

# **S** *Semi-Annual Report*

January - June

O

R

O

N



NATURAL RESOURCES  
RESEARCH INSTITUTE

Our research goes to work.

# Table of Contents NRRI Semi Annual Report January – June 2010

PROJECT HIGHLIGHTS .....	1-9
<b>CENTER FOR APPLIED RESEARCH AND TECHNOLOGY DEVELOPMENT .....</b>	<b>10-77</b>
Forest Products	
Creation of Energy Efficient Inorganic-Bonded Structural Insulated Panels .....	11
Devil's Track General Store NRRI Product Development Fund .....	12
Epicurean Cutting Surfaces .....	13
Evaluation and Demonstration of Nondestructive Assessment Technologies for Sorting Eastern Hardwoods .....	14
Goodwill Industries, Inc. - NRRI Product Development Fund .....	15
Heat Treatment of Firewood - Meeting the Phytosanitary Requirements .....	16
House3: FEMA-Housing Assessment Tool Demonstration.....	17
Iron Phosphate Bonded OSB.....	18
Mat Inc. - NRRI Product Development Fund .....	19
Nondestructive Assessment of Advanced Composite Material.....	20
Phosphate Bonded Fiber and Waste Residual Composites for Applied Commercialization.....	21
Thermally-Modified Eastern Hardwoods as High-Tech Fenestration and Exterior Shuttering .....	22
Total Productive Maintenance for the Wood Products Industry .....	23
Use of Laser Scanning Technology to Obtain As-Built Records of Historic Covered Bridges .....	24
Wood Utilization Options for Urban Trees Infested by Invasive Species.....	25
Wood Utilization Research .....	26
Wood Utilization Research 2009 .....	27
Forestry	
Assessment of Biomass Sources for Energy in Northern Minnesota for the Laurentian Energy Project.....	28
Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel .....	29
Minnesota Forest Productivity Research Cooperative .....	30-31
Regional Biomass Feedstock Partnership-Poplar.....	32
Energy	
Minnesota's Geothermal Energy Production .....	33
Polymetallic Gas to Liquid Catalysts .....	34
Environmental Chemical	
Distribution of Mercury During the Processing of Copper-Nickel Ores.....	35
Full Scale Mercury Sorbent Testing at Boswell.....	36
Investigation of Mercury Vaporization During Induration and Removal of Mercury from Scrubber Solids.....	37
Mercury Reduction Tests - Bench/Pilot Scale - Western Lake Superior Sanitary District .....	38
Slip Stream Pilot Plant for Testing Mercury Removal Methods for Taconite Flue Gases .....	39
Minerals, Ferrous	
Closing the Loop on Filter Cake Moisture Analysis and Control .....	40
Continuation of the Concentrator Modeling Center at CMRL.....	41
Development of Engineered Tiles with Radiation Absorbing Properties from Taconite Raw Materials.....	42

Effect of Fluorine and Chlorine on Fired Pellet Metallurgical Properties.....	43
Effect of Preheat Burners on a Straight Grate Induration Furnace.....	44
Environmental Taconite Particulate Project-Mesothelioma.....	45
Evaluation of Tailings.....	46
Grant Writing and Grant Search for Minnesota Taconite Operations, State and Federal Department of Energy.....	47
Hydroseparator Modeling.....	48
Metallized Iron Nodule Production.....	49
Next Generation Metallic Iron Nodule Technology in Electric Furnace Steelmaking.....	50
Pellet Fines Removal System.....	51
Performance of Taconite Aggregates in Thin Lift HMA.....	52
Preclassification of the Final Stage of Magnetic Separation Feed.....	53
Research, Development and Marketing of Minnesota`s Iron Range Aggregate Materials for Midwest and National Transportation Applications.....	54
Shallow vs. Deep Bed Sinter Quality Comparison.....	55
Taconite Industry Products and By-products: An Investigation of Alternative Uses and Their Economic Potential.....	56
Up-Grade CFD Cooler Models for Grate-Kiln Systems, and Perform Cooler Evaluation of Cooler Speed/Bed Depth on Process Energy Recovery.....	57
Up-Grade Computational Fluid Dynamic Cooler Models and Evaluate Bed Depth vs. Energy Recovery.....	58
Utility of Taconite Materials as Road Patch for Highway Construction.....	59
<b>Minerals, Industrial</b>	
Geologic and Stratigraphic Controls of the Aggregate Potential of the Mesabi Iron Range.....	60
<b>Minerals, Non-Ferrous</b>	
Compile and Make Digital the Lithologic Data for all NRRI Drill Logs, Emphasis on Duluth Complex Drill Holes....	61
Copper-Nickel-PGE Mineralization Potential of the Cloquet Lake Intrusion, NE MN.....	62
Further Evaluation of Diamond Base Metal and Precious Mineral Potential of Minnesota Using Various Glacial Till Sampling and Analytical Methods.....	63
Heavy Stream Discharge from the Falcon Concentrator.....	64
History and Compilation of All Gold Exploration Data in Minnesota.....	65
Investigation of Various Flotation Reagent Schemes for the Flotation of Sulfides from Minnesota`s Copper-Nickel Deposits.....	66
Origin and Distribution of Chromium Mineralization in the Duluth Complex and Related Keweenawan Intrusives in Minnesota, and Its Relationship to PGE Mineralization.....	67
Precambrian Research Center.....	68
Reconnaissance Evaluation of the Volcanogenic Massive Sulfide (VMS) Potential in Lake of the Woods, Koochiching & Beltrami Counties.....	69
<b>Peat, Horticultural</b>	
Peat Expansion Premier Horticulture, Inc.....	70
Wetland Banking Fens Research Facility.....	71
Wetland Mitigation in Abandoned Gravel Pits.....	72
CARTD Program Notes.....	73-77

<b>CENTER FOR WATER AND THE ENVIRONMENT</b> .....	78-106
<b>ECOSYSTEM STUDIES - Land Resources</b>	
Acceleration of Inorganic Nutrient Release and Mineral Organic Matter Association by Biophysical Soil Mixing along an Earthworm Invasion Chronosequence.....	79
Biomass Harvest Effect on Wildlife.....	80
Canada Lynx and Snowshoe Hare Habitat Use Interactions.....	81
Development of Sampling Framework/Key Protocols for Monitoring Natural Resources in the Great Lakes Network.....	82
Exotic Earthworm Invasions: Integrated Research and Education to Achieve Natural Resource Protection.....	83
Grand Portage National Monument-Baseline Earthworm Survey.....	84
Long-term Soil Productivity: Vegetation Sampling - Chippewa National Forest.....	85
Minnesota Breeding Bird Atlas.....	86
Monitoring Birds in Great Lakes National Forests.....	87
Prevention and Early Detection of Invasive Earthworms.....	88
Statewide Ecological Ranking of CRP Lands.....	89
Survey of Beaver Ecology in Grand Portage National Monument.....	90
Synoptic Mapping of Native Plant Communities of the Laurentian Mixed Forest.....	91
Vegetation Characterization and Conifer Regeneration Strategies for the Grand Portage National Monument.....	92
<b>ECOSYSTEM STUDIES - Water Resources</b>	
Assessing the Condition of Great Rivers using Benthic and Planktonic Algal Indicators.....	93
Data for Discovery and Decision-making: Lake Superior Streams.....	94
Duluth Residential Stormwater Reduction Demonstration.....	95
Great Lakes Biological Monitoring: Phytoplankton.....	96
Minnesota`s Water Resources: Impacts of Climate Change - Phase II.....	97
Predicting Impacts of Development on Lake Superior North Shore Streams/GIS Data.....	98
Research Development Testing and Evaluation Facility for Ballast Treatment in the Great Lakes Region.....	99
Restoring Impaired Lake Superior Tributaries: Stormwater BMP Evaluation, Education, and Outreach.....	100
St. Louis River Watershed Streams and Lakes: Water Quality Biological Monitoring.....	101
Volunteer-Assisted Water Quality/Bio Monitor North Shore Superior Streams.....	102
Weather and Water: Combining Broadcast Meteorology and Stream Data Animations to Protect Superior.....	103
<b>CWE Program Notes</b> .....	104-106
<b>NRRI BUSINESS DEVELOPMENT</b> .....	107-110
<b>NRRI PUBLIC RELATIONS</b> .....	111-112

## **Project Highlights**

## CENTER FOR APPLIED RESEARCH & TECHNOLOGY DEVELOPMENT

### *Wood Products and Forestry*

#### **Forest Products Program Continues to Stabilize and Strengthen the Forest Products Industry**

Brian Brashaw was invited to make a presentation during the General Session of the 64<sup>th</sup> International Convention of the Forest Products Society. This presentation titled, "Building on a Century of Successful and Innovative University Research" highlighted a number of key university research success stories leading to successful commercialization of particleboard, medium density fiberboard, and machine stress rated lumber. Future emphasis areas of research were also highlighted including: woody biomass conversion, biofuels, bio-based products, nanotechnology, sustainability, advanced construction designs and processes, and traditional forest products. These and other research topics will help to stabilize and strengthen the forest products industry, leading to continued and future employment, especially in rural and urban/rural interface areas of the United States.

#### **NRRI Successfully Demonstrates a Hybrid Prefabricated Housing System to FEMA Inspection Team**

Patrick Donahue and Scott Johnson successfully demonstrated to a FEMA inspection team a hybrid prefabricated housing system. The inspection process was the final stage in an elaborate assessment of the technology by FEMA as an alternative ready to assemble disaster response delivery system for medium term housing event deployment. The project continues to move towards commercialization.

#### **Successful Hybrid Poplar Research Program Receives National Attention**

The NRRI Hybrid Poplar research program continues to play a major role in the development of woody energy crops nationally. The NRRI program has been asked to participate in several national-scale proposals to develop renewable biomass sources. NRRI continues to receive national attention for its successful poplar breeding program and biomass production research.

#### **Forestry Team Begins Planning to Set Up Woody Biofuel Research and Outreach Center at NRRI**

NRRI forestry team continues to build a core capacity to serve the woody biomass sector in Minnesota through research and outreach. Plans have been established to set up the Woody Biofuel Research and Outreach Center at NRRI, with goals to support the characterization and understanding of the affects for various woody biomass sources as potential feedstocks for densified fuels or thermally processed biofuels. Background research will be completed, technical data developed, small production capacity established, and short courses will be developed to support the current and future biomass industry. Several proposals were prepared and selected to provide initial funding for this effort.

### *Energy*

**Minnesota's Heat Flow Mapping** -- Downhole temperature collection continued into January 2010 until it was too cold to collect data. Dr. Gosnold (consultant) did a preliminary report on the downhole temperature data from three boreholes at the Tamarack Ni-Cu deposit on the Aitkin-Carlton County line. One borehole has preserved an 800 year old climate signal. During the last six months, two additional boreholes were probed at Duluth Metals Corporation's Nokomis Cu-Ni-PGE deposit southeast of Ely in Lake Co., bringing the total of probed holes at this location to six. Also, two boreholes at PolyMet Mining Corporation's NorthMet Cu-Ni-PGE deposit near Babbitt were probed. All downhole temperature data from the 11 boreholes have been turned over to Dr. Gosnold for analysis. Additional collection of granite samples has begun for thermal conductivity and radionuclide analyses. Borehole rock samples for thermal conductivity analyses were requested and received from Rio Tinto/Kennecott. These samples were added to samples previously collected at Duluth Metals' Nokomis Cu-Ni-PGE deposit. A total of 32 granite samples have been collected. In addition, 37 additional rock samples have been collected to better characterize the range of thermal conductivity in non-granitic rocks. All of these analyses will be used to calculate heat flow in areas of Minnesota that do not have accessible drill holes for downhole temperature data collection. Also, all of the granitic samples will be sent out for geochemistry and polished thin sections next quarter to further characterize the granites. In addition, Dr. Gosnold is running model studies using different amplitudes of the post-glacial warming signal and to develop subsurface temperature maps. Based upon data collected to date, the data indicate if the post-glacial warming signal is as large as we think (12-15°C), the depth to usable geothermal temperatures for EGS is at least 1 km less than the current published data, that is, temperature

versus depth geothermal maps, indicate. Dr. Gosnold plans to submit the data from the boreholes that have been logged so far to the borehole paleoclimate website maintained by the University of Michigan.

**Biomass Pretreatment**--Igor Kolomitsyn and Andriy Khotkevych explored the differences in behavior of hardwood and softwood during thermochemical decomposition (torrefaction). It was found that torrefaction of softwood begins by the decomposition of the arabinoglucoronoxylan in the hemicelluloses. Naturally occurring monomolecular compounds are stable at these conditions. These findings may further help in fine-tuning the torrefaction process of woody biomass, as well as lead to development of a new technological pathway for manufacturing of bio-based chemicals. Scientific data were presented at the TCBiomass2009 conference in Chicago, September 2009.

**Biomass Characterization** -- Biomass characterization has been ongoing with the IKA calorimeter performing well. Thermogravimetric analysis (TGA) has been performed on a number of samples.

**Utilization of Assorted Gasifier Feedstock Ash as a Fertilizer -- Jim Barbour**, Plant Services Administrator at the University of Minnesota Morris, began a service agreement with the Coleraine Minerals Research Laboratory (CMRL) to research the utilization of assorted gasifier feedstock ash as a fertilizer. Feedstocks to be used for CMRL's Biomax25 gasifier include corn stover, prairie grass, wood chips, soybean straw, corn cobs and wheat straw. Previous research conducted by the United States Department of Agriculture (USDA) and other institutions have found that ash remaining after biomass gasification has the potential to be used as a fertilizer. This study will expand this research by using assorted feedstock found in the Midwest. **Matt Mlinar** will be the engineer at CMRL responsible for this project, which is being conducted in collaboration with CMRL, the University of Minnesota Morris, and the USDA.

**New Catalysts for Liquid Fuel Production** -- Fischer Tropsch metal catalysts were prepared to allow for the production of high octane automobile fuels from biomass gasification syngas using woody or agricultural biomass fuel sources.

#### ***Direct Reduction and Iron Nodule Production***

**DOE Metallization Program** – *Oxy-coal burner evaluation*. A 560,000 BTU oxy-coal burner was positioned to fire horizontally from the end of the furnace, down the length of the Linear Hearth Furnace (LHF). The pulverized (approximately 80% passing 100 Mesh) coal was conveyed by an air blower through an eductor system to give it sufficient velocity through the burner. The system was designed for the feed rate of the coal to operate as a baseline energy load, while temperature control is provided through the current oxy-natural gas combustion system. Recent modifications to the furnace included removing a baffle wall separating zones two and three, which subsequently created an extended firing zone. The extended zone was necessary to accommodate the energy load from the coal burner with the volume of conveying airflow required to prevent plugging and still maintain a reducing atmosphere. These modifications have resulted in the LHF operating successfully on the coal-oxygen burner system, controlling both atmosphere and temperature. This was accomplished by reducing the ratio of conveying air to coal with increased fuel flow rates, and by using sub-stoichiometric oxy-gas burners to control oxygen content. The coal-oxygen burner system was capable of controlling the set point temperature of 2575°F in zone 3 while maintaining good atmosphere control for production of NRI.

**Use of PRB as a Reductant**. Conditions have been identified that will allow effective use of Powder River Basin (PRB) coals in the iron nodulization process. There is a need to reflect the amount of binder added and the amount of processed coal used in the reaction mixture to allow optimum results to be attained. The use of processed PRB coals versus other coal types will be evaluated on an economic basis in future work for the project.

**Mass Energy Balances/CFD Models**. Process variables leading to simulation divergence were identified. They were used to redefine furnace design, producing a furnace that converges under a wide range of operating conditions. Six simulations were performed with the new furnace design, outlining a process operating map based on oxygen concentration and coal volatile content. These simulations converged at the corner points of the map, demonstrating that convergence and operating stability can be controlled through a combination of furnace design and appropriate choices of operating conditions. To date nine simulations are complete, remaining simulations

should be completed by end of August 2010. Once completed, statistical analysis will be used to understand process variable interactions.

**Dust Reduction Project for Nucor, Trinidad Operations** -- CMRL was chosen by Nucor to research methods of reducing fines generation from direct reduced iron (DRI) pellets produced at DRI operations in Trinidad. New methods are being scaled up to test the technologies in Trinidad.

**New DOE Grant Awarded to CMRL** -- The Coleraine Minerals Research Laboratory was awarded a \$400,000 Phase I research grant for continuation of the Nodular Reduced Iron project utilizing biomass solid fuels, with the potential for an additional three years of \$3 million funding with the installation of a biomass torrefaction system at Coleraine.

**AISI DRI Project** -- An additional American Iron and Steel Institute ( AISI ) project was awarded to CMRL for fabricating a high temperature furnace for DRI production.

**NuIron Technologies Prototype Plant for Iron Nodules** -- A site visit to Conway, Arkansas, was made in February to prepare for an extended furnace run in April. **Kyle Bartholomew's** work focused on preparing for gas analysis during the run. We designed and implemented a sequencer to deliver gas to the NOVA analyzer. Sample conditioning equipment was also specified and installed. A document describing the gas analysis equipment and strategy was generated and distributed. In April the extended run in Conway took place. **Kyle Bartholomew** worked with Ryan Spoering to calibrate all of the flowmeters used in the gas analysis system. The Testo 350XL analyzer was also calibrated for high CO<sub>2</sub> operation, as we anticipated needing it in the furnace exhaust. The NOVA analyzer was connected to the plant's PI datalogging system, and seemed to be performing well. The extended trial was cut short due to plant mechanical failures and subsequent refractory damage to the car surfaces.

#### *Minerals Processing Development Activities*

**Ermaden Iron Ore Flowsheet Development Project in Turkey** -- CMRL was chosen by Hatch Engineering, Canada, to develop a full concentrator and pellet plant flowsheet for a new magnetite ore body in Turkey; 35 metric tons of magnetite crude ore were received at Coleraine to crush, grind, concentrate, ball, and pelletize according to guidelines provided by Ermaden engineers as well as recommendations made by CMRL project engineers. Preliminary concentrator results are very promising and Ermaden engineers are planning a visit to Coleraine later this year.

**Iron Ore Fines Removal** -- NRRI's pellet fines removal system (FRS) was configured with new wear resistant chevron lifters for improved service life. The newly modified system will be tested at Northshore Mining, Silver Bay, MN, during the fall of 2010.

**Upgraded Sinter Pilot Plant** -- CMRL's sinter pot simulation furnace for sinter production and its pot grate simulation furnace for taconite pellet firing and production were newly upgraded with Programmable Logic Controls (PLC) and deeper beds to be able to simulate any sinter furnace depth and pellet firing cycle found in the world.

**Plasma Stone from Taconite By-Products** -- A Phoenix Solutions plasma arc furnace was installed and commissioned at CMRL to evaluate the production of unique quality tiles from taconite ore and tailings materials. On May 18, 2010, a demonstration of the plasma tile making process was held at CMRL. This was led by Len Frame of Phoenix Solutions, and several potential investors and economic development representatives were in attendance. The process was described, and samples of product were available for viewing. Mr. Frame discussed his desire to start a company based on making decorative items cast from molten taconite tailings. These items could include flower pots, accent pieces, basins, backsplashes, roofing tile, etc. He envisions NRRI as a business incubator for this company. In addition to the possibility of using the cast taconite tailings as decorative or architectural items, NRRI recently received a \$50,000 University of Minnesota Initiative for Renewable Energy and the Environment (IREE) Seed Grant to use the cast taconite tailings in a passive solar application. CMRL will generate a series of small tiles to try to determine which recipe has the best solar absorption potential. Then, using



the most promising recipe, a larger volume of tiles will be cast to populate an 8 ft by 8 ft wall that will be installed outside to measure its passive solar heating performance.

### ***Environmental Characterization Studies***

**Hg Emission Characterization** -- In June, CMRL assisted United Taconite with stack testing and mercury sampling. Stack testing was conducted on the unit 2A waste gas stack. The Testo 350XL stack gas tester was used to measure SO<sub>x</sub> and NO<sub>x</sub>. United Taconite was working on their sample probe for their continuous emissions monitor and wanted a cross check of their numbers. The data were delivered to United Taconite in a memo on June 11. CMRL also assisted United Taconite with the internal mercury audit they conducted in June. To complete a mercury balance, UTAC was attempting to use an ultrasonic flowmeter to measure slurry flows. They had assigned a summer intern (who had attended our classes at CMRL) to the project. He was having difficulty getting the meter to work, so it was brought to CMRL to test it in a more controlled environment. It was possible to get the meter to work well on clear water, but when used in a slurry recirculation loop, the meter was unable to register a reading. Further consultation with the manufacturer helped us to confirm that the meter was not appropriate for this type of application. UTAC used a pump audit to estimate slurry flow during the mercury sampling campaign. During the mercury sampling campaign, Tim Kemp assisted with slurry sampling, and Jeff Antonovich and Kyle Bartholomew ran our Ohio Lumex on-line mercury analyzer on the unit 2A waste gas stack. Mercury concentration in the stack was recorded for several hours during the test.

**Keewatin Taconite Air Flow Survey** -- CMRL also assisted Keewatin Taconite in June with an airflow survey. Our researchers worked with Marty Hanninen of Metcom Consulting to conduct this survey. The goals of the survey were to measure the flow balance between the two scrubber booster fans and to compare plant operation to a baseline survey done in 2005 before the scrubber was installed. The survey was attempted on June 29, but was aborted due to plant operational issues. The survey was successfully conducted on June 30. Data have been processed and a draft report has been issued to KeeTac for review. The scrubber fans were well balanced, and cost savings opportunities were identified

**Environmental Study of Airborne Particulates on the Mesabi Iron Range** -- During the first six months of 2010, in-plant air sampling occurred at various processing sites (crusher, magnetic separator, balling drums, and kiln pellet discharge areas) within the ArcelorMittal (Minorca, 3 events), Northshore (2 events), Minntac (1 event), Keetac (1 event), Hibtac (1 event), and Utac (1 event) taconite plants. Drill core samples from two locations on the Mesabi Iron Range have been analyzed by the elutriator method. A meeting in March with the University of Minnesota School of Public Health (SPH) developed reporting protocols. Age dating of lake sediment samples continues as does laboratory analysis of particulates utilizing transmission electron microscopy, scanning electron microscopy, proton-induced x-ray emission, energy dispersive spectrometry, and electron back scatter diffraction. A combined external science advisory board (NRRI and SPH) has been planned for September 2010.

## **CENTER FOR WATER AND THE ENVIRONMENT**

### ***Land Resources***

#### **Breeding Bird Atlas**

CWE field staff recently completed the first two years of an anticipated six-year effort in the development of the Minnesota Breeding Bird Atlas – the first-ever statewide survey of Minnesota's breeding birds. Our objectives were to gain uniform statewide coverage for all of Minnesota's birds, estimate breeding bird populations by habitat type, and contribute to a nationwide network of bird atlases in the United States. During the last two breeding seasons (2009 and 2010) we sampled 40% of Minnesota townships (>920). We observed over 200 species of birds and counted over 78,000 individual birds in over 950 townships and in over 2,800 individual point counts. CWE bird censusers also contributed thousands of observations to the Minnesota Atlas data base in the complementary study organized by Audubon Minnesota. This represented over 4,000 probable or confirmed breeding records for Minnesota birds.

#### **Moose GPS Collar Project**

Moose in northwestern Minnesota declined from over 4,000 to about 100 counted in the last aerial survey by the Minnesota DNR. Moose in northeastern Minnesota may also be declining. We began collaring moose in January 2010 in Voyageurs National Park and on the Grand Portage Indian Reservation. We will collar about 20 moose near Isabella and possibly along the Gunflint Trail in 2011. With this project we will develop habitat management guidelines for moose, improve understanding about thermal refuge requirements for moose, and help understand possible causes for a moose decline. The project has cooperators in the National Park Service, the Minnesota DNR, the Grand Portage Indian Reservation, the 1854 Authority, and the U.S. Geological Service.

#### **Coastal Zone Bat Project**

We are in the second year of monitoring bat use of different forest cover types using acoustical bat detectors. This year we are also using mist nets to capture bats and confirm calls being made by each species. Bats are more commonly found on corridors such as rivers, roads, and trails than in the interior of the forest.

#### **Grand Portage National Monument Beaver Project**

We are finishing a project for the Grand Portage National Monument to count the number of beaver in the only currently active beaver pond on the monument. We also measured forage use and availability along the pond, and took several thousand images with trail cameras.

#### **Canada Lynx Project**

We are continuing field work on the Canada lynx project. Canada lynx are considered a Threatened Species under the Endangered Species Act in Minnesota. There are now two Canada lynx still wearing transmitting collars in Minnesota. One of these lynx has been wearing a radiocollar for over five years now. The project is transitioning, with a decreased emphasis on field work and an increased emphasis on using what we have learned for management. In a project receiving partial funding from LCCMR (proposed in the last round) we will work with different stakeholders to reduce animosity towards Canada lynx, determine ways to streamline permitting issues, and avoid lawsuits such as those that have occurred with wolf recovery in the lower 48 states.

### ***Water Resources***

#### **Algae and Paleoecology**

Members of NRRI-Ely's research team are gearing up for their 8<sup>th</sup> sampling cruise of the Great Lakes for the USEPA Great Lakes National Program Office's monitoring program. Phytoplankton collections from the research vessel Lake Guardian are being used to track long-term shifts in open-water conditions in the lakes. Data so far indicate that dramatic changes have occurred in the food web due to species invasions and several as-yet unexplained factors.

The Great Ships Initiative ballast water research facility is in the midst of evaluating three candidate treatment systems. Candidate treatments for ballast water are tested to determine if they are sufficiently effective to meet criteria for ship-board applications. NRRI personnel are ensuring that candidate treatments meet Federal and International Maritime Organization criteria for mortality of microorganisms, such as potentially invasive algae

and protozoans being transported in the ballast water of ships. New and innovative methods to evaluate treatment effectiveness have been developed by NRRI personnel, and these methods were just published in the Journal of Great Lakes Research.

The Paleolimnology of Lake Superior project is well under way. Several sediment cores have been collected from Lake Superior and analyses have been initiated. This Sea Grant funded work will evaluate the long-term changes in the great lake to determine human impacts from various stressors such as pollution, climate change and changes to food web dynamics. Sediments will be analyzed for biological and chemical remains, and results will supplement various long-term analyses that are used to track ecosystem changes.

