential for carbon sequestration in Minnesota's shallow lakes and wetlands. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Shallow lakes are effective carbon sinks and could be used to mitigate carbon dioxide released from use of fossil fuels. Minnesota currently emits over 150 million metric tons of carbon dioxide annually due to fossil fuel use and has a stated goal to stabilize future emissions at 1990 levels. Reaching this goal will require both minimizing sources and maximizing carbon sinks such as shallow lakes. The University of Minnesota will use this appropriation

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to study how effectively shallow lakes and wetlands in different regions of Minnesota remove and retain carbon dioxide from the atmosphere. Findings will be used to provide guidance on how to manage shallow lakes to maximize carbon sequestration and evaluate the potential for Minnesota shallow lakes and wetlands to have roles on the global carbon trading market.

OVERALL PROJECT OUTCOME AND RESULTS

We examined the potential for shallow lakes to mitigate carbon dioxide release from fossil fuels. The CO₂ concentration in the atmosphere is increasing and it is a greenhouse gas that has been strongly connected to climate change on Earth. The state of Minnesota emits over 150 million metric tons of CO₂ annually due to fossil fuel burning and a stated goal is to stabilize releases at 1990 levels. Reaching this goal will require both minimizing sources and maximizing sinks such as lakes.

To determine how much CO₂ is removed from the atmosphere by shallow lakes, we collected sediment samples from over 100 lakes throughout the state, determined how much organic carbon resides in the sediments and determined the burial rate using a new method that is based on lead isotope dating. Our goals were to identify important variables that facilitate carbon burial and to estimate burial rates for the entire state. We found that shallow lakes bury organic carbon at very high rates compared to other landscape features and that effective burial is facilitated by high rates of productivity that occurs in these systems; anaerobic (no oxygen) conditions, when they occur, particularly in the wintertime under the ice, also facilitate increased carbon burial. Although burial represents a large quantity of carbon, about 6 Tg per year (or 6 million metric tons), the State of Minnesota releases about 150 million metric tons of carbon per year through the burning of fossil fuels.

In addition to the scientific results of our work, this project has helped train 10 undergraduate students from both the University of St. Thomas and University of Minnesota, two graduate students at the University of Minnesota and one post-doctoral fellow for two years.

More information on the results of this project can be found in our final project report.

PROJECT RESULTS USE AND DISSEMINATION

The results from this project have been incorporated into materials for use in the class room at St. Thomas and University of Minnesota. Cotner and Zimmer have used material from this project in lectures they have given locally, nationally and internationally (Sweden, Brazil, Japan). At the recent Ecological Society of America annual meeting, members of our team presented 11 posters and/or oral presentations that were very well received. We also organized a special session on terrestrial-aquatic linkages that had a strong focus on carbon burial. This was an extremely well-attended session at this international meeting. Also, 6 members of our group (Cotner, Zimmer, Hobbs and Ramstack-Hobbs, Herwig, and Hanson) presented results from this project at a Shallow Lakes Workshop that we helped organize in Fergus Falls this past August. This workshop was completely full and was attended by resource managers from throughout the state. Cotner has also been presenting some of this work through informal education talks that he has been giving in the past 18 months to various groups (mostly senior citizens) in the Twin Cities area. He has given approximately 20 presentations that have focused on marine and freshwater resources. Lastly, we have published three papers in the scientific literature based on results from this and a related project funded through the National Science Foundation. We have four other papers that are either currently being reviewed or that will be submitted by June 2014.

Project Publications:

- The altered ecology of Lake Christina: A record of regime shifts, land-use change, and management from a temperate shallow lake (PDF - 1.4 MB)
- Estimating modern carbon burial rates in lakes using a single sediment sample (PDF - 0.6 MB)

Project completed: 06/30/2013

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Ecosystem Services in Agricultural Watersheds

Subd. 03i \$247,000

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Appropriation Language

\$247,000 is from the trust fund to the commissioner of natural resources for an agreement with the Chippewa River Watershed Project to develop local food and perennial biofuels markets coupled with conservation incentives to encourage farmers to diversify land cover in the Chippewa River Watershed supporting improvement to water quality and habitat. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

The Chippewa River watershed faces many serious environmental problems such as water quality degradation, threats to biodiversity, and increased flooding. Agricultural practices have contributed to these problems, but they can also contribute to solutions. Through this appropriation, the Chippewa River Watershed Project and the Land Stewardship Project are collaborating to pilot an innovative approach that works with farmers to combine community-based markets for alternative crops and products with utilization of conservation incentives programs to achieve the level of landscape change needed to meet water quality goals and other environmental objectives.

OVERALL PROJECT OUTCOME AND RESULTS

The Chippewa River Watershed (CRW) subbasin of the Minnesota River has extensive corn and soybeans, grazing livestock, diminishing longer crop rotations and natural systems. Stream and lake impairments in the CRW include turbidity, bacteria, and excessive nutrients. The LCCMR project is part of the ongoing Chippewa 10% Project (C10) that includes: stream monitoring, mapping sensitive areas, modeling cropping systems with historical and future climate to predict changes and extensive farmer engagement through individual contacts, organizing four farmer learning networks and connecting farmers to markets, conservation incentives and technical assistance. We held a total of twelve educational events attracting 494 people with Environment and Natural Resources Trust Fund (ENRTF) and other funding. Partners developed four networks working with 63 farmers and landowners on 8500 acres with ENRTF and other funding. These will continue and grow past the completion of this project. Networks and events developed during this time with assistance from other funding, as detailed in the report, include:

- Women Caring for the Land network with 15 women landowners engaged in conservation efforts on their land
- Nitrogen management network with 8 farmers utilizing soil tests, corn stalk nitrate tests and nitrogen management strategies
- Soil Health workshop with 270 attendees

The goals for the ENRTF project were to identify sensitive fields on 10% of corn and soybean fields, engage landowners with information about benefits of diversification, including available conservation incentives and markets, and monitor for changes on fields. ENRTF funds and other funding accomplished these deliverables to achieve the goals:

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- Mapped three focal areas based on water quality monitoring, multi-year crop rotations and scenarios for diversifying 110,000 acres to rotational grazing, forage strips at the toe of steep fields, longer rotations on poorer soils or cover crops;
- Calculated Ecosystem Service Coefficients (ESC) using the Agricultural Production Systems Simulator model for localized future climate and included warm season grass and grazing operations;
- Modeling predicted decreases of 16% sediment load and 7% NO₂-NO₃ nitrogen load when converting sensitive fields to perennial crops;
- Integrated ESC into the Hydrologic Simulation Program - Fortran for the CRW;
- Conducted one-on-one interviews and follow-up with 74 landowners;
- Networks developed included: 1) The 25-landowner Simon Lake Challenge, a landscape-scale grazing network on 6,000 acres; and 2) Cover crop network of 15 farmers on 943 acres; soil biological activity was monitored with soil tests on 150 acres, showing higher soil moisture from cover crops resulted in higher biological activity in the fall;
- Five educational events attracting 165 people;
- Published multiple articles and a website (<http://landstewardshipproject.org/stewardshipfood/foodsystemslandstewardship/chippewa10>).

PROJECT RESULTS USE AND DISSEMINATION

Within the team and beyond, interaction with research scientists, agency personnel, farmers and nonprofit staff create opportunities for longer-term engagement. These opportunities may help bring about land management and landscape changes that result in increased ecosystem goods and services along with better community support.

We have learned together that:

- There are many benefits associated with grazing systems and longer-term rotations.
- Riverine or stream systems can be very flashy in terms of flow, and by extension, ecosystem services the more corn and soybeans dominate the landscape.
- Market signals can sometimes be amplified, distorted or misinterpreted so that the price of one commodity can drive behavior in a direction that may not necessarily be benefiting farmers in the long run.
- It may be possible to tie monitoring, modeling and on-farm changes in practices by linking scenarios, modeling diverse production systems, stream monitoring linked to land-cover, and on-farm practices being monitored with and by farmers and demonstrated through farmer networks.
- Better modeling output can be developed if research scientists work with applied scientists, extension personnel, producers and nonprofit staff to generate information from models on different grazing systems, conventional and organic production systems and different weather patterns.

Based on the strength of the Chippewa 10% Project and its partners and modeling, the Chippewa River Watershed was chosen by the United States Department of Agriculture's Agricultural Research Service to be part of the Long-term Agroecological Research Sites (LTAR). This was officially announced in 2012 and funding allocated to North Central Soil Conservation Research Lab in Morris for this purpose in 2013.

The Chippewa 10% Project regularly provides opportunities for farmers and landowners to learn about new approaches they may not be familiar with. For example, most of the farmers we have engaged who graze ruminant livestock use continuous grazing or a very non-intensive, low-level management, e.g., moving the animals every 8 days. Early winter of 2013 we brought a group of farmers to a presentation on soil health building strategies. A number of them were quite taken with a presentation by North Dakota rancher Gene Goven who has increased the productivity of his grasslands to boost his cattle stocking rate by 400%. He did so using sound planning strategies, fundamental soil-building techniques, and building diversity of flora and fauna above and below his soil, not by acquiring more land or throwing money at his challenges.

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Since then we have selected a few farmers from the group who are open to the message of planning for a grazing system that is multi-functional, improving profit, water quality, wildlife habitat and soil health, and gave them an intense two day course on the Holistic Planning techniques they could use to move their farms toward those goals. Seven farmers participated, some enthusiastically embracing the approach and expressing willingness to show others what they're doing and provide some coaching for friends and neighbors.

LSP staff working in the Root River Watershed were engaged to learn about GIS and outreach techniques and begin to plan for and apply them in Minnesota's Root River Watershed.

The Chippewa 10% Project has shared information through conference presentations at National Institute of Food and Agriculture Project Directors meeting, two Green Lands Blue Waters conferences about watersheds in IA and MN, the 4th Interagency Conference on Research on the Watershed in Anchorage, AK, the MOSES conference in La Crosse and several other in-state venues with staff from multiple agencies.

In addition we are sharing information for the general public through extensive coverage in the Land Stewardship Letter published by the Land Stewardship Project and front page coverage through AgriNews in November, 2013.

We have held 9 field days with 166 attendees over the course of this project and several workshops on cover crops, grazing, markets and conservation programs. There have been eight team meetings over the period.

A list of other reports and posters appended to the project is as follows:

- Rohweder, J.R, G. Boody, S. Vacek. 2012. Modeling Important Bird Habitat Using Multiple Alternative Land Cover Scenarios within the Chippewa River Watershed, Minnesota. US Geological Survey.
- A study by USGS paid for with funds by National Institute of Food and Agriculture.
- DeVore, B. 2012. Feeding the subterranean herd: How putting soil at the center could help revitalize farmland...& farming. September to December 2012. Land Stewardship Project
- Olson, K, et al. 2013. The Chippewa 10% Project: Achieving Needed Ecosystem Services in an Agricultural Watershed. Poster and presentation at the Green Lands Blue Waters annual conference section on watersheds. November 20-21, 2013. Minneapolis, MN. Published by Land Stewardship Project.
- LSP et al. 2013. Farmer/Landowner Outreach and Organizing in the Chippewa and Root River Watersheds: Achieving a healthy ecosystem in agricultural watersheds. Poster presented at Green Lands Blue Waters annual conference section on watersheds. November 20-21, 2013. Minneapolis, MN. Published by Land Stewardship Project.
- Jaradat, A.A, J. Starr, G. Boody. 2014. Comparative Assessment of Organic and Conventional Production of Row Crops under Climate Change: Empirical and Simulated Yield Variation in the Chippewa River Watershed, MN. Poster at MOSES conference on Organic Farming. La Crosse, WI. February 2014

Materials are being added to the Chippewa 10% Project website at <http://landstewardshipproject.org/stewardshipfood/foodsystemslandstewardship/chippewa10>. A related website is <http://landstewardshipproject.org/stewardshipfood/foodsystemslandstewardship/soilquality>. LCCMR and other funders are acknowledged on these websites.

In addition, research papers were published with other funding. More research will be published that references ENTRF funding.

Project Publication:

Modeling Important Bird Habitat Using Multiple Alternative Land Cover Scenarios within the Chippewa River Watershed, Minnesota (PDF - 5.0 MB)

Project completed: 06/30/2014

M.L. 2010 Projects Completed in 2013-2014

Identifying Critical Habitats for Moose in Northeastern Minnesota

Subd. 03k \$507,000

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RESEARCH

Appropriation Language

\$507,000 is from the trust fund to the Board of Regents of the University of Minnesota for the Natural Resources Research Institute to identify critical habitats for moose, develop best management habitat protection practices, and conduct educational outreach in cooperation with the Minnesota Zoo. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Moose are one of Minnesota's most prized wildlife species. Recently observed increases in mortality rates amongst some moose in northeastern Minnesota have led to concern that the population there may be starting 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. Researchers from the Natural Resources Research Institute at the University of Minnesota - Duluth, are using this appropriation to determine what factors may be responsible for increases in moose mortality rates in northeastern Minnesota in order to determine if it is possible to slow or prevent significant, long-term decline in the moose population there.

OVERALL PROJECT OUTCOME AND RESULTS

Moose are one of Minnesota's most prized wildlife species. In less than 20 years moose in northwestern Minnesota declined from over 4,000 to fewer than 100. The northeastern Minnesota moose population, which had over 7,000 moose until 2009, is in the middle of what appears to be a similar decline. Higher mortality in radiocollared moose is correlated with warmer temperatures. We used satellite collars to track moose in northeastern Minnesota and collected GPS locations day and night 365 days a year. Over 2 million moose locations and activity data were obtained. Specific habitats needed by moose were identified using the satellite collars. Spatial distribution and availability of habitat types has guided identification of specific sites for enhancement, protection, or acquisition. Habitat guidelines and recommendations help private and public land managers provide the best possible habitat for moose.