### **Global Great Lakes: Integrating Yesterday, Today and Tomorrow and Transforming Environmental Data into Anticipatory Ecosystem Management**

This project, developed by the Large Lakes Observatory and currently funded by the University of Minnesota's Institute on the Environment, aims to identify meaningful metrics of ecosystem health for the ten large lakes in North America, Africa, and Eurasia which collectively hold 60% of all the liquid freshwater on the globe. This phase of the project focuses on improving the capacity to monitor and model these metrics in real-time or near real-time, with an initial focus on the western arm of Lake Superior and the St. Louis River Estuary, and develop the capacity to anticipate pressing environmental issues in order to change how the great lakes of the world are viewed and managed by scientists and the public. NRRI is currently operating water quality sensors at the Duluth inlet to Lake Superior, helping to develop a project website ([www.globalgreatlakes.org](http://www.globalgreatlakes.org)), and adapting our on-line, interactive data visualization tools for displaying Large Lakes Observatory's Lake Superior buoy data streams, Lake Superior fisheries and climate data, and St. Louis River and Lake Superior watershed stressor gradients derived from GIS data and prior GLEI-related studies. Project partner activities have focused on development of a nowcast, weather-based model of hydrodynamics in the Duluth-Superior Harbor, development of uniform data formats for Lake Superior fisheries managers (binational), and implementation of decision support system and forecasting the conditions of surface water resources, and to notify responsible staff and the public of current conditions on a routine basis. NRRI has also been working with Large Lakes Observatory on developing plans for a related series of workshops focused on Lake Victoria, East Africa. The first is being held in Jinja, Uganda in September 2010, and is entitled Global Great Lakes Data Management and Visualization: Enhancing Utilization of Lake Victoria Fisheries Information for Decision Support. This project would facilitate a sharing of expertise between scientists and managers working on the two largest lakes in the world.

### ***Land/Water Interaction***

#### **Minnesota's Water Resources: Impacts of Climate Change**

Minnesota's climate has become increasingly warmer, wetter, and variable, resulting in unquantified economic and ecological impacts. More recent changes in precipitation patterns combined with urban expansion and wetland losses have resulted in an increase in the frequency and intensity of flooding in parts of Minnesota with extensive and costly damage to the state's infrastructure and ecosystems. We are examining historic climate records and developing a database of key climatic measures and their variability in a current LCCMR project 'Impacts on Minnesota's aquatic resources from climate change.' To assess the consequences of past climate trends on aquatic resources we are analyzing hydrologic, water quality, and fish community responses. A comprehensive database containing more than 2 million data records has been assembled containing water quality data from Minnesota lakes having a minimum of 15 years of data for at least one parameter. In addition, ice out records, fisheries survey data, and data on lake and stream levels have been assembled. Data retrieval tools have been developed to access historic climate data; a lake water quality data retrieval tool displays trends for individual or groups of lakes.

Ice-out dates are occurring earlier, with statistically significant trends apparent across the state. Walleye spawning dates also appear to be occurring earlier, lagging the ice-out by approximately one-half to a full day. Fish communities also appear to be changing, with greatest changes occurring in the bass and sunfish species. Lake surface water temperatures are trending upwards, but there are strong regional differences associated with these trends. Lake levels also are increasing, and also show strong regional trends. An economic analysis of climate change and environmental quality has been completed, with completion of a literature review and estimation of the effects of climate change on the public's benefits from recreational fishing based on altered ranges and

abundances of game fish (both expansions and declines). Further analyses are ongoing to identify trends in climate and associated water quality and fish communities.

### **The Weber Stream Restoration Initiative**

The Weber Stream Restoration Initiative began in 2005 with a private endowment to create a partnership of University scientists and extension educators along with local, state, and federal agency staff to restore and protect Lake Superior basin trout streams ([www.lakesuperiorstreams.org/weber/index.html](http://www.lakesuperiorstreams.org/weber/index.html)). The initiative features a demonstration project targeting the sediment-impaired Amity Creek watershed for multiple restoration activities that include long-term monitoring and assessment using novel, interactive, web-based data visualizations of intensive real-time water quality where the stream discharges into western Lake Superior. The construction phase of three major projects was completed in 2009: 1) bank stabilization and channel restoration of Graves Road Creek in Lakeside/Lester Park; 2) two bank stabilizations, riparian zone re-vegetation, and in-stream flow on an upper East Branch Amity reach; and 3) a neighborhood stormwater reduction retrofit project. Extensive monitoring activities have continued in 2010 on these projects and a Great Lakes Restoration Initiative proposal to EPA for continued restoration work in the Amity watershed has been recommended for funding. The Weber Initiative also was presented with the Lake Superior Binational Forum's 2010 Environmental Stewardship Award.

### **Stressor Gradients and Spatial Narratives of the St. Louis River Estuary**

The St. Louis River Estuary, simultaneously an EPA area of concern and soon to become Superior National Estuarine Research Reserve, is a complex mosaic of high quality plant, animal, and aquatic habitat intermingled with areas of heavy industrial use, contaminated sediments, and effluents from an urban landscape. Communities surrounding the estuary are actively developing land use plans that will set the course for their future environmental and socioeconomic health, and it is imperative that local decision makers have access to data, tools and technologies that allow them to make the best decisions for their communities. Scientists and educators from University of Minnesota Duluth (NRRI and Sea Grant), Bemidji State University, University of Wisconsin-Madison (Landscape Architecture, Sea Grant, Curriculum & Instruction, Local Games Lab), and University of Wisconsin-Superior (Natural Sciences) are collaborating via both Minnesota and Wisconsin Sea Grant funding to provide an assessment of reference and at-risk aquatic habitats in the St. Louis River watershed and estuary to guide future monitoring, restoration, remediation, land use planning, along with community awareness and stewardship. We will do this by systematically characterizing water quality, and plant and macroinvertebrate communities along a watershed-based human stressor gradient, and using the results to map reference and at-risk sites within the estuary. This gradient will be used to help build spatial narratives through multifaceted land, ship, and Internet-based outreach and collaborative learning activities designed to communicate results to a wide variety of targeted end users, including youth, teachers, citizens, managers, and local decision makers, as well as existing partnerships such as the Superior Regional Stormwater Protection Team. Communication and education tools include an open geospatial archive, a 'deep map' that incorporates vignettes of local communities, augmented reality games and geo-tours of the estuary, ship-based activities, and a diverse array of complementary online resources. Results of this study are intended to help guide implementation of the St. Louis River Habitat Plan, help prioritize monitoring, restoration, and remediation activities, and enhance public awareness and understanding of estuaries in coordination with the development of the St. Louis River Estuary/Superior National Estuarine Research Reserve

### ***Public Outreach/Information Dissemination***

#### **The Western Lake Superior GLISTEN Collaborative Cluster**

GLISTEN is the Great Lakes Innovative Stewardship through Education Network. It is a program funded through the Learn and Serve Higher Education program of the National Corporation for National and Community Service that has been designed to build capacity in STEM (science, technology, engineering, mathematics) faculty and curriculum, to train students to act as environmental stewards, and to prepare students for green jobs.

GLISTEN provides funds to create clusters of academic and community environmental groups in areas around the Great Lakes. The Western Lake Superior GLISTEN Cluster has been organized by CWE personnel and also includes faculty, staff, and students from Lake Superior College (Duluth), University of Wisconsin Superior, and Northland College (Ashland, Wisconsin). Funding for our cluster started in February, and is anticipated to continue for three years.

The Western Lake Superior GLISTEN cluster has partnered with local and regional community environmental groups, including the St. Louis River Alliance, Great Lakes Aquarium, Bad River Watershed Association, Hawk Ridge Observatory, and Trout Unlimited. Students from GLISTEN courses will work on community-based projects designed by our non-profit partners.

The bridge between the GLISTEN classroom and our community partners will be formed by a group of advanced undergraduate students, called Stewardship Liaisons, who will be specially trained in leadership skills, service-learning, and community engagement. These liaisons will receive training not only in the academic sphere, but also from leaders in our community groups. The Stewardship Liaisons will assist in the design and implementation of GLISTEN service learning curriculum, direct the undergraduate community projects, and critically assess both academic and community outcomes. This position will provide invaluable experience for students interested in leadership positions in the emerging Green Economy.

### **The Lakesuperiorstreams.org Website**

The [www.lakesuperiorstreams.org](http://www.lakesuperiorstreams.org) website was developed by NRRI, Minnesota Sea Grant, and the city of Duluth, Minnesota, as part of a regional effort to provide relevant water quality, landuse, and water quality impact data and interpretive materials, as well as prevention and remediation guidance to contractors, developers, realtors, agency staff, decision makers, and homeowners. The website has a strong emphasis on stormwater and is a key element of the education and outreach program for the 25 member organization Superior Regional Stormwater Protection Team. It integrates animated, intensive data streams with climate and GIS landuse data, interpretive information, curricula, case studies, and a conservation design toolkit. There are five cross-linked, data-rich, educational/public access websites at NRRI that receive more than two million requests per month; the [lakesuperiorstreams.org](http://lakesuperiorstreams.org) site represents about 20-25% of those requests. The other four websites are: [www.waterontheweb.org](http://www.waterontheweb.org), [www.mnbeaches.org](http://www.mnbeaches.org), [www.lakeaccess.org](http://www.lakeaccess.org), and [www.nrri.umn.edu/coastalGIS](http://www.nrri.umn.edu/coastalGIS). The website continues to grow and peak in May and October every year, presumably in part due to student/teacher usage cycles. Overall website activity in 2009 totaled 4.9 million requests or 'hits' and 1.21 million page requests (i.e., web pages downloaded); as of Jun 17, 2010 it had received 24,002,017 successful server requests and 5,201,608 successful page requests. The websites have received numerous awards at the regional, state, Great Lakes, and national scale-(see [www.lakesuperiorstreams.org/general/aboutus.html](http://www.lakesuperiorstreams.org/general/aboutus.html)).

**Center for Research and Applied Technology Development**

## Creation of Energy Efficient Inorganic-Bonded Structural Insulated Panels

---

### Objective

Phase 1 objectives are to select suitable raw materials for the production of the inorganic binders that are compatible with low-value and underutilized wood fibers, fabricate bench-scale structural insulated panel samples, and optimize binder composition and content. Phase 2 objectives are to further define material compatibility and processing requirements, document environmental and economic benefits of the new structural insulated panels, and conduct energy and cost audits for the new structural insulated panels.

### Background

This project combines the unique properties of chemically-bonded inorganic binders with those of regionally-sourced, low-value, and recycled wood fibers to develop moisture-, decay-, fire-, and mildew-resistant value-added structural insulated panels (SIPs). Specifically, this project will assess the technical and economic opportunity for developing new SIPs that contain not traditional oriented strandboard (OSB) skins, but chemically- and inorganic-bonded wood fiber skins. The environmentally-friendly and energy-efficient inorganic cements do not contain formaldehyde and are not petroleum-based, are manufactured from natural minerals, and set at room temperature in the presence of moisture.

### Previous Activity

The most promising SIP skins are manufactured by briefly soaking the wood strands in a strong magnesium chloride solution (up to 133 percent concentration) and then sprinkling light-burned MgO powder onto the damp strands. This mixture is then consolidated under pressure, without heat, to form the panel. We have produced low-density skins of approximately one-inch thickness, and higher density skins of approximately 0.75 inches. It appears that a wood to MgO ratio of approximately 0.65 produces a strong and stiff panel. We also believe these skins may have applicability as a high-performing laminating platform for engineered wood flooring.

### Current Activity

Prototype panels were formed using both the H-frame cold press and the large full-size press (cold). The panels were equilibrated in the NRRI test lab and have undergone mechanical and performance testing. The tests conducted include water absorption/thickness swell, screw withdrawal, internal bond, MOR (bending strength), and MOE (stiffness). Preliminary results are very favorable. The testing data will be analyzed and compared directly to plywood and OSB. We are currently in the process of building a thermal resistance (R-value) testing unit. An undergraduate mechanical engineering student is assisting in the design and fabrication of this unit. Once the unit is complete, we will fabricate complete SIP samples and test for their R-values. After writing the final report for the project sponsor, we will submit an Intellectual Property Disclosure Form to the University. We will also continue to search for new research funding to further develop the technology.

### Principal Investigator(s)

Matthew Aro  
Patrick Donahue

### Project Sponsor(s)

MN Dept of Commerce

Amount	Account	Active
52,650	3005-10414-00011018	06/01/2009 07/15/2010
<b>Total</b>	\$52,650	

**Start Date:** 07/01/2009

**End Date:** 05/31/2011

**Project ID:** 1551

---

## Devil's Track General Store NRRI Product Development Fund

---

### Objective

Assist entrepreneur, Brian Kizzek, refine and further develop a modular ice fishing shelter system.

### Background

Brian Kizzek owns and operates the Devil's Track General Store in Grand Marias, Minnesota. Mr. Kizzek has extensive experience in fabricating industrial sewn goods, he has invented a simple shelter system for sports recreation and other leisure market applications. Mr. Kizzek was referred to the NRRI by a Cook Country Commissioner and successfully submitted a product development fund proposal. The goal of the proposal was to have NRRI scientists and engineers assist him in the process of refining his invention and to provide him market ready prototypes.

### Previous Activity

This is a new project.

### Current Activity

Mr. Kizzek provided a high degree of project direction throughout the project. Mr. Kizzek along with NRRI Scientist and UMD engineering student refined the original design to meet the project objective. The shelter has four major elements; the sled, the box, the frame, and the fabric. The sled was redesigned to use a single sheet of recycled high density polyethylene. The new design reduced the number of parts and eliminated steel framing. A local plastic fabricator who builds customer geometric plastic window components developed a method to create a monolithic sled design. The box was redesigned using thermally modified wood in place of untreated pine. The box design was also reconfigured so that it would collapse for ease of transportation and storage. The frame was re-designed with flexible hubs reducing the number of parts and ease of erection. Mr. Kizzek invested in a compact powder coating equipment to begin production. The fabric was optimized to maximize the yield and a contract vendor selected. An event was executed that demonstrated the improved product to a major sporting good distributor.

### Principal Investigator(s)

Patrick Donahue

### Project Sponsor(s)

NRRI Product Development

### Amount Account

5,500 3001-10412-00015253

### Active

08/17/2009 04/01/2010

### Total

\$5,500

**Start Date:** 08/17/2009

**End Date:** 04/01/2011

**Project ID:** 1584

---



## Epicurean Cutting Surfaces

---

### Objective

The goal is to assist Epicurean to complete the business and technical assessment required to successfully enter the field of resin saturated paper board production.

### Background

Epicurean's specialty products have found success in the cooking accessories niche as a food prep. and cutting board surface for both residential and commercial kitchens. Epicurean has seen continued growth and desires to develop other products both related to kitchen accessories and beyond. Vertically integrating composite board production as a core manufacturing capacity and taking full advantage of a regional base material supplier will lower Epicurean's cost of resin saturated boards for increased profitability and a stronger competitive advantage. This added capacity would improve Epicurean's long-term added-value business development potential.

### Previous Activity

Several pilot plant trials were completed, and we experienced difficulty in the performance of the paper feedstock. In the first trial, the paper supplied was not manufactured with National Food Safety-grade resin. This was not discovered until after the trial was complete. The second trial was only partially successful. The black composite panels work very well, however the tan paper failed because of decorative appearance. A third trial is being planned. Due to manufacturing and technical challenges, our project partner has chosen not to pursue primary manufacturing of resin boards and instead will focus on remanufacturing opportunities assessing (1) flooring products manufactured from resin-saturated paper, and (2) acrylic-saturated natural wood cutting surfaces.

### Current Activity

A third trial to prototype resin-saturated paper was completed with marginal success. The concept of creating a new resin board production facility was indefinitely tabled. Prototypes of engineered wood flooring with resin saturated wear layers were manufactured. These materials have been installed and are being evaluated for performance. Prototypes of acrylic-saturated natural wood cutting surfaces were created. This is a variation from the original core concept. The prototypes have been undergoing laboratory testing for the past two months and appear to maintain their durability after multiple dishwasher cycles. Further investigation on National Food Safety-grade certification is underway. The new product would be the first food- and dishwasher-safe real wood cutting surface on the market.

### Principal Investigator(s)

Brian Brashaw  
Patrick Donahue

### Project Sponsor(s)

John S & James L. Knight Foundation  
**Total**

Amount	Account
32,500	3001-10412-00009804
\$32,500	

Active
11/01/2008 11/30/2010

**Start Date:** 11/01/2008    **End Date:** 11/30/2010    **Project ID:** 1554

---

## Evaluation and Demonstration of Nondestructive Assessment Technologies for Sorting Eastern Hardwoods

---

### Objective

To evaluate several technologies including vibration, acoustic, tomography, thermography, and laser technologies for identifying critical material defects and for assessing potential product performance from hardwood materials prior to manufacturing into guitars and baseball bats, to assess the potential for these technologies to be used for other high value end products, and to identify commercial vendors that are capable of adapting equipment or developing new equipment.

### Background

Recent advances in nondestructive assessment technologies offer opportunities to evaluate hardwood raw materials, particularly the potential quality of material that is used in the manufacture of high value specialty products. This proposed effort will focus on evaluation of several technologies for assessing the quality of material to be used in high value specialty products, with an emphasis on raw materials for use in manufacturing guitars and baseball bats. The outputs from this project would include an evaluation of these technologies and equipments, demonstration on these products, and the suitability for use in other high-value products.

### Previous Activity

A tour of both C.F. Martin Guitar (Nazareth, Pennsylvania) and Rawlings Adirondack (Dolgeville, New York) was completed to understand the types of defects and opportunities for including nondestructive evaluation technologies in their operations. The specific defects identified at C.F. Martin was identified as compression microcracking that occurred from wind breaks during forest growth or harvest. Samples were obtained for conducting in-depth trials using nondestructive evaluation technologies such as thermography or laser shearography.

### Current Activity

Samples of guitar raw wood back and side blanks were obtained for further inspection. A simple trial using thermography was conducted using a local building inspector. This inspector provided a low resolution temperature scan of the wood surface that included the defect and good material. It appeared that the microcracks were evident as cold spots during the preliminary scan. A second preliminary scan was conducted using laboratory thermography equipment at NDT Solutions in New Richmond, Wisconsin. Again, the trial appeared to have potential for using thermography as an inspection aid. Additional in-depth trials will be conducted with NDT Solutions and a separate trial conducted with a second equipment provider during the next reporting period.

### Principal Investigator(s)

Brian Brshaw

### Project Sponsor(s)

USDA Forest Service

### Amount Account

50,000 3002-10414-00008448

### Active

07/01/2009 06/30/2010

**Total** \$50,000

**Start Date:** 07/01/2009

**End Date:** 06/30/2011

**Project ID:** 1552

---

**Goodwill Industries, Inc. - NRRI Product Development Fund**

---

**Objective**

To develop and exploit a local market outlet for compacted mattress innersprings recovered from mattresses.

**Background**

Goodwill Industries, Inc. (GWI) operates a mattress recycling operation in Duluth, Minnesota. They have been operational since June 2004 processing over 46,000 units for deconstruction and recycling through 14 collection sites spanning ten counties in northeast Minnesota and Wisconsin. The operation has generated over \$282,699 in tipping fees, processed over 913 tons of steel, wood, cotton, foam toppers, and shoddy generating \$37,486 in sales for GWI and saved over 5,448 cubic yards of landfill space valued at \$169,962.

These activities create steady work for five GWI individuals, contributing over \$294,000 in the form of wages and overhead to the local economy. GWI has been significantly challenged by deteriorating market outlets for the steel spring units recovered in their recycling operation. Previously, a local steel recycler would take the spring units and process them through an automobile shredding operation. However, the high tensile strength of the spring units have caused significant problems in the shredding operation and the processor recently banned any mattress or box spring unit from being accepted at the facility. This has caused an immediate backlog and buildup of stripped mattress and spring units at GWI. There is a critical need to find a sustainable and efficient means by which the steel mattress innersprings can be handled, properly processed, and prepared for sale into the local steel recycling market.

**Previous Activity**

The acquisition, installation, and full implementation of the mattress spring compactor was delayed because of potential weight restrictions on the concrete floorings at Goodwill Industries, Inc. As a result, an engineering firm was hired to assess the potential floor loadings and recommend the best location for the spring compactor. Projected delivery and set up of the compactor was scheduled for mid January 2010.

**Current Activity**

The concept of mattress recycling continues to move forward in the state of Minnesota. The triple axis mattress spring compactor was successfully installed at Goodwill Industries in January 2010. St Olaf Industries provided training and operational procedures for the compactor to material handlers at the Goodwill Mattress recycling operation. The compaction routine generally takes four (4) mattress springs and compacts them into essentially a one cubic foot cube. The compacted cubes are then sent over to the ME ElecMetal foundry in Gary New Duluth to be melted down and turned into wear castings for use up on the iron range. The acquisition and design of this equipment provides more efficient material flows at Goodwill Industries, Inc., it generates a paying revenue stream for the steel, and provides jobs and opportunities. A grand opening event for the facility is planned.

**Principal Investigator(s)**

Brian Brashaw  
Timothy Hagen

<b>Project Sponsor(s)</b>	<b>Amount</b>	<b>Account</b>	<b>Active</b>
Blandin Foundation	17,925	3001-10412-00009803	10/17/2008 04/01/2010
<b>Total</b>	<b>\$17,925</b>		

**Start Date:** 10/17/2008      **End Date:** 04/01/2010      **Project ID:** 1547

---

## Heat Treatment of Firewood - Meeting the Phytosanitary Requirements

---

### Objective

The purpose of this project is to transfer the knowledge and most advanced heat treating technology to field application through demonstration projects and via on-site and web-based training workshops.

### Background

Due to the potential risk associated with moving emerald ash borer (EAB) infested firewood, the interstate movement of all hardwood firewood is currently restricted under the federal quarantine. Heat treatment is an approved treatment to kill the emerald ash borer in firewood and prevent their transfer between regions and states. However, states and firewood producers are faced with challenges on implementing a heat treating process and safely treating their firewood for interstate commerce. Federal Plant Protection and Quarantine officers and regulatory field staff have had little training and few internal resources to bring their knowledge of heat treatment operations to the level desired for program integrity.

### Previous Activity

A cost-effective temperature monitoring system has been installed at Green Thumb Farm, Inc. We conducted the first training workshop on heat treatment of firewood in February 2009, covering the following topics: Wisconsin federal and state regulations on EAB infested firewood, current heat treatment standard for firewood and treating facility certification process, fundamentals of the heat treating process, and heat treating options, temperature monitoring, and thermal verification. The second temperature monitoring system was built and installed at John's Welding in Tomah, Wisconsin, in May 2009, incorporating a new thermocouple data logger. This data logger is powered directly by the USB port of a PC, allowing real-time monitoring of the heat treatment process.

### Current Activity

This project has been completed and the final report is being prepared for the project sponsor. The purpose of this project was to conduct technology transfer on up-to-date science and advanced heat treating technology to field application through field demonstration projects and via on-site or web-based training workshops. In this project, we evaluated a series of temperature sensors/probes and data loggers and built easy-to-install temperature monitoring systems that are suitable to field heat treatment operations in different scales. Specific recommendations are included in the final report. On-site heat-treatment demonstrations were conducted at four firewood heat treating facilities: Two in Wisconsin, one in Illinois, and one in Indiana. Two training workshops were developed and presented to regulatory field staff and firewood producer, one through on-site meeting and field hands-on demonstration (Feb 25, 2009) and one via web-based on seminar (December 9, 2009). The content of training included (1) certification of treatment facilities, (2) recommended heat treating strategies, and (3) temperature monitoring and thermal verification.

### Principal Investigator(s)

Brian Brashaw

### Project Sponsor(s)

USDA Forest Service

### Amount Account

89,500 3002-10414-00005000

### Active

07/01/2008 06/30/2010

**Total** \$89,500

**Start Date:** 07/01/2008

**End Date:** 06/30/2010

**Project ID:** 1531

---

### House3: FEMA-Housing Assessment Tool Demonstration

---

#### Objective

To build two demonstration buildings that serve Coleraine Minerals Research Laboratory's expanding office needs and also demonstrate ready to assemble housing technology for FEMA.

#### Background

The Natural Resources Research Institute has been creating an economic development initiative focused on wood-based systems for transitional housing. The chief aim is maximizing the industrial development potential of added-value regional forest resources that results in new manufacturing and technology employment opportunities. The current work is based on a request by FEMA and will fulfill a need for additional temporary office space at the Coleraine Minerals Research Laboratory.

#### Previous Activity

The architectural, engineering, and construction services (as in-kind contributions) have exceeded \$100,000. The donated materials and discounts on materials have been substantial; 18 private companies have provided materials free or at cost. UMD Facilities Management and the Twin Cities Building Inspection Department have been proactively assisting the project with code compliance. Unit #1 was installed at Coleraine. Construction of Unit #2 is underway and is scheduled to be completed in summer 2010. The FEMA Joint Housing Solutions Group – Housing Assessment inspection is scheduled for the week of April 12, 2010. A presentation was made to the Deputy Director of Public Safety of the State of Texas in early December resulting in a potential business development opportunity of 1,500 units. There was a visit by staff of the University of Minnesota Office of Technology Commercialization and General Counsel's Office. A project collaborator hosted an open house to build interest/support of community business leaders. Our technology partner, Knapp Verbinder from Austria visited in October 2009.

#### Current Activity

Unit #1 was completed at Coleraine and the University Building Inspection department issued a certificate of occupancy. Unit #2 has been completed and is ready to install in the summer of 2010. A FEMA site inspection took place during the week of April 12, 2010. The FEMA team from Washington D.C. visited the NRRI, the housing systems pilot plant in West Duluth, and the field test site in Coleraine. The opportunity to have a regional solution to bid on FEMA needs of up to 1,000 units was discussed. FEMA discussed next step details including a building site at their training facility in Virginia. No final report has been issued by FEMA. Vendors have continued to show support; Kohler hosted another visit to their headquarters to discuss the possible collaboration on a series of technology demonstration buildings. 3M hosted a "deep dive event" on ready-to-assemble housing where the team explored new 3M technologies as possible areas of collaboration. Business development activities continued to progress; no agreements have been reached, however several opportunities have surfaced to create one or more new manufacturing pilot plants that will move closer to a new regional industry.

#### Principal Investigator(s)

Patrick Donahue

#### Project Sponsor(s)

	Amount	Account	Active
Blandin Foundation	15,000	3001-10414-00006709	01/01/2009 01/01/2010
PUF Mineral Endowment	140,000	1750-10414-20090-	11/20/2008 06/30/2010
<b>Total</b>	<b>\$155,000</b>		

**Start Date:** 11/20/2008

**End Date:** 06/30/2010

**Project ID:** 1536

---

## Iron Phosphate Bonded OSB

---

### Objective

The overall objective is to demonstrate technology to produce iron phosphate-bonded oriented strandboard (OSB) building construction panels and thermally-conductive refractory board, both of which have the potential to outperform current products and reduce overall production energy requirements.

### Background

This project proposes to develop novel oriented strandboard building construction panels and thermally-conductive refractory board using innovative inorganic iron-phosphate ceramic binders. These iron-phosphate binders may be useful for the treatment of a distinct and locally-available iron-rich feedstock – magnetite (Fe<sub>3</sub>O<sub>4</sub>) concentrate produced from the beneficiation of magnetic taconite.

Fe<sub>3</sub>O<sub>4</sub> generated from iron ore mining operations in northern Minnesota's Iron Range will be combined with an activator comprised of phosphoric acid (H<sub>3</sub>PO<sub>4</sub>) and/or other acids, phosphate salts, supplemental additives, and wood fibers with specific geometries to produce bench-scale iron phosphate-bonded OSB panels and thermally-conductive refractory board.

### Previous Activity

The main technical challenges with coating OSB with an iron-phosphate coating is that significant shrinkage of the coating occurs, thus causing wide-scale cracking. Our next step will be to overcome the shrinkage issue we experimented with different salts (such as monopotassium phosphate, which has a lower dissociation constant than NaH<sub>2</sub>PO<sub>4</sub>), various latex additives, and fiber reinforcement via short and thin fiberglass fibers (such as those used to reinforce concrete and reduce cracking). Also, we have experimented with using other phosphates (such as triple super phosphate) to replace the more expensive H<sub>3</sub>PO<sub>4</sub>. We have learned that triple super phosphate, magnetite, MgO, and NaH<sub>2</sub>PO<sub>4</sub> (without the addition of H<sub>3</sub>PO<sub>4</sub>) can produce a rapid setting binder with good strength. We continue to assess opportunities in the construction products field for using these new formulations and focus our efforts to look at new opportunities for iron phosphate-based bonded wood fiber composites products.

### Current Activity

We have begun to experiment with methods to saturate the wood strands with phosphate salts prior to the addition of the iron oxide materials. We believe this could create a new class of durable construction wood strand materials. The experiments have been limited to hand samples. The optimum binder formulations are not fully defined and validity of production processes has yet to be determined. This discovery project will be completed in the upcoming quarter and a final report issued December 2010.

### Principal Investigator(s)

Matthew Aro  
Patrick Donahue

### Project Sponsor(s)

PUF Mineral Endowment

### Amount Account

47,000

### Active

08/27/2008 06/30/2010

### Total

\$47,000

**Start Date:** 11/03/2008

**End Date:** 12/31/2010

**Project ID:** 1553

---

## Mat Inc. - NRRI Product Development Fund

---

### Objective

To develop sustainable market outlets for reclaimed mattress cotton.

### Background

Mattress recycling is a viable and sustainable path way towards saving valuable air space in landfills. Partnerships with Goodwill Industries, Inc., the NRRI, and a local non-woven manufacturer, have shown cotton materials recovered from mattresses being used in filtering oil in diesel and locomotive engines. With the average mattress containing over 8 lbs of cotton and recent cotton prices hovering around \$0.42/lb, there are market forces contributing to the need and justification for finding ways to re-use mattress cotton. Until recently, market outlets for this material were few and far between. However, if the cotton batting is re-formed and processed with specially prepared wood fibers, it becomes a viable substrate to use in oil filtering applications. In addition, if these fibers are blended with lofted fibers, high-flow stormwater filtration textiles become possible. Mat Inc. operates a 60 inch non-woven line which it uses to air lay synthetic and natural fibers such as wood, kenaf, jute, and flax into filtering and landscape fabrics. The NRRI has partnered Mat Inc. to develop product applications for mattress cotton spanning from stormwater filtration and absorbent wipes to oil filtration mats

### Previous Activity

Residual metal contaminants and staple fragments found in some of the re-processed filtration battings continue to prevent the further potential of using recovered mattress cotton for filtering applications. Many of the cotton battings recovered from individual mattresses have hundreds of staples that are difficult to remove manually. Several staples ended up in the re-laid battings produced at Mat Inc. This effectively put this application on hold until a reliable and fool proof method of removing the staples from the cotton is gained. The NRRI proposed a solution of opening the cotton, magnetically pulling off the staples, and capturing and re-baling the cotton battings into smaller bales. Goodwill Industries is considering this approach. A full size storm water filter met the objectives of 75% TSS removal at 15 gpm. Subsidence was found to be an issue for the full size filter.

### Current Activity

Mat Inc. has requested one of its clients to provide a roof top oil water separator commonly used to remove oil from ventilation systems at restaurants. These oil water separators commonly use peat as the absorbent placed inside a specific contactor. Plans are in place to formulate a molded fiber composite into the contactor as a replacement for the peat substrate. A base formulary was visually demonstrated for Mat Inc by pouring an oil water emulsion through a capsule containing intermixed cotton and polyester fibers. The emulsion went into the filter a dark brown and exited as clean water. The result was so impressive that Mat Inc wants to present the concept to their client and offer a molded fiber concept for particularly hard to break oil/water emulsions.

### Principal Investigator(s)

Brian Brashaw  
Timothy Hagen

Project Sponsor(s)	Amount	Account	Active
Blandin Foundation (was Knight)	25,000	3001-10412-00012499	11/15/2008 04/01/2011
<b>Total</b>	<b>\$25,000</b>		

**Start Date:** 07/17/2009      **End Date:** 11/30/2010      **Project ID:** 1548

---

## **Nondestructive Assessment of Advanced Composite Material**

---

### **Objective**

The purpose of this research is to investigate the potential of using several emerging nondestructive evaluation technologies to assess the performance of wood/nonwood based composite materials.

### **Background**

As new wood/nonwood based composite materials are being developed and used in structural and nonstructural applications, their performance and product quality need to be tested as part of product development and production quality assurance. There is an urgent need from the manufacturers' perspective to develop effective nondestructive assessment procedures to evaluate the performance of these new composite materials and detect internal defects that could cause failure in-service.

### **Previous Activity**

We have identified and reviewed several emerging nondestructive testing technologies by attending the 2008 American Society of Nondestructive Testing Conference and a subsequent literature search. The techniques with potential to meet the project's objectives include: (1) portable laser shearography - a vibration resistant imaging laser interferometer, designed for the nondestructive inspection of aerospace composite repairs, structures, and components; (2) infrared thermography - a widely used imaging technique for nondestructive inspection of different materials and structures; (3) ultrasonic phased array system - incorporates an array of sensors to detect defects in different depths, provide B-, C-, and D-scans of the materials; and (4) resonant acoustic inspection system.

### **Current Activity**

A number of different types of wood composite materials were investigated using infrared thermography. This technique appears to have potential for use in identifying defects, but would not be effective in providing information on strength and stiffness properties. Several of these samples were also assessed with direct coupling ultrasound. This would have potential for any advanced wood composites that contained fiberglass surface laminates as a means to assess for potential delamination. Additional testing with laser shearography is planned for the next reporting period.

### **Principal Investigator(s)**

Brian Brashaw

### **Project Sponsor(s)**

USDA Forest Products Lab

### **Amount Account**

20,000

### **Total**

\$20,000

### **Active**

07/14/2008 08/31/2010

**Start Date:** 07/14/2008

**End Date:** 08/31/2010

**Project ID:** 1532

---



## Phosphate Bonded Fiber and Waste Residual Composites for Applied Commercialization

---

### Objective

To develop durable building materials from paper mill waste using novel phosphate ceramic binders.

### Background

This project has been funded by the Wisconsin Business Innovation Corporation with resources they received from the U.S. Environmental Protection Agency. There is over 3,000 tons of primary paper mill waste in Wisconsin daily. This waste consists of 50 percent fiber and 50 percent clay. The goal is to use novel mineral based binder technology to create a series of durable building materials using this waste stream as the primary manufacturing feedstock.

### Previous Activity

We manufactured 3'x 3'x 1.75" prototype panels for burn testing at Marshfield Door Systems. In February, Matt Aro traveled to the company to witness the tests first-hand; the results were very impressive. After a 90-minute burn and water-spray test, the panels did not combust and they retained a substantial amount of their original strength and integrity. One concern is the panels tend to warp toward the heat source - we believe we can overcome this technical challenge. Marshfield Door Systems personnel appeared pleased with the results. They continue to see an opportunity for the panel to be used as door core, stile and rail material, or even niche products. We are currently working with the Wisconsin Business Innovation Corporation and Marshfield Door Systems to determine terms for a possible sponsored research project with Marshfield Door Systems. The goal of this project would be to conduct the technical tasks to bring our prototype concepts to commercialization, specifically for Marshfield Door Systems.

### Current Activity

We continue to receive strong interest in our technology from Marshfield Door Systems, and we hope to negotiate a sponsored research agreement with them to further develop the technology. Currently, the prototype panels are undergoing corrosion testing at UMD's department of Civil Engineering. This work is being led by Dr. Eric Musselman and one of his graduate students. The objective of this work is to determine the corrosive effect (if any) our panels have on traditional metal fasteners (including zinc-plated, stainless steel, brass, ceramic-coated, and others). The results of this work will be reported back to Marshfield Door Systems. If results are satisfactory, the development of the technology will proceed.

### Principal Investigator(s)

Matthew Aro  
Patrick Donahue

### Project Sponsor(s)

	Amount	Account	Active
Wisconsin Bus Innov Corp-Prime EPA	136,407	1653-187-6609-00	11/01/2007 09/30/2010
<b>Total</b>	<b>\$136,407</b>		

**Start Date:** 11/01/2007      **End Date:** 09/30/2010      **Project ID:** 1501

---

## Thermally-Modified Eastern Hardwoods as High-Tech Fenestration and Exterior Shuttering

---

### Objective

To assess thermally modified wood as a feed stock for the regional wood window and door industry.

### Background

The project goal is to analyze ThermoWood®-modified basswood and yellow poplar hardwood lumber with advanced screening methods developed by the Window and Door Manufacturers Association to provide a direct comparison of their performance properties with those of traditional softwood lumber used by the fenestration and exterior shuttering industry. The outcome will provide an opportunity for these advanced materials to be thoroughly vetted by manufacturers, engineers, and designers in the fenestration and exterior shuttering industries with a detailed technical baseline for new Eastern hardwood applications.

### Previous Activity

Basswood and yellow poplar lumber was thermally modified at our partner's facilities. Even though the lumber has slightly reduced strength properties than traditional lumber, we believe the properties are sufficient for industrial use. Sample sets consisted of a set of thermally-modified wood fiber and a set of non-modified controls. Work has continued on the primary project objective: performance testing based on Window and Door Manufacturing Association (WDMA) Industrial Standard IS-10. WDMA IS-10 consists of 21 ASTM/WDMA performance testing protocols to understand the properties of modified and composite cellulosic fiber. Ten of the 21 test protocols have been completed. The initial results indicate significant improvement in dimensional stability, but also an expected drop in mechanical strengths. The research focus has yielded an additional industrial development award. The new associated project is in collaboration with Lakehead University of Thunder Bay, Ontario, Canada. The focus is a planning grant to create a North American performance standard for thermally-modified lumber and composites. Three other grant proposals directly related to specific product and process development have been submitted and are pending.

### Current Activity

The mechanical testing has been completed. We were able to complete 17 of the 21 testing protocols. The industrial standard WDMA IS-10 was developed for wood plastics composites and four of the testing protocols were not possible with solid wood materials. Results for decay resistance are still pending. Thermally modified lumber continues to show promise as a regional economic development focus, and there has been additional private sector investment in new products and processes. The mechanical testing results are encouraging in terms of using regional hardwoods for traditional softwood applications. The project will be completed during the fourth quarter and a final report will be issued in December 2010.

### Principal Investigator(s)

Patrick Donahue

### Project Sponsor(s)

USDA Forest Service

### Amount Account

47,514 3002-10414-00008459

### Active

07/01/2009 06/30/2010

**Total** \$47,514

**Start Date:** 07/01/2009

**End Date:** 06/30/2011

**Project ID:** 1550

---

## Total Productive Maintenance for the Wood Products Industry

---

### Objective

Develop customized total productive maintenance programs for wood products manufacturers through development of short courses and in-plant demonstration projects. A secondary objective is to use web-based video conferencing to conduct total productive maintenance training for regional groups of manufacturers as a means of reducing travel costs for employees and instructors.

### Background

The project cooperators at Virginia Tech, Iowa State University, and the University of Minnesota Duluth have worked to help wood products manufacturers understand and implement lean manufacturing as a preferred continuous improvement program to support their economic stability and growth. Through these efforts, these cooperators have identified the need for wood products companies to strengthen their equipment reliability, minimize downtime, and improve productivity. Total productive maintenance programs are widely accepted as a key strategy by world class manufacturers as a means to satisfy these needs. The total productive maintenance concept grew from the broader lean manufacturing philosophy, which is based on continuous improvement.

### Previous Activity

During the first six months of the project, our team of cooperators attended training from Fuss & O'Neil and the Marshall Institute and participated in total productive maintenance events at Andersen Windows (Bayport, Minnesota), Merrilat (Akins, Virginia), and Anchor Packaging (Paragould, Alaska). A one day hands-on training course was developed and conducted for our wood products cooperators including Crystal Cabinet Works, Epicurean Cutting Surfaces, Shell Lake Furniture, Birchwood's Best, and Ferche Millwork. A relationship was established with ColdJet LLC, a manufacturer of dry ice blasting equipment used to clean equipment and other work surfaces. Using matching funds, we purchased a unit from ColdJet LLC for use in conducting demonstration projects. A comprehensive total product maintenance project was completed with Shell Lake Furniture in their stain and varnish spray booth, resulting in reduced time looking for materials and equipment, reduced downtime for their equipment, and improvements in finish quality.

### Current Activity

The project was reactivated after a 6 month delay that was caused by our external cooperators availability due to the significant industry slowdown. Several cooperators are working with our staff to schedule total productive maintenance training and events for the fall. Each event will have both an educational and a equipment specific activity associated with it. These events will be conducted in Minnesota and Wisconsin.

### Principal Investigator(s)

Brian Brashaw

### Project Sponsor(s)

USDA Forest Service

Amount	Account	Active
95,479	1637-187-6601-00	07/01/2007 12/31/2010
<b>Total</b>	\$95,479	

**Start Date:** 07/01/2007

**End Date:** 12/31/2010

**Project ID:** 1467

---

## Use of Laser Scanning Technology to Obtain As-Built Records of Historic Covered Bridges

---

### Objective

To examine the technical feasibility of using laser scanning technologies for obtaining as-built records for historic, covered timber bridges.

### Background

Covered bridges have been the fabric of American life. Today there are several hundred historic covered bridges remaining. Although there is much effort to preserve these structures, often times high cost of restoration, neglect, and vandalism takes its toll, and many are lost forever. One of the more famous bridges from the movie "Bridges of Madison County" was burned down last year. The National Park Service's Historic American Engineering Record (HAER) has efforts underway to document historic structures and consists of measured and interpretive drawings, large-format photographs, and written historical reports. In order to assist in this effort newer technologies need to be explored which can provide as built records at a faster rate and with more accuracy. This research will explore the use of laser scanning technology to scan existing bridges for purposes of obtaining as-built records.

### Previous Activity

We identified Faro, Inc., a laser equipment manufacturer, as a strategic partner in this project. A demonstration of the Faro scanner demonstration was held in July 2009 as a historic steel bridge was scanned on the grounds of Minnesota's St. Louis County Richard H. Hansen Public Works and Transportation Complex.

### Current Activity

Since the laser scanning equipment was too expensive to purchase or lease, Faro introduced us to a 3D Laser scanning company from Milwaukee, Wisconsin, that would offer a substantially reduced price to conduct the laser scanning of six bridges and help us with data processing. This company, SightLine, LLC, conducted scanning of the Red Bridge in Cedarburg, Wisconsin in April. Approximately 40 scans of the bridge were conducted from both the interior and exterior of the bridges. The data was processed creating a point cloud of the bridge and its surroundings. This data was further developed into 3D and 2D computer aided design images that contained accurate dimensions of the bridge. Further, a demonstration of the scanning equipment and a poster was developed for the Centennial Celebration at the USDA Forest Products Laboratory (June 23, 2010). The remaining five bridges will be scanned and the data processing completed during the next reporting period.

### Principal Investigator(s)

Brian Brshaw

### Project Sponsor(s)

USDA Forest Products Lab

### Amount Account

50,000 3002-10414-00012627

### Active

07/28/2009 12/31/2010

### Total

\$50,000

**Start Date:** 07/28/2009

**End Date:** 12/31/2010

**Project ID:** 1570

---

## Wood Utilization Options for Urban Trees Infested by Invasive Species

---

### Objective

To develop web-based information archives and user-friendly guidelines for assessing wood utilization options for woody materials obtained from trees infested by various invasive species.

### Background

Invasive species have been identified as one of the four significant threats to our Nation's forest and rangeland ecosystems, characterized as a "catastrophic wildfire in slow motion." Emerald ash borer (EAB), for example, was discovered in southeastern Michigan in 2002 and has spread to many other states in the northeastern region of the U.S. including: Illinois, Wisconsin, and most recently Minnesota. As a result of infestation from invasive species, particularly EAB, tremendous numbers of infested trees are being removed each year for control and ultimate eradication of the pests. Proper utilization and safe disposal of woody biomass from these trees constitute challenges to many local communities and land owners. Urban forestry professionals are faced with the task of selecting appropriate utilization options for the materials and locating necessary technical information for making such decisions. Although many studies and wood utilization projects have been done for wood species attacked by invasive species, much of the basic information on wood materials, product options, and corresponding manufacturing requirements is scattered in technical reports prepared by universities and other research organizations. There is no central location (publications or websites) that fully address this need. As invasive species control efforts increase, a comprehensive wood utilization guideline is needed by urban communities and forestry professionals to quickly assess utilization options for wood obtained from infested trees.

### Previous Activity

This is a new project.

### Current Activity

The initial book chapter focused on the material properties of ash and other affected species of the book on wood utilization options were completed in draft form. Editing, layout, and completion are scheduled for the next quarter. Additional work is ongoing on the other sections that include: (1) quarantine zones and their affect on wood supply movement; (2) wood utilization options; and (3) a special section on finishing wood. NRRI staff participated in listening sessions that were conducted in cooperation with the Minnesota DNR. These listening sessions confirmed the direction of this project as it identified the greatest challenge for ash utilization in Minnesota. The greatest challenges is the lack of information and education on ash markets including access to existing markets (currently limited) and developing markets, utilization options, and wood properties. This information will be used to guide the completion of the project. An extension was requested from the project sponsor until 6/30/2011 to allow for completion of the project.

### Principal Investigator(s)

Brian Brashaw

### Project Sponsor(s)

USDA Forest Service

### Amount Account

46,845 3002-10414-00008444

### Active

07/01/2009 06/30/2010

**Total** \$46,845

**Start Date:** 07/01/2009

**End Date:** 06/30/2011

**Project ID:** 1573

---

## Wood Utilization Research

---

### Objective

To help the forest products sector develop new products, new technologies, and new business systems to position Minnesota as a continued leader in wood products manufacturing and renewable energy.

### Background

The Wood Utilization Research is a special research grant from the USDA Cooperative State Research Education and Extension Service. This program has been funded by Congress to provide needed research, education, and outreach to the wood products industry to help enhance the competitiveness of the industry. These funds are leveraged with University state special funds to conduct applied research in the areas of wood materials and manufacturing, market oriented wood technology, applied forestry, and chemical derivatives, to facilitate economic growth and stability of Minnesota and other Lake States wood product manufacturers.

### Previous Activity

Subprojects focused on total productive maintenance and thermal modification of wood were initiated. In the total productive maintenance effort, a band saw rebuild was initiated. A 1960 Northfield (Minneapolis, Minnesota) band saw is being used to return the equipment to original equipment condition. Dry ice blasting was successfully utilized to clean the equipment. Damaged or defective parts were ordered from the manufacturer. A case study is being prepared to document the potential for rebuilding equipment instead of purchasing new equipment. In the thermal modification project, opportunities for using basswood for window applications are being assessed. A relationship is being developed with Stellac, a European equipment manufacturer, for completing test runs for these materials so that samples can be developed.

### Current Activity

The final project activities that are being conducted include forest biomass assessments. Evaluation of aspen stand data as part of aspen thinning research indicates that as much as ten dry tons of biomass could likely be removed through the thinning operation without impacting the final rotation volume. This assumes that 600 trees remain on-site to continue to grow to full rotation. Establishment of thinning studies is ongoing with one study site completed and another measured and slated for thinning this fall on lands managed by the Minnesota Department of Natural Resources.

### Principal Investigator(s)

Brian Brashaw

### Project Sponsor(s)

	Amount	Account	Active
USDA Coop ST Res ED&Ext Srvc(CSREES)	163,130	3002-10414-00000-00002756	09/01/2008 08/31/2010
<b>Total</b>	<b>\$163,130</b>		

**Start Date:** 09/01/2008

**End Date:** 08/31/2010

**Project ID:** 1538

---

## Wood Utilization Research 2009

---

### Objective

To help the forest products sector develop new products, new technologies, and new business systems to position Minnesota as a continued leader in wood products manufacturing and renewable energy.

### Background

The overall objective of the project is to complement a program of the University of Minnesota Duluth Natural Resources Research Institute. Major goals include: (1) helping existing small and mid-size wood products companies remain or become competitive through research and development; (2) conducting forest productivity work in hybrid poplar, red pine, and other Minnesota species to ensure the sustainability of the forest products industry and to help Minnesota meet their 2025 renewable energy mandate; and (3) formation of new regional industries based on forest products materials and technologies. Specific sub-projects include the following topics: (1) development of assessment models for woody biomass utilization; (2) fenestration development using thermally modified wood; and (3) development of new silicone/cellulose sealant/rubber materials.

### Previous Activity

This is a new project.

### Current Activity

Preliminary discussions have been held with collaborators on the woody biomass assessment subproject and cooperation has been secured with the USDA Forest Products Laboratory. Further contacts with the Superior National Forest have been established. A literature review has been conducted on equipment options for assessing value of woody biomass through wood quality assessments. In the thermal modified wood subproject, our staff is collaborating with LakeHead University in planning to develop strategies for creating a North American thermally modified wood standard. They have also successfully produced thermal modified strand composite panels and plywood panels that appear to have potential for door and window applications. Additionally, the project team has developed close collaboration with an international supplier of heat treat oven production technology and with a Minnesota wood heat treat production facility. Finally, they have assisted in the creation of a new wood drying research and development business in collaboration with the Wisconsin Business Innovation Corporation to develop new biological kiln methods and to offer prototyping services for wood heat treat pre-production prototype services.

### Principal Investigator(s)

Brian Brashaw

Project Sponsor(s)	Amount	Account	Active
USDA Coop ST Res ED & Ext Srvc(CSREES)	147,372	3002-10414-00000-00011599	09/01/2009 08/31/2011
<b>Total</b>	\$147,372		

**Start Date:** 09/01/2009      **End Date:** 08/31/2011      **Project ID:** 1572

---

## Assessment of Biomass Sources for Energy in Northern Minnesota for the Laurentian Energy Project

---

### Objective

To assess resources and economic feasibility of procuring woody biomass from poplar plantations, brushlands, and forest harvest residues for energy for the Laurentian Energy Authority project.

### Background

This project is funded through the US Department of Energy with the purpose to assess the feasibility of producing woody biomass for energy for delivery to the Laurentian Energy Authority facilities in Virginia and Hibbing, located in northern Minnesota. The project will evaluate the economic and practical feasibility of the various biomass options and conduct research on plantation forestry and harvesting of brushlands. The following tasks are part of this project: (1) Assessment of Best Management Practices for Harvesting of Brushlands and Forest Harvest Residues, (2) Development and Analysis of Best Available Technology for Harvesting Brushlands, (3) Biomass Availability and Collection Technology for Forest Harvest Residues, (4) Biomass Availability from Rights-of-Way and, (5) Evaluation of Available Soils and Variation in Productivity of Hybrid Poplar Plantations.

### Previous Activity

This project has been extended and amended to include analysis of Red Pine and Aspen biomass production for energy in addition to the current research topics. We completed an analysis of biomass distribution in Red Pine. Our results to date show that top and limb biomass as a proportion of roundwood biomass is higher than expected ranging from 40 to 50 percent. Work continued on establishment of the research network to evaluate growth of Red Pine stand following first-thinning. Analysis of poplar yield data showed that relatively high biomass yields are possible with DN5, a *P. deltoides* X *P. nigra* in northwestern Minnesota. Average annual increment of stands of DN5 are 4.4 oven-dry tons per acre per year, near the high end of the range of expected yield in Minnesota.

### Current Activity

Data were collected on a felling and baling harvesting system at two brushland sites, one near Grand Rapids, Minnesota and the other near Floodwood, Minnesota. Felling and baling data were collected and estimates were made of biomass processing time. The average tonnage processed per hour was 1.6 green tons per hour which is too low to compete in the biomass energy market at this time. The density of brush in specific locations was found to greatly affect felling and baling efficiency with harvesting in more densely-stocked areas approximately twice as productive as the average for the site. This underscores the need to select sites having high biomass density for harvesting. Wood density samples collected from Red Pine stands were found to be approximately 20 percent lower than values published for the species. Using these data, the percentage of top and limb biomass can be as high as 60 percent when expressed on a dry weight basis. Field test sites of hybrid poplar are being maintained and data analyzed to determine growth rates of new genotypes produced at NRRI.

### Principal Investigator(s)

William Berguson

### Project Sponsor(s)

	Amount	Account	Active
Laurentian Energy Authority, LLC	150,000	3002-10414-00013380	06/01/2009 05/31/2011
Laurentian Energy Authority LLC (USDOE)	652,439	1906-187-6616-00	01/01/2007 05/31/2011
<b>Total</b>	<b>\$802,439</b>		

**Start Date:** 01/01/2007

**End Date:** 05/31/2011

**Project ID:** 1513

---



## Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel

---

### Objective

To evaluate the potential to produce methanol through thermochemical processes using wood resources native to Minnesota.