The project was part of a coordinated effort involving many resource management agencies to determine if it is possible to slow or prevent a decline in the northeastern MN moose population. Public outreach and education was accomplished with a website that provides information on moose in Minnesota and allowed the public to report almost 2,000 moose sightings. The Minnesota Zoo developed an on-site informational kiosk about Minnesota moose and zoo educators developed a curriculum for teacher workshops to be held both at the zoo and at the Boulder Lake Environmental Learning Center near Duluth. We gave over 70 moose presentations during the project, and continue to give presentations now.

The project combined research and education to increase public understanding of Minnesota moose now and in the future. Results and data from this project are still being used in current projects. We expect that there will be at least 2 more M.S. theses, 5 peer-reviewed publications, and additional NRRI Technical Reports developed from

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the data collected in this project that will be used to improve moose management. We also continue to work with the MN DNR adult and calf moose mortality projects using data and expertise obtained during this moose research project, and we have an ongoing collaboration with the Minnesota Zoo in Apple Valley with a deer-moose parasite project and a moose-wolf predation project.

PROJECT RESULTS USE AND DISSEMINATION

The project has had relatively wide dissemination, both in formal settings and in working with DNR and other resource management agencies to implement recommendations arising from the project. We gave over 70 presentations to the public about this project. We also developed a moose website that is used extensively by both biologists and the public. We will continue to update this website in the future.

In addition, because of the interest in moose, the project has received attention from the media, with newspaper and magazine articles, and radio and television interviews. Among the media outlets are the Duluth News Tribune, Minneapolis Star Tribune, and St. Paul Pioneer Press Dispatch, local TV stations, Minnesota Public Radio, Duluth News Tribune, Minneapolis Star Tribune, Los Angeles Times, BBC in Ontario and Newfoundland, Sweden Public Radio, Toronto Star, and others.

Although not limited to this project, Moen was also asked by the DNR to present on the current status of moose in Minnesota at the 2014 Roundtable, and also gave testimony to the Environment and Natural Resources Policy Committee on February 25, 2014.

Finally, there are several peer-reviewed publications, theses, and technical reports that have arisen from work conducted on this project. Some of these publications are currently being peer-reviewed. We expect to produce several additional publications and theses from the data obtained in this project.

Project completed: 06/30/2013

Subd. 04 Land, Habitat, and Recreation

Ecological Restoration Training Cooperative for Habitat Restoration

Subd. 04a \$550,000

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Appropriation Language

\$550,000 is from the trust fund to the Board of Regents of the University of Minnesota for improving ecological restoration success in Minnesota by developing and offering training programs for habitat restoration professionals. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Restoration work is increasingly relied on as a conservation strategy in Minnesota even though project failure rates remain high. Although there are many competent professionals working in the field, the quality of work varies

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across the profession and lack of expertise contributes to failures, partly because there is currently a lack of professional restoration training available. In order to help improve the success rates of restorations, scientists and educators at the University of Minnesota's Department of Horticultural Science are using this appropriation to develop an ecological restoration education program and cooperative. The effort will make training opportunities for practicing restoration professionals available statewide and facilitate improved and increased communication amongst the restoration community.

OVERALL PROJECT OUTCOME AND RESULTS

Ecological restoration is increasingly relied on as a conservation strategy in Minnesota even though project failure rates remain high. To improve ecological restoration success in Minnesota, this project developed training opportunities for practicing restoration professionals. We established the Ecological Restoration Training Cooperative (ERTC), which is based at the University of Minnesota, and coordinated as a partnership between state agencies and the University. A program of web-based, instructor-guided learning, combined with field sessions offered at multiple locations, are the first of its kind in the US for restoration. As part of this project, the training cooperative developed and offered five application-oriented online courses accessible statewide. These courses covering site assessment, seeding, planting, vegetation management and monitoring, were taken by 113 people during the "pilot phase". Each course will be offered at least twice a year through the U of MN College of Continuing Education. In conjunction with the online courses, field training sessions were developed for the seeding and vegetation management courses. These sessions focus on hands-on restoration skills introduced in the online courses. A four-year agreement with DNR Parks and Trails will allow each of the two field sessions to be taught by DNR natural resource specialists at four out-state locations each year in order to facilitate access to the training opportunities by individuals from around the state.

In addition to the five training courses, the ERTC developed several other ways for restoration practitioners to learn skills and stay current. A webinar series, an annual workshop, social network, and website were all launched as part of ERTIC programming. During this grant period, five webinars were held, which were attended by over 1000 people. These presentations were recorded and are available on the practitioner's network, which has 187 members to date. The first annual conference, focused on restoration monitoring, was held in May 2013. Information on all upcoming events, including online courses can be found on the ERTC website, www.restoringminnesota.umn.edu. Details about the content of online courses, field sessions, webinars, and the workshop are presented in a supplemental report.

PROJECT RESULTS USE AND DISSEMINATION

Information from this project has been made available in the following ways:

- Information on training opportunities is made available through the ERTC website, which was accessed over 2600 times in the past 18 months.
- Recorded webinar presentations are available through the ERTC practitioner's network, which is also linked to the website.
- Course and workshop information has been (and will continue to be) disseminated to over 6000 people, which is part of an active marketing effort led by the College of Continuing Education.
- The innovative approaches taken to the online courses have been communicated by press-releases connected to the R1Edu national university network.
- The innovative suite of training opportunities will be communicated with restoration researchers and practitioners at a talk to presented to the Society for Ecological Restoration International Congress to be held in October 2013.

Of the 140 people that completed the course as beta-testers or in the pilot phase, many were middle-level managers responsible for contracting and program coordination. These individuals have first-hand experience with the course and are in a position to recommend it to colleagues that need/want to advance their skills.

Project Publication:

M.L. 2010 Projects Completed in 2013-2014

Ecological Restoration Training Cooperative: Supplemental Report (PDF - 6 MB)

Project completed: 06/30/2013

Scientific and Natural Areas and Native Prairie Restoration, Enhancement, and Acquisition

Subd. 04b \$1,750,000

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Appropriation Language

\$1,750,000 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 parts of scientific and natural areas, and provide assistance and incentives for native prairie landowners. 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, 2013, 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 conduct restoration activities on approximately 3,200 acres in existing SNAs, to acquire an additional 80 acres to be added to the SNA system, and to provide technical assistance to private landowners of native prairie.

OVERALL PROJECT OUTCOME AND RESULTS

Permanent protection of biodiversity significance sites was achieved on 235 acres: 162 acres were acquired in fee as Scientific and Natural Areas (SNAs) and 73 acres were protected through Native Prairie Bank (NPB) conservation easements. This appropriation helped create the new Mille Lakes Moraine SNA and Badoura Jack Pine Forest SNA. Additions were acquired to Blanket Flower Prairie and St. Wendel Tamarack Bog SNAs. Two NPB easements were acquired in the Correll Working Lands area. Seventeen NPB easement baseline property reports were completed.

Restoration and enhancement accomplishments on over 4,000 acres included: native seed collection from 186 acres (16 sites) and seeding of 68 acres (11 sites); invasives species control on 1,175 acres (about 73 sites), invasive species inventory on 2,646 acres (36 sites), and 4 invasives boot brush kiosks installed (3 sites); prescribed burning of 3,733 acres (54 sites); new interpretive signs for 5 SNAs and installation of other signs (31 sites); 4.3 miles of fence removed, repaired or built; and 6 sites cleaned up. About 84 of these projects involved CCM. Twenty-six adaptive management plans were completed by primarily by contractors (covering 5603 acres) all or in part with this appropriation. Ecological prairie monitoring has been conducted on pollinators at 14 SNAs, snakes at 1 SNA, birds at 2 SNAs, and prairie vegetation at 6 SNA and 6 NPB sites. Improvements to the Adaptive Management Spatial Database were implemented.

M.L. 2010 Projects Completed in 2013-2014

Prairie stewardship work was comprised of two prairie landowner workshops, three prairie practitioner forums, presentations at an environmental fair, and direct technical assistance to 75 native prairie landowners. Contractors prepared 36 Prairie Stewardship Plans and staff have completed 2 Prairie Stewardship Plans. All 500 Prairie Tax Exemption sites were reviewed, re-enrollment letters were sent to 250 PTE landowners, and 30 applications were processed.

Project completed: 06/30/2014

State Park Improvements

Subd. 04c \$814,000

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Appropriation Language

\$567,000 is from the trust fund to the commissioner of natural resources for state park capital improvements and natural resource restoration. Of this amount, \$250,000 is for solar energy installations in state parks and the remaining amount shall be used for park and campground restoration and improvements. Priority shall be for projects that address existing threats to public water resources. On July 1, 2010, the unobligated balance, estimated to be \$200,000, of the appropriation for clean energy resource teams and community wind energy rebates in Laws 2005, First Special Session chapter 1, article 2, section 11, subdivision 10, paragraph (a), as amended by Laws 2006, chapter 243, section 15, and extended by Laws 2009, chapter 143, section 2, subdivision 16, is transferred and added to this appropriation. On July 1, 2010, the \$47,000 appropriated in Laws 2009, chapter 143, section 2, subdivision 6, paragraph (f), for native plant biodiversity, invasive plant species, and invertebrates is transferred and added to this appropriation.

PROJECT OVERVIEW

Several of Minnesota's state parks and recreation areas will be receiving energy efficiency improvements, water quality enhancement upgrades, or additional visitor facilities. The Minnesota Department of Natural Resources is using this appropriation to install photovoltaic energy generation equipment and solar-powered water wells, rehabilitate stormwater collection and storage systems, repair and stabilize stream bank erosion, and construct rustic camper cabins. A number of parks are slated for improvements, including St Croix State Park near Hinckley, Soudan Underground Mine State Park near Ely, and Split Rock Lighthouse State Park and Tettegouche State Park along the north shore of Lake Superior.

OVERALL PROJECT OUTCOME AND RESULTS

The purpose of this project was to focus on renewable energy improvements, water quality enhancement, and attracting new users at Minnesota State Parks and Recreation Areas. This project consisted of installation of photovoltaic solar generation facilities at Tettegouche State Park, the construction of 4 rustic camper cabins at Lake Bemidji State Park, and the major rehabilitation of the storm water management system and repair of an eroding river bank at St. Croix State Park.

The first activity was to install photovoltaic solar panels at Tettegouche State Park. This allows us to showcase renewable energy at one of our busiest parks. There were 24KW of pole-mounted photovoltaic generating equipment installed. The system has 96 panels and each panel has a nameplate power rating of 250 watts. These

M.L. 2010 Projects Completed in 2013-2014

panels will generate power for the brand new visitor center that will open to the public in the spring of 2014. Any excess power is exported to the electrical grid. The Utility, MN Power will credit any net excess kWh generation on the meter's monthly invoice. Annual saving are \$3,200.

The second activity was to rehabilitate storm water collection and storage systems at the St. Croix State Park Visitor Center and repair and stabilize river bank erosion on the St. Croix River. Storm water treatment and storage facilities were lacking. The original storm water management system was built by the Civilian Conservation Corps (CCC) in the 1930's. A 20 car parking lot was re-graded and repaved with historic features such as stone curbing preserved. Best management practices are now demonstrated including natural treatment systems such as rain gardens, grassy swales and infiltration pipes were used to redirect storm water from the parking lot away from the river. The hillside that had eroded into the St. Croix River has been stabilized. It was re-graded and restored with native vegetation. The delta of sediment has been removed from the river.

The third activity was to construct 4 rustic camper cabins at Lake Bemidji State Park. They are well insulated to exceed the energy code by 30% and they exceed Minnesota Sustainable Design Guidelines. FRC sustainably grown lumber was used. Camper cabins have been found to attract new users who may not have camping equipment or feel comfortable sleeping out in a tent. These cabins are open for use year round. All 4 cabins have heat and electricity, a screened in porch, an outdoor fire ring for cooking and a picnic table. Two of the cabins sleep 6 while the other two are wheelchair accessible and sleep 5. Along with the cabins, 2 vault toilets were installed within close proximity as well as 2 wells for drinking water. Since the cabins opened in June 2012 there have been 959 occupied site nights.

Project completed: 6/30/2014

State Park Land Acquisition

Subd. 04d \$1,750,000

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Appropriation Language

\$1,750,000 is from the trust fund to the commissioner of natural resources to acquire and preserve critical parcels within the statutory boundaries of state parks. Land acquired with this appropriation must be sufficiently improved to meet at least minimum management standards as determined by the commissioner of natural resources. A list of proposed acquisitions must be provided as part of the required work program.

PROJECT OVERVIEW

Privately owned lands exist within the designated boundaries of state parks throughout Minnesota. Purchase of these lands from willing landowners for addition to the state park system makes them permanently available for public recreation and enjoyment and facilitates more efficient management. The Minnesota Department of Natural Resources is using this appropriation to acquire 9 acres for Crow Wing State Park northeast of Brainerd, 160 acres for Scenic State Park north of Grand Rapids, 55 acres for Tettegouche State Park north of Silver Bay, and 19 acres for Split Rock Lighthouse State Park northeast of Two Harbors.

OVERALL PROJECT OUTCOME AND RESULTS

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Environment and Natural Resources Trust Fund funding resulted in the Department of Natural Resources acquiring approximately 267 acres of land within the statutory boundaries of five Minnesota State Parks:

- Acquired approximately 13 acres in Crow Wing State Park comprised of three parcels on the Crow Wing River. This acquisition provides additional shoreline protection and adds to the recreational opportunities now offered in this State Park such as hiking, and access to the river.
- Acquired approximately 160 acres at Scenic State Park with very high quality natural and cultural resource value and adjacent to state park lands on two sides. A Civilian Conservation Corps. (CCC) built cabin is located on the lakeshore.
- Acquired approximately 55 acres at Tettegouche State Park to preserve and protect over 700 feet of the Baptism River gorge and views from nearby Illgen Falls. The state park surrounds this parcel on three sides and may offer additional hiking trail opportunities.
- Acquired a portion of 19 acres at Split Rock Lighthouse State Park which directly overlooks Lake Superior with views of Split Rock Lighthouse. The property is surrounded by state park land.
- Partially funded the acquisition of approximately 20 acres of land in Nerstrand Big Woods State Park located in Rice County. This property was identified as outstanding biodiversity significance by Minnesota County Biological Survey and has not been logged in over 100 years. Spring ephemerals are prevalent in this area of the park and the site is important to maintaining the closed canopy and diverse understory characteristic of 'big woods' in Nerstrand Big Woods State Park.

PROJECT RESULTS USE AND DISSEMINATION

As state park maps are updated these former private lands are identified as public land open to use by all park visitors.

Project completed: 06/30/2013

Protection of Rare Granite Rock Outcrop Ecosystem

Subd. 04e \$1,800,000

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Appropriation Language

\$1,800,000 is from the trust fund to the Board of Water and Soil Resources, in cooperation with the Renville Soil and Water Conservation District, to continue to acquire perpetual easements of unique granite rock outcrops, located in the Upper Minnesota River Valley. \$418,000 of this appropriation is for fiscal year 2010 and is available the day following final enactment.

PROJECT OVERVIEW

Granite rock outcrops along the Upper Minnesota River are among the oldest exposed rock in North America, dating back approximately 3.6 billion years. These outcrops are also home to rare and specialized plant and animal communities rarely found elsewhere in Minnesota, including several types of cactus and one of Minnesota's only three lizard species, the five-lined skink. However, these rock outcrops are increasingly threatened by mining, overgrazing, and development. Through this appropriation, the Renville County Soil and Water Conservation

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District is working with Minnesota's Board of Water and Soil Resources to acquire conservation easements that will permanently preserve approximately 700 acres of this endangered habitat in Chippewa, Lac qui Parle, Redwood, Renville and Yellow Medicine counties.

OVERALL PROJECT OUTCOME AND RESULTS

A total of 748.4 acres of rare and unique Minnesota River Valley landscape were permanently protected and sixteen landowners were paid \$1,741,580 for voluntarily placing perpetual conservation easements on those acres. Five counties participated in the project including Lac qui Parle, Chippewa, Yellow Medicine, Redwood, and Renville. Easement applications were scored by resource professional teams and funding was based on those scores.

Soil & Water Conservation District (SWCD) employees saw a need to protect the natural environment and to provide economically viable choices for the landowners. The Minnesota River Valley contains exposed ancient granite rock outcrops that provide unique landscape features and habitat for specialized plant and animal communities rarely found elsewhere in Minnesota. No programs existed that would give landowners a payment if they chose to protect the area from development by mining, overgrazing, and other development interests. Rock outcrops are a component of the Minnesota River's riparian zone, and destruction of this unique habitat degrades water quality and wildlife habitat in the Minnesota River and its tributaries. Removal of the rock results in severe degradation and permanent loss of these unique landscape features. The Minnesota River Corridor is easily susceptible to fragmentation because it comprises such a small percentage of the Minnesota River Watershed. Past development activities and mining operations have already fragmented large areas of the fragile Minnesota River Corridor.

Demand for aggregate is growing as our population and infrastructure grow. Interest in mining exposed granite rock outcrops in the Minnesota River Valley is high because the rock is readily available and there is no overburden to remove. This encourages the practice of horizontal mining, removing the easiest and most profitable rock, and moving on. Unlike gravel mining operations, there is no reclamation plan possible for replacing this unique landscape feature once it is removed.

PROJECT RESULTS USE AND DISSEMINATION

The Renville SWCD website (www.renvillewcd.com/) continues to update the public on the Rock Outcrop projects by posting information & photos in the "News" section of the website. Each SWCD in Minnesota is required to maintain a website. Those websites contain information on available programs and update the public on current topics of interest in the county.

Each SWCD has a unique position within their community to deliver conservation programs. SWCDs are the local "go to" agency for conservation program delivery and the staff are both trusted and respected by local landowners. Each SWCD office will personally contact landowners who have high quality rock outcrop landscapes on their property. This one-on-one contact will be a major source of providing information to the public.

Individual SWCD offices will continue to keep their local press informed on the progress of the program. In November 2009 the West Central Tribune featured a front page story which reported on Mr. Kalahar's appearance at the Renville County Board work session where he updated the County Board on the status of the project.

Project completed: 06/30/2013

Conserving Sensitive and Priority Shorelands in Cass County

Subd. 04h \$300,000

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M.L. 2010 Projects Completed in 2013-2014

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Appropriation Language

\$300,000 is from the trust fund to the commissioner of natural resources for an agreement with Cass County to provide assistance for the donation of perpetual conservation easements to protect sensitive shoreland parcels for long-term protection of recreation, water quality, and critical habitat in north central Minnesota. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Cass County's 500+ high quality lakes provide habitat for fish and wildlife, recreation opportunities for Minnesotans, and they are the cornerstones for the region's local economy. However, the future of these water resources is threatened by increasing population growth and shoreland development. Cass County is using this appropriation to provide assistance to riparian landowners interested in permanently protecting critical shoreline areas through donation of perpetual conservation easements on their lands. County officials expect they will be able to help protect 1,200 to 1,500 acres of riparian land, including 3-5 miles of shoreland.

OVERALL PROJECT OUTCOME AND RESULTS

Cass County's 500+ high quality lakes provide critical fish and wildlife habitat and opportunities for public recreational enjoyment. These natural resources are also the economic engines that sustain local communities. Yet, the future quality of these water resources is threatened by increasing population growth primarily along priority lakeshores.

This project focused on permanently protecting some of the most critical shorelands in Cass County using donated conservation easements. Target shorelands were strategically identified by Cass County, the Leech Lake Area Watershed Foundation, and the Minnesota DNR through its Sensitive Shoreland Study (2008-21010) on 17 lakes in Cass County. Nine (9) landowners donated a conservation easement on their sensitive shoreland to permanently limit future development. As an incentive, the project funds assisted landowners with the closing costs associated with the conservation easement, including an IRS appraisal to enable them to take a charitable deduction for the public conservation benefit donated to the people of Minnesota. In total, 305 acres and 12,039 feet (2.5 miles) of sensitive shoreland was permanently protected.

Cass County holds 8 easements and the Minnesota Land Trust holds one easement. They will annually monitor the properties to ensure compliance with the easement terms. The 9 participating landowners on six lakes (Ten Mile, Washburn, Wabedo, Little Boy, Deep/Rice Portage, and Pine Mountain lakes) donated almost a million dollars of land value to permanently protect critical shorelands by voluntarily restricting future development. The public benefit is the protection of critical fish and wildlife habitat, reduced runoff to further protect water quality, and ultimately the assurance of continued high quality recreational opportunities on some of Minnesota's best recreational lakes. With permanent conservation accomplished at approximately \$13/shoreland foot, this project is a model for cost-effective, long-term protection of recreational opportunity, water quality, and critical land and aquatic habitats on highly developed and sensitive lakeshores in North Central Minnesota.

PROJECT RESULTS USE AND DISSEMINATION

The science-based identification of sensitive shorelands and methodology for this project was the premise for Legacy Amendment funding for donated conservation easements on critical shorelands in Cass County and expanded into Crow Wing and Aitkin Counties as recommended by the Lessard Sams Outdoor Heritage Council and approved by the Minnesota Legislature in 2011. The Legacy Funding resulted in an additional 320 acres and 3.5 miles of critical shorelands permanently conserved in North Central Minnesota. To date, the two projects have

M.L. 2010 Projects Completed in 2013-2014

permanently protected over 6 miles of high priority shorelands in North Central Minnesota. Subsequently, due to the success of both of these projects, Phase II Legacy Funding for additional shoreland conservation in the North Central region was approved by the 2014 Minnesota Legislature.

In addition, it is anticipated that several conservation easements initiated but not completed for various reasons within the ENRTF project time frame will still come to fruition within the next several years to potentially conserve another 100 acres and 1.5 miles of critical shorelands.

The location of the 9 conservation easements in Cass County is included as a data layer in the interactive mapping on the Cass County website at www.co.cass.mn.us.

Throughout the project, hundreds of targeted landowners of sensitive shoreland received information on the benefits of conservation easements. Many presentations were made to lake associations, local governments, and community groups about the benefits of shoreland conservation. Landowner stories can be read on the Leech Lake Area Watershed Foundation website at www.leechlakewatershed.org. Seeds of interest have been sown that could result in future conservation of priority shorelands and continued assurance of public enjoyment of Minnesota's high quality lake resources in Cass County.

Project completed: 06/30/2014

Reconnecting Fragmented Prairie Landscapes

Subd. 04i \$380,000

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Appropriation Language

\$380,000 is from the trust fund to the commissioner of natural resources for an agreement with the Nature Conservancy to develop prairie landscape design plans and monitoring protocol involving local landowners and businesses to guide conservation, restoration, and related economic development. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Less than 1% of Minnesota's original tallgrass prairie remains today and what is left exists in scattered remnants. Restoration of healthy prairie ecosystems requires both protection and reconnection of remnants to create prairie-dominated landscape areas of 10,000-50,000 acres. However, it is unlikely such aims can be achieved without balancing desired conservation goals with an ability for local communities to utilize prairies for generating sustainable income. Through this appropriation the Nature Conservancy will work with the University of Minnesota and the local communities of two prairie landscapes in order to develop a framework for how prairie-based economic uses that balance with prairie conservation goals could provide sufficient return on labor and investment to sustain rural families and communities.

OVERALL PROJECT OUTCOME AND RESULTS

The Minnesota Prairie Conservation Plan calls for protecting native prairie and restoring connectivity to prairie core areas using grass-based agriculture as a conservation tool. To provide information and techniques needed to

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meet these goals, we studied two prairie landscapes in western Minnesota: Agassiz Beach Ridges (127,000 acres) and Glacial Lakes (169,000 acres). Using GIS analysis and field survey, we developed a current land use/land cover map that revealed that even in high-quality prairie landscapes, over 25% was cropland and 31% was invasive dominated or mixed native-invasive grassland. To guide conservation activities, we identified conservation targets and specified methods for measuring progress. To rebuild functioning prairie systems, we identified all parcels containing native prairie for possible management and protection, as well as tracts that if restored, could buffer and reconnect prairie. A social analysis using interviews with local constituencies revealed support for conservation if it were tied to working grasslands that promoted rural socio-economic vitality. To facilitate needed restoration, we developed a state transition model that identified feasible restoration transitions from common "start states" (based on current land cover) to conservation and utility prairie and meadow "end states". We developed restoration plans including techniques, seed mixes, and estimated costs for twenty transitions. To make the expansion of grass-based agriculture feasible, landowners will need assistance with the restoration costs. As land use decisions are driven not only by financial returns but also potentially by the value of ecological services, ongoing InVest modeling will highlight land use patterns where the provision of public and private benefits in future scenarios is optimized. These scenarios are designed to reflect the goals of the Prairie Plan, as well as social and economic constraints. This comprehensive approach provides resources for implementing prairie conservation in western Minnesota and could serve as a model for conservation planning elsewhere.

PROJECT RESULTS USE AND DISSEMINATION

The primary purpose of this project was to provide information and techniques for the implementation of the Minnesota Prairie Conservation plan in two prairie landscapes in western Minnesota. The primary audience is individuals and organizations interested or involved in prairie conservation, especially the Prairie Plan Local Technical Teams. Some parts of the final report, including the prairie conservation planning maps and the social analysis, have already been shared with the teams. Information from the report has also been included in presentations to the teams and other local groups including the County Board of Commissioners. Parts of the report will be available on Conservancy or University websites. Over the next year, information from the report will form the basis for several planned publications in scientific journals.

Project Publication:

Implementing the Minnesota Prairie Conservation Plan in Landscapes of Western Minnesota (PDF - 11 MB)

Project completed: 6/30/2014

Subd. 05 Water Resources

Understanding Sources of Aquatic Contaminants of Emerging Concern

Subd. 05a \$640,000

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RESEARCH

Appropriation Language

M.L. 2010 Projects Completed in 2013-2014

\$640,000 is from the trust fund to the Board of Regents of the University of Minnesota to identify chemical markers to characterize sources of endocrine disruptors and pharmaceuticals entering surface waters in the Zumbro River Watershed. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Pharmaceuticals, hormones, and other contaminants of emerging concern are increasingly being found in surface waters in Minnesota and elsewhere. These contaminants can cause adverse ecological and human health impacts. However, there is a lack of understanding regarding the sources of these contaminants. Scientists at the University of Minnesota's Water Resources Center are using this appropriation to study these contaminants in the Zumbro River watershed in order to:

- Help determine what contaminants are associated with specific land uses;
- Identify methods for monitoring sources and loads of the contaminants;
- Develop science-based recommendations for prevention, reduction, and remediation strategies.
- Ultimately this information should help lead to cleaner surface waters in Minnesota.