### Background

The purpose of this project is to assist the University of North Dakota, Energy and Environmental Research Center (EERC) in the development and on-site testing of a portable gasification-to-methanol process unit. The participation of the UM-NRRI includes two tasks: (1) assistance in the location of an adequate site for testing of the mobile fuel production system; and (2) assessment of wood resources for conversion to liquid fuels in Minnesota. The UM-NRRI will assist the EERC in locating a test site that meets the requirements of the project. Also, we will assist the EERC in identifying and locating sources of wood species that may be particularly suitable for conversion to liquid fuels. We will recommend species-specific tests based on volume availability and price and assist in arranging for shipment of biomass materials to the test site as needed by EERC staff.

### Previous Activity

Contacts have been made with an owner of a facility that may be suitable for the eventual testing of the mobile, truck-mounted liquid fuels production system. We are evaluating electrical, waste disposal, and network connection capabilities of the facility. The fuels production unit is expected to be available for on-site testing in the fall of 2010 and the preferred site will be in the forested zone. Also, we have been in contact with the EERC to begin the process of developing a plan to bring the required raw material to the site for testing. At this time, the project is in the early stages and work is expected to begin to identify a suitable site and contact loggers to supply wood for gasification and conversion tests in the summer of 2010.

### Current Activity

Testing of the truck-mounted gasification system has been delayed due to delays in shipment of components to the EERC. Assistance has been provided by NRRI to the EERC in evaluation of several prospective sites for field tests of the gasifier. A site has been identified in northern Minnesota that has all of the necessary infrastructure to support the tests. Work is underway to complete the gasifier and field tests are expected to begin in the fall.

### Principal Investigator(s)

William Berguson

### Project Sponsor(s)

Univ of North Dakota (Prime: USDOE)

**Total**

### Amount Account

24,693 3014-10414-00011388

\$24,693

### Active

01/01/2009 12/31/2010

**Start Date:** 01/01/2009

**End Date:** 12/31/2010

**Project ID:** 1574

---

## Minnesota Forest Productivity Research Cooperative

### Objective

To improve the productivity and value of natural stands and plantations in Minnesota, develop economically and environmentally sound silvicultural practices, and transfer this knowledge to Minnesota Forest Productivity Research Cooperative (MFPRC) members and the public.

### Background

This MFPRC is a consortium of University of Minnesota personnel, industry members, and the USDA Forest Service with the purpose to enhance the productivity of Minnesota's forests. Research done as part of the MFPRC includes Norway Pine management, aspen productivity research, and hybrid poplar genetics and yield improvement. The goal of Norway Pine research proposed is to better understand productivity of Norway Pine plantations and optimize management of these stands both in terms of productivity and value. Aspen research is concentrating on assessment of productivity of regenerating aspen stands, an important issue as it relates to future wood resources. Hybrid poplar breeding and yield improvement is ongoing and replaces the previous activity done as part of the MFPRC.

### Previous Activity

Red pine thinning research continued with a total of nine research sites established. An additional four sites have been identified for establishment of new studies in the spring of 2010. All trials consist of a variety of thinning treatments including above, below, and average-diameter thinning with varying levels of residual stand basal area. Results of our oldest trial at age four shows that incremental stand growth after thinning is most sensitive to trees per acre and not residual basal area. The treatment leaving the lowest number of trees is the thin-from-below to 60 square feet total stand basal area. This treatment resulted in a depression in near-term stand growth following thinning with most other treatments being equal to the unthinned control.

### Current Activity

Hybrid poplar breeding continues with the 2010 breeding effort focused on generating first-generation, F1, inter- and intra-specific hybrid combinations – specifically, DxN and DxN families. These crosses have been made successfully in the greenhouse at NRRI and the harvesting of seed has recently been completed. Seed is currently being sown in the NRRI greenhouse to begin the process of propagation for nursery planting in 2011. A series of clone trials, yield blocks and pure-species genetics tests were planted in the spring of 2010 at three field sites. Work continues on Red Pine thinning trials with six multi-treatment thinning trials thinned, two additional sites measured and ready for thinning and five sites selected and to be thinned dependent on landowner's timetable for these stands. A total of 13 studies are anticipated to be established by 2012. Data analyzed at this point in these studies indicate considerable flexibility in the application of thinning treatments.

### Principal Investigator(s)

William Berguson

Project Sponsor(s)	Amount	Account	Active
MN Power	20,000	1664-187-6594-00	07/01/2006 12/31/2006
MN Dept of Natural Resources (DNR)	400,000	1663-187-6581-00	07/01/2005 06/30/2007
Blandin Paper Company	20,000	1664-187-6534-00	11/01/2004 06/30/2005
Boise White Paper LLC	20,000	1664-187-6535-00	07/09/2004 06/30/2005
International Paper Company	20,000	1664-187-6536-00	09/01/2004 06/30/2005
Minnesota Power	20,000	1664-187-6537-00	07/14/2004 06/30/2005
Potlatch Corporation	20,000	1664-187-6538-00	10/28/2004 06/30/2005
Forest Capital Partners LLC	20,000	1664-187-6558-00	07/01/2005 06/30/2006
International Paper Company	20,000	1664-187-6559-00	07/01/2005 06/30/2006
MN Power	20,000	1664-187-6560-00	07/01/2005 06/30/2006
Plum Creek	20,000	1664-187-6561-00	07/01/2005 06/30/2006
Potlatch Corporation	20,000	1664-187-6562-00	07/01/2005 06/30/2006
MN Dep of Natural Resources(DNR)	40,000	1663-187-6542-00	11/30/2004 06/30/2007
Forest Capital Partners LLC	20,000	1664-187-6593-00	01/01/2007 06/30/2008
MN DNR	200,000	3005-10414-00005642	06/26/2008 06/30/2009
Plum Creek	20,000	1664-187-6595-00	01/01/2007 06/30/2008
Blandin Paper Company	20,000	1664-187-6597-00	01/01/2007 06/30/2008
Verso Paper	20,000	1664-187-6598-00	01/01/2007 06/30/2008
St Louis County Land Department	20,000	1676-187-6585-00	11/15/2005 06/30/2007

Minnesota Power	20,000	3000-10414-00006971	12/17/2008	12/31/2009
Blandin Paper Company	20,000	3000-10414-00006973	12/01/2008	12/31/2009
Forest Capital Partners, LLC	20,000	3000-10414-00006974	12/05/2008	12/31/2010
Potlatch Corporation	20,000	3000-10414-00006975	12/01/2008	12/31/2009
Verso Paper	20,000	3000-10414-00006976	12/01/2008	12/31/2009
Plum Creek Timber Company, Inc	20,000	3000-10414-00007251	12/01/2008	12/31/2009
St Louis County	20,000	3003-10414-00011548	07/01/2009	06/30/2010
State of Minnesota	20,000	3005-10414-00005615	07/01/2007	06/30/2009
Blandin Paper Company	20,000	1664-187-6563-00	07/01/2005	06/30/2006
<b>Total</b>	<b>\$1,140,000</b>			

**Start Date:** 10/28/2004      **End Date:** 06/30/2010      **Project ID:** 1363

---

## Regional Biomass Feedstock Partnership-Poplar

---

### Objective

To conduct research to determine biomass yields of short rotation woody crops using poplar and develop new high-yielding, disease-resistant poplar clones for biomass production nationally.

### Background

This project is part of the DOE-funded SunGrant Initiative’s Biomass Feedstock Partnership national effort to develop dedicated biomass crops for production of renewable energy. The purpose of this research is to improve yields of woody crops for energy production focusing on poplar species. The research team is national in scope and consists of personnel from the University of Minnesota-NRRI, GreenWood Resources (Portland, OR), Mississippi State University, and ArborGen LLC (Summerville, SC) which has a history of research in the genetic improvement and production of poplars as well as commercial application of poplar plantations for fiber and energy production. The project is viewed as a first step in a process to develop a longer term plan leading to improvement of biomass yield through genetic improvement and plantation management research. Proposed research involves analysis of the state of current poplar research, evaluation of the potential land resource suitable for poplar production, and establishment of new genetic material at various locations across the U.S. to evaluate genotype performance over a range of conditions.

### Previous Activity

Tasks identified include work to explore opportunities to expand the dataset of plantation yield in the Southeast U.S. and begin to contact researchers that are known to have conducted poplar research in the past. We are in the process of determining availability of archived yield data produced by the Mead/Westvaco program in Kentucky as well as programs in the South, Midwest, and the Pacific Northwest. In addition to description of past research, this group is in the process of establishing new trials of poplar clones nationally.

### Current Activity

This project began in 2009 and continues into 2010 with the purpose to conduct research related to the development of poplar as a woody energy crop nationally. Proposed work for 2010 includes three primary tasks: (1) development of new clone trials nationally, (2) breeding to produce new *Populus* taxa and, (3) evaluation of growth and yield of poplar plantations at the various cooperator locations. Breeding has begun to produce new populations composed of a variety of species. Nurseries of pure-species *P. nigra* (Minnesota) and *P. nigra* and *P. maximowiczii* (GreenWood Resources-Oregon) are being maintained to provide for future breeding and clone exchanges. Yield measurement is ongoing at several locations including previously-established stands and in yield studies of new genotypes planted in 2010. In the spring and summer of 2010, the project team established a series of clone tests at locations in Minnesota, Missouri, Mississippi, and Georgia. These tests are referred to as “Consolidated Field Tests” as they contain a composite of clones collected from the SunGrant Poplar team’s genetic improvement programs.

### Principal Investigator(s)

William Berguson

### Project Sponsor(s)

	<b>Amount</b>	<b>Account</b>	<b>Active</b>
South Dakota State Univ-(USDOE-prime)	149,791	3014-10414-00012404	01/01/2009 09/30/2010
<b>Total</b>	\$149,791		

**Start Date:** 01/01/2009      **End Date:** 09/30/2010      **Project ID:** 1571

---

## Minnesota's Geothermal Energy Production

---

### Objective

To (1) Collect downhole temperatures from over 100 water wells and exploration drill holes; (2) Collect, analyze, and describe 100 granite samples; and (3) Issue a final report with the new heat flow and temperature vs. depth maps.

### Background

Enhanced Geothermal Systems (EGS) for future energy recovery are primary technologies needed for future electrical power and/or thermal heat production systems. The U.S. DOE in their 2007 study conducted by MIT concludes EGS extraction is one of the most promising clean energy technologies that can be used nationwide. EGS could provide 100 GWe (gigawatt - electric) or more of cost-competitive generating capacity in the next 50 years at sites throughout the U.S.A. where geothermal heat transfer conditions, rock stability, and appropriate hydrothermal environments are present at depths greater than 5 km. However, the heat flow and temperature versus depth maps in the DOE-MIT report indicate that temperatures at depth in Minnesota are very cold, based on four data points within Minnesota and about 90 data points under Lake Superior. All but one of these data points were collected 2.5 meters under lakes. Temperatures at shallow depths are affected by climate, and recent research shows that temperatures begin to stabilize at about 300 ft. or 100 meters, which eliminates all but one of the previous data points.

### Previous Activity

Training for the downhole temperature probe and associated equipment occurred November 17-19, 2009, by Dr. W. Gosnold (Consultant) at the University of North Dakota-Grand Forks. Temperature collection began in December at Rio Tinto/Kennecott's Tamarack deposit, in Carlton Co., Minnesota. Downhole temperature data were collected from three of the four boreholes. The fourth borehole was plugged at ~12 ft. Temperature data collection then moved to Duluth Metals Corporation's (DMC) Nokomis deposit southeast of Ely, MN, in Lake County. Due to cold temperatures, data collection was slower, but good data were obtained from six drill holes (with one reprobated).

### Current Activity

Downhole temperature collection continued into January 2010 until it was too cold to collect data. Dr. Gosnold did a preliminary report on the downhole temperature data from 3 boreholes at the Tamarack deposit on the Aitkin-Carlton Co. line. One borehole has preserved an 800 year old climate signal. During the last 6 months, 2 additional boreholes were probed at Duluth Metals Corporation's Nokomis deposit southeast of Ely, bringing the total of probed holes at this location to six. Also, two boreholes at PolyMet's NorthMet deposit near Babbitt were probed. All temperature data from the 11 boreholes have been turned over to Dr. Gosnold for analysis. A total of 32 granite samples have been collected. Also, 37 more rock samples have been collected to better characterize the range of thermal conductivity in non-granitic rocks. All of these analyses are used to calculate heat flow in areas of Minnesota that do not have accessible boreholes for downhole temperature data collection.

### Principal Investigator(s)

Steven Hauck

### Project Sponsor(s)

	Amount	Account	Active
PUTF Mineral Endowment	40,000	1750-10416-20090-	08/25/2009 06/30/2010
MN Department of Commerce	300,000	3005-10416-00013310	11/02/2009 09/30/2011
<b>Total</b>	<b>\$340,000</b>		

**Start Date:** 11/22/2009      **End Date:** 09/30/2011      **Project ID:** 1580

---

## Polymetallic Gas to Liquid Catalysts

---

### Objective

To conduct research and development to produce novel catalysts for thermochemical processing of biofuels based on local mineral sources.

### Background

Recent publications show the significant potential of polymetallic catalysts in Fischer-Tropsch Reaction and related processes. Compared to the traditional pure iron or cobalt formulations, modification of iron catalysts with copper, chromium, titanium, manganese and/or others gives better conversion, improves the lifetime of the catalyst, positively influences the "C5+" selectivity and other parameters. Preparation of polymetallic catalysts requires multistep procedures to obtain the proper composition. On the other side, a number of minerals available for mining in Minnesota, such as ilmenite and magnetite, already contain the necessary metals in good proportion alongside the proper carrier compounds. These minerals may show the catalytic activity, and may be valuable for gas to liquid technology.

### Previous Activity

Complex iron titanate catalysts have been synthesized and tested in the Fischer-Tropsch process. Study proceeded in the direction of conversion of low-hydrogen (below 50% H<sub>2</sub>) Syngas. This composition is typical for the Syngas obtained via biomass gasification. It was found that ilmenite-based catalysts, modified with additional amounts of iron or cobalt, are working well for this purpose.

### Current Activity

Study has continued in the direction of iron titanate catalysts, modified with promoter metals, such as copper, nickel and cobalt. Sets of catalysts containing the named metals in various proportions have been synthesized and tested in the Syngas conversion process. Effects of promoter metals on the reaction rates and on the composition of final products have been explored. Certain kinetic investigations have been done as well. It was found that cobalt is the most active promoter for the iron titanate catalysts. Activity of a copper promoter under the same conditions is moderate, and is reduced at higher concentrations. In the case of nickel, no significant effect was found, except that of increasing methane formation. The above results will be reported at the TCS2010 Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products (Ames, Iowa, Sept. 21-23, 2010). In the meantime, complex research of iron titanate catalysts in Syngas conversion processes is planned, working in the liquid phase reaction environment.

### Principal Investigator(s)

Andriy Khotkevych  
David Hendrickson  
Richard Kiesel

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

115,000 1896-783-1239-00

### Active

02/29/2008 06/30/2010

**Total** \$115,000

**Start Date:** 02/29/2008

**End Date:** 06/30/2011

**Project ID:** 1500

---

## Distribution of Mercury During the Processing of Copper-Nickel Ores

---

### Objective

To determine the distribution of mercury during flotation and subsequent pressure leaching of the bulk flotation concentrate.

### Background

The development of a copper-nickel mine and processing plant would be a large economic boost to the area. The proposed development area is within the Lake Superior Basin, which is an environmentally sensitive area. Therefore, mercury in the ore and resultant concentrates and tailings will be of great concern. Preliminary analyses of analytical laboratory pulps from previous copper-nickel studies indicated a mercury concentration in the head sample of 65 nanograms per gram (ng/g) (or parts per billion - ppb) and 108 ng/g in a flotation concentrate sample. It should be noted that the samples had been previously pulverized (no effort to prevent mercury contamination) and had been stored in paper envelopes for as long as nine years prior to analyses. While the absolute values of the above analyses may be suspect, they do indicate the presence of mercury in the ore and in the concentrate.

### Previous Activity

It was decided to collect fresh concentrate for the autoclave tests from the "Investigation of Various Flotation Reagent Schemes for the Flotation of Sulfides from Minnesota's Copper-Nickel Deposits," previously reported under #1556 in this NRRI semi-annual report Project Tracking system. It was planned that new flotation concentrate would thus be prepared for the autoclave pressure leaching work. Mercury distribution was to be evaluated during the concentration and leaching process.

### Current Activity

Awaiting production of sufficient concentrate from project #1556 for autoclave testing.

### Principal Investigator(s)

Blair Benner

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
18,750	1896-783-1203-00
<b>Total</b>	<b>\$18,750</b>

Active
02/09/2005 06/30/2010

**Start Date:** 02/09/2005    **End Date:** 06/30/2011    **Project ID:** 1381

---

## Full Scale Mercury Sorbent Testing at Boswell

---

### Objective

To run a full scale sorbent addition test on Unit 1 at Minnesota Power's Boswell Energy Station in Cohasset, Minnesota. One or more mercury removal sorbents developed at the Coleraine Minerals Research Laboratory will be injected as dry sorbents into the 75 megawatt (MW) unit's 250,000 cubic foot/minute (cfm) stack gas stream prior to the unit's baghouse. Stack gas mercury measurements will be conducted before and after the sorbent addition to evaluate the efficiency of mercury removal.

### Background

Three years of mercury removal research test work, utilizing funding from an Economic Development Agency (EDA) grant and the Permanent University Trust Fund (PUTF), has shown that chemically modified iron ore concentrate is an effective sorbent for the removal of oxidized and elemental forms of mercury in a 250 cfm flue gas slip stream from Unit 4 at Minnesota Power's Boswell Generating Station in Cohasset, Minnesota. NRRI-developed sorbents were shown to remove greater than 90% of total mercury at pilot scale in the stack gas stream. Previous test work has shown that it is possible to efficiently separate the sorbent from the fly ash. The mercury sorbent is capable of being reused and reinjected back into the gas stream for additional mercury removal. Sorbent regeneration work has shown that it is possible to remove greater than 90% of the total mercury from the "loaded" sorbent by heating in an inert atmosphere on a batch basis. Volatilized mercury can then be condensed and totally removed from the environment. Attempts to remove the mercury on a continuous basis, using an indirectly fired calciner, have shown that temperature control is critical to efficient removal. In addition to plant test work, computational fluid dynamics analysis of duct work in Unit 1 was also conducted at the Coleraine Minerals Research Laboratory to design an efficient dry sorbent injection system, ensuring good gas-sorbent contact.

### Previous Activity

Full-scale dry sorbent injection equipment was obtained for sorbent injection into Unit 1 or 2 at Minnesota Power's Boswell facility. Work was postponed pending successful pilot scale tests being conducted on Unit 4 using a 250 cfm flue gas slip stream setup. The flue gas sampling point was changed to provide a consistent 250°F flue gas temperature for sorbent testing in the gas stream. New dry sorbent materials were tested in the pilot scale stack gas mercury removal system to investigate potential full scale mercury removal testing on Units 1 or 2. Based on results of new mercury reduction chemistry planned for use at pilot scale on Boswell Unit 4 stack gas, a full scale trial test on Unit 4 was planned for summer 2010.

### Current Activity

Discussions are ongoing with Minnesota Power to conduct new mercury reduction test studies on Unit 4 stack gas from the Clay Boswell Generating Station in Cohasset, MN. Pilot scale test results would be evaluated for possible full scale mercury reduction testing on Units 1 or 2 at Boswell.

### Principal Investigator(s)

Blair Benner  
David Hendrickson

### Project Sponsor(s)

	Amount	Account	Active
PUTF Mineral Endowment	350,000	1896-783-1227-00	04/10/2007 06/30/2010
<b>Total</b>	<b>\$350,000</b>		

**Start Date:** 04/10/2007      **End Date:** 06/30/2011      **Project ID:** 1476

---



## **Investigation of Mercury Vaporization During Induration, and Removal of Mercury from Scrubber Solids**

---

### **Objective**

To determine how mercury is volatilized during induration and to investigate methods of removing mercury from the scrubber solids.

### **Background**

The taconite industry is under pressure to reduce the emissions of mercury from their induration process. Previous studies have shown that greater than 90 percent of the mercury in the green balls is vaporized during induration. What is not known is whether the mercury is vaporized quickly, early in the process, or is slowly evolved over the entire process. Once the temperature-time relationship for mercury volatilization is established, then it may be possible to treat a smaller portion of the gas stream to remove mercury. Previous studies have shown that the fine solids removed by the scrubbers contain mercury, which is recycled back to the indurating furnace. The solids cannot be simply discarded without a significant loss in iron units. However, if the solids could be treated to remove the mercury, then they could be recycled to recover the iron and still reject mercury.

### **Previous Activity**

Modification of the mini-pot system has continued. A sample of sodium bromide has been obtained for addition to the green balls.

### **Current Activity**

Awaiting availability of mini-pot and Ohio Lumex on-line mercury analyzer.

### **Principal Investigator(s)**

Blair Benner

### **Project Sponsor(s)**

PUTF Mineral Endowment

<b>Amount</b>	<b>Account</b>
45,500	1896-783-1200-00
<b>Total</b>	<b>\$45,500</b>

<b>Active</b>	
02/09/2005	06/30/2010

**Start Date:** 02/09/2005

**End Date:** 06/30/2011

**Project ID:** 1378

---

## Mercury Reduction Tests - Bench/Pilot Scale - Western Lake Superior Sanitary District

---

### Objective

To reduce the level of total mercury in the Western Lake Superior Sanitary District's discharge water from two parts per trillion to one part per trillion for Duluth's 40 million gallon per day wastewater treatment plant.

### Background

As the new discharge limits for mercury in waters being discharged into Lake Superior have been reduced by the Minnesota Pollution Control Agency, the Western Lake Superior Sanitary District (WLSSD) needs to reduce to one part per trillion the mercury in their discharge water which flows into Lake Superior. WLSSD is Duluth's 40 million gallon per day wastewater treatment plant located in west Duluth along the Lake Superior waterfront.

### Previous Activity

Bench scale work was scheduled to continue during the spring of 2009 to support the continuing effort requested by WLSSD to reduce its water discharge mercury levels to below 1.30 parts per trillion (ppt) total mercury. NRRI is part of a mercury reduction team assembled by WLSSD to continue bench and in-plant mercury reduction work at their waste water treatment plant. Previous in-plant test work showed relatively low mercury removal, therefore, WLSSD is seeking a more effective mercury reduction in-plant process. It was planned that new chemical design research would be tested in early 2009 to evaluate its mercury removal efficiency, and also that the mercury reduction team formed by WLSSD would meet in the summer of 2009 to initiate new test work described by the team. NRRI planned to test new mercury sorbents to remove oxidized and elemental mercury forms in WLSSD's discharge waters in the fall of 2009 and spring of 2010. Could they remove 2 ppt total mercury as they are placed in the sand section of the plant's final carbon/sand filter which filters the plant's discharge water?

### Current Activity

Mercury removal test work was rescheduled to the fall of 2010 to test the ability of new mercury sorbents to lower total mercury in WLSSD's discharges from 2ppt to less than 1.3ppt.

### Principal Investigator(s)

David Hendrickson

### Project Sponsor(s)

	Amount	Account	Active
Western Lake Superior Sanitary District	44,048	1933-187-6583-00	06/02/2006 12/31/2007
<b>Total</b>	<b>\$44,048</b>		

**Start Date:** 06/02/2006      **End Date:** 06/30/2010      **Project ID:** 1428

---

## Slip Stream Pilot Plant for Testing Mercury Removal Methods for Taconite Flue Gases

---

### Objective

To design and install a slip stream pilot plant at one of the taconite plants so that various mercury removal methods can be evaluated using real plant gases.

### Background

Taconite plants are currently considered to be the second largest mercury emitters in the state. While millions of dollars have been spent on research and plant trials regarding mercury removal from power plant flue gases, relatively little has been done on taconite gases. With the large differences between the power plants and taconite plants, it is not clear that methods effective in power plants will be as effective in taconite plants. A slip stream is a more economical way to evaluate a relatively large number of alternatives without having the balance of the plant issues.

### Previous Activity

The Ohio Lumex mercury continuous emission monitor was taken to Minntac for comparison testing with the Energy and Environmental Research Center (EERC) at the University of North Dakota (UND). About a week was spent installing the unit and ancillary equipment and trying to get the unit to work. We were unable to get the unit to work, so it was brought back to Coleraine, where it was discovered that a gasket had been installed backwards, so that we were not drawing in gas from the stack. Subsequent testing at Boswell Unit 4 indicated that the unit was working properly. The work at Minntac pointed out a need for a longer heated sample line from the stack to the detector and a better environment for the instruments. A longer heated sample line was purchased so that this on-line analyzer can now be used at all of our Minnesota taconite operations in the sampling locations required on the stacks of the various pellet plants. Mercury sampling work at Minntac was completed, and a final report was being prepared. A new mercury reduction team was assembled by the taconite operations, the Minnesota Department of Natural Resources (MN DNR), the Minnesota Pollution Control Agency (MPCA), and NRRI, and meetings were initiated in late 2009.

### Current Activity

NRRI engineers and technicians met and conducted on-line continuous speciated mercury analysis baseline testing at Minnesota taconite operations. Additional baseline testing is planned for the fall of 2010. NRRI researchers were also chosen to participate in mercury removal research for the taconite operations in conjunction with researchers from UND's EERC facility. Preliminary test work will be conducted at CMRL followed by larger scale tests using pellet plant stack gas emissions.

### Principal Investigator(s)

Blair Benner  
David Hendrickson

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

350,000 1896-783-1228-00

### Active

04/10/2007 06/30/2010

**Total** \$350,000

**Start Date:** 04/10/2007

**End Date:** 06/30/2011

**Project ID:** 1477

---

## Closing the Loop on Filter Cake Moisture Analysis and Control

---

### Objective

To determine what the best and least expensive on-line moisture analyzer and associated sampling system is and then how best to structure the actual moisture control loop program to achieve constant filter cake and green ball moisture.

### Background

Previous test programs conducted by taconite plants and R&D laboratories have evaluated various on-line filter cake moisture analyzers, yet have not identified any analyzer that gives accurate and reproducible moisture data.

### Previous Activity

Programming was ongoing for the NRRI moisture analysis system using Allen Bradley DeviceNet communications and an Allen Bradley Programmable Logic Controller (PLC). Design components were built into the system to make it capable of future automation in a taconite plant so as to create an automated on-line filter cake moisture analysis system. Work progressed to complete the system with PLC installation.