Project due to be completed: 6/30/2014* [Extended in M.L. 2013]

***PROJECT INCOMPLETE - FINAL REPORT DUE 08/15/14 NOT RECEIVED**

Managing Mineland Sulfate Release in Saint Louis River Basin

Subd. 05b \$270,000

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RESEARCH

Appropriation Language

\$270,000 is from the trust fund to the commissioner of natural resources to map current sulfate sources and assess treatment options to minimize potential impacts of mercury on fish and wildlife from sulfate releases in the St. Louis River Basin. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Over a century of iron mining in northeastern Minnesota has left numerous waste rock piles, open pits, and tailings basins that appear to be the dominant sources of sulfate in the St. Louis River. This sulfate has become a recent environmental concern due to the possibility that one of the byproducts of its increased presence, methylmercury, may lead to mercury contamination in fish and other wildlife. Through this appropriation, the Minnesota Department of Natural Resources and the University of Minnesota are evaluating the sources and fate of sulfate in the St. Louis River Basin in order to better understand its impacts and determine the best means for reducing or eliminating these impacts, particularly in environments where methylmercury is a byproduct of sulfate presence.

M.L. 2010 Projects Completed in 2013-2014

OVERALL PROJECT OUTCOME AND RESULTS

Taconite mining on the Iron Range sends an average of approximately 35 tons of sulfate per day down the St. Louis River. Another 15 tons per day arises from non-mining sources. Loading from both sources is episodic and depends on hydrologic conditions in the watershed. Most mining-related sulfate arises from the oxidative weathering of minor iron sulfide minerals present in the mined rocks. The predominant pathway for sulfate introduction into the streams is through pumping and overflow of water from taconite pits.

In some source regions, a large percentage of sulfate released near the mines was removed by natural reactions that convert sulfate back to insoluble sulfides ("sulfate reduction"). However, once the sulfate reached the open channel ways in streams, little, if any, additional sulfate was removed by sulfate reduction. Laboratory experiments demonstrated that sulfate reduction can also be stimulated artificially in mine waters by adding organic compounds and iron minerals and eliminating oxygen. However, water hardness and the production of hydrogen sulfide were difficult to control using the methods that were tested.

Methylmercury is a toxic compound that can form as a byproduct of biologic sulfate reduction. Widespread sampling and measurement of methylmercury reveal that its concentration is minimally impacted by sulfate concentration in the main stream or river channels. The dominant source of methylmercury to streams involves the slow passage of water falling on the land through reduced, organic rich materials that surround streams in this area. Except in a few instances, sulfate from mining, added directly to streams, has limited ability to access and impact methylmercury formed in this source region. Laboratory experiments conducted on estuary sediments also indicated that the rate of methylmercury addition to the water column is not directly controlled by sulfate concentration in the overlying water.

PROJECT RESULTS USE AND DISSEMINATION

The work by our group has been widely presented to outside groups including scientists and stakeholders. Plans are in works to publish all or parts of the above reports in peer reviewed journals over the next year.

Three reports and two MS theses were produced directly as a result of this research. Several reports were placed on the DNR's website in late October 2012. This website will be updated to reflect more recent reports by October 2013.

Project Publications:

- Carbon and Iron Additions to Stimulate In-Pit Sulfate Reduction and Removal (PDF - 0.7 MB)
- On the Cycling of Sulfur and Mercury in the St. Louis River Watershed, Northeastern Minnesota (PDF - 5.5 MB)
- Mineralogy, Spatial Distribution, and Isotope Geochemistry of Sulfide Minerals in the Biwabik Iron Formation (PDF - 4.6 MB)
- Sulfur and Carbon Controls on Methyl Mercury in St. Louis River Estuary Sediment - Phase II (PDF - 1.4 MB)
- Sulfate and Mercury Chemistry of the St. Louis River in Northeastern Minnesota (PDF - 1.3 MB)
- Sulfate and Mercury Cycling in Five Wetlands and a Lake Receiving Sulfate from Taconite Mines in Northeastern Minnesota (PDF - 7.0 MB)

Project completed: 06/30/2013

Ecological Impacts of Effluent in Surface Waters and Fish

Subd. 05c \$340,000

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RESEARCH

Appropriation Language

\$340,000 is from the trust fund to the Board of Regents of the University of Minnesota in cooperation with St. Cloud State University to determine the chemical and biological fate of phytoestrogens in surface waters and the impacts on fish. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Phytoestrogens are plant-based compounds that are discharged into surface water from wastewater treatment plants and certain industrial facilities. Phytoestrogens mimic the hormone estrogen and can therefore interfere with normal biological development. For example, it is known that they can feminize male fish. However, the broader effects of phytoestrogens have not been studied and almost nothing is known about their long-term fate or persistence in the environment. Through this appropriation scientists from the University of Minnesota and St. Cloud State University will collaborate to examine the persistence of phytoestrogens in surface waters and their effects on fish. Findings will be used to enhance wastewater treatment and help facilitate continued industrial development and production in Minnesota done in an environmentally sensitive manner.

OVERALL PROJECT OUTCOME AND RESULTS

Phytoestrogens are plant-based compounds that mimic estrogen and can interfere with normal biological development. Research shows that phytoestrogens are discharged into surface water from wastewater treatment plants and certain industries. The biological effects of these compounds have not been well studied, although it is known that they can feminize male fish. Almost nothing is known about their environmental fate. When these compounds enter rivers and streams, it is likely that they will be degraded and therefore may have a lessened impact on biota, but this needs to be confirmed.

In this project, the persistence of two common phytoestrogens (genistein and daidzein) was studied. Fathead minnow exposure experiments at realistic environmental concentrations were also performed. Experiments demonstrated that genistein and daidzein reacted with sunlight. These two compounds also biodegraded rapidly in natural water samples; the rate of degradation depended on phytoestrogen concentration, water/incubation temperature, and the source of the water. Sorption experiments showed that phytoestrogens sorb to sediment, but this is not likely to be an important loss mechanism. Adult fathead minnow exposure experiments showed that only subtle effects on anatomy, physiology, and behavior of fathead minnows occurred as a result of exposure to phytoestrogens singly or in mixtures. The one exception to this was the fact that adult fathead minnows produced significantly more eggs when exposed to daidzein. Larval minnow exposures showed that exposure to genistein, formononetin (another common phytoestrogen), and a mixture of phytoestrogens had a negative impact on larval survival. Adult and larval exposures to microbologically degraded phytoestrogens showed negative impacts on adult egg production. This research indicates that genistein, daidzein, and formononetin are unlikely to cause widespread ecological harm themselves in the absence of other stressors; nevertheless, caution should be exercised with respect to high concentration effluents due to the potentially anti-estrogenic effects of phytoestrogen degradates.

PROJECT RESULTS USE AND DISSEMINATION

M.L. 2010 Projects Completed in 2013-2014

Results have been disseminated at several conferences. In addition, one manuscript has been published, two additional manuscripts have been submitted, and a fourth is being revised and will be submitted for publication in August or September, 2013. This project also resulted in the generation of two Master's theses and one Ph.D. thesis.

Project Publications:

- Phytoestrogens in the Environment I: Occurrence and Exposure Effects on Fathead Minnows (PDF - .7 MB)
- Phytoestrogens in the Environment II: Microbiological Degradation of Phytoestrogens and the Response of Fathead Minnows to Degradate Exposure (PDF - 1.2 MB)
- Direct and Indirect Photolysis of the Phytoestrogens Genistein and Daidzein (PDF - 2 MB)

Project completed: 06/30/2013

Assessing Septic System Discharge to Lakes

Subd. 05e \$594,000

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RESEARCH

Appropriation Language

\$594,000 is from the trust fund to the commissioner of health for department activities and for an agreement with the United States Geologic Survey in cooperation with St. Cloud State University to develop quantitative data on septic system discharge of estrogenic and pharmaceutical compounds and assess septic and watershed influences on levels of contamination and biological responses in Minnesota lakes. The United States Geologic Survey is not subject to the requirements in Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Pharmaceuticals, hormones, and other contaminants of emerging concern are increasingly being found in surface waters in Minnesota, including the state's lakes. Recent research surveying Minnesota lakes found that the most frequent occurrence of these chemicals was in lakes with a high density of septic systems. In river ecosystems some of these chemicals have been known to cause extinction of forage fish species and abnormal sexual development in other fish species, such as bass and walleye. However, little is known about how these compounds affect fish populations in lake ecosystems. Researchers from the U.S. Geological Survey, St. Cloud State University, and the Minnesota Department of Health will cooperatively use this appropriation to help assess which of these chemicals are most frequently present in lakes with high septic system concentration and determine whether native fish populations are being affected. Part of this appropriation will help pay for specialized equipment to study these chemical compounds, expanding the capability of the research laboratory at the Department of Health.

OVERALL PROJECT OUTCOME AND RESULTS

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The current study (1) sampled 20 Minnesota lakes that receive groundwater under the potential influence of septic systems to determine the occurrence of pharmaceutically active compounds (PhACs) and endocrine active compounds (EACs), (2) assessed watershed and groundwater characteristics that may contribute to the frequency of PhAC and EAC detections, (3) assessed the histo-pathology of actively spawning bluegill sunfish for biomarkers of EAC exposure to compounds in the near-shore zone of four target lakes, and (4) enhanced EAC analytical capabilities at the Minnesota Department of Health (MDH) through the purchase of new analytical equipment. Study lakes were chosen based on depth to water table, septic system density regardless of functionality, bluegill nesting habitat, and groundwater temperature surveys in the near-shore zone. Lake water or lake-sediment pore water (water stored between sediment particles, contained within the lake-bed sediment) samples were collected and analyzed for a broad suite of 179 PhACs, EACs, and other waste compounds. All surface water samples and over three quarters of pore water samples had at least one compound detected. Overall, 43 of 69 (62%) waste compounds and 5 of 110 (4%) pharmaceuticals were detected in all samples. Twelve known or suspected endocrine active compounds were detected in at least one lake. On average, the prevalence of detections normalized to the number of compounds tested was three to four times higher in near-shore lake water than in near-shore pore water. Actively spawning male bluegill sunfish were collected from reference and groundwater discharge sites in four lakes. Pathologies were more common in fish collected at near-shore sites when compared to fish collected across entire lakes in the 2008 statewide study. The greater abundance of indicators of adverse biological impact suggests that a lake-wide sampling of fish will underestimate the impact of contaminant exposure to fish during reproductively important life stages.

PROJECT RESULTS USE AND DISSEMINATION

Information from this project has been disseminated to scientific audiences via presentations at Minnesota Water Resources and Midwest Groundwater Conferences.

Project completed: 6/30/2014

Assessing Cumulative Impacts of Shoreline Development

Subd. 05h \$300,000

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RESEARCH

Appropriation Language

\$300,000 is from the trust fund to the Board of Regents of the University of Minnesota to evaluate near-shore, in-water habitat impacts from shoreline development activities to assist in the design and implementation of management practices protecting critical shorelands and aquatic habitat. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Near-shore areas of lakes are critical to the health of lake ecosystems because they contain a majority of the vegetation and are generally the spawning areas for fish. Increases in the rate and extent of shoreline development - including docks, boatlifts, and other structures - and disturbance from recreational activity may be having cumulative detrimental impacts on these ecosystems. However, there is a lack of scientific knowledge

M.L. 2010 Projects Completed in 2013-2014

about these impacts and that has been hindering lake managers in their ability to guide landowners toward better practices. Researchers from the University of Minnesota and the U.S. Geological Survey are using this appropriation to study the cumulative impacts of shoreline development on aquatic habitat, water quality, and fish populations in order to develop a tool that can be used to help guide sustainable near-shore development. Approximately 100 lakes in Aitkin, Becker, Cass, Crow Wing, Douglas, Hubbard, Morrison, Otter Tail and Todd counties will be used in the study.

OVERALL PROJECT OUTCOME AND RESULTS

The littoral zone contains all of the vegetation within a lake and is critical to the physical and biological integrity of lakes. Aquatic macrophytes and coarse woody structure provide refuge, foraging area, and spawning substrate for many fish species. The goal of this study was to evaluate shoreline development by measuring a number of variables that reflect human activity, including terrestrial vegetation, physical alterations, and in-lake structures. Previous studies have found reductions in abundance of aquatic vegetation and coarse woody structure; however, few studies have quantified the specific influence of docks on aquatic habitat structure. Coarse woody structure and three measures of macrophyte abundance increased with distance to the nearest dock structure. Presence of coarse woody structure and emergent species were significantly and negatively related to lake-wide dock density. We intensively investigated effects of lakeshore development on nearshore habitat across 11 northern Minnesota lakes using the Minnesota Department of Natural Resources Score Your Shore (SYS) survey to assess development intensity. Developed sites (a residence and dock present) had lower macrophyte species richness, emergent, and floating-leaf macrophytes and coarse woody structure than undeveloped sites (no residence, no dock). SYS score was a significant factor in models of most macrophyte community variables, supporting the hypothesis that site-scale development intensity is related to littoral vegetation. A fish Index of Biological Integrity decreased as the density of docks increased for the 11 intensively studied lakes. Development density across 29 lakes and 114 lakes were also examined, but less intensively. Effects of development in these less intensively studied lakes were less apparent for most lake macrophyte and fish community variables than for the intensively studied lakes. These findings suggest that riparian management on residential lots and reduced removal of aquatic macrophytes and coarse woody structure could improve fish habitat at both local and lake-wide scales of development.

PROJECT RESULTS USE AND DISSEMINATION

The project was conducted in conjunction with the Minnesota Department of Natural Resources and several meetings to disseminate our findings took place with Jacquelyn Bacigalupi, the Lake IBI Coordinator with MNDNR and colleagues. Additionally multiple conference presentations were given and two Master's theses resulted from the work on this project.