### Current Activity

This automated filter cake moisture analysis system is being advanced by a new electrical engineer at the Coleraine Minerals Research Laboratory. He is assembling the components for bench scale testing.

### Principal Investigator(s)

David Hendrickson  
Kyle Bartholomew  
Matthew Mlinar  
Richard Kiesel

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
88,800	1896-783-1060-00
<b>Total</b>	<b>\$88,800</b>

Active
02/01/2002 06/30/2010

**Start Date:** 02/01/2002

**End Date:** 06/30/2011

**Project ID:** 1181

---

## Continuation of the Concentrator Modeling Center at CMRL

---

### Objective

To re-establish concentrator modeling capabilities at the Coleraine Minerals Research Laboratory (CMRL).

### Background

Over the past ten years, under the direction of Dr. Salih Ersayin, the Concentrator Modeling Center has provided invaluable services to the taconite industry. Numerous taconite specific models have been developed and successfully applied in the plants. These models are unique to the modeling Center at CMRL. Since Dr. Ersayin's departure, however, the Center has been unable to supply these services. A new program director for the modeling Center has been hired and will require time to get up to speed on the taconite models and needs of the industry.

### Previous Activity

The modeling Center's new Program Director, Dr. E. Caner Orhan, was scheduled to begin work at the Center during March 2010. It was planned that he would be introduced to the Center's version of USIMPAC and to taconite industry contacts. It would be necessary for him to become familiar with the previous work of the Center so that he would be able to demonstrate proficiency in modeling the various concentrators on the Iron Range.

### Current Activity

Dr. E. Caner Orhan began working at the Center in March 2010. Since then, previous concentrator modeling work and projects were reviewed, and various concentrators on the Iron Range were visited. The modeling and simulation software, USIM PAC, together with plant data available at the Center were examined. Currently, some well-known and robust equipment models not included in USIM PAC are being integrated into the software. This will enable the re-evaluation and cross-checking of the predictions made by USIM PAC's built-in models.

### Principal Investigator(s)

Blair Benner  
Eren Caner Orhan

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

75,000 1896-783-1220-00

### Active

07/16/2006 06/30/2010

**Total** \$75,000

**Start Date:** 07/16/2006

**End Date:** 06/30/2011

**Project ID:** 1581

---

## Development of Engineered Tiles with Radiation Absorbing Properties from Taconite Raw Materials

---

### Objective

To determine the feasibility of producing architectural quality tiles with unique engineering attributes from taconite iron ore raw materials. The tiles will be produced through high temperature melting in a plasma melting system provided by MetalRecovry, sited at the Coleraine Minerals Research Laboratory (CMRL), and tile formation and annealing in other equipment at the same site, also provided by MetalRecovry.

### Background

Based on previous test work already conducted at NRRI, it has been shown that taconite rock and magnetite concentrate have radiation absorbing properties, especially for UV and microwave radiation. It is thought that the creation of high density tiles and other consolidated products will result in material having unique engineering properties. This program will determine the conditions required for making high quality materials and will determine the processing conditions that will allow enhanced radiation absorption properties to be developed.

### Previous Activity

Taconite tailings were successfully melted in the plasma furnace, and molten tailings have been successfully cast into tiles. Testing of additives and heat treatments was in progress to produce a variety of tiles with varying physical properties.

### Current Activity

A presentation and demonstration of plasma tilemaking was held at CMRL on May 18, 2010. The audience included potential investors, economic development personnel, and representatives from grantmaking agencies. The purpose of the demonstration was to familiarize the audience with the production process and products. An IREE (Initiative for Renewable Energy and the Environment) Seed Grant was applied for and received using the results of this project. The grant will focus on using the unique aesthetics and UV and solar absorbing capabilities of the taconite tiles in a passive solar application. Work continues on improving the process of making cast materials from taconite tailings. Phoenix Solutions has agreed to upgrade the annealing oven to include more precise temperature control. We are also learning how to make cast items that are three dimensional. This involves adaptations to moldmaking and hot-work procedures. Plasma torch electrode life is being extended by operating in a nitrogen atmosphere.

### Principal Investigator(s)

David Hendrickson  
Donald Fosnacht  
Kyle Bartholomew  
Lawrence Zanko  
Richard Kiesel

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
279,396	1896-783-1241-00
<b>Total</b>	\$279,396

### Active

04/28/2008 06/30/2010

**Start Date:** 04/28/2008

**End Date:** 06/30/2011

**Project ID:** 1517

---

## Effect of Fluorine and Chlorine on Fired Pellet Metallurgical Properties

---

### Objective

To evaluate the effect of fluorine and chlorine on fired pellet metallurgical properties, specifically Reducibility (R40) and Low Temperature Disintegration (LTD). This will include the influence of halogenated process water for agglomeration and when applied to the surface of fired pellets for the purpose of pellet cooling, conveyor belt protection, and dust control.

### Background

Reducibility (R40) and Low Temperature Disintegration (LTD) are established metallurgical tests used to distinguish the quality of iron ore pellets for their performance in the blast furnace. Fired pellet quality has been historically influenced by chlorinated water when applied as dust control or cooling water. Process water containing high levels of chlorine has been shown to be detrimental to metallurgical properties when applied to the surface of cooled pellets. Quenching hot fired pellets for cooling or with conveyor belt protection water is known to degrade metallurgical properties due to the stresses created within the microstructure of the pellet. However, the impact of the chlorine levels in this water must be evaluated. The concentration of these halogens in process water used for agglomeration should also be included in this investigation for its effect on R40 and LTD.

### Previous Activity

Quench tests for 20 sets of fired pellets were completed. Initial analytical data indicated a strong effect of temperature on LTD and compression. The scale of the effect of chloride, fluoride, and temperature appeared to be about equal on R40. It was found that chloride and fluoride affected porosity, but quench temperature did not. Full quantitative analysis of the fired pellet quench data were undertaken. It was planned that testing of the effect of chloride and fluoride on agglomeration would continue as technician time permits.

### Current Activity

Data analysis for fired pellet testing is complete. Results indicate that compression strength is negatively influenced by quench temperature, fluoride has a negative effect on LTD at elevated quench temperature, chloride has a negative effect on R40 at elevated quench temperature, and fluoride has a negative effect on porosity. Testing of the effect of chloride and fluoride on agglomeration is planned for this summer. A report will be issued in the fall of 2010.

### Principal Investigator(s)

Kyle Bartholomew  
Richard Kiesel

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

30,000 1896-783-1075-00  
\$30,000

### Active

06/01/2003 06/30/2010

**Total**

**Start Date:** 06/01/2003

**End Date:** 06/30/2011

**Project ID:** 1317

---

## Effect of Preheat Burners on a Straight Grate Induration Furnace

---

### Objective

To utilize pot-grate testing to evaluate the effect of adding preheat burners to supplement the thermal energy required when adding low levels of fluxstone.

### Background

The addition of low level limestone can have a positive effect on fired pellet quality and can be advantageous to blast furnace iron reduction. The addition of limestone (calcite) to magnetite concentrates requires a significant amount of energy to calcine the fluxstone. This energy "sink" will partially prevent the pellets from reaching an effective induration temperature under normal operating conditions. This is because the calcination reaction takes place at relatively the same temperature as that when the oxidation of the magnetite begins to accelerate (600-800°C). The CO<sub>2</sub> released from the fluxstone fills the pellet pores, inhibiting the diffusion of oxygen into the pellet and slowing the oxidation kinetics. Although the same thermal energy is eventually available, the temperature rise as a result of the oxidation will be slower. Supplemental burners in the preheat section of the furnace may be required to add additional heat during critical stages of induration to maintain production levels and pellet quality.

### Previous Activity

Development of a typical straight grate furnace firing cycle was established. Green balls were collected from a commercial balling drum to eliminate any variance associated with balling, and these were then fired as a baseline. It was planned that pot grate tests would be used for comparing the standard firing cycle to one adding additional heat in the pre-heat zone. Pelletizing feed mixtures were prepared containing bentonite binders with 0.3% and 1.2% fluxstone. Mini-pot furnace tests were conducted to observe the effect of additional temperature in the pre-heat section of a straight grate furnace. Pre-heat tests were also conducted with the mini-pot furnace using the same cycles. A pre-heat test is quenched in nitrogen following the preheat stage of induration to stop the oxidation, so as to compare physical quality at this intermittent point in the process.

### Current Activity

Additional full pot grate firings will be used to confirm the results using the temperatures for pre-heat established by the mini-pot tests and compared to the previously established baseline. These tests are currently pending the completion of the pot grate upgrade. The furnace has been relocated, and purchase orders have been issued. We are awaiting delivery of orders to begin the rebuild process.

### Principal Investigator(s)

Richard Kiesel

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account	Active
25,000	1896-783-1215-00	02/09/2005 06/30/2010
<b>Total</b>	\$25,000	

**Start Date:** 02/09/2005

**End Date:** 06/30/2011

**Project ID:** 1391

---



## Environmental Taconite Particulate Project-Mesothelioma

---

### Objective

To characterize particulates associated by taconite mining in northeast Minnesota, both on the mining properties and in the population centers surrounding the taconite operations. The work being done on the mining properties will support an exposure assessment of taconite workers being performed by University of Minnesota School of Public Health researchers. The community environmental study is an inventory of particulates across the Mesabi Iron Range that can be compared with the particulate characteristics in other locations in Minnesota.

### Background

A recent update by the Minnesota Dept. of Health on a cohort of former iron miners from northeast Minnesota reported that in this group there have now been a total of 58 cases of mesothelioma. The report renewed longstanding concerns over the safety of exposure to dust derived from crushing taconite. The State requested the U of MN to take a lead in studying whether the mesothelioma (and possibly other lung diseases) were caused by exposure to taconite dust, as opposed to workplace exposure to commercial asbestos. NRRI will conduct in-plant area sampling and detailed analysis of particulate characteristics. NRRI will inventory particulate characteristics in population centers around taconite operations. The results of the inventory can be used to compare the particulate populations in communities on the Mesabi Iron Range with other towns in Minnesota.

### Previous Activity

Air sampling occurred at Mesabi Range community sampling sites (Virginia, Silver Bay, Babbitt, Hibbing, Keewatin) and baseline sites (Duluth, Ely). In-plant sampling (crusher, magnetic separator, agglomerator/ball drums, and kiln pellet discharge area) occurred at the Northshore, Hibtac, Keetac, and ArcelorMittal mines. Laboratory analyses (scanning electron microscopy/energy dispersive spectrometry, transmission electron microscopy, proton induced x-ray emission, and elutriator methodology) continue. Reporting protocols will be established during the first six months of 2010.

### Current Activity

During the first six months of 2010, in-plant air sampling occurred at various processing sites (crusher, magnetic separator, balling drums, and kiln pellet discharge areas) within the ArcelorMittal (Minorca, 3 events), Northshore (2 events), Minntac (1 event), Keetac (1 event), Hibtac (1 event), and Utac (1 event) taconite plants. Drill core samples from 2 locations on the Mesabi Iron Range have been analyzed by the elutriator method. A meeting in March with the University of Minnesota School of Public Health (SPH) developed reporting protocols. Age dating of lake sediment samples continues. Laboratory analysis utilizing transmission electron microscopy, scanning electron microscopy, proton-induced x-ray emission, energy dispersive spectrometry, and electron back scatter diffraction are ongoing. A combined external science advisory board (NRRI and SPH) has been planned for September 2010.

### Principal Investigator(s)

George Hudak  
Steven Hauck  
Tamara Diedrich

Project Sponsor(s)	Amount	Account	Active
PUTF Mineral Endowment	200,000	1896-783-1237-00	07/23/2007 06/30/2010
U of M School of Public Health	350,349		07/01/2008 06/30/2011
<b>Total</b>	<b>\$550,349</b>		

**Start Date:** 07/01/2008      **End Date:** 06/30/2011      **Project ID:** 1539

---

*Minerals, Ferrous*  
**Evaluation of Tailings**

---

**Objective**

To provide baseline data by characterizing Duluth Complex copper-nickel (Cu-Ni) ore tailings and assessing their potential for additional mineral recovery and/or value-added beneficial uses on or beyond the mine-site.

**Background**

Cu-Ni ores from the Duluth Complex will generate more than 30 tons of tailings for every ton of bulk sulfide concentrate produced. This project will provide baseline data by characterizing Duluth Complex Cu-Ni ore tailings and assessing their potential for additional mineral recovery and/or value-added beneficial uses on or beyond the mine-site. Following a battery of physical, chemical, and mineralogical tests, potential end-use options will be identified and prioritized for further bench- and/or pilot-scale testing and evaluation. The short-term goals are to thoroughly characterize the tailings, determine the viability of extracting additional value from them, e.g., the oxide fraction, and identifying realistic end uses. The long-term goals are to provide the emerging non-ferrous mining industry and/or entrepreneurs with practical alternatives that are environmentally sound to pursue, technologically simple to implement, and economically beneficial to practice. The short-term and long-term benefits to the State of Minnesota include reducing tailings disposal impacts, maximizing resource use, and generating additional revenue streams.

**Previous Activity**

This is a new project. Work on this project will likely start during the second quarter of 2010.

**Current Activity**

None to report. Budget was not formally finalized/approved until late in the second quarter of 2010. Collaborative work between NRRI Duluth and Coleraine will begin during the second half of 2010.

**Principal Investigator(s)**

Blair Benner  
Lawrence Zanko  
Steven Hauck

**Project Sponsor(s)**

PUTF Mineral Endowment

<b>Amount</b>	<b>Account</b>
15,000	1750-10416-20090-
<b>Total</b>	<b>\$15,000</b>

<b>Active</b>
09/25/2009 06/30/2010

**Start Date:** 09/25/2009      **End Date:** 06/30/2010      **Project ID:** 1577

---

## Grant Writing and Grant Search for Minnesota Taconite Operations, State and Federal Department of Energy (DOE)

---

### Objective

To provide funding to NRRI/CMRL Director and staff engineers to evaluate State and Federal DOE grant opportunities, and to work with Minnesota taconite operations to write and submit grants for energy projects in taconite.

### Background

More and more State and Federal Department of Energy (DOE) grants are appearing that apply directly to the taconite industry. For example, the Federal DOE "Industries of the Future" program requests specific grant projects for the mining industry that apply to taconite mining. On a State level, NRRI/CMRL can now work directly with the Minnesota State Energy Office to submit grant proposals for potential energy reduction projects in various fields of research and development.

### Previous Activity

A Federal DOE Grant was applied for to investigate a novel use of olivine minerals, found in the State of Minnesota, to chemically sequester carbon dioxide from our State coal-fired power plants. On a State basis, four DNR Iron Ore Co-op grants were received for advancing taconite research. NRRI participated in the submission of two additional grant requests to the State Department of Energy for advancing wind turbine design and efficiency.

### Current Activity

A number of state and federal grant proposals were written and submitted. Grant funding was received from the DOE, U.S. Economic Development Agency (EDA), Legislative-Citizen Commission on Minnesota Resources (LCCMR), Minerals Coordinating Committee (MCC), Initiative for Renewable Energy and the Environment (IREE), and the MN-DNR/Iron Ore Co-Op.

### Principal Investigator(s)

Andriy Khotkevych  
Blair Benner  
Dave Englund  
David Hendrickson  
Eren Caner Orhan  
Iwao Iwasaki  
Kyle Bartholomew  
Matthew Mlinar  
Richard Kiesel

Project Sponsor(s)	Amount	Account	Active
PUTF Mineral Endowment	156,315	1896-783-1214-00	02/09/2005 06/30/2010
<b>Total</b>	<b>\$156,315</b>		

**Start Date:** 02/09/2005      **End Date:** 06/30/2011      **Project ID:** 1390

---

## Hydroseparator Modeling

---

### Objective

To develop a mathematical model of hydroseparators, which could be used for simulation, optimization, and control of hydroseparator operating conditions.

### Background

The existing hydroseparator model does not take into account the effect of any operating variables. Available plant data indicate that there are large differences in hydroseparator performance from one plant to another. They are not operated at their optimum due to a lack of quantitative information defining their performance. Analysis of plant data led to the development of the current model, which could simulate the effect of variations in feed grade. Although there appears to be a good correlation between upward velocity and separation efficiency, systematic test work is required to establish such a relationship. Recently, the Coleraine Minerals Research Laboratory (CMRL) received Iron Ore Co-Op (IOC) funding to carry out pilot scale hydroseparator tests in plants to demonstrate the benefits of magnetic field application. These tests will produce samples that could generate data needed for hydroseparator modeling. Funding will be used for additional analysis of these samples and for model development.

### Previous Activity

A final report will be drafted after liberation analytical results have been received from the Julius Kruttschnitt Mineral Research Centre (JKMRC) in Australia. We are still awaiting results from the JKMRC.

### Current Activity

Working with former PI and JKMRC to expedite liberation results.

### Principal Investigator(s)

Blair Benner  
Salih Ersayin

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
36,000	1896-783-1201-00
<b>Total</b>	<b>\$36,000</b>

Active
02/09/2005 06/30/2009

**Start Date:** 02/09/2005      **End Date:** 12/31/2010      **Project ID:** 1379

---

## Metallized Iron Nodule Production

---

### Objective

To demonstrate the ability to continuously produce high-quality iron nodules at low cost as a result of a team effort between Nucor and the University of Minnesota Duluth's Natural Resources Research Institute (NRRI) through their joint venture - Nu-Iron Technologies, LLC.

### Background

This project has been implemented to scale up the previous results obtained in converting iron oxide concentrates from the Mesabi Range into nodular reduced iron. The project is focused on development of a prototype processing facility that will allow design and engineering of a full-scale commercial unit to be undertaken with reduced risk. The project is being funded by a joint venture company, Nu-Iron Technologies, LLC.

### Previous Activity

Work with NuIron Technologies continues both at the prototype plant and at our Coleraine Minerals Research Laboratory. Various campaigns have shown that iron ore nodules can be produced under various material mixes and operating regimes. Research focused on development of a robust processing procedure that optimizes working ratio, product yield and quality, and the overall cost of the reduced iron units produced in the process. As this is a proprietary development, no detailed reporting can be given on the overall findings to date. A multiplicity of patent applications have been filed on various aspects of the work, with 10 patents issued to date.

### Current Activity

During the reporting period, another test program was initiated at the Conway facility. Due to its proprietary nature, the results cannot be reported at this time. All work to date has pointed out critical engineering and operational features which will be incorporated into any future commercial design for the process. It is anticipated that the next reporting period will involve significant design engineering for a report to the Board of Managers during the late spring of 2011.

### Principal Investigator(s)

Donald Fosnacht

### Project Sponsor(s)

	Amount	Account	Active
Nu Iron Tech LLC	1,329,850	1664-187-6564-00	01/20/2006 01/20/2008
NU Iron Tech LLC	1,835,004	1664-187-6600-00	04/01/2007 01/20/2010
<b>Total</b>	<b>\$3,164,854</b>		

**Start Date:** 06/10/2005

**End Date:** 06/30/2011

**Project ID:** 1447

---

## Next Generation Metallic Iron Nodule Technology in Electric Furnace Steelmaking

---

### Objective

To investigate the following three major issues for producing high-quality metallized iron nodules at low cost: (1) reduce the processing temperature; (2) control the furnace gas atmosphere over the metallized iron nodules; and (3) effectively use sub-bituminous coal as a reductant.

### Background

To counteract the oxidizing effect of CO<sub>2</sub> and the high turbulence of combustion gas in the gas-fired Linear Hearth Furnace (LHF), several atmosphere control methods are proposed. Also, previous work shows that medium-volatile bituminous coal is the most desirable reductant and is routinely used in the process. Western sub-bituminous coal is an economically attractive alternative, however, its direct use has led to operational difficulties. Effective use of this char as an iron reductant or hearth layer material, with the volatile matter providing supplemental fuel for heating the furnace, will contribute toward reducing the overall cost.

### Previous Activity

The oxy-coal system was installed on the LHF at the Coleraine Minerals Research Laboratory. In addition, various atmosphere control methods have been tested using gaseous and solid atmosphere control agents. The oxy-coal system appeared to work very well with bituminous rank coals, but some difficulties have occurred in using sub-bituminous coals, due to clumping issues associated with contained moisture levels in this type of coal. Further testing is planned to determine what preparation methods will be required to make the sub-bituminous coals more readily usable with the oxy-coal burner system. Other work demonstrated that sub-bituminous coal can be used in the reaction mix after it has been processed to a char material. The char can be formed at various coal processing temperatures.

### Current Activity

Current work has focused on activating the solids fuel/oxygen burner system and demonstrating the potential use of the system with different coal types in producing iron nodules in the linear hearth furnace. Initial work with this burner identified some key furnace modifications that would be required to control atmosphere and furnace operating stability. The furnace was modified and the system was operating on a stable basis using both bituminous and prepared sub-bituminous coals. The next period will pull together all the different systems to demonstrate a quasi steady state operation on the linear hearth system to validate key concepts. The furnace system model has now reached a sophisticated state and we are able to reach convergence under a variety of potential furnace conditions.

### Principal Investigator(s)

Donald Fosnacht  
Iwao Iwasaki  
Richard Kiesel

Project Sponsor(s)	Amount	Account	Active
PUTF Mineral Endowment	125,000	1896-783-1213-00	02/09/2005 06/30/2007
PUTF Mineral Endowment	402,535	1896-783-1229-00	04/10/2007 06/30/2010
US Dept of Energy (USDOE)	1,017,768	1643-187-6554-00	09/15/2005 09/30/2010
<b>Total</b>	<b>\$1,545,303</b>		

**Start Date:** 09/15/2005      **End Date:** 03/31/2010      **Project ID:** 1407

---

## Pellet Fines Removal System

---

### Objective

To construct and test a larger scale of a prototype fines removal system in a pellet plant operation that processes 300-500 long tons per hour (LTPH) of fired pellets. A prototype fines removal system was developed at the Coleraine Minerals Research Laboratory as an alternative method for the sizing of pellets, ores, agglomerates, or coarse materials. Conventional screening methods typically use vibrating or roll screens. However, the high capital and maintenance costs associated with this equipment make the separation of fines uneconomical. The potential of this unit operation is to conduct a clean fines separation at a low cost and by more efficient means, replacing screening operations that are both costly and maintenance intensive.

### Background

The fines removal system is proposed as a low cost, more efficient means of separating fines from coarser materials. Preliminary results show that 80-90 percent of the fines can be effectively removed, while retaining 97-98 percent of the fired pellets in the product.

### Previous Activity

Meetings were held with a Minnesota taconite operation. They agreed to test the newly modified fines removal system (FRS) on their stockpiled pellets during the summer and fall seasons of 2009. The FRS was being further modified to better fix the specialized AR400 chevron lifters affixed to the surface of the belt. It was planned that the newly modified system would then be tested in the spring of 2010 at one of the Minnesota taconite operations.

### Current Activity

CMRL's patented pellet Fines Removal System (FRS) is being equipped with newly designed AR400 chevron lifters which will resist abrasive wear from the taconite pellets. To accommodate these new metal lifters, the lower return belt carrying idlers on the unit were also modified. The newly modified FRS will be tested at Northshore Mining Company in late August 2010.

### Principal Investigator(s)

David Hendrickson  
Richard Kiesel

### Project Sponsor(s)

	<b>Amount</b>	<b>Account</b>	<b>Active</b>
MN Department of Natural Resources	115,000	1663-187-6506-00	09/18/2003 06/30/2005
PUTF Mineral Endowment	136,664	1896-783-1073-00	02/01/2003 06/30/2007
<b>Total</b>	<b>\$251,664</b>		

**Start Date:** 02/01/2003      **End Date:** 06/30/2010      **Project ID:** 1309

---

## Performance of Taconite Aggregates in Thin Lift HMA

---

### Objective

To develop and evaluate the performance of hot mix asphalt (HMA) mix designs made with taconite fine aggregate (coarse taconite tailings) and recycled materials like asphalt shingles and recycled asphalt pavement (RAP), to compare the physical properties of these mix designs with conventional HMA mixes, and to conduct chemical leachate (metal) testing of both aggregates and final HMA mixes.

### Background

This project is funded by the U.S. Department of Transportation (U.S. DOT), Federal Highway Administration (FHWA). Its goal is to develop and evaluate the performance of hot mix asphalt (HMA) mix designs made with taconite fine aggregate (coarse taconite tailings) and recycled materials like asphalt shingles and recycled asphalt pavement (RAP). NRRI will be the lead organization for this project, and will work closely with research partners at the Minnesota Department of Transportation (MnDOT) Office of Materials, and with the University of Minnesota's Department of Civil Engineering (U of M CE). The project will focus on leachate testing of aggregates, mix designs, and low temperature bending and/or fracture tests on both taconite-based and control HMA mix designs. Proposed research activities will help advance and encourage the beneficial use of recycled/byproduct materials like durable and wear- and skid-resistant taconite aggregates, recycled asphalt pavement (RAP), and asphalt shingles. In combination, the use of each is highly desirable because it promotes resource conservation, safety, and energy-savings.

### Previous Activity

Project funding was awarded in late 2009. An initial project team conference call, between NRRI, FHWA, MnDOT and the U of M Department of Civil Engineering, took place in early December 2009 to discuss project tasks and scheduling. A follow-up meeting was held the same week between NRRI and MnDOT in Maplewood, MN. MnDOT provided NRRI with conventional aggregate samples for the leachate portion of the project. Background data compilation work began in December.

### Current Activity

Two progress reports were submitted to FHWA in the first half of 2010 (January and June). Report I provided an overview of initial project meetings and work plan coordination. Report II highlighted the project's 5 major Study Areas:

1: Literature review of research on taconite's engineering properties/uses in highway test sections

STATUS: Completed

2: Literature review of "thin layers" of asphalt materials in pavements

STATUS: Near completion

3: Experiments to determine leaching potential of asphalt mixtures made with taconite aggregates

STATUS: In progress; samples obtained, initial analyses performed

4: Develop mix design for thin layer of asphalt mixture made with taconite aggregates and evaluate laboratory mechanical properties

STATUS: In progress; taconite tailings acquired and obtained by MnDOT

5: Develop guidelines for the construction and field evaluation of taconite-based thin layers of asphalt mixture. Document the guidelines in a draft final report

STATUS: Pending

### Principal Investigator(s)

Lawrence Zanko

Steven Hauck

### Project Sponsor(s)

	Amount	Account	Active
PUTF Mineral Endowment	20,000	1750-10416-20090-	10/22/2009 06/30/2010
USDOT (Prime)	17,402	3002-10416-00014216	09/25/2009 11/24/2010
US DOT Federal Hwy Admin	82,598	3002-10416-00013020	09/25/2009 01/30/2011
<b>Total</b>	<b>\$120,000</b>		

**Start Date:** 09/25/2009

**End Date:** 11/24/2010

**Project ID:** 1579

---



## Preclassification of the Final Stage of Magnetic Separation Feed

---

### Objective

To investigate the utility of pretreating the feed material to the final stage of magnetic separation via size classification.

### Background

Conventional magnetic separation units are relatively efficient at separating liberated non-magnetic material from magnetite. However, middling particles, high in non-magnetic material, are passed into the concentrate and are difficult to separate via further magnetic separation without additional grinding and liberation. Adjustment of operating conditions such as field strength and pulp density can facilitate higher rejection rates of non-magnetic material, but at a cost of usually unacceptable iron losses. This leaves the obvious alternative of regrinding the tailing material to reclaim iron units, but this process is prohibitively expensive. However, preclassifying the feed to magnetic separation, particularly the final stage of separation, may provide an alternative approach to this problem. Preclassification would provide two independent streams of material to magnetic separation: (1) the fine stream, which is low in non-magnetic material/silica and, (2) the coarse stream, which is high in non-magnetic material. Therefore, the fine stream can be treated in a magnetic separator to maximize iron recovery, and the coarse stream can be treated to maximize silica rejection. To gain benefits, the magnetic reject from the coarse stream will require regrinding. However, the volume of material requiring regrinding will be significantly lower than without preclassification at equivalent upgrading. This should facilitate an improvement in the grind/grade relationship in taconite facilities.

### Previous Activity

Results indicate that Davis tube concentrate grade increases with decreasing magnetic strength, but as the size distribution becomes finer, the degree of upgrading seems to approach a limiting value. Bulk magnetic separator feed samples were obtained from an operating plant; a series of tests of unclassified feed was conducted with varying magnetic field strengths, percent solids, and feed rates. Two bulk cyclone underflow samples with unique size distributions were prepared for continuous magnetic separator testing. Test work has been completed. Final chemical analyses were completed and sent to the principal investigator. This test work was completed by an engineer who left the University. Test results will be reported by a newly assigned process engineer at the Coleraine Minerals Research Laboratory, with an expected completion date of June 1, 2009. Kyle Bartholomew was assigned this project and plans to draft a final report after a complete review of project data.

### Current Activity

Further review of the project experimental data suggested substituting a fine screening system for the cyclone to achieve an improved removal of fine silica and middlings in mag separator feed reporting to final stages of the magnetic separation circuit. As a result, the current Permanent University Trust Fund (PUTF) project will be closed and a new project submitted to better achieve the project goals. Included in this new study will be comparisons to final magnetic separator feed upgrading circuits already in place in our existing taconite plants, as well as a thorough review of process economics involved in making these circuit modifications. A concentrator modeling study will also be included as a part of this new project.

### Principal Investigator(s)

Jeremy Pletka  
Kyle Bartholomew

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

26,200 1896-783-1076-00

### Active

06/01/2003 06/30/2005

### Total

\$26,200

**Start Date:** 06/01/2003

**End Date:** 06/30/2010

**Project ID:** 1318

---

## Research, Development and Marketing of Minnesota's Iron Range Aggregate Materials for Midwest and National Transportation Applications

---

### Objective

To develop various applications for taconite aggregates in highway and construction applications and identify the logistical and transportation requirements for bringing these materials to market.

### Background

The economics of mining taconite ore relative to other worldwide iron mining resources show our mining resources are more costly to extract than many competitors. In order to secure a stable future for our mining operations, new revenue sources from current mining activities are required. One avenue for this purpose is to find uses for taconite mining by-products in highway and construction applications and to develop a logistical and transportation system that will economically bring these products to marketing areas. This project is being undertaken to fully explore how taconite by-products can be utilized as highway and construction aggregates and in other value-added opportunities related to these markets.

### Previous Activity

(1) Completion of geological work, including draft report in final editing stage; (2) Highway 53 bridge deck demonstration project in Virginia, MN, in collaboration with Mn/DOT and POLY-CARB of Ohio, using washed, screened and dried coarse taconite tailings supplied by United Taconite; (3) Acquisition of 3,000 tons of coarse taconite tailings from U.S. Steel Minntac and ArcelorMittal Minorca, for processing by Ulland Brothers, Inc., into friction products. These friction products were stored at the Coleraine Minerals Research Laboratory for anticipated use in 2010 projects; (4) Completion of Mn/DOT sub-award work; final report to be edited in 2010; (5) Accepted invitation to make a presentation to the Mineral Aggregates Committee of the Transportation Research Board (TRB) at the January 2010 TRB meeting in Washington, DC; (6) Efforts to secure follow-up funding continued.

### Current Activity

Major project activities during the first half of 2010 including the following: (1) Completed geological/stratigraphic work for identifying the most promising taconite aggregate intervals; (2) Advance pothole/road patch formulations; field demos planned; (3) Field tested mobile microwave-based pothole repair technology; (4) Field tested microwave technology as a potential lower-cost, more energy efficient method for taconite aggregate drying; (5) Mineralogical characterization of taconite aggregate materials; (6) MnROAD completed final report related to taconite aggregate evaluations conducted by Mn/DOT; (7) Updated compilation of road and paving applications in which taconite aggregate materials were used through 2009; (8) Worked with a Minnesota company and other national companies interested in using commercially processed taconite fine aggregate for bridge deck friction applications; (9) Worked with local taconite aggregate producer to facilitate larger-volume shipments to Lower Great Lakes market locations; (10) Continued follow-up funding efforts. Final report to EDA to be completed second half of 2010.

### Principal Investigator(s)

Donald Fosnacht  
Lawrence Zanko  
Steven Hauck

Project Sponsor(s)	Amount	Account	Active
Blandin Foundation	10,000	1670-187-6516-00	02/01/2004 12/31/2006
Minnesota Power	10,000	1831-187-2680-00	02/08/2005 06/30/2010
USDOC EDA	1,250,000	1661-187-6565-00	01/01/2006 06/30/2010
<b>Total</b>	<b>\$1,270,000</b>		

**Start Date:** 01/01/2006      **End Date:** 06/30/2010      **Project ID:** 1411

---

## Shallow vs. Deep Bed Sinter Quality Comparison

---

### Objective

To demonstrate shallow bed vs. deep bed sintering characteristics using the newly constructed sinter pot test facility at the Coleraine Minerals Research Laboratory (CMRL). This test program will permit establishing important statistics on test variances and sintering optimization studies.

### Background

The sinter test facility has recently been completely renovated, giving it the capability to fire deep sinter beds (up to 26 inches in depth). Prior to renovation, the maximum depth was limited to 16 inches. Additionally, the suction blower capacity was increased to achieve wind box pressures in excess of -65 inches water at the pot. This proposed test program will allow CMRL to refine sinter procedures for deep beds and ultimately to generate data in report form that can be used for discussion purposes with prospective clients. A former client has donated the sinter mix components that will be used in this study.

### Previous Activity

Thirty tests were completed, including six deep bed tests. Equipment was working well as designed. One problem with air flow measurement was identified, and the installation design of the apparatus was modified, requiring a change from a six-inch diameter to a three-inch diameter exhaust pipe and purchasing a new pitot tube for the three-inch pipe. This modification was planned to take place during February 2010.

### Current Activity

Forty tests were completed. The test program achieved two objectives: (1) Commissioning of the equipment and evaluation of overall capability. In this regard, CMRL now has a working deep bed sinter pot that is available to North and South American clients. Tests identified a need for a permeability test device so that granulation tests can be carried out with smaller quantities of mix. Deep bed tests require approximately 250 lbs of mix, which consumes significant quantities of raw materials, during moisture and binder evaluations aimed at optimizing bed permeability and, hence, productivity. (2) Evaluate differences between deep and shallow bed sinter characteristics. In achieving this goal, CMRL demonstrates the capability to evaluate sinter products over a range of bed depths, providing baseline data in report form that can be distributed to potential clients as a representative sample of our ability to perform sinter tests. In this regard, sinter product produced from deep bed tests exhibited larger particle sizes (less -1/2" material) relative to shallow bed tests (more -1/2" material). Larger sizes are beneficial in blast furnace charges. Tumble strength was about 4% higher for the deep bed sinter product as determined by the +1/4" after tumble fraction 69% vs 73% in deep bed. Productivity was about 7% higher in the shallow beds. The location of a sinter pot test facility at CMRL is beneficial to North American clients, as other commercial sinter test facilities are located in South America, Asia and Europe. A final report is in progress.

### Principal Investigator(s)

Dave Englund

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

62,930 1750-10417-20090-

### Active

10/20/2009 06/30/2010

**Total** \$62,930

**Start Date:** 10/20/2009

**End Date:** 06/30/2011

**Project ID:** 1557

---

## Taconite Industry Products and By-products: An Investigation of Alternative Uses and Their Economic Potential

---

### Objective

To investigate and identify alternative uses for taconite mining products and by-products from each Mesabi Range taconite operation, which have the best potential for providing the greatest short- and long-term economic benefit to the industry. These products and by-products can include gross physical features such as pits, stockpiles, and tailings basins; mined materials such as crude taconite, waste rock, and overburden; and processed materials including crushed taconite, tailings, taconite concentrate, and pellets. The project will attempt to quantify the potential economic impact of the various alternative uses and assign real dollar and cents values to each. The challenge will be to find opportunities that could have meaningful positive economic impacts, given the scale at which the industry operates. Therefore, the project's focus will be on finding alternatives that have the best income-generating potential, such as those that: (1) demand large volumes/tonnages of lower value materials, (2) have a significant value-added component, or (3) command a steady stream of revenue via property or equipment rental or lease arrangements.

### Background

Minnesota's taconite industry is experiencing difficulties that are negatively impacting the region and the entire state. While everyone's main focus should be on helping the industry remain competitive in its primary role, i.e., making iron units from Minnesota ore, it is very important that we try to expand the industry's revenue-generating options by investigating alternative uses and markets for the products and by-products of taconite mining. Even if only one new alternative use or market were identified, it could benefit the entire taconite industry.

### Previous Activity

Because this project is closely related to NRRI's ongoing taconite aggregate research efforts, it has provided additional resources that were used for pursuing alternative value-added use options such as various size fractions of taconite tailings; potential as a raw material source for cement making; and communicating related research findings to others.

### Current Activity

None to report. A summary report will be filed in the second half of 2010, coincidental with finalization of NRRI's other taconite by-product and co-product activities.

### Principal Investigator(s)

Julie Oreskovich  
Lawrence Zanko  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

65,000 1896-783-1065-00  
Total \$65,000

### Active

05/01/2002 06/30/2010

**Start Date:** 02/01/2002

**End Date:** 06/30/2010

**Project ID:** 1186

---

## Up-Grade CFD Cooler Models for Grate-Kiln Systems, and Perform Cooler Evaluation of Cooler Speed/Bed Depth on Process Energy Recovery

---

### Objective

To up-grade cooler model grids to Solid Works 3D model versions, because original grids exist in an electronic format that can no longer be modified if future studies require evaluation of physical changes to cooler. This project will also involve performing an evaluation of cooler speed and bed depth effects on process stream temperatures and energy recovery.

### Background

The grate-kiln plants were designed around fixed bed depths, which translate into constant speed operation. In time, plant operators pushed production rates to the point where the coolers often become the rate limiting step in the process. The development of Computational Fluid Dynamic (CFD) models makes it possible to easily simulate cooler performance under a variety of operating conditions. It would be of interest to evaluate cooler performance under conditions of varied bed depth to determine the best depth for optimum heat recovery and pellet discharge temperature. Because each operating line is unique in productivity and ductwork layout, the studies are dependent on the operating line. It is necessary in most cases to perform this evaluation for each line of interest. Additional information with regard to maximum bed temperatures achieved, effect of magnetite oxidation, and oxygen concentration in air streams entering the kiln, will also be evaluated.

### Previous Activity

A related earlier project was successful in starting a collaborative effort between the NRRI Coleraine Minerals Research Lab (CMRL) and the Itasca Community College (ICC) Engineering Program. One of the engineering students was hired as a 2009 summer intern at CMRL and conducted work to build models during July/August. The Iron Ore Co-Op portion of this project ended on June 30, 2009. A continuation of the project received high ranking and was awaiting budget approval.

### Current Activity

Contracts between the University and the Minnesota Department of Natural Resources Lands and Minerals Division have recently been signed. New work on this project has not yet begun.

### Principal Investigator(s)

Dave Englund

### Project Sponsor(s)

MN DNR

Amount	Account	Active
34,984	3005-10417-00014193	05/01/2010 06/30/2011
<b>Total</b>	\$34,984	

**Start Date:** 05/01/2010      **End Date:** 06/30/2011      **Project ID:** 1583

---

## Up-Grade Computational Fluid Dynamic Cooler Models and Evaluate Bed Depth vs. Energy Recovery

---

### Objective

The objective of this project is two-fold as follows: (1) To up-grade cooler model grids to Solid Works 3D model versions, because original grids exist in an electronic format that can no longer be modified if future studies require evaluation of physical changes to cooler, and (2) To perform an evaluation of cooler speed and bed depth effects on process stream temperatures and energy recovery.

### Background

Computational Fluid Dynamics (CFD) cooler models were developed for five operating taconite lines in Minnesota between 1997 and 2002. However, as the result of a change in CFD software, and advances to mesh generation software, the grids for these models have become obsolete. They cannot be modified to reflect proposed physical changes, and they are not compatible with existing CFD software. This project will develop new cooler grids using Solid Works 3D modeling software, which will leave them in a forwardly compatible format so that future changes can be made as needed. Revised models will be completed for the seven existing grate-kiln taconite lines.

### Previous Activity

It was planned that one model would be selected to perform a fundamental study of cooler performance where bed depth is varied over a pellet production range. This study will lead to a better understanding of energy recovery as a function of bed depth and production rate, and may ultimately lead to new control strategies for the cooler. A collaborative initiative was proposed, using Itasca Community College (ICC) students to begin the model development. The proposal was approved and work was scheduled to begin effective March 2009. Two first-year engineering students were used to begin developing 3D SolidWorks models for this project. The goal was to complete as many coolers as possible. Only one model was completed (United Taconite Line 2) by the project deadline of June 30, 2009, which prevented starting the CFD modeling phase. However, the project was successful in starting a collaborative effort between the NRRI Coleraine Minerals Research Lab (CMRL) and the ICC Engineering Program. One of the students was hired as a summer intern at CMRL and continued building remaining models during July/August. The Iron Ore Co-Op portion of this project ended on June 30, 2009. A continuation of the project received high ranking and was awaiting budget approval.

### Current Activity

Last summer (2009) one student successfully produced solid works files for all remaining coolers in Minnesota. The files are ready for incorporation into CFD, but no work has been performed yet to begin the model evaluations. Contracts between the University and the Minnesota Department of Natural Resources Lands and Minerals Division have been signed. This work is now being continued under a new budget, described under NRRI Project Tracking (PT) #1583. Work under this PT#1497 is complete.

### Principal Investigator(s)

Dave Englund

### Project Sponsor(s)

MN DNR

### Amount Account

55,200 1663-187-6607-00

### Active

11/07/2007 06/30/2009

### Total

\$55,200

**Start Date:** 11/07/2007

**End Date:** 06/30/2010

**Project ID:** 1497

---

## Utility of Taconite Materials as Road Patch for Highway Construction

---

### Objective

To confirm the utility of using inorganically bound taconite aggregate and concentrate as highway road patching and construction materials.

### Background

Preliminary test work using a proprietary binder formulation has demonstrated the utility of using taconite mining products as a highway patching material. Actual field demonstrations show that the material, if properly formulated, can act as a semi-permanent patch.

### Previous Activity

Testing of modified patch blends began. New taconite materials were acquired, and adjustments were made to the binder formulation. Testing is planned to continue in 2010, with the goal to conduct a field demonstration in the spring.

### Current Activity

Significant progress was made in adjusting mix-design formulations for both inorganic and water-based activators. Control of set-times has also been achieved via a formulation modification. Compressive strength testing of standard 2" x 2" cubes was conducted on both formulations, with excellent results. Follow-up freeze/thaw tests are being conducted. The investigators believe that the mix designs are near optimal, so several hundred pounds of each taconite by-product/co-product component were acquired in preparation for field trials/demonstrations planned for late August 2010.

### Principal Investigator(s)

Donald Fosnacht  
Lawrence Zanko  
Steven Hauck  
Tamara Diedrich

### Project Sponsor(s)

PUTF Mineral Endowment

<b>Amount</b>	<b>Account</b>	<b>Active</b>
50,000	1896-783-1216-00	02/09/2005 06/30/2010
<b>Total</b>	<b>\$50,000</b>	

**Start Date:** 02/09/2005      **End Date:** 06/30/2010      **Project ID:** 1392

---

## Geologic and Stratigraphic Controls of the Aggregate Potential of the Mesabi Iron Range

---

### Objective

To continue to compile and generate baseline geological, technical, and economic information on the quality of potential higher-value aggregate products (e.g., Class A-type aggregate, concrete aggregate, railroad ballast) derived from the major stratigraphic units within the Biwabik Iron Formation. This research will build upon our current investigation of the Virginia Horn area (Mittal Steel-Minorca through United Taconite), by continuing westward in the iron formation through U.S. Steel Minntac in 2006 and through Hibbing Taconite in 2007.

### Background

Minnesota's taconite industry generates potentially huge amounts of aggregate in the form of taconite mining and processing byproducts. However, geology and stratigraphy control the ultimate quality of the taconite rock used for aggregate, just as geology and stratigraphy control the quality of the ore used for pellet production. A more systematic and larger-scale research program of geologic mapping, sampling, and testing is geared toward identifying "optimal" (both technically & economically) geologic units.

### Previous Activity

The report is very near completion, and the second draft has been edited. Corrections are pending. The final report will be issued before summer of 2010.

### Current Activity

The final report has been completed and has been distributed to the general managers and geologists at each of the taconite mines on the Mesabi Iron Range. It will soon be posted on the NRRI website and thus will be available for distribution to the general public.

### Principal Investigator(s)

Mark Severson  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

176,000 1896-783-1225-00

### Active

07/16/2006 06/30/2010

**Total** \$176,000

**Start Date:** 07/16/2006

**End Date:** 06/30/2010

**Project ID:** 1437

---



## Compile and Make Digital the Lithologic Data for All NRRI Drill Logs, with Emphasis on the Duluth Complex Drill Holes (an Update)

---

### Objective

To update a 2003 NRRI report which provided a database that listed the lithologic/geologic picks in over 600 drill holes that the NRRI had logged in the Duluth Complex.

### Background

The above-referenced report presented virtually all of the publicly available drill hole location data and Cu-Ni assay data for 2,145 drill holes in and near the Duluth Complex. These databases are also available online and have been extensively used by at least four exploration companies (PolyMet, Teck Cominco, Duluth Metals, and Encampment Exploration) in order to more fully understand and model the mineralization trends at their respective properties. Since 2003, all of the remaining publicly available holes (approximately an additional 200 holes) along the western margin of the Duluth Complex will have been logged by NRRI personnel. The lithologic information from these holes needs to be added to the 2003 database. Locations for holes drilled in the Duluth Complex since 2003 will also be added to the database.

### Previous Activity

A first draft report has been produced, edited, and corrected. While there is no longer any available funding for this project, further input of data has been conducted on an intermittent basis (during personal hours) and is very near to completion. The final report will be published before summer 2010.

### Current Activity

The report was finished in February and is now available on the Natural Resources Research Institutes' website. The project is now complete.

### Principal Investigator(s)

Mark Severson  
Steven Hauck

### Project Sponsor(s)

	Amount	Account	Active
MN DNR	40,000	1663-187-6613-00	03/07/2008 06/30/2009
PUTF Mineral Endowment	40,000	1896-783-1240-00	04/01/2008 06/30/2010
<b>Total</b>	<b>\$80,000</b>		

**Start Date:** 03/07/2008      **End Date:** 06/30/2010      **Project ID:** 1505

---

## Copper-Nickel-PGE Mineralization Potential of the Cloquet Lake Intrusion in Northeast Minnesota

---

### Objective

To conduct a first pass reconnaissance sampling campaign to evaluate the potential of the Cloquet Lake Intrusion to host basal Cu-Ni-PGE deposits and/or stratiform PGE reef deposits related to a sulfide saturation event.

### Background

The Cloquet Lake Intrusion, comprising part of the Beaver Bay Complex, represents one of the largest Keweenaw-age intrusions in northeast Minnesota. The intrusion is 2-3 times larger than either the Partridge River or South Kawishiwi intrusions, which contain several Cu-Ni-PGE deposits. However, exploration for base and precious metals in the Cloquet Lake Intrusion has been limited to three drill holes. All three holes intersected massive sulfide at the basal contact, but PGE, Cu, and Ni values were generally low, and further exploration efforts were discontinued. Despite this lack of encouraging results, the Cloquet Lake Intrusion should still be explored for the following reasons: (1) the intrusion is situated near a buried crustal ridge of older country rock that may have served as a local sulfur source for basal disseminated Cu-Ni-PGE sulfide deposits; (2) the massive sulfide in the 3 holes may be related to proximity to a vent, wherein, additional massive sulfide with higher Cu-Ni-PGE values (related to fractional crystallization) may be present and could be located more distally to the vent; and (3) the layered nature of this intrusion suggests that it may be possible that one or more stratiform PGE reefs (associated with low sulfide contents) lies hidden in the upper portions of the intrusion. This project would be aimed at collecting more samples of weak to moderately-mineralized rock in order to gain a better appreciation of the mineralized potential of the Cloquet Lake Intrusion.

### Previous Activity

A considerable portion of the summer of 2009 was spent conducting searches for rock outcroppings of this poorly exposed intrusion that covers a 274 square mile area. All public roads (72 linear miles), almost all logging roads (18 linear miles), and several back country traverses (38 linear miles) were driven or walked in attempts to further refine the known geology. In the end, several new outcrops were found in the northeast corner of the intrusion, and additional outcrops were found in the southeast corner of the intrusion. The majority of the intrusion is not exposed except for one outcrop that is present along the side of Lake County Road #15. All of the new outcrop information has been added to a preliminary map, and a final geologic map will be produced pending review of the mineralogy in thin sections from collected rock samples. No obvious zones of Cu-Ni mineralization were located; however, a unique alteration pattern was discovered in the northeast corner of the intrusion that may be related to potential mineralization.

### Current Activity

Twenty-eight samples were submitted for copper, nickel, sulfur, platinum, and palladium analysis. Polished thin-section heels were also sawn, but have yet to be sent in for preparation of thin-sections.

### Principal Investigator(s)

Mark Severson  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
15,000	1896-783-1082-00
<b>Total</b>	<b>\$15,000</b>

### Active

09/01/2004 06/30/2010

**Start Date:** 09/01/2004

**End Date:** 06/30/2010

**Project ID:** 1358

---

## Further Evaluation of Diamond Base Metal and Precious Mineral Potential of Minnesota Using Various Glacial Till Sampling and Analytical Methods

---

### Objective

To: (1) compile all pertinent Minnesota geological and geophysical information that are relevant to the formation of diamond pipes; (2) conduct additional processing and mineral analyses on some of the 120 previously collected glacial till samples from the Vermilion District for mineral potential; and (3) conduct a down-ice glacial till demonstration study in the International Falls area using the methods of Larson and other recognized glacial till sampling methodologies for identifying kimberlite and base and precious mineral indicator minerals.

### Background

In Canada, sampling glacial till has been successfully used to locate diamond pipes and base metal mineralization. Very limited similar surveys have been conducted in Minnesota, but there has not been a systematic glacial till sampling survey conducted in northern Minnesota.

### Previous Activity

Gold data from a new DNR Lands & Minerals survey have been added to the database and gold map and will be incorporated into the final report.

### Current Activity

Work is progressing on the final report.

### Principal Investigator(s)

John Heine  
Steven Hauck

### Project Sponsor(s)

	<b>Amount</b>	<b>Account</b>	<b>Active</b>
MN Department of Natural Resources	74,700	1663-187-6586-00	08/10/2006 06/30/2008
PUTF Mineral Endowment	95,000	1896-783-1223-00	07/16/2006 06/30/2010
<b>Total</b>	\$169,700		

**Start Date:** 08/10/2006    **End Date:** 06/30/2010    **Project ID:** 1438

---

## Heavy Stream Discharge from the Falcon Concentrator

---

### Objective

To test various modifications designed to enable a free flow of the heavy mineral stream out of the standard Falcon concentrator bowl. If successful, a performance evaluation will measure the device's ability to separate low silica magnetite out of a mixed stream that contains middlings and gangue.

### Background

Previously, the Coleraine Minerals Research Laboratory completed evaluation of the Falcon concentrator, which is a device that separates minerals based on specific gravity. While performance was promising, the previous researcher was concerned regarding clogging of the heavy mineral discharge hardware. On the other hand, investigators from the gold industry state that the Falcon is the device of choice for "fine" particle size distributions, such as those used in the taconite industry. In addition, they report: "The ability to recover a mineral of density equal to 5.2 from a gangue of density 2.7, especially below 50 um (270 Mesh), is clearly demonstrated," (La Plante, Andre, "A Comparative Study of Two Centrifugal Concentrators," CMP Mineral Processing Proceedings, 1993). Existing magnetic separators are designed to remove magnetite out of the tailings stream, while sending both liberated magnetite and middlings on to further processing. These machines are not designed to separate pure magnetite away from the middlings. However, if that can be done with a Falcon, then the combination of the two devices could produce a returning mill feed stream consisting of only middlings. As the net mill feed tonnage is reduced, so the line productivity increases. In addition, if the heavy concentrate is sufficiently low in silica, then flotation recovery will increase. Solving the heavy particle discharge problem with the Falcon concentrator could result in large improvements for taconite plants.

### Previous Activity

Tom Larson left the employ of the University, and a new principal investigator, Kyle Bartholomew, was assigned to prepare the final report for the completed study using the Falcon concentrator to separate a low silica magnetite concentrate from middlings and gangue. The centrifuge-type device was recommended for use in a tungsten processing circuit in the Yukon and was run successfully at that location. The unit was also being evaluated for possible copper-nickel upgrading for Minnesota copper-nickel ore. Tom Larson was contacted by the new principal investigator, and data from the project have been located. Testwork is complete and final report writing is underway. The primary conclusion from the project is that the concentrator shows technical promise for upgrading taconite ore, but the physical configuration of the Falcon concentrator likely makes it too capital intensive for the proposed application. It was planned that the final report would be completed in the spring of 2010. New uses of the Falcon concentrator will also be evaluated in 2010.