Project completed: 6/30/2012

Trout Stream Assessments

Subd. 05i \$300,000

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RESEARCH

Appropriation Language

M.L. 2010 Projects Completed in 2013-2014

\$300,000 is from the trust fund to the Board of Regents of the University of Minnesota to assess cold water aquatic insect abundance related to warming water temperatures as predictors of trout growth in southeastern Minnesota and assess options to minimize stream temperature changes. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Trout require streams with excellent water quality that are fed by groundwaters that keep streams cold in summer but ice-free in winter. Minnesota has more than 680 designated trout streams that represent a valuable natural resource having high economic, sport, and habitat importance. However, over the long term this resource is under threat from climate change, which will likely increase stream temperatures and could detrimentally impact trout behavior, reproduction success, and food sources, particularly the cold-adapted aquatic insects that are essential in winter diets of trout. This appropriation is enabling University of Minnesota's Department of Entomology to study the health of trout streams in southeastern Minnesota and how changes in stream temperatures could impact the diets and growth of trout populations.

OVERALL PROJECT OUTCOME AND RESULTS

Trout streams in southeastern Minnesota differ markedly in brown trout abundance and growth during winter. Our project objectives were to better understand stream thermal regimes, fish feeding, and fish growth patterns between November and March, so habitat management strategies can be designed to maximize trout production. Prior to this study there was very little detailed knowledge of the winter diets of trout, and virtually no knowledge of the kinds and quantitative abundances of aquatic insects growing during winter. To achieve project objectives, we assessed trout lengths and mass two or three times per winter in 36 streams (12 streams/year for three years) and determined the types of aquatic invertebrates eaten by the trout, the abundances of these dietary organisms in the streams, and the corresponding patterns of trout growth. Our findings show trout are most abundant in streams where groundwater (springs and seeps) inputs keep water temperatures significantly warmer and ice-free in winter. These thermal conditions promote high abundance or emergence of aquatic insects specifically adapted for emergence and reproduction in winter, even when air temperatures are substantially below freezing. Some species that we discovered have never been described and are new to science. We developed predictive models relating air temperatures to water temperatures in areas buffered by groundwater. The models also demonstrate linkages between groundwater input and (1) the corresponding aquatic insect composition and their abundances, (2) the trout diets during winter and (3) trout growth patterns as a function of types of aquatic insects eaten. Based on our predictive models we are able to recommend conditions under which in-stream habitat management efforts can be better spatially focused to maximize trout growth and abundance. This information is being communicated to Trout Unlimited and the MN Department of Natural Resources to help inform their programs to manage trout streams.

PROJECT RESULTS USE AND DISSEMINATION

Our results have been presented at local, state, regional, national and international scientific meetings and at local and state conservation planning sessions. Staff of the MN DNR assisted with much of our field work and have participated in interpreting and writing summaries and drafts of manuscripts for peer review. Consequently, they are very familiar with our findings. In addition, we are communicating our results to regional Trout Unlimited members, and hope to be able to discuss how our findings can help guide the in-stream habitat improvement programs. Two theses have been completed, and three additional graduate students will use portions of our findings as sections for their Ph.D. dissertations. One undergraduate worked on a class activity in Spanish to help serve as an "in-reach" effort to inform undergraduates in areas such as humanities and arts of our research. One newspaper article was written, and we have put videos of our field work on-line for public viewing via our Facebook sites.

Project Publication:

Winter feeding, growth and condition of brown trout *Salmo trutta* in a groundwater dominated stream

Project completed: 6/30/2013

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Subd. 06 Aquatic and Terrestrial Invasive Species

Biological Control of European Buckthorn and Garlic Mustard

Subd. 06a \$300,000

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RESEARCH

Appropriation Language

\$300,000 is from the trust fund to the commissioner of natural resources in cooperation with the commissioner of agriculture to continue the development and implementation of biological control for European buckthorn and garlic mustard. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

European buckthorn and garlic mustard are non-native, invasive plant species that have rapidly spread throughout Minnesota posing serious threats to native plant communities and degrading wildlife habitat in forests and riparian areas. The two plants are considered to be the species of highest priority for development of long-term management solutions, such as biological control, which involves using natural enemies of a non-native species from its native region to control or reduce the impact of the species in the areas where they are invasive. Introducing one non-native species to control another, though, is something that must be done with care so that the introduction doesn't have unintended consequences. This appropriation is enabling the Minnesota Departments of Natural Resources and Agriculture to continue to research and evaluate biological control options for European buckthorn and garlic mustard.

OVERALL PROJECT OUTCOME AND RESULTS

European/common buckthorn (*Rhamnus cathartica*) and garlic mustard (*Alliaria petiolata*) are non-native invasive plants that severely threaten native plant communities and degrade wildlife habitat. They are widely distributed in the state and current control options, such as mechanical and chemical control, are labor and cost-intensive. They are of the highest priority for development of long-term management solutions, such as biological control. The purpose of this research was to determine 1) if there are suitable insects that can be used to reduce impacts caused by buckthorn and 2) implement introduction of insects to control garlic mustard and assess their establishment and success.

Over 30 specialized insects were identified as potential common buckthorn biocontrol. Most of these species were discarded because they lacked host-specificity. Two psyllids were host-specific, but did not cause significant damage to buckthorn and the insects were infected with the plant disease 'Candidatus *Phytoplasma rhamni*' (buckthorn witches' broom). A seed-feeding midge proved too difficult to work with in a research setting. After 11 years of searching for a biological control insect that is host-specific and damaging to buckthorn, we conclude that there are not promising agents at this time.

Four *Ceutorhynchus* weevil species are being studied as biological control agents for garlic mustard. Petitions for release were submitted to the USDA-APHIS Technical Advisory Group starting in 2008, but they have requested

M.L. 2010 Projects Completed in 2013-2014

additional host-specificity testing over time. No biological control insects have been approved for release as of 2014. Studies conducted in the University of Minnesota Containment Facility allowed the development of efficient and consistently reliable methods to rear *C. scrobicollis* from garlic mustard plants. Long-term monitoring at twelve sites in Minnesota shows that garlic mustard populations can fluctuate widely from year to year. There is little garlic mustard herbivory in Minnesota. Garlic mustard cover is negatively correlated with cover of other species.

PROJECT RESULTS USE AND DISSEMINATION

Buckthorn biological control research has been disseminated in one peer reviewed journal publication, a summary report by CABI, four poster presentations, and a webpage on the DNR website:

<http://www.dnr.state.mn.us/invasives/terrestrialplants/woody/buckthorn/biocontrol.html>.

Garlic mustard biological control research has been disseminated in one peer reviewed journal publication, a U.S. Forest service report (http://www.fs.fed.us/foresthealth/technology/pdfs/GarlicMustardBiocontrol_FHTET-2012-05.pdf), project reports, and seven conference presentations.

Project Publications:

- Garlic Mustard (*Alliaria petiolata*) Monitoring in Minnesota: 2005-2013 (PDF - 1.2 MB)
- Biology and Biological Control of Garlic Mustard (PDF - 2.8 MB)
- Garlic Mustard Biological Control Developing Biological Control Insects, Working Towards Field Release (PDF - 0.2 MB)
- The Garlic Mustard (*Alliaria petiolata*) Case, What Makes a Good Biological Control Target: The Intersection of Science, Perspectives, Policy and Regulation (PDF - 0.4 MB)
- Biological control of common buckthorn, *Rhamnus cathartica* (PDF - 4.6 MB)
- Biological control of *Rhamnus cathartica*: is it feasible? A review of work done in 2002-2012 (PDF - 0.1 MB)

Project completed: 06/30/2013

Healthy Forests to Resist Invasion

Subd. 06c \$359,000

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RESEARCH

Appropriation Language

\$359,000 is from the trust fund to the Board of Regents of the University of Minnesota to assess the role of forest health management in resisting infestation of invasive species. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

M.L. 2010 Projects Completed in 2013-2014

Invasive plants cause considerable ecological and economic damage in Minnesota and their control is often difficult to achieve in a long-term cost-effective manner. Although not immune from invasion, healthy forests may be somewhat resistant to invasion; therefore management aimed at maintaining, restoring, or enhancing key forest characteristics might be a useful strategy for slowing forest invasion. Scientists from the University of Minnesota's Department of Forest Resources will use this appropriation to study 80 different forest sites in order to determine the links between forest attributes and plant invasion. Findings will be used to make recommendations for how to best manage forests to resist invasive species.

OVERALL PROJECT OUTCOME AND RESULTS

The primary project goal was to identify forest characteristics effective as deterrents to invasive plants. Healthy forests are likely more resistant to invaders, so management to enhance these key characteristics might slow the spread of invaders.

Invasive plants sometimes form dense thickets that affect recreation and wildlife and exclude native plant species. To determine how various site characteristics affected the abundance of common buckthorn and other invaders, we surveyed plant diversity in 67 sites in central and southern Minnesota. At each site, we measured environmental characteristics to simultaneously account for other factors that might influence invasibility. Buckthorn was most abundant in sites with sparse leaf litter, where seed availability was high, and where native plant diversity was low. Both a greenhouse experiment and a second field study indicated that introduced earthworms also benefit germinating invasive plants by eliminating leaf litter.

We propose the idea of "preventive environmental care" that, like preventative medicine, manages forests to maintain "wellness". Although not a panacea for reducing invasion, it is worth considering given the challenges of controlling established invasive species. We suggest managers enhance the competitive challenge to invaders by increasing the diversity of native species by seeding natives and/or reducing the density of white-tailed deer, a species that severely impacts native forest plants. Furthermore, timber harvests should be limited to the winter season and trail maintenance should be done in a way that limits disturbance. This will help maintain intact native understory plants and litter layers, important deterrents to invasive plant establishment. However, none of these approaches are likely to be successful without a strong effort to control landscape level seed availability. Collaborative management with neighboring landowners is crucial to any effort that hopes to reduce invasibility.

PROJECT RESULTS USE AND DISSEMINATION

To summarize results from the project and provide guidelines for management, we prepared a pamphlet that included all aspects of the research, as it pertains to the invasion of buckthorn. The pamphlet also provides suggestions for pre-invasion management to reduce invasibility, the main focus of the "Healthy Forests" research project. We distributed the pamphlet to all participants at a symposium held on August 14, 2013. The pamphlet is available as a pdf from the project website, <http://forestecology.cfans.umn.edu/Research/Buckthorn/index.htm>.

We presented talks at the Upper Midwest Invasive Species conference (a regional meeting focused on invasive species) and the Ecological Society of America conference (an international conference focusing on all aspects of ecology) in 2012 and 2013. The talks focused on measuring propagule pressure, the greenhouse study, the relationship between earthworm and buckthorn buckthorn, and the effects of native species diversity on buckthorn abundance.

On August 14, we hosted a symposium on the St. Paul campus that brought together managers, researchers, and private landowners to share the latest information on invasive plants in Minnesota forests. In addition to talks based on this LCCMR project, other speakers presented information about buckthorn invasion on the prairie-forest border in west central Minnesota, garlic mustard (another common plant invader in Minnesota's forests) as a driver of species invasion, management of buckthorn from a forester's perspective, and management efforts to control other common invasive plants. The symposium was attended by 100 people. The project website has links to recordings of all the symposium talks, as well as links to the MS Access database, species lists from all survey sites, and a photo gallery.

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We have published one paper ("Community phylogenetic diversity and abiotic site characteristics influence abundance of the invasive plant *Rhamnus cathartica* L.") in the *Journal of Plant Ecology*. A second paper based on results from our greenhouse experiment (Native plant diversity and introduced earthworms have contrasting effects on the success of invasive plants") has been submitted to the peer-reviewed journal *Biological Invasions*. More papers are in preparation including one focusing on propagule pressure and another that documents the relationship between earthworms and buckthorn abundance.

Project completed: 6/30/2013

Bioacoustic Traps for Management of Round Goby

Subd. 06d \$175,000

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RESEARCH

Appropriation Language

\$175,000 is from the trust fund to the Board of Regents of the University of Minnesota to evaluate bioacoustic technology specific to invasive round goby in Lake Superior as a method for early detection and population reduction. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

The round goby is an invasive fish that is rapidly spreading throughout the Great Lakes. One reason for its rapid expansion is that round goby outcompetes native fish through its ability to spawn throughout the spring and summer in contrast to native fish, which only spawn once a year. Interrupting this reproductive cycle in some way could be used to help halt further expansion of round goby and control existing populations. Scientists from the University of Minnesota - Duluth are using this appropriation to develop and test a method for trapping these fish using sounds that mimic those that male gobies use to attract females to the nest.

OVERALL PROJECT OUTCOME AND RESULTS

The bioacoustics of the round goby population in the Duluth-Superior Harbor were investigated over the course of three summers. The goal of the project was to assess the behavior and the sound production of this invasive species to develop a fish trap to target this invasive species. Fish were found to move offshore during the winter and thus subsequent concentrations were thought to have great potential for collection. However, fish were found to be inactive the majority of the winter and did not produce sound. Sound production coincided with the resumption of swimming activity and feeding in late spring with vocalization first recorded when water temperature exceeded 8 degrees C, which correlated with the initiation of spawning. Two choice experimental trials succeeded in attracting the fish to sound sources using both pure tones and round goby vocalizations, indicating that fish can find the origin of sound. Several different traps were produced and bioacoustical field trials were conducted. We were able to capture, for the first time, round gobies in unbaited traps using sound as the only stimulus and observed many round gobies approach sound sources but fail to enter the traps. As they readily enter the same traps when baited, it was concluded that although sound is an effective attractant, it is not the only sensory modality that round goby use to approach calling males. Future experiments that would combine sound

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with a large sexually mature fish and/or pheromones could significantly increase the number of fish that enter the trap and could prove to be an effective strategy.