### Current Activity

Test data have been received from the previous PI. This information will shortly be compiled into a summary report.

### Principal Investigator(s)

Kyle Bartholomew  
Thomas Larson

Project Sponsor(s)	Amount	Account	Active
PUTF Mineral Endowment	40,000	1896-783-1208-00	02/09/2005 06/30/2006
<b>Total</b>	<b>\$40,000</b>		

**Start Date:** 02/09/2005      **End Date:** 06/30/2011      **Project ID:** 1386

---

## History and Compilation of all Gold Exploration Data in Minnesota

---

### Objective

To compile all available information (maps, assays, reports, etc.) from historical records to produce a Guidebook that describes “who did what, where, and how, and what did they find?” regarding the gold exploration history of northeastern Minnesota.

### Background

Overall, the history of gold exploration in Minnesota may be summarized as very brief periods of activity: Vermilion Gold Rush of 1865-1867, Rainy Lake Gold Rush of 1893-1895, Raspberry Prospect (west of Ely) circa 1900, and more recently, a brief intense campaign in the 1980s following the discovery of the Hemlo gold deposit in Ontario. The latter includes such areas as the Virginia Horn, Lost Lake area in Itasca County, and the Mud Creek Shear Zone/Vermilion Fault area.

### Previous Activity

Waiting for Minerals Coordinating Committee (MCC) proposal with a similar name to be funded.

### Current Activity

Work consisted of obtaining exploration-related materials (drill logs, geologic maps, and geochemistry results for rock, soil, and drill core samples) from the Minnesota Department of Natural Resources "minerals archive" website. Areas completed thus far are: Rainy Lake area located to the east of International Falls; Lost Lake area of northern Itasca County; and the Virginia Horn area located near Gilbert. All of these data have been organized, and the paper copies stored at the Department of Natural Resources office in Hibbing will be cross-checked for omitted or poorly scanned data. Collection of additional data from the "minerals archive" website for the Mud Creek/Vermilion Fault area has been initiated and is about 50% complete.

### Principal Investigator(s)

Mark Severson  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

31,000 1750-10416-20090-  
\$31,000

### Active

09/25/2009 06/30/2010

**Total**

**Start Date:** 09/25/2009

**End Date:** 06/30/2010

**Project ID:** 1576

---

## Investigation of Various Flotation Reagent Schemes for the Flotation of Sulfides from Minnesota's Copper-Nickel Deposits

---

### Objective

To determine the best reagent schemes for recovering copper and nickel sulfides from the various Minnesota deposits, to train Coleraine Minerals Research Laboratory (CMRL) technicians in the "art" of sulfide flotation, and to develop analytical expertise in copper and nickel.

### Background

Much of the sulfide flotation work on Minnesota copper-nickel deposits has been conducted by Lakefield Lab in Canada. Once they have established the "best practice" for one deposit, they appear to apply that practice to all deposits. There are some mineralogical differences between the various deposits, and it may be beneficial to develop different reagent schemes for the different mineralogies. There is a lack of experience at CMRL regarding the flotation of sulfide ores. Running a series of bench scale flotation tests would be a training opportunity. Likewise, the CMRL analysts have little experience in conducting determinations on sulfide samples.

### Previous Activity

Tests were run using sodium isopropyl xanthate as the collector to determine the effect of grind on copper recovery by size fractions. Grind times were 25, 35 and 45 minutes. Overall copper recovery in the rougher concentrate increased with grind time with 89.11% at 25 minutes, 90.15% at 35 minutes, and 91.92% at 45 minutes. The resultant rougher tails were screened through 10 microns, and the fractions were analyzed. The highest copper concentrations were in the minus 10 micron fractions and ranged from 0.125% at 25 minutes to 0.118% at 35 minutes and 0.097% at 45 minutes. Although the copper content of the minus 10 micron fractions decreased with grind time, because of the increase in the amount of minus 10 micron material, the actual percentage of total copper in the minus 10 micron fraction increased from 37.1 to 39.5 to 44.2 percent with the finer grinds.

### Current Activity

Work will continue on other ores and reagents when laboratory flotation cells become available again.

### Principal Investigator(s)

Blair Benner

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
43,500	1750-10417-20090-
<b>Total</b>	<b>\$43,500</b>

Active
08/25/2009 06/30/2010

**Start Date:** 08/25/2009

**End Date:** 06/30/2011

**Project ID:** 1556

---

## Origin and Distribution of Chromium Mineralization in the Duluth Complex and Related Keweenawan Intrusives in Minnesota, and Its Relationship to PGE Mineralization

---

### Objective

To expand our knowledge of Cr-mineralization and its potential relationship to PGE mineralization by: (1) using existing geochemistry data and collecting Cr-bearing samples for polished thin section analysis; (2) identifying other unassayed drill core that may contain chromium mineralization, analyzing the drill core, and collecting samples for polished thin sections; (3) supporting one Ph.D. thesis on the Birch Lake area that will investigate the PGE-Cr mineralization and relationships to oxide mineralization; (4) conducting quantitative microprobe analyses to determine the various chromium-related minerals; and (5) evaluating and further analysis of one chromium occurrence identified in a drill hole outside of the Duluth Complex.

### Background

Chromium (Cr) mineralization associated with PGEs in the Duluth Complex was first recognized by Sabelin and Iwasaki (1985, 1986) in Du-15 in the Birch Lake area. The presence of chromium spinels was noted earlier by Weiblen and Morey (1976) at the Spruce Road deposit. Severson (1995) identified chromium and platinum mineralization in drill hole SL-19 northeast of the Water Hen deposit. Severson (1991) identified Cr-rich spinels in the Local Boy ore zone of the Babbitt deposit. Hauck et al. (in prep.) have identified a variety of Cr-rich spinel in the Birch Lake area, not all of which are directly associated with PGE mineralization. In addition, Heine et al. (1998) reported 1.64% Cr<sub>2</sub>O<sub>3</sub> in saprolite in a drill hole drilled into a Keweenawan ultramafic body in Stearns County.

### Previous Activity

The microprobe identification of materials continues, but is still in preliminary stages due to more immediate commitments. A new chromite deposit has been discovered in the James Bay Lowlands. Steve Hauck is trying to get a sample for comparison with the Duluth Complex chromites.

### Current Activity

Several attempts to get samples of the new Ring of Fire chromite deposits have not yet born fruit, but efforts will continue. Locating chromite and/or Cr-magnetite grains continues as time allows.

### Principal Investigator(s)

Mark Severson  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

76,000 1896-783-1071-00

### Active

05/01/2002 06/30/2010

### Total

\$76,000

**Start Date:** 02/01/2002

**End Date:** 06/30/2010

**Project ID:** 1192

---

## Precambrian Research Center

---

### Objective

To provide training and support to the next generation of geoscientists in modern methods of geological mapping and mapmaking. This training will focus on the unique attributes of mapping the ancient Precambrian rocks of the southern Canadian Shield. The Canadian Shield and similar terranes on every continent are host to many of the world's premier ore deposits.

### Background

The Precambrian Research Center (PRC) was created at the University of Minnesota Duluth (UMD) in 2006 to satisfy an urgent, long-term demand for and critically low supply of geoscientists skilled in field mapping. The PRC seeks to reverse the two decades-long decline in the teaching of geologic mapping skills in U.S. colleges and to provide advanced training to professional geologists.

### Previous Activity

July 1 to Dec. 31, 2009 Activities:

Field Camp: 2009 field camp enrollment was full with 20 students from 18 different US schools attending.

Workshops: Conducted a professional workshop on Mafic Layered Intrusions held at UMD, Oct 4-10; involved 22 participants from academia, industry, and government and 10 instructors.

Student Awards: 08-09 PRC Graduate Research Assistantship (GRA) recipient Tom Johnson successfully defended his MS thesis in September. No GRAs were awarded for the 09-10 academic year.

Fundraising: Corporate and individual contributions for 2009 totaled \$41,500.

Other Activities: J. Miller attended Geological Society of America (GSA) in Portland, OR, to give a talk about PRC field camp at a special session on field camps; Updated and expanded PRC board of advisors to 14 members from industry, government, and academia in December.

### Current Activity

Field Camp: Promoted 2010 camp by distributing posters to US schools; 28 students applied by March 31st; 22 students were accepted.

Workshops: Promoted and planned a professional workshop on Precambrian Iron Formations to be held at UMD in October 2010.

Student Awards: UMD students Dan Foley and Michael Totenhagen received PRC GRA's for the 2010-11 academic year. Research grants were awarded to eight students in March (4 UMD, 1 U of W-Milwaukee, 1 Princeton, 1 Harvard, 1 Idaho State).

Fundraising: Solicitations were made by email correspondence, distribution of the annual report, and contacts made at industry conferences - Prospectors & Developers Assoc. of Canada (PDAC) and SME.

Other Activities: 2009 PRC Annual Report published in March. PRC Board of Advisors meeting held in March at PDAC meeting in Toronto was attended by 10 board members.

### Principal Investigator(s)

Dean Peterson

George Hudak

Jim Miller

Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

### Amount Account

150,000 1896-783-1226-00

### Active

07/18/2006 06/30/2010

**Total** \$150,000

**Start Date:** 07/18/2006

**End Date:** 06/30/2010

**Project ID:** 1432

---



## Reconnaissance Evaluation of the Volcanogenic Massive Sulfide (VMS) Potential in Lake of the Woods, Koochiching & Beltrami Counties

---

### Objective

To determine the volcanogenic massive sulfide potential of an area drilled between the late 1960s and middle 1980s using new ideas about the generation and occurrence of base-metal sulfides.

### Background

The main objective of this proposal is to make a first pass evaluation of the volcanogenic massive sulfide potential, through logging of selected drill holes, within a portion of a greenstone belt (80 mile strike-length) that was drilled by several exploration companies from the late 1960s through the middle 1980s. Many of the holes drilled by the companies intersected massive sulfide horizons associated with a variety of volcanic, chemical, and sedimentary rock packages. However, the massive sulfides in the holes were mainly pyrite and pyrrhotite with limited amounts of base metal sulfides, a fact that discouraged further exploration in the area. At the time, detailed alteration and volcanic facies studies were not routinely conducted by the companies, nor was it recognized that volcanogenic massive sulfide districts typically contain some amounts of base metal-deficient massive sulfides that are distally-located relative to volcanogenic massive sulfide vent areas. In essence, the exploration companies never tried to put together a “big picture” in an attempt to further refine the mineral potential of the area. The goal of this project is to begin to relog the holes, with emphasis on conducting alteration studies and detailed volcanogenic facies mapping (as has been recently done in the Vermilion District by the NRRI and UW-Oshkosh) in order to fully assess and document the mineralization potential of this greenstone belt.

### Previous Activity

All of the drill hole data and exploration data have been reviewed and summarized in preliminary maps, tables, and various databases. This review indicates that out of the 210 drill holes that were drilled in the area, 44 drill holes intersected massive sulfides, but most of these are base metal-poor. The abundance of massive sulfides in this terrain suggests that base metal-rich massive sulfides may be present and could potentially be discovered with more intense exploration efforts. Drill logs for all but a few of the holes have been summarized. Remaining logs apparently do not exist, and these holes will be logged in the near future in order to complete the database and write a final report.

### Current Activity

Exploration company-related drill logs no longer exist for three holes in the study area. One of these holes (A-9-2) was logged during the report period. Rocks intersected in this particular hole consist of highly metamorphosed and structurally-deformed volcanic rocks. The hole intersected some weak sulfide mineralization, including disseminated copper mineralization (chalcopyrite), in a 60 foot thick zone.

### Principal Investigator(s)

Dean Peterson  
Mark Severson  
Steven Hauck

### Project Sponsor(s)

PUTF Mineral Endowment

Amount	Account
10,000	1896-783-1087-00
<b>Total</b>	<b>\$10,000</b>

Active
09/01/2004 06/30/2010

**Start Date:** 09/01/2004

**End Date:** 06/30/2010

**Project ID:** 1356

---

**Peat Expansion Premier Horticulture, Inc.**

---

**Objective**

To locate, assess, and secure a suitable horticultural peat resource for Premier Horticulture, Inc., to allow expansion of their Peatrex operation, and to initiate the environmental review and permitting process.

**Background**

Premier Horticulture, Inc., contacted NRRI for assistance in expanding their Peatrex operation located west of Cromwell, Minnesota. It is estimated that their current peat resource (approximately 240 acres) will be depleted in the next 5 to 10 years. Also, their packaging facilities are presently operating under capacity and could readily handle additional peat from another resource, making the operation more cost-effective and profitable. An expansion would not only maintain present employment at Peatrex, but would also result in 15 additional jobs at the processing plant and harvesting site. Supplementary employment would also occur in spin-off industries such as trucking. NRRI will assist Premier Horticulture, Inc., by: (1) conducting a detailed assessment of potential peat resources in proximity to the Peatrex operation, (2) identifying financial assistance and other incentives available for peatland development from State, County, and local agencies, and (3) assisting in the purchase or lease of the property, and beginning the environmental review and permitting process required by Federal and State regulatory agencies prior to peat development.

**Previous Activity**

NRRI's involvement in the Wright Bog horticultural peat development remains on hold while Premier negotiates an easement with a local landowner to allow construction of a drainage ditch from the site.

**Current Activity**

No progress to report for this period.

**Principal Investigator(s)**

Kurt Johnson  
Steven Hauck

<b>Project Sponsor(s)</b>	<b>Amount</b>	<b>Account</b>	<b>Active</b>
Minnesota Technology, Inc	99,982	1673-187-6441-00	07/01/1999 06/30/2004
		1196-187-2428-00	10/25/2001 06/30/2010
<b>Total</b>	<b>\$99,982</b>		

**Start Date:** 07/01/2000      **End Date:** 06/30/2010      **Project ID:** 1074

---

## Wetland Banking Fens Research Facility

---

### Objective

To restore most of the effectively drained Fens Research Facility (Fens) to a variety of wetland types so new wetland credits can be deposited into a state wetland bank for future withdrawal as wetland mitigation credits.

### Background

For about 100 years, the Fens has been used for agriculture, horticulture, fuel peat production, and peatland research. The peat soils have been intensively drained. With recent demand for wetland mitigation credits, the Fens became a candidate for peatland restoration. The Minnesota Board of Water and Soil Resources (BWSR) and the Minnesota Department of Transportation (Mn/DOT) approached NRRI about establishing numerous wetland banks at the Fens. After lengthy review, five banks are in the process of being established. A variety of wetland types are being established. New wetland credits (NWC) are being deposited into BWSR wetland banks. NWC are used for wetland replacement mitigation following loss of wetlands as a result of road construction in Northeast Minnesota.

### Previous Activity

In 2002 and 2005, the University of Minnesota (UM) entered into agreements with BWSR and Mn/DOT to restore 333.2 acres of drained peatlands for NWC at the Fens. Under the 2002 and 2005 agreements, the land was cleared, vegetation killed, and the soil rototilled. Subsequently, the ditches were filled, the land leveled and donor material (plant fragments) from nearby bogs was gathered and spread at the Fens. Water wells and vegetation plots were monitored and herbicide was sprayed on invasive species in August and September of each year since bank establishment. In 2008, UM entered into another agreement with BWSR to restore 145.4 acres of drained peatlands for NWC at the Fens. The construction and establishment of monitoring sites followed the same process as that for the 2002 and 2005 agreements.

### Current Activity

Vegetation and well monitoring of the 2002, 2005 and 2008 BWSR and Mn/DOT banks were carried out in the spring and early summer of 2010. A mosaic of wetland types has been established at the banks. Annual reports were written for the wetland banks. In June 2010, three important milestones were met: 1) Bank I (2002 agreement) was approved for closure and all NWC deposited, 2) Banks II and III (2005 agreement) were given preliminary approval for closure at the end of 2010, and 3) approval was received for twenty-five percent of NWC for Bank IV (2008).

### Principal Investigator(s)

Steven Hauck  
Thomas Malterer

Project Sponsor(s)	Amount	Account	Active
MnDOT	1,344,258	1196-187-2426-00	05/01/2001 06/30/2010
MN Board of Water and Soil Resources	1,828,136	1196-187-2426-00	05/01/2001 06/30/2010
<b>Total</b>	<b>\$3,172,394</b>		

**Start Date:** 07/01/2002      **End Date:** 09/30/2013      **Project ID:** 1367

---

## Wetland Mitigation in Abandoned Gravel Pits

---

### Objective

To determine if viable mitigation wetlands can be created on abandoned gravel pit sites to compensate for wetland impacts due to road construction in northeastern Minnesota.

### Background

It is becoming increasingly difficult to provide on-site mitigation for wetland impacts due to road construction in northeastern Minnesota counties which retain greater than 80 percent of their pre-settlement wetlands. Abandoned gravel pits are one of the few remaining areas that can serve as wetland mitigation sites within the impacted watersheds. The main goal of this project is to determine if viable mitigation wetlands can be created on abandoned gravel pit sites to compensate for wetland impacts due to road construction in northeastern Minnesota. To achieve this goal, a wetland creation demonstration site will be established in an abandoned gravel pit within the U.S. Trunk Highway 53 reconstruction corridor. The site will allow research and evaluation of hydrologic controls, soil amendments, direct seeding, mulch, and other techniques for wetland establishment. Soil and plant materials displaced by the TH 53 reconstruction will also be evaluated for use in wetland creation. The completed demonstration site will consist of a complex of several wetland types most likely to be impacted in northeast Minnesota (Types 2, 6, 7, and 8). The research will result in preliminary recommendations for creating wetlands in abandoned gravel pits based on information acquired during the funding period.

### Previous Activity

Control of invasive plant species continued by spraying with glyphosate herbicide on the Mitigation 4 and 5 sites in July 2009. Completed the fall 2009 plant surveys of the research plots in early September 2009. Presented the paper "Wetland Mitigation in Abandoned Gravel Pits - Creating Fresh Meadow and Shrub Swamp" at the International Conference on Ecology and Transportation held in Duluth, Minnesota, September 13-17, 2009. Submitted the proposal "Wetland Mitigation in Abandoned Gravel Pits (Phase II)" to the Center for Transportation Studies (CTS) in October 2009. The article "From Gravel Pit to Wonderful Wetland" was published in the Autumn issue of NRRI NOW. Plant survey data organization and analysis were ongoing in preparation for the draft final report.

### Current Activity

The proposal "Wetland Mitigation in Abandoned Gravel Pits (Phase II)" submitted to the Center for Transportation Studies (CTS) in October 2009 was not funded. The final report for the project "Wetland Mitigation in Abandoned Gravel Pits" was completed in March 2010. The full report is available at: <http://www.lrrb.org/pdf/201011.pdf>

### Principal Investigator(s)

Kurt Johnson

Project Sponsor(s)	Amount	Account	Active
MN Dept of Transportation (MNDOT)	109,562	1663-187-6591-00	10/09/2006 03/31/2010
<b>Total</b>	\$109,562		

**Start Date:** 10/09/2006      **End Date:** 03/31/2010      **Project ID:** 1445

---

## Center for Applied Research and Technology – Program Notes

### Forestry/Forest Products

#### *Personnel*

**Don Riemenschneider** was hired as a Research Associate in the CARTD Forestry Group. Don recently retired from the USDA Forest Service and is a world renowned expert in the field of poplar genetics and breeding.

**Sam Anderson** was hired as a student engineer in the Wood Materials and Manufacturing Program. He is working on data processing and modeling data for the 3 dimensional laser scanning project for historic covered bridges.

**Eric Hagen**, a recent UMD Economics graduate, was hired in a temporary position, as a business development research assistant.

**Paul Knapp**, the son of the founder of Knapp Verbinder, our core technology vendor partner on our demonstration housing systems project, began a three year internship at NRRI sponsored by his father's company. Paul is a recent graduate of a Timber Engineering program in Austria and will participate in business development projects.

#### *Scientific Meetings/Presentations*

**Bill Berguson** gave an overview of the SunGrant Regional Feedstock Partnership's Poplar Team research program at a national conference in San Antonio, Texas, sponsored by the Department of Energy and the SunGrant Initiative. Bill is the national coordinator of the SunGrant Initiative's Poplar Team.

**Brian Brashaw** was invited to give a presentation entitled, "Building on a Century of Successful and Innovative University Research" at the 64th International Convention of the Forest Products Society held in Madison, Wisconsin.

**Brian Brashaw** gave a poster presentation entitled, "History of NRRI's Forestry/Forest Products Research, Development, and Technology Transfer Programs" at the 64th International Convention of the Forest Products Society held in Madison, Wisconsin.

**Brian Brashaw** and **Bob Vatalaro** gave a presentation entitled, "Lean Manufacturing Strategies for the Prince of Wales Forest Products Industry" held in Thorne Bay, Alaska.

**Brian Brashaw** and **Bob Vatalaro** gave a presentation entitled, "Total Productive Maintenance Opportunities for the Prince of Wales Forest Products Industry" in Thorne Bay, Alaska.

**Brian Brashaw** gave a presentation entitled, "Structural Condition Assessment of Wood Structures" in Juneau, Alaska.

Robert Ross, **Brian Brashaw**, Xiping Wang, and Zhiyong Cai gave a presentation entitled, "Structural Condition Assessment of Timber Structures" at the 64th International Convention of the Forest Products Society held in Madison, Wisconsin.

**Donald Fosnacht**, David Hendrickson and **Timothy Hagen** gave a presentation entitled, "Effectively Utilizing Biomass for Various Energy Applications" at the Biomass Seminar held at NRRI in Duluth, Minnesota.

**Brian Brashaw** and Matthew Hemmila gave a presentation entitled, "Minnesota Timber Bridge Maintenance and Construction – A County Perspective" at the SmallWood 2010 conference in Hot Springs, Arkansas.

**Brian Brashaw**, **Bob Vatalaro**, **Kevin Sarvela**, **Matthew Verreux**, Xiping Wang, Robert Ross and James Wacker gave a joint presentation entitled, "Development of Flexural Vibration Inspection Techniques to Rapidly

Assess the Structural Health of Timber Bridge Systems” at the University of Minnesota 21st Annual Transportation Research Conference held in St. Paul, Minnesota.

**Patrick Donahue** attended the 2010 European Solar Decathlon in Madrid, Spain, and participated in a technology tour of Passivhaus factories and research Universities in Germany.

### ***Publications***

The NRRI has completed a technical report entitled “Evaluation of Hybrid Poplar Yield in Minnesota”.

**Brian Brashaw**. 2010. H.B. Fuller Resin Trial. Natural Resources Research Institute Technical Report NRRI/TR-2010/04.

**Victor Krause**. 2010. Laminate Performance Testing of Boltaron – Northern Contours. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/05.

**Victor Krause**. 2010. Evaluation of Mar Resistance on Various Materials - Synergy Thermal Foils. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/07.

**Brian Brashaw**. 2010. H.B. Fuller Resin Trial. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/09.

**Brian Brashaw**. 2010. Great Lakes Wood Manufacturing Partnership: Lean Production for Forest Harvesting and Primary Wood Processing. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/10.

**Victor Krause**. 2010. Maple Door Corner Joint Strength Testing – Northern Contours. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/13.

**Victor Krause**. 2010. Surface Performance Testing (Laminate and UV Coatings on Wood) – Northern Contours. Natural Resources Research Institute Technical Report Number NRRI/TR-2010/14.

### ***Outreach***

Arrowhead Electric Cooperative, Grand Marais, Minnesota: Provided technical information on the use of stress wave timing and resistance micro drills to identify decay in utility poles. Stress wave timing and resistance drills were demonstrated and lent to the Cooperative for review in consideration of future purchases.

Cirrus Design, Duluth, Minnesota: Conducted resin flow testing in support of the quality assurance program for incoming materials. Performed shear testing of various products. Conducted sample conditioning in advance of flame spread testing.

Eltomation BV, Netherlands: Matthew Aro, NRRI scientist, assisted Eltomation BV at the International Builders Show in Las Vegas, Nevada in January 2010. Matthew joined Eltomation BV's Export Manager, Peter Lewis, to showcase Eltomation BV's cement-bonded panels and related manufacturing equipment.

Epicurean Cutting Surfaces, Duluth, Minnesota: Facilitated the production of prototype rolling pins from their Richlite substrates by the NRRI Machine Shop. Provided potential Minnesota manufacturing companies for potential contract manufacturing.

Glacierland RC & D, Green Bay, Wisconsin: Moderated a webinar on phytosanitary treatment options and requirements based on ISPM 15.

Hardwood Weekly Review, Charlotte, North Carolina: Provided information on webinar platforms and options for educational webinars aimed at the hardwood industry.

Johnson Controls, Duluth, Minnesota: Provided information and comment on wood pellet production and quality for potential use in heating schools in NE Minnesota.

Northern Contours, Fergus Falls, Minnesota: Conducted KCMA kitchen cabinet assessment testing, and laminate performance testing. Provided technical assistance for a variety of products and manufacturing processes in support of their product families.

PND Engineers, Juneau, Alaska: Provided information on acoustic scanning technology and potential equipment manufacturers for use in structural condition assessment of timber and wood structures.

Qualtim, Inc., Madison, Wisconsin: Provided information on the use and interpretation of stress wave velocities in parallel strand lumber.

Robert F. Bell, Delta, Colorado: Provided information and review of torrefaction technologies for treating wood biomass including insect kill timber in Colorado.

Rockland Flooring, Red Wing, Minnesota: Conducted static bending, and shear strength testing on truck flooring samples.

Rockland Industries, Red Wing, Minnesota: Provided key contacts and publications on topics including carbon sequestration and forest growth and harvest levels in Minnesota and Wisconsin.

Stephenson-Warner, Cloquet, Minnesota: Conducted proof loading of their “Wide Receiver” skid steer attachment product.

Synergy Thermal Foils, Maple Grove, Minnesota: Conducted laminate performance testing on new thermofoil products.

United Technologies Corporation: Assistance was provided to United Technologies Corporation, a major U.S. corporation involved in development of renewable aviation fuels to provide wood from various poplar clones for testing at United Technologies Corporation’s fuels processing laboratories. United Technologies is interested in cooperating with NRRI in the development of proposals to pursue renewable production of wood-based aviation fuel. NRRI staff provided assistance to the Department of Energy staff in a national effort to update the “Billion Ton Study,” the definitive assessment of biomass sources for renewable fuels nationally. Assistance was provided in the form of biomass yield analysis and cash flow models to estimate biomass production costs.