PROJECT RESULTS USE AND DISSEMINATION

Project manager collaborated with the Great Lakes aquarium to produce a audio video exhibit on invasive fish. Two master's students, Jared Leino (degree pending) and Elise Cordo (degree in progress), received funding from the project and five undergraduate students received funding for summer research. Additionally several manuscripts are in preparation and will be submitted for publication.

Project completed: 6/30/2013

Subd. 07 Renewable Energy

Algae for Fuels Pilot Project

Subd. 07a \$900,000

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Appropriation Language

\$900,000 is from the trust fund to the Board of Regents of the University of Minnesota to demonstrate an innovative microalgae production system utilizing and treating sanitary wastewater to produce biofuels from algae. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Biomass-based energy holds important potential as a viable renewable alternative to non-renewable fossil-based energy supplies; however significant challenges to biomass energy technologies remain to be overcome before such a role can be achieved at a large scale. Researchers at the University of Minnesota's Center for Biorefining, in partnership with the Metropolitan Council, are using this appropriation to develop, build, and test a pilot scale fuel production system that uses the nutrients in sewage wastewater to grow algae that can then be harvested to produce biodiesel. Additional benefits resulting from the system may include improved water quality, minimized freshwater and land use, reduced carbon emissions, and capture and recycling of plant nutrients. With additional research and development of this system it could potentially be implemented at other wastewater treatment facilities and adapted to other waste streams throughout Minnesota and beyond.

OVERALL PROJECT OUTCOME AND RESULTS

Current biomass energy technologies have encountered economic, ecological, and policy concerns, including feed stock procurement, energy balance, carbon footprint, competition for food and fuel, water use, and others. This project was built on our existing collaborative R&D partnership to demonstrate an innovative photosynthetic algae production system which simultaneously produces high lipid oil for bio-fuel production, captures and recycles nitrogen and phosphorus from wastewater, and sequesters carbon dioxide. The goal of the project was to develop, build, and test a pilot scale algae production system that will treat concentrated wastewater and animal facility wastewater and generate algal biomass for production of biofuels and bioproducts. More than 10 high

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performance algae strains have been developed for specific applications such as oil accumulation, nutrient removal, growth under low temperature and low light conditions, and accumulation of high value lipids. Growth conditions were optimized for specific applications. A pilot cultivation facility with a cultivation volume of 20,000 liters was developed and demonstrated. The microwave assisted pyrolysis was found to be an excellent conversion alternative to conventional oil extraction based biodiesel process, and the hydrothermal process is a cost effective pretreatment technology to improve dewatering of algal biomass. The life cycle analysis results indicate that our technologies, which integrate wastewater into algal cultivation, can improve the environmental performance of algal biofuels. The life cycle analysis study also suggests that utilization of multiple major waste streams in wastewater plants should be developed to maximize the economic and environmental benefits of algae based technologies. The outcomes of the project point to a great potential of algae technologies for simultaneous removal of nitrogen, phosphorus, chemical oxygen demand (COD), and other nutrients in municipal and animal wastewaters; sequestration of carbons in organic matters and flue gas; and at the same time accumulation of biomass for production of high value biofuels and bioproducts.

PROJECT RESULTS USE AND DISSEMINATION

Information about the project results were disseminated through more than 10 presentations at national and international conferences, five demonstrations to stakeholders, eleven peer-reviewed journal publications, and through a website: <http://biorefining.cfans.umn.edu>.

Project completed: 6/30/2014

Sustainable Biofuels

Subd. 07b \$221,000

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RESEARCH

Appropriation Language

\$221,000 is from the trust fund to the Board of Regents of the University of Minnesota to determine how fertilization and irrigation impact yields of grass monoculture and high diversity prairie biofuel crops, their storage of soil carbon, and susceptibility to invasion by exotic species. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Perennial grasslands have the potential to provide Minnesota with locally grown energy sources that reduce greenhouse gas emissions, improve water quality, and provide other important benefits. However, much remains unknown about how these crops will be impacted by factors such as climate change and invasive species. Through this appropriation, researchers at the University of Minnesota's Cedar Creek Ecosystem Science Reserve will study how irrigation, fertilization, and climate warming impact perennial grassland biofuel crops in terms of yield, carbon sequestration, plant biodiversity, water quality, and susceptibility to invasive species. Findings will be used to develop methods for optimizing biofuel production, carbon storage, and habitat restoration.

OVERALL PROJECT OUTCOME AND RESULTS

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Minnesota's perennial grasslands produce considerable biomass that could become a valuable resource for producing renewable energy. How might Minnesota's capacity to produce biomass for biofuels be impacted by climate change and anticipated mitigation practices? We explored the impacts of warming, fertilization, and irrigation on biomass production at the Cedar Creek Ecosystem Science Reserve.

Our major overall finding is that high diversity mixtures of prairie perennials provided the best combination of biomass production, invasion resistance, carbon storage in soil, and response to climate warming of all the biomass crops we tested.

Specific findings from the Climate Experiment include:

- Compared to low diversity mixtures of prairie plant species, high diversity mixtures produced much more biomass when experiencing normal weather, were more resilient to the stress of warming, and had their biomass production increase the most from warming.
- High diversity mixes enhanced ecosystem services more than low diversity mixes by sequestering more carbon in soils and being less prone to invasion by non-native species.
- Warming inhibited seed establishment. This could reduce invasions by non-native species, but might threaten establishment of native prairie restorations.

The Fertilization & Irrigation Experiment found:

- Fertilization had similar impacts across all species mixtures.
- Moderate fertilization and irrigation increased productivity, with the largest effects in the Panicum, Panicum+Grasses, and High Diversity plots.

Overall findings on plant invasion showed:

- Invasion is inhibited by higher diversity species mixtures.
- A potential biofuel crop, Miscanthus (as a sterile hybrid), was ineffective at producing biomass in central Minnesota, at least on sandy, drier soils. It had detectable, but moderate invasion into native prairies.

This research has been documented in one publication. Two manuscripts have been submitted and are either in review or under revision. Another manuscript is in preparation. We anticipate additional publications will follow. In 2012, the education programming Cedar Creek reached 6,619 users, including K-12 students, teachers, and the general public.

PROJECT RESULTS USE AND DISSEMINATION

The data from these studies will be included in Cedar Creek's database and made publicly available on the Cedar Creek website. Researchers around the world access and use the data on this site for diverse ecological analyses in many research areas including, among others, biodiversity, invasion, and climate change studies.

The results of these studies are integrated into the educational programming and outreach at Cedar Creek. In 2012, 1,777 K-12 students participated in on-site programs. 1,062 K-12 students participated in off-site programs. Furthermore, 120 K-12 teachers participated in professional development opportunities at Cedar Creek and in their schools. At the university level, 845 students and faculty have made use of Cedar Creek programs, courses, meetings, and workshops both on and off-site. There have been 1,070 visitors to the experimental sites where this study took place.

One journal article that documents findings from this study has been published. See: Isbell, F., 2013, Nutrient enrichment, biodiversity loss, and consequent declines in ecosystem productivity, PNAS, 110: 29.

M.L. 2010 Projects Completed in 2013-2014

A second publication by Heather Whittington is under revision in *Oecologia* and a third has been submitted to *Functional Biology*. Jane Cowles has a fourth article in preparation. We anticipate additional publications will result from this work.

Project completed: 6/30/2013

Linking Habitat Restoration to Bioenergy and Local Economies

Subd. 07c \$600,000

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Appropriation Language

\$600,000 is from the trust fund to the commissioner of natural resources to restore high quality native habitats and expand market opportunities for utilizing postharvest restoration as a bioenergy source. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

More than 7,000 acres of public and private lands needing restoration have been identified within 75 miles of St. Paul. Given the various emerging markets for woody biomass, a unique opportunity has been identified. The Minnesota Department of Natural Resources will use this appropriation to continue development of an innovative approach to improving lands by harvesting ecologically inappropriate woody vegetation and working with local markets to turn the resulting biomass into marketable products such as mulch, animal bedding, firewood, and wood pellets for energy generation. Funds raised from the sale of these products could then be used to expand this type of model into other areas of Minnesota. In addition to helping stimulate local economies, benefits of this approach also include enhanced biodiversity and effective utilization of woody material traditionally burned or landfilled.

OVERALL PROJECT OUTCOME AND RESULTS

This innovative project helped restore 385 acres of critical habitat and high quality native plant communities by removing ecologically inappropriate woody vegetation (exotic and/or native species) while stimulating local economies through jobs and strategic utilization of the biomass material for bioenergy and other products. This project facilitated habitat restoration efforts that might not have otherwise occurred while making the woody material, traditionally burned or landfilled, available to established and emerging woody biomass markets.

Of the \$600,000 appropriation, \$490,666 was spent on eleven projects. Seven non-DNR public and private landowners received a total of \$324,530 granted through a competitive process. Four DNR projects received a total of \$166,136. A variety of types of projects (based on restoration goals, species/type of woody biomass material, density, distance, land ownership, utilization opportunity, etc.) were completed.

Projects were selected based on critical requirements including ecological value and recovery potential of the project site, current ecologically-based management plan, project-specific harvest plan, post-harvest restoration plan, and demonstrated capacity and long-term commitment to effectively manage the site to achieve and maintain restoration goals.

M.L. 2010 Projects Completed in 2013-2014

Viable markets were identified prior to project implementation. Utilization of the woody biomass resulted in 291 semi-truck loads or 5,280 tons for bioenergy, 242 semi-truck loads of commercial mulch, 450 cords of pine sawlogs, 6 log loads of cottonwood for pallets, and pine cabin logs. Biomass material was either sold separately from the harvest with revenue collected, or in conjunction with the harvest where contractors valued the material (deducted from the harvest bid) and were responsible for final utilization. Revenues collected (\$11,100) and values attributed (\$4,000) were reinvested for further purposes of the project.

This project demonstrated that there are opportunities to sell or properly utilize ecologically inappropriate woody vegetation removed through habitat restoration activities. The long-term vision for this effort is to achieve an ecologically sound and systematic approach that addresses: current and future issues of habitat restoration and enhancement; renewable energy and climate change; invasive species, and natural resources conservation planning and implementation - all of which are effected, to some degree, by the impacts and opportunities of woody biomass.

PROJECT RESULTS USE AND DISSEMINATION

The webpage "Linking Habitat Restoration to Bioenergy and Local Economies" located at http://www.dnr.state.mn.us/eco/habitat_biomass.html provides an overview of the entire project, the project fact sheet, the LCCMR-approved Work Program, and the final report.

Project data were compiled and regularly updated for the DNR's Grant Outcomes webpage to provide project descriptions, funding information, indicators, targets and outcomes information. The website is located at <http://www.dnr.state.mn.us/grants/outcomes/index.html>.

Project information was shared at public workshops, conferences and meetings through formal presentations, panel discussions, informal conversations and handouts, such as the project fact sheet and other printed materials, targeted for the audience. Project information was also shared with DNR staff through staff meetings, project coordination, formal presentations, and informal discussions.

Telephone conversations and meetings were convened with land managers/owners, harvest contractors, and biomass market industry representatives to discuss the project, garner insights for improvements to implementing this project, identify challenges and opportunities to move this effort forward and to facilitate connections between landowners, contractors, and biomass end-users.

The key messages were:

- For land managers/owners conducting habitat restoration projects: explore and implement the option to utilize the biomass material removed versus piling and burning or landfilling;
- For contractors: provide the combined service of harvest and utilization of the material; and
- For end-users: acknowledge habitat restoration projects as a potential significant source of material and to seek this opportunity.

Project completed: 6/30/2013

Subd. 08 Environmental Education

Minnesota Conservation Apprenticeship Academy

Subd. 08a \$368,000

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Appropriation Language

\$368,000 is from the trust fund to the Board of Water and Soil Resources in cooperation with the Minnesota Conservation Corps or its successor to train and mentor future conservation professionals by providing apprenticeship service opportunities to soil and water conservation districts. This appropriation is available until June 30, 2013, by which time the project must be completed and the 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 find and place a total of 60 students in apprenticeship positions with county soil and water conservation district offices throughout the state. This unique program will provide 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

Many of Minnesota's conservation districts' most experienced conservation professionals and practitioners are nearing retirement age but due to budget constraints will not be replaced until they have left employment. Consequently, Minnesota is missing a great opportunity to transfer knowledge and experience to the next generation responsible for Minnesota's conservation.

While college graduates with conservation-related degrees are knowledgeable in technology, theory, and research methods, their practical, on-the-ground skills need development. Communicating with landowners and adjusting designs for field nuances are vital skills for the success of conservation projects and are best learned from seasoned professionals. In turn, apprentices bring knowledge of emerging technologies and other innovations to improve the quality and productivity of current conservation efforts. This allows for a cross-pollination of ideas and solutions for natural resource challenges.

From 2011 to 2012, 65 students were placed with 60 Conservation Districts. During this time, the apprentices planted 33,339 trees, took 5,219 samples to monitor water quality; provided environmental education to 1,495 people; conducted 1,372 surveys; restored 1,542 acres of habitat through invasive species removal; completed 466,773 square feet of rain garden planting and maintenance; 272,173 square feet of erosion control and shoreline restoration; and 12,933,645 square feet of seeding. Due to the 2011 state shut down, a shifting of allocated funds allowed for the placement of an additional 35 students with conservation districts in May of 2013.

This program has benefits to both students and conservation districts. 100% of apprentices indicated the hands-on experience gained during the apprenticeship will enhance their future academic studies, and that they now have increased technical conservation skills and are more prepared for a future career in conservation.

98% of the Districts were satisfied with the work their apprentices completed, and 100% indicate 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.

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PROJECT RESULTS USE AND DISSEMINATION

Information from the project has been disseminated through reports to LCCMR, press releases by BWSR and the Governor's Office, local press releases by SWCDs, and through the Conservation Corps newsletter and annual report. Information was used to recruit apprentices and increase awareness of the project.

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, to plant biodiversity.

Project completed: 6/30/2013

Engaging Students in Environmental Stewardship through Adventure Learning

Subd. 08b \$250,000

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Appropriation Language

\$250,000 is from the trust fund to the commissioner of natural resources for an agreement with the Will Steger Foundation to provide curriculum, teacher training, online learning, and grants to schools on investigating the connection between Minnesota's changing climate and the impacts on ecosystems and natural resources. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Climate change poses many challenges for Minnesota's future. To successfully engage people in overcoming these challenges it is important for them to have a developed sense of connection to Minnesota's ecosystems and an understanding of the immediate and long-term impacts climate change will have on them. Through this appropriation, the Will Steger Foundation will partner with a number of academic and civic organizations to develop an age appropriate program for students in grades 3-12 that ties Arctic explorer Will Steger's adventures with engaging content on Minnesota's natural environment, the short and long term impacts of climate change, and related student-led action projects.

OVERALL PROJECT OUTCOME AND RESULTS

The Will Steger Foundation developed Engaging Students in Environmental Stewardship through Adventure Learning (MCC) with the understanding that environmental stewardship begins with a local connection and sense of appreciation, or environmental sensitivity, towards the natural environment. This project's primary audience, educators, have the unique opportunity to lead their students through the environmental education continuum of knowledge, awareness, and skills that lead to an informed and active environmental citizenry.

Climate change is one of the most critical environmental issues of our time and educators have an important role to play in educating their students and providing them the skills to mitigate and adapt to climate change. In order to make the issue relevant and connected to the lives of those reached through our project, we focused specifically

M.L. 2010 Projects Completed in 2013-2014

on the impacts of climate change on Minnesota's biomes. Additionally, we wove in stories from Will Steger's life and examples of his own early observations of the natural world and his curiosity of weather and climate. We also tapped into the expertise of many Minnesota scientists and educators in the development of our Grades 3-12 curriculum, online classroom and two public forums and three Summer Institutes for climate change education.

Over the three years of the project we were able to reach and increase the climate literacy of over 5000 educators, members of the public and students via our Summer Institutes for Climate Change Education, year round workshops, conference presentations, school visits, field trips, public forums and our online classroom (classroom.willstegerfoundation.org). The project also resulted in the development of a number of valuable, mutually beneficial, and long-term partnerships. The partnership with the Mississippi River Fund, National Park Foundation and Mississippi National River and Recreation Area resulted in the ability to support 20 student service projects and field trips for over 500 students to enhance their learning on Minnesota's changing climate. MCC was recognized in 2012 by Environmental Initiative in the area of environmental education in part due to these important partnerships. A final evaluation report showed overall success for the project in providing a curriculum and training that increased climate literacy, environmental stewardship and educator confidence in teaching about climate change.

PROJECT RESULTS USE AND DISSEMINATION

Over 500 formal and informal educators from all four biomes received a copy of the Minnesota's Changing Climate Curriculum via three Summer Institutes and customized workshops for school districts and at professional education conferences. The curriculum was used to teach over 10,000 Grades 3-12 students about Minnesota's unique biomes, what makes them unique, how they are threatened by climate change and what they can do to mitigate the impacts. Additionally, the curriculum has been shared nationally and regionally via the Climate Literacy Network, the Great Lakes Education Collaborative, Green Teacher, Humphrey Institutes Innovations in Education Forum and the North American Association for Environmental Education as a model of place based climate change education.

Additionally, over 1,000 students submitted their observations of Minnesota's biomes during the school year to our online classroom, with at least 2,000 more viewing and/or commenting on their observations.

Minnesota's Changing Climate curriculum has been used as a framework to develop curriculum specifically focused on the Mississippi River and climate change impacts on Wisconsin. Additionally the Minnesota Phenology Network and Minnesota Master Naturalists have used portions of it and endorse its effectiveness for communicating the connection between phenology and climate change. The curriculum has been aligned with the St. Paul Public Schools "power standards" and Minneapolis Public schools elementary STEM standards and used as an example of how to meet those standards. Finally, teachers from Minnesota American Indian reservations that are participating in The CYCLES project, a project of the STEM Center at the University of Minnesota, received training and are using the curriculum in their schools because the place based focus of the curriculum resonates culturally.

The online classroom, created in partnership with Hamline's Center for Global Environmental Education, has been used by educators around the state to learn more about Minnesota's unique biomes, their cultural history and climate change impacts. Finally, the Minnesota Phenology Network has utilized it has the perfect curriculum for connecting individuals with a reason why phenology is important.

Project completed: 6/30/2013

Urban Wilderness Youth Outdoor Education

Subd. 08d \$557,000

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Appropriation Language

\$557,000 is from the trust fund to the commissioner of natural resources for an agreement with Wilderness Inquiry to provide an outdoor education and recreation program on the Mississippi River. This appropriation is available until June 30, 2013, 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 urban youth. 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 - will use this appropriation to expand an environmental education and recreation program that provides disadvantaged urban youth and families, some of whom have never even been on a boat, with hands-on educational and recreational experiences of the Mississippi River in 24 foot Voyageur canoes. Funds are enabling the program to serve an additional 23,000 urban youth and families in the Twin Cities metro area. Public school groups have day trips and overnight excursions available to them to augment their classroom learning, while other youth and families have access through community events.

OVERALL PROJECT OUTCOME AND RESULTS

The goal of Urban Wilderness Youth Outdoor Education (UWYOE) was to provide accessible, outdoor education and recreation opportunities on the Mississippi River and surrounding watershed for more than 20,000 urban youth over a three-year period. UWYOE was developed in response to the sharp decline in participation in outdoor education and activities such as canoeing, camping, hunting and fishing by urban youth.

UWYOE provided experiential environmental learning experiences on the Mississippi River and surrounding watershed for 24,899 Twin Cities middle and high school students, exceeding our initial goal of 20,000. 80% of the youth served identify as a person of color and 80% are eligible for free or reduced lunch. The majority, 76%, had very little or no prior experience with outdoor activities.

Environmental education experiences were provided through outdoor workshops on local lakes and rivers, guided day trips on the Mississippi River, and overnight camping trips in local parks. National Park Service Rangers and Wilderness Inquiry guides provided natural and cultural history and science lessons as part of each program activity. We developed, refined and implemented classroom activities, provided three teacher trainings for Minneapolis Public Schools summer school staff, and developed a program website. We also purchased four 24' Voyageur canoes to expand our capacity to serve more youth.

A three-year evaluation was conducted by the University of Minnesota's Center for Applied Research and Educational Improvement (CAREI). Major outcomes include:

- 77% of participants reported an increased interest in science and the environment
- 87% of teachers agreed that students learned about environmental issues
- 100% of students said they would like to participate in an outdoor activity like this again

This program has gained national attention as a model for engaging urban youth with the environment and building skills to grow future stewards and managers of our public lands. In the summer of 2012, Secretary of the Interior Ken Salazar and Governor Mark Dayton recognized the program as a leader in America's Great Outdoors initiative.

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PROJECT RESULTS USE AND DISSEMINATION

The Environment and Natural Resources Trust Fund's investment in UWYOE has resulted in the establishment of a model program for engaging youth in the outdoors, which we now call Urban Wilderness Canoe Adventures (UWCA). The UWCA has been recognized by the EPA, the Department of Interior, and Gov. Mark Dayton, among others, as a leader in America's Great Outdoors Initiative. Within the National Park Service and National Forest Service, the UWCA is being held up as an example of how these agencies need to engage in urban communities across the country.

In 2010, Wilderness Inquiry and the Mississippi National River and Recreation Area unit of the National Park Service piloted the UWCA concept developed in the Twin Cities to Washington DC, with support from the National Park Service, US Forest Service, the US Army Corps of Engineers, and several DC based nonprofit organizations. Serving 1,000 DC area school kids on the Anacostia River, this effort helping bring together 20 DC area organizations focused on though and/or the Anacostia River. To build on this success, we launched the "Canoemobile" to introduce youth to urban waters in multiple cities, and to help build local coalitions dedicated to providing outdoor opportunities to disadvantaged youth. In 2013, the Canoemobile will serve youth in Milwaukee, Michigan City, Chicago, Louisville, Cincinnati, Cleveland, Philadelphia, New York City, and Washington DC. Nature Valley has signed on as a sponsor of the Canoemobile.

We held two outcomes briefings (one in 2011 and one in 2013) to present the University of Minnesota's Center for Applied Research and Educational Improvement (CAREI) evaluation results. The first was hosted by the Minneapolis Foundation and the second by Mayor Chris Coleman and the Saint Paul Foundation. Each had more than 35 community leaders, funders, and educators present. Information about the project has also been disseminated through the project website.

The UWCA has received coverage on Kare 11 News, the Star Tribune, Pioneer Press, and Mpls/St. Paul Magazine.

Project completed: 6/30/2013

Get Outside - Urban Woodland for Kids

Subd. 08e \$218,000

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Appropriation Language

\$218,000 is from the trust fund to the commissioner of natural resources for an agreement with the city of St. Paul, Department of Parks and Recreation, to restore and develop an outdoor classroom for ecological education and historical interpretation at Como Regional Park in St. Paul. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Outdoor classrooms provide students and community members with an opportunity to have hands-on experiences learning about the environment and about core subjects like science, math, and social studies using nature as the base context. This appropriation will help the city of St Paul develop an outdoor classroom at Como Regional Park

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that will provide environmental education, historical interpretation, and habitat for native wildlife in an inner-city community where environmental learning opportunities are rare. The development plan calls for control of invasive species for the 17 acre area, gravel pathways and signs to help visitors travel and interpret the site, and outdoor study areas featuring coniferous forest, oak savanna, tall-grass prairie, sedge meadow, transitional woodland, and propagation gardens for native plants. Site planners will work to establish the area as a MN DNR School Forest.

PROJECT OVERVIEW

Trends amongst youth are showing decreasing interest in the nature world and declining involvement in outdoor recreation. Some attribute these changes to increased usage of computers and other technology that compete for the attention of young people. Through this appropriation, the Minnesota Department of Natural Resources is partnering with several organizations to build on this potential contributing factor as being part of a possible solution by expanding a successfully piloted environmental education program that uses digital photography as a bridge between technology and outdoor experiences. Outdoor nature photography workshops for at least 1,000 teachers and naturalists are being conducted throughout the state that provide guidance on how to use outdoor digital photography to enhance student learning on classroom subjects including math, science, geography, arts, and language arts.

OVERALL PROJECT OUTCOME AND RESULTS

The City of Saint Paul developed a 17.65 acre outdoor classroom in Como Regional Park to provide environmental education, historical interpretation, and habitat for native wildlife in an inner-city community where environmental learning opportunities are rare. The woodland is located within five miles of over 75 public and private schools. To date, the Como Woodland Outdoor Classroom has been utilized by 2,103 students and educators. It has become the School Forest for Great River School and Crossroads Elementary School through the MN DNR's School Forest Program.

The Environment and Natural Resources Trust Fund's investment in the Como Woodland Outdoor Classroom has resulted in the development of outdoor study areas featuring coniferous woodland, oak savanna, tallgrass prairie, shortgrass prairie, transitional woodland, and terrace forest plant communities. Additionally, a propagation garden area has been constructed within the Classroom that will serve as a native plant demonstration garden for the public and will be utilized by students to grow native plants for the Classroom. ENRTF funds were also utilized to install 2,525 feet of ADA accessible gravel trails within the Classroom.

Funds were used to install four entry signs at each of the major entrances to the Como Woodland Outdoor Classroom. 27 numbered, interpretative posts were installed at key locations throughout the site. The City of Saint Paul has received \$17,000 from the Minnesota Historical Society and is in the final stages of developing a guide book to the cultural and natural history of the site, referencing these numbered posts. When published, the guide book will be an invaluable resource for educators wishing to bring students to the Como Woodland Outdoor Classroom.

Community volunteers were engaged throughout the restoration process. 2,005 volunteers participated in restoration activities, including planting, invasive species removal, and trail construction.

PROJECT RESULTS USE AND DISSEMINATION

Our advisory committee, the Como Woodland Advisory Committee, has set up a website dedicated to the classroom: <http://www.comowoodland.org/>. Progress about our project has been shared with the general public through our blog (<http://restoresaintpaul.blogspot.com/>) and our Facebook page (<https://www.facebook.com/saintpaulnaturalresources>). Community volunteer events taking place in the classroom are highlighted on the City's website (<http://www.stpaul.gov/index.aspx?NID=1043>). The Minnesota Lottery recently highlighted the Como Woodland Outdoor Classroom in their newly launched blog: http://blog.mnlottery.com/blog/2014/07/24/64/where_the_money_goes_como_woodland_outdoor_classroom.

Project completed: 06/30/2014

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Expanding Outdoor Classrooms at Minnesota Schools

Subd. 08f \$300,000

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Appropriation Language

\$300,000 is from the trust fund to the commissioner of natural resources to establish additional and enhance existing outdoor school forest and prairie classroom networks throughout Minnesota.

PROJECT OVERVIEW

Since 1949 the School Forest Program has been providing Minnesota's K-12 students with outdoor classrooms where they can learn core subjects like math, science, and social studies outdoors using nature as the base context. Statewide there are currently 100 School Forests - which can also include prairie, wetland, and other natural areas other than forest - located in both urban and rural areas. This appropriation will help the Minnesota Department of Natural Resources establish 20 new school forests and provide better training and support services for teachers and school districts with existing forest areas.

OVERALL PROJECT OUTCOME AND RESULTS

The School Forest Program is Minnesota's outdoor classroom program. This project provided support to create new School Forest sites; develop and deliver site-specific outdoor education trainings, regional workshops, a multi-day conference, and a summit; create new online and in-person resources to better support School Forests; and investigate long-term support options for the School Forest Program. Funding provided 1.5 FTEs of School Forest educators for three years and an additional .75 FTE School Forest Specialist for one year.

Minnesota has 125 School Forests throughout the state. As a result of this project, 22 new School Forest sites were developed on 256 acres of land, complete with proper applications, legal paperwork, School Forest committees, and land management plans. To meet teacher needs, several assessments were conducted (see 2012 School Forest Survey Report) and the results were used to create support materials for online and in-person delivery. The School Forest website was revamped and new sections relating to land management, outdoor education, and lesson plans/activities were created. More than 39,000 visitors used the website. School Forest staff participated in hundreds of crucial in-person site visits, meetings, and presentations to bolster support for new and existing School Forests.

To encourage and support outdoor education activities, this project delivered 21 site-specific outdoor education trainings, reaching 523 teachers. These workshops involved Project Learning Tree materials and content was tied to Minnesota academic standards in math, science, and social studies. One hundred outdoor education kits were developed and delivered. The kits provided tools, materials, and lesson plans to allow teachers to easily prep and teach age-appropriate outdoor activities meeting Minnesota academic standards. In addition, two regional trainings, one multi-day conference, and one summit were developed and delivered. These events provided School Forest teachers the opportunity to delve into outdoor education strategy, discover practical teaching tips, and network with teachers, natural resource, and education experts; 106 teachers participated in these events.

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Over three years, this project provided new outdoor education opportunities to over 400 teachers and 11,000 students at 22 new School Forests. The total project activities reached over 1,500 teachers and 30,000 students statewide at all 124 School Forests.

PROJECT RESULTS USE AND DISSEMINATION

The School Forest website (www.mndnr.gov/schoolforest) houses many materials created by this project. It is viewed by thousands of people every month. The School Forest Activity Board, within the website, is home to more than 100 new lesson plans created by School Forest teachers and staff. Of particular note are over 20 newly developed activities and lesson plans that correlate to math standards from Prekindergarten to eighth grade, meeting the need to effectively teach math outside.

Dozens of newspaper articles and websites posts were created regarding the new 22 School Forest sites created during this grant.

The results of the School Forest Survey were presented at the 2013 Minnesota Environmental Education Conference and are being reviewed by DNR staff, teachers and naturalists statewide. This information is being used to create or provide better resources to support teachers interested in outdoor education.

Delivery of the "How to Teach in Your School Forest" trainings have evolved and been modified to meet teacher needs. For example, appropriate outdoor and reflection time is incorporated into each training and several other DNR and partner education programs have begun to use these techniques. In addition, the Minn. Dept. of Education asked School Forest staff and teachers to present much of the outdoor education training delivered as part of their ENRTF Environmental and Outdoor Education project. This provided positive outcomes for all partners involved.

About 70 percent of the 22 new School Forest sites are in an urban area. Results from the 2013 Urban School Forest focus groups were used to identify needs specific to urban sites. Strategies are needed for dealing with vandalism, dogs, invasive species, and high community use on small, urban parcels.

Two School Forest site coordinators were awarded the "Formal Environmental Educator of the Year" by the MN Association for Environmental Education for their work with their school forests (2012 & 2013). The School Forest program was recognized as one of Governor Dayton's Education Highlights for 2011-2012.

Project completed: 6/30/2013

Integrated Environmental and Outdoor Education in Grades 7-12

Subd. 08g \$300,000

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Appropriation Language

\$300,000 is from the trust fund to the commissioner of education in cooperation with the commissioner of natural resources to train and support grade 7-12 teachers to integrate environmental and outdoor education into the instruction of academic standards.

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PROJECT OVERVIEW

Trends amongst youth are showing declining participation in outdoor recreation, a decreased understanding of the natural world, and a shift to a more sedentary lifestyle. Through this appropriation, the Minnesota Department of Education is working to combat these trends while also improving the achievement of students in grades 7-12. Professional development and grants for innovative programs are being provided to help teachers use the environment and outdoors as a context for student learning in science, mathematics, social studies, and physical education.

OVERALL PROJECT OUTCOME AND RESULTS

With research indicating that students are increasingly disconnected from nature, the Minnesota Department of Education (MDE) in cooperation with the Department of Natural Resources was funded to hire a full-time coordinator to lead a project to train and support grade 7-12 teachers to integrate environmental and outdoor education (EOE) into the instruction of academic standards. Professional development and grants of up to \$8,500 were provided to six pilot schools to support 50 teachers and administrators in their use of the environment and outdoors as a context for student learning, which resulted in engaging over 1,000 students in EOE on a regular basis. A full report of the project, including evaluation of the training and student learning and model lessons, was submitted to LCCMR.

Beyond the original goals of the project, the project coordinator also developed partnerships with several EOE providers to coordinate and offer five, additional, day-long regional workshops at minimal cost that were attended by 108 additional educators not from the pilot schools.

The project coordinator also developed and implemented Minnesota's participation in the first two years of the U.S. Department of Education's Green Ribbon Schools Program that recognizes schools for efforts to reduce their environmental impact and implement EOE throughout their curriculum. Minnesota led the nation with the most applicants in 2013 and seven Minnesota schools and districts were among 156 schools that received the national award to date. Workshops led by the coordinator at the sites of Minnesota's three 2012 national honorees were attended by over 100 people.

A position at MDE to integrate EOE has provided credibility and prioritization of EOE at Minnesota schools and within the department. It has resulted in better coordination among Minnesota's many EOE providers and plans exist for future coordination with MDE standards and health program staff.

PROJECT RESULTS USE AND DISSEMINATION

Information about the project, including the final report and model lessons, will be posted on the SEEK (Sharing Environmental Education Knowledge) website at www.seek.state.mn.us, hosted by the Minnesota Pollution Control Agency.

In addition to the numerous EOE workshops and training led by the coordinator, the coordinator has directly reached over 2,300 other educators through technical assistance and teaching, including participating in several workshops, programs and events. The coordinator also made regular efforts to promote activities related to the project and the benefits of environmental and outdoor education whenever possible throughout the duration of the project. EOE information, resources and achievements, such as the Green Ribbon Schools honorees, were regularly shared through MDE's Superintendents mailings and department listserves, and newsletters and listserves by SEEK, Minnesota Association for Environmental Education, Minnesota Science Teachers Association, Green Schools Coalition, Children and Nature Connection, Minnesota Sustainable Communities Network and many others.

The coordinator had occasional opportunities to do some media activities, including a 20 minute interview about the value of EOE on the April 1, 2013 show of the podcast, Mom Enough, which has a national following of several thousand listeners. The interview can be found at <http://momenough.com/2013/04/lets-get-outside-tips-for-parents-and-teachers-from-an-environmental-educator-and-creative-dad>. Local media from the communities of

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the pilot schools and Green Ribbon School honorees also developed news stories covering the value of EOE activities.

The introductory EOE regional workshops developed with the DNR, Jeffers Foundation and other local partners have led to additional opportunities for coordinated workshops. In particular, the Jeffers Foundation has expressed interest in continuing to work with MDE on future workshops patterned after those developed during the project.

The evaluation of the project, which was conducted by Dr. Julie Ernst, University of Minnesota - Duluth, was a great opportunity for her to expand on her nationally-recognized environmental education research. She is hoping to publish a research paper at some point summarizing the evaluation of the project, which will hopefully help inform and guide future research in the field.

Project completed: 6/30/2013

Fishing: Cross Cultural Gateway to Environmental Education

Subd. 08i \$155,000

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Appropriation Language

\$155,000 is from the trust fund to the commissioner of natural resources for an agreement with the Association for the Advancement of Hmong Women in Minnesota to provide environmental information and teaching skills to and increase participation of Southeast Asian communities through the gateway of fishing skills. Information on mercury in fish advisories must be included as part of the educational outreach. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

The number of people from other cultures and with other native languages is increasing in Minnesota. It is important for these new Minnesota residents to have knowledge of behaviors that best ensure protection of Minnesota's natural resources into the future. However, effectively communicating with people across cultures to change behaviors can be challenging. Through this appropriation, the Association for the Advancement of Hmong Women in Minnesota and the Mississippi Watershed Management Organization are partnering to use the common ground of fishing as a foundation for community outreach on environmental stewardship to Southeast Asian elders, youth, and families. Public events will be held that combine fishing and environmental education on topics including water quality, invasive species, lead-free tackle, mercury and other contaminants, fish consumption advisories, and fishing regulations.

Project Incomplete: Project failed to comply with reporting requirements and was closed out as incomplete in 2013. No final report.

Minnesota WolfLink

Subd. 08j \$193,000

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M.L. 2010 Projects Completed in 2013-2014

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Appropriation Language

\$193,000 is from the trust fund to the commissioner of natural resources for an agreement with the International Wolf Center to develop interactive onsite and distance learning about wolves and their habitat. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

PROJECT OVERVIEW

Wolves are an important part of Minnesota's ecosystems and natural history. Minnesota is one of the only places in the lower 48 states where wolves were not completely eliminated by the 1970's and the state has been at the center of wolf population recovery and range expansion ever since. Because of people's widespread interest in wolves, they also provide an important vehicle for educating about nature and the environment. The International Wolf Center in Ely will use this appropriation to expand an educational program to an additional 2,500 students that utilizes wolves as an interdisciplinary educational tool for K-12 students, their teachers, and others throughout Minnesota. The program uses live, interactive distance learning through video conferencing in conjunction with on-site kits to bring wolves directly into the classroom.

OVERALL PROJECT OUTCOMES AND RESULTS

The project funded:

- 118 live interactive video broadcasts from the International Wolf Center in Ely, Minnesota to inner-city, suburban and rural schools throughout Minnesota.
- Two new loan boxes. These boxes are shipped to schools in advance of the broadcast. Each box contains: Wolf pelts, claws, teeth, scat, bones of the wolf prey, wolf related books, ink stamps, projects that they can work on and keep and lesson materials in English, Spanish, Hmong, Somali, and Braille.
- New video broadcasting equipment. It will provide quality broadcasts for many years.
- A portion of an educator wages and benefits. The educator has a master's degree and many years of wolf exposure and training.
- The creation, printing and mailing of promotional materials and some promotional travel expenses.

The original goal was to offer 100 WolfLink programs reaching 2,500 students and teachers along with the wolf loan boxes to educate, engage, and promote future stewardship of the state's environmental resources. To provide translation for three languages and braille to the classroom educational materials. Also, to provide improved broadcasting technology by acquiring new technology.

International Wolf Center was able to reach 118 schools and 3,804 students, exceeding the original goal by 18 schools and 1,304 students. The 2 additional loan boxes were added and much needed due to the frequency of programs. One Minnesota school was able to be included in a broadcast with schools from Canada and Mexico, making their wolf education also a multi-cultural event with the ability to interact with these foreign students. The lesson materials are translated and opened the education to children where English is their second language.

There were several schools that were not aware they possessed the necessary technology to receive the live interactive broadcasts. After the wolf broadcasts those schools were open to Internet broadcast learning opportunities.

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Minnesota tourism increased somewhat as many children brought home their souvenirs and other lesson materials from the wolf loan boxes and requested their family make a trip to Ely, where many families visited the International Wolf Center and viewed in person the same live wolves seen in their WolfLink program.

The advanced technology made available by this grant will continue to serve well for many years.

The question may be asked why this education is important and even relevant today. It is best answered by the enthusiasm displayed by the children's faces when the wolves howled or showed other wolf behavior. They learned all about wolves based on scientific based research. They were able to figuratively leave their school, via the internet broadcast, to experience the great outdoors of Minnesota, all the while learning about taking care of Minnesota's natural resources. By involving children in this educational process it is preparing our next generation to be stewards of Minnesota resources. The facts are taught in the hopes that a better informed public can be involved in making better informed public policy relative to wolves and other Minnesota natural resources.

PROJECT RESULTS USE AND DISSEMINATION

The WolfLink programs reaching out to 118 schools has been spread by word of mouth. The original plan of having 100 interactive broadcasts was an aggressive goal at the time of grant application. Having exceeded it has shown how successful the new technology presents the materials. When a teacher in a school completed a program, they naturally shared their enthusiasm with their fellow teachers. This led to other teachers within the same school to request programs for their classroom.

Part of the marketing plan included printing of postcards which were done for less money than originally planned. The Internet and emails, which were not funded by this grant, were also used effectively to market the WolfLink programs to Minnesota schools. In all the communications credit was given to the Minnesota Environment and Natural Resources Trust Fund for making these free programs possible.

The lessons plans were updated before and during the WolfLink presentations. The updating is a continue process. The split screen capability allows the teacher and the wolves to be presented on the same screen to hold the attention of the class to what is being taught. We believe that part of this program that teachers will repeat this process each year, as the cost after the completion of this grant is not cost prohibitive.

Project completed: 6/30/2013