University of Minnesota Duluth, Department of Civil Engineering, Duluth, Minnesota: Matt Aro is working with UMD's Department of Civil Engineering to understand the corrosion properties of a newly-developed mineral-bonded fiber composite panel for the manufacture of fire-rated doors.

Van Technologies, Duluth, Minnesota: Conducted abrasion resistance and coefficient of friction testing for various products.

### ***Facilities***

The NRRI greenhouse and controlled-environment chambers continue to be used to support the CARTD’s Forestry Group’s efforts in breeding of hybrid poplar. This greenhouse facility has been updated to provide for more accurate control of temperature and air flow.

## **Coleraine Minerals Research Lab & Economic Geology Group**

### ***Personnel***

**Blair Benner** was awarded the 2010 Mining Professional of the Year at the 83rd annual meeting of the Minnesota SME.

**Mark Severson** reached a milestone in March 2010 when he completed logging (geologically describing) 1,000,000 feet of drill core (cylinders of rock) from the Duluth Complex. This event, while seemingly unimportant to non-geologists, was actually reported in several newspapers statewide.

**Mark Severson** was a co-leader on a five-day field trip associated with the 11th International Platinum Symposium held in Sudbury, Ontario. The field trip concentrated on copper-nickel-precious metals deposits in the Lake Superior region and included drill core displays from several deposits in Minnesota.

**Matt A. Mlinar** joined the Coleraine Minerals Research Lab staff as a Research Fellow June 30, 2010. In 2007, Matt was part of an intern project (GTI/NRRI hydrogen membrane) at CMRL. Matt's focus at CMRL is on supervising the biomass gasification projects and in renewable energy and power/controls.

### ***Scientific Meetings/Presentations***

**Blair Benner** presented a paper entitled "The Effect of Demagnetizing Cyclone Feed - Plant Tests" at the 83rd annual meeting of the Minnesota SME.

**E. Caner Orhan** participated in the XVI International Coal Preparation Congress (ICPC) held in Lexington, Kentucky, on April 25-29, 2010. ICPC is the world's largest conference related to coal preparation, and this was the first time ICPC was held in the United States since 1966.

### ***Publications***

#### **Coleraine Technical Reports**

NRRI/TR-2010/06) – Confidential Report issued to Barr Engineering – D. J. Englund – March 23, 2010 – 7 pgs.

NRRI/TR-2010/12) – Confidential Report issued to Rio Tinto Minerals – R. F. Kiesel and D. W. Hendrickson – June 10, 2010 – 5 pgs.

#### **Economic Geology Group Technical Reports**

Severson, M.J., Heine, J.J., and Patelke, M.M., 2009, Geologic and Stratigraphic Controls of the Biwabik Iron Formation and the Aggregate Potential of the Mesabi Iron Range, Minnesota: University of Minnesota Duluth, Natural Resources Research Institute, Technical Report NRRI/TR-2009/09, 173 p.+ 37 plates.

#### **Economic Geology Group Posters**

NRRI/POSTER-2010/01

Environmental Study of Airborne Particulates in Population Centers on the Mesabi Iron Range: Progress Report, April 2010, G. Hudak, T. Diedrich, S. Monson Geerts, M. Schreiber, L. Zanko, and A. Schwanke, 2010.

NRRI/POSTER-2010/02

Taconite-Derived Mineral Dust in Population Centers on Mesabi Range—An Update: University of Minnesota, Duluth, Natural Resources Research Institute, G. Hudak, T. Diedrich, S. Monson Geerts, M. Schreiber, L. Zanko, and A. Schwanke, 2010.

NRRI/POSTER-2010/03

Bedrock Geological Map of the Disappointment Lake Area, Lake County, Northeastern Minnesota, L. Mulvey, C. Ross, J. Zeitler, M. Pendleton, A. McCarthy, L. Copp, R. Nowak, G. Hudak, and D. Peterson, 2010.



### ***Facilities additions and modifications***

**DRI reactivity** -- A Direct Reduced Iron (DRI) reactivity apparatus was constructed. This apparatus consists of a reactor which holds a 200 gram charge of DRI, a closed loop gas system, a heated water tank to heat the reactor, a gas circulation pump, and an oxygen meter. The system measures DRI reactivity by measuring oxygen depletion in a closed volume over time as the DRI oxidizes. The procedure has also been accelerated using a salt-water activation of the oxidation process.

**TGA apparatus** --The TGA (Thermogravimetric Analyzer) has been improved over the past six months to reduce ingress leakage and an afterburner has been installed in the exhaust to combust volatiles. Software has been updated to improve collected data quality. Modifications will also be made to allow hydrogen to be used for reduction and sintering studies.

**Center for Water and the Environment**

## Acceleration of Inorganic Nutrient Release and Mineral Organic Matter Association by Biophysical Soil Mixing along an Earthworm Invasion Chronosequence

---

### Objective

Two major life sustaining processes of the terrestrial earth surface are the release of inorganic nutrients through mineral weathering and carbon cycling, which are strongly influenced by soil organisms. We propose that vertical soil mixing by earthworms will have far reaching impacts on the rates of mineral weathering and carbon cycling when viewed against the steep vertical gradients in: 1) the concentrations, compositions and dynamics of minerals and organic matter, and 2) the geochemical environment affecting mineral weathering that define soil types. Our goal is to understand how and to what degree soil perturbation by earthworms affects the rates of chemical weathering and organic matter-mineral association in soils. Although earthworms are widely perceived to have beneficial influences on soil structure and nutrient dynamics, recent research has shown them to have negative impacts on soil structure, nutrient availability and water dynamics in cold-temperate hardwood forests.

### Background

Dr. Hale's research characterized earthworm invasion chronosequences in the Chippewa National Forest that could be used to examine the effects non-native earthworms have on carbon and mineral weathering dynamics in cold-temperate hardwood forests.

### Previous Activity

In 2009 earthworm sampling was conducted using the mustard extraction technique at 30 plots along three transects along an earthworm invasion chronosequence, midden counts were also conducted to estimate populations of deep dwelling species.

Soil sampling was conducted in 6 excavated soil pits with varying degrees of earthworm invasion. Detailed soil morphologic description was made and two sets of samples by horizons were collected for analysis of bulk density, elemental composition, C and N concentrations, stable isotope ratios, mineralogical compositions, and the activities of short-lived isotopes. Another set of samples were collected specifically for <sup>14</sup>C analysis.

At each excavated soil pit, three zero tension lysimeters were installed below the A and E1 horizons and at the depth of 45 cm; five piezometers were installed. The lysimeters and piezometers will be allowed to equilibrate with the surrounding environments until the next snow melt when water sampling will begin.

### Current Activity

#### Principal Investigator(s)

Cindy Hale

#### Project Sponsor(s)

University of Delaware (USDA Prime)

#### Amount Account

16,223 3014-10424-00002871

#### Active

09/01/2008 08/31/2011

#### Total

\$16,223

**Start Date:** 09/01/2008

**End Date:** 08/31/2011

**Project ID:** 1565

---

**Biomass Harvest Effect on Wildlife**

---

**Objective**

Forest fuel reduction near houses and removing residual woody material for biomass energy plants (biomass harvest) seem to be complementary solutions that would help save property, conserve energy, and reduce the risk of large forest fires. A hidden cost to biomass harvest may be a negative effect on species that depend on down and decayed woody material for survival. Acquiring data on mammal and amphibian responses to biomass harvest that will enable planning for appropriate levels of biomass removal is the primary objective of this research.

**Background**

**Previous Activity**

We trapped beaver with Hancock live traps in the fall of 2008 following protocols and methods currently being used in an ongoing study in Voyageurs National Park.

**Current Activity**

No results to report at this time.

**Principal Investigator(s)**

Ronald Moen

**Project Sponsor(s)**

National Fish & Wildlife Foundation

**Amount Account**

10,637 3011-10430-00001053

**Active**

01/15/2009 09/30/2010

**Total**

\$10,637

**Start Date:** 01/15/2009

**End Date:** 09/30/2010

**Project ID:** 1541

---

## Canada Lynx and Snowshoe Hare Habitat Use Interactions

---

### Objective

The objective of this project is to understand the factors affecting the apparent reappearance, current distribution, and long-term persistence of the Canada lynx in Minnesota. This requires a much greater understanding of the biology and ecology of lynx in this geographic region than we currently have. Methods used will include telemetry, snow-tracking, documentation of habitat use, and geographic information system analysis of locations.

### Background

This project will increase understanding of Canada lynx (*Lynx canadensis*) in Minnesota, ranging from demographic information to habitat use data that can be used to make management recommendations for Canada lynx, a species which is listed as threatened under the Endangered Species Act. The only previous study on Canada lynx in the region was conducted by L. David Mech in the 1970s.

### Previous Activity

To date 19 Canada lynx have been captured and fitted with either VHF or GPS collars since March 2003. About 700 VHF locations and almost 3000 GPS collar locations have been obtained from collared animals. Two collared animals have died; one was trapped in Ontario, cause of death of the second animal is unknown. Three den sites were found in June 2004. Kittens were raised by the female through at least December 2004. Kitten survival will be monitored through the winter. The trapping program continues, with attempts to recapture previously collared animals and deploy collars on uncollared animals.

### Current Activity

Thirty Canada lynx have now been live-trapped and radiocollared on the project. Almost 10,000 global positioning system locations of lynx have been collected with GPS radiocollars. Other lynx are wearing standard VHF telemetry collars. Several mortalities have been documented over the past year. The project website at [www.nrri.umn.edu/lynx](http://www.nrri.umn.edu/lynx) provides full details and a current update.

### Principal Investigator(s)

Ronald Moen

### Project Sponsor(s)

	Amount	Account	Active
USDA Forest Service/Superior National Forest	30,000	1636-189-6186-00	09/03/1999 10/13/2000
USDA/Forest Service	117,000	1636-189-6202-00	08/29/2000 09/30/2005
USDI US Geological Survey	56,242	1727-189-6251-00	06/09/2003 12/31/2006
USDI US Geological Survey	285,482	1648-189-6255-00	04/21/2003 12/31/2006
MN DNR	180,165	1662-189-6287-00	06/01/2005 04/30/2008
USDA Forest Service	121,210	1636-189-6252-00	07/16/2003 07/16/2008
NCASI National Council for Air & Stream	49,750	1665-189-6288-00	04/01/2005 06/30/2010
<b>Total</b>	<b>\$839,848</b>		

**Start Date:** 09/03/1999      **End Date:** 06/30/2010      **Project ID:** 740

---

## Development of Sampling Framework/Key Protocols for Monitoring Natural Resources in the Great Lakes Network

---

### Objective

Coordinate development of field sampling protocols among five investigative groups.

### Background

The National Park Service Great Lakes Inventory and Monitoring Network developed a prioritized list of 46 indicators, termed Vital Signs, for monitoring long-term ecosystem health for nine National Park Service units in the Great Lakes region. Great Lakes Inventory and Monitoring Network must submit a draft final monitoring plan, the phase three report, to their national inventory and monitoring office by December 15, 2005. This draft plan must describe how Great Lakes Inventory and Monitoring Network intends to monitor Vital Signs across all nine parks. The plan must also include an overall sampling framework, protocols for high priority Vital Signs, brief summaries for lower priority Vital Signs, and a data management plan. This phase three report will be peer reviewed and approved by the National Park Service national inventory and monitoring team before the network can proceed with monitoring.

This project coordinates the development of protocols for several suites of Vital Signs.

### Previous Activity

The phase three document was submitted to the national review team in December 2005, and was well-received. National Park Service cooperators are revising the document based on review comments.

An extension was granted to the project to develop a manuscript on National Park Service sampling designs for the peer-reviewed literature.

### Current Activity

We have completed a first draft of a manuscript that details the statistical design behind sampling across multiple biological and physical variables (amphibians, toxicants, lake water quality, large river water quality, and several others. This draft is now under internal review.

A project website was created and can be found at [www.nrri.umn.edu/npsprotocol](http://www.nrri.umn.edu/npsprotocol).

### Principal Investigator(s)

George Host  
Richard Axler

Project Sponsor(s)	Amount	Account	Active
USDI National Park Service	25,850	1648-189-6272-00	07/01/2004 07/31/2010
USDI National Park Service	66,849	1648-189-6271-00	07/01/2004 07/31/2010
USDI National Park Service	75,346	1648-189-6270-00	07/01/2004 07/31/2010
<b>Total</b>	<b>\$168,045</b>		

**Start Date:** 07/01/2004      **End Date:** 07/31/2010      **Project ID:** 1345

---

## Exotic Earthworm Invasions: Integrated Research and Education to Achieve Natural Resource Protection

### Objective

We will conduct surveys for earthworms in each of eight state parks in the Coastal Zone (Jay Cooke, Gooseberry Falls, Split Rock, Tettegouche, George Crosby Manitou, Temperance River, Cascade River and Judge Magney). Walk through surveys of each park will provide distributional data on earthworm presence and absence across each park. A minimum of 12 stands in each park will be surveyed to assess the relative abundance and diversity of earthworm populations and the level of impact earthworm invasions are having on forest soils in a range of forest habitat and soil types in relation to human centers of activity in the parks.

Public education and involvement in this project is also a key component. We will present public programs at each park on the issues of exotic earthworms. Citizen volunteers and MN Conservation Corp crews will be trained and assist in the detailed surveys at each park. Educational displays will be created for each state park highlighting the research and its results. All aspects of the research and education activities will be incorporated into the Great Lakes Worm Watch citizen science program.

### Background

Non-native earthworms are altering the fundamental structure and function of previously earthworm-free hardwood forests in North America. These forests developed over thousands of years in the absence of earthworms and historically had thick layers of leaf litter that serve as rooting medium for herbaceous and woody species. Following invasion of a northern forest by earthworms, a cascade of ecological effects occurs. Identification and protection of earthworm-free areas in the Coastal Zone could substantially limit the impacts for generations to come.

### Previous Activity

#### Current Activity

Summer walk-through surveys were completed in nine state parks and two waysides. A total of 1,328 samples points were surveyed for visual indicators of earthworm invasion, wedge prism measurements, canopy composition and upper soil horizon data. Fall quantitative surveys of earthworm populations were completed at 160 of the survey points.

Ryan Hueffmeier, an M.S. student, is taking lead on the analysis to create a 'Rapid Assessment Visual Indicators Tool' for land managers. Zach Bennett began a study in Tettegouche State Park to examine how the March 2009 ice storm, which caused catastrophic canopy damage hardwood forests in the park, may interact with earthworm invasion status to alter the successional trajectories of the understory plant communities in these forests; laying the groundwork for his M.S. thesis.

Educational displays illustrating the research conducted and the results of the study are being developed for public programs at each park.

Nicole Vander Heiden conducted a study using a combination of bait shop surveys, bait disposal containers and bait container labels to assess the effectiveness of educational efforts on anglers earthworm bait disposal practices.

### Principal Investigator(s)

Cindy Hale

Project Sponsor(s)	Amount	Account	Active
MN Lake Superior Coastal Program	46,935	3013-10424-00000337	08/22/2008 12/31/2010
<b>Total</b>	<b>\$46,935</b>		

**Start Date:** 08/22/2008      **End Date:** 12/31/2010      **Project ID:** 1525

## Grand Portage National Monument-Baseline Earthworm Survey

---

### Objective

A study was conducted to assess the presence, absence or relative abundance of invasive earthworms at up to 80 pre-approved sample points in the Grand Portage National Monument. This data will be integrated with the data from the project "Exotic Earthworm Invasions: Integrated Research and Education to Achieve Natural Resource Protection" funded by the Minnesota Coastal Program.

### Background

GIS data and metadata documenting the distribution of exotic earthworms, relative abundance and relative impacts in relation to forest type, soil and/or landforms and distance from human centers of activity in Grand Portage National Monument will be gathered through field surveys. In particular, we will identify areas that are earthworm-free or minimally impacted by earthworms.

### Previous Activity

#### Current Activity

Summer walk-through surveys were conducted in August 2009, including regularly stratified sample points (~every 50 meters) along designated routes. At each point, visual indicators of earthworm presence/absence or relative abundance were collected (i.e. earthworms themselves, burrow entrances, cast material, middens, A horizon and forest floor thickness).

Fall quantitative sampling of earthworms in a randomly selected subset of the pre-approved sample points was conducted in September and October 2009, using Minnesota Conservation Corps crews, trained volunteers, and NRRI field staff. Crews will conduct earthworm sampling (liquid extraction) in a minimum of three randomly located plots within a minimum of 12 stands to provide species list and relative abundance of earthworms.

### Principal Investigator(s)

Cindy Hale

### Project Sponsor(s)

USDI National Park Service

### Amount Account

2,875 3002-10424-00011181

### Active

05/29/2009 08/31/2010

### Total

\$2,875

**Start Date:** 05/29/2009

**End Date:** 08/31/2010

**Project ID:** 1566

---



## Long-term Soil Productivity: Vegetation Sampling - Chippewa National Forest

---

### Objective

A long term experiment to assess long-term effects of soil compaction and organic matter removal on aspen forests of the Great Lakes.

### Background

The Long Term Soil Productivity (LTSP) study is a national effort to document the effects of soil compaction and organic matter removal on forest productivity and biodiversity. As part of the Region 9 LTSP study, ground-flora has been sampled periodically since the installation of treatments in the early 1990s. Treatments are in place on the Chippewa National Forest in Minnesota, and the Ottawa and Huron-Manistee National Forests in Michigan.

### Previous Activity

The Natural Resources Research Institute was responsible for sampling the Chippewa National Forest LTSP plots prior to harvest and compaction in 1992, and again in 1994, 1995, 1998, and 2004. This sampling will provide the cooperators data required to analyze and report on results from this study.

### Current Activity

The year 2009 represents a 15-year interval from the first treatment record, and an important milestone in the project. This sampling will provide the Forest Service information on how the floristic community has changed in response to soil compaction and organic matter removal.

One of the three main replicates of the study was sampled in September 2009, and data entered. The remaining two replicates are being sampled this summer (2010).

### Principal Investigator(s)

George Host

### Project Sponsor(s)

USDA Forest Service

	<b>Amount</b>	<b>Account</b>	<b>Active</b>
	15,631	3002-10424-00012648	07/28/2009 12/31/2010
<b>Total</b>	\$15,631		

**Start Date:** 09/12/1991    **End Date:** 12/31/2010    **Project ID:** 811

---

## Minnesota Breeding Bird Atlas

---

### Objective

To complete a systematic count of breeding birds in all townships in the state of Minnesota as part of the Minnesota Breeding Bird Atlas. The methodology will allow samples to be gathered in the future in a representative and repeatable fashion.

### Background

Minnesota is one of only six states in the United States that does not have a breeding bird atlas. An atlas is important to define the distribution and abundance of breeding species throughout the state. It will be useful for conservation planning and environmental impact assessment.

### Previous Activity

Breeding birds were counted in over 540 townships during the 2009 field season (May-July). This exceeded the number of townships we anticipated sampling and will allow several townships to be re-sampled in 2010 to examine annual variability.

### Current Activity

Data are being double-entered for quality control. Field crews and logistics for sampling in the 2010 field season are being completed.

### Principal Investigator(s)

Gerald Niemi

Project Sponsor(s)	Amount	Account	Active
LCCMR	101,000	3015-10429-00000576	07/01/2008 06/30/2010
LCCMR	161,000	3015-10429-00019124	07/01/2010 06/30/2012
<b>Total</b>	<b>\$262,000</b>		

**Start Date:** 07/01/2008

**End Date:** 06/30/2012

**Project ID:** 1529

---

## Monitoring Birds in Great Lakes National Forests

---

### Objective

To develop strategies to monitor the abundance of forest bird populations.

### Background

Forest bird populations are a key biological indicator of the health and stability of forest ecosystems. Recent evidence suggests that some North American species are declining in abundance, in particular, Neotropical migrants or species that breed in North America and winter in Central or South America. With the increased interest and awareness of the status of Neotropical migrant birds in the United States, several organizations have developed strategies to monitor abundance of these species. We have established monitoring programs in three Great Lakes national forests: Chippewa (1993), Superior (1991), and Chequamegon (1992). Long-term monitoring will give us information on species abundance patterns over time and data will be used to identify species that are significantly increasing or decreasing in abundance.

### Previous Activity

The summer of 2009 marked the 18th year of sampling for the forest bird monitoring project. Over 70 species have been tested for their trends over this period. In general, more species have been increasing compared with those decreasing. Species that have been increasing include permanent residents and many species that nest in shrubs and trees. Species declining have generally been those that nest on the ground such as the Winter Wren, Veery, Hermit Thrush, Ovenbird, Mourning Warbler, and Song Sparrow.

### Current Activity

Trend analysis through 2009 indicated that 16 species increased across all three national forests over the past 19 years, while nine species declined. Increases in populations are still detected in permanent resident species such as Blue Jay, Black-capped Chickadee, and Red-breasted Nuthatch. Ground nesting species continue to be the most prominent species that have declined in population; they represent six of the nine species that are declining. Field crews and preparations are being made for the 2010 field season.

### Principal Investigator(s)

Gerald Niemi

### Project Sponsor(s)

	Amount	Account	Active
USDA Forest Service	198,710	1635-186-6037-00	05/01/1991 12/31/1995
USDA/Nicolet National Forest	30,000	1637-189-6129-00	01/01/1996 12/31/1996
USDA/Nicolet National Forest	49,000	1637-189-6146-00	05/01/1997 04/30/1998
Chequamegon/National Forest	49,000	1637-189-6171-00	05/01/1998 10/31/1999
USDA/Chequamegon/Nicolet National Forest	98,000	1637-189-6187-00	05/01/1999 04/30/2001
USDA/Forest Service	290,554	1637-189-6219-00	05/01/2001 12/31/2005
USDA Forest Service	61,148	1637-189-6294-00	05/19/2006 12/31/2006
USDA Forest Service	66,156	1637-189-6327-00	04/15/2008 12/31/2008
USDA Forest Service	66,156	3002-10429-00011308	05/15/2009 12/31/2009
USDA Forest Service	70,000	3002-10429-00018489	04/01/2010 12/31/2010
<b>Total</b>	<b>\$978,725</b>		

**Start Date:** 05/01/1999

**End Date:** 12/31/2010

**Project ID:** 420

---

## Prevention and Early Detection of Invasive Earthworms

### Objective

The goal is to use a multi-pronged approach to greatly reduce the introduction and spread of invasive earthworms through rigorous quantification of the relative importance of different vectors of introduction for earthworm species (result1), development and testing the effectiveness of management recommendations for resource managers to limit the spread and introduction of earthworms (result 2), and through a comprehensive effort involving research and educational institutions, governmental agencies, non-governmental organizations and citizen science to inform and actively engage diverse stakeholders in efforts to accumulate distributional data on invasive earthworm and their relative impacts across the state/region and to identify earthworm-free and minimally impacted areas worthy of protection (result 4). Results 1, 2 & 4 will provide key information and evidence for the development of regulation recommendations/policies to respond to early detection of incipient invasions of new invasive earthworm species that have begun to appear in adjacent states but are not yet detected or established in the state (result 3). Anticipated results and outcomes include a publication summarizing the in-state and interstate risk assessment of the vectors of invasive earthworms spread; a publication of the results of the testing of the effectiveness of management recommendations; a plan for regulatory response by various governmental agencies for early detection of non-established invasive earthworms in the state; public education and conference presentations of our research and results.

### Background

Result 1: Risk-Assessment of Vectors of Earthworm Introduction: In contrast to the traditional approach of species-based risk assessments, we propose to identify, describe and quantify the potential vectors of in-state spread of established earthworm species and of interstate transport and introduction of non-established earthworm species.

Result 2: Testing Effectiveness of Management Recommendations: Management recommendations will be field tested to determine the cost-benefit and relative effectiveness of different recommendations to actually limit the spread/introduction of different earthworm species. The project partners will collaborate to identify, describe and prioritize a list of management recommendations they want to explicitly test. Sampling methods and protocols will be developed for each and field testing/sampling will be conducted in 2010.

Result 3: Regulatory Responses to Early Detection of Asian Earthworms: In cooperation with governmental agencies, a plan for regulatory responses will be developed to respond to early detection of earthworm species not already established in the state (i.e. Amyntas species) including possible control or eradication measures and monitoring for incipient invasions of new species.

Result 4: Identify Priority Areas for Protection: A comprehensive and coordinated three-year effort involving research and educational institutions, governmental agencies, non-governmental organizations and citizen science will inform and involve diverse stakeholders to identify earthworm-free and minimally invaded areas of the state/region in order to prioritize protection efforts and provide rapid detection and response for new species introductions.

### Previous Activity

#### Current Activity

Progress summary as of December 30, 2009: Result 1 –protocol-based internet searches and KAP studies (knowledge, attitudes & practices) of potential target audiences, and is expected to be finish in spring 2010.

Result 2 - A KAP study has been developed and will be delivered at 5 conferences (Jan-June 2010).

Result 3 - no activity on this,

Results 1&2 need to be largely completed first.

Result 4 - Earthworm species profiles are being developed for all 16 species in the “Earthworms of the Great Lakes” book, development and implementation of protocols for handling earthworm survey data and voucher specimens has been finalized, 2010 workshops are being scheduled, and several hundred new citizen-based data points have been added to our database across the Great lakes region.

### Principal Investigator(s)

Cindy Hale

### Project Sponsor(s)

Legislative Commission on MN Resources

### Amount Account

59,539 3015-10424-00007735

### Active

07/01/2009 06/30/2010

### Total

\$59,539

Start Date: 07/01/2009

End Date: 06/30/2012

Project ID: 1545

## Statewide Ecological Ranking of CRP (Conservation Reserve Program) Lands

---

### Objective

Identify Minnesota lands with high habitat quality that may be taken out of the Conservation Reserve Program (CRP).

### Background

This project will identify and rank the ecological value of CRP and other critical lands throughout Minnesota using soil productivity, landscape, water, wildlife, and other relevant natural resource factors.

### Previous Activity

This is a new project.

### Current Activity

We are acquiring and analyzing soil productivity data in light of the critical habitat information generated through Minnesota's Statewide Conservation and Preservation Plan. Our collaborators have generated a crop productivity index that will determine the probability of land being removed from the CRP program.

By intersecting critical habitat with the above data sets, we can identify individual land parcels that can be targeted for acquisition, conservation easements, or other land preservation policies.

### Principal Investigator(s)

George Host

### Project Sponsor(s)

	<b>Amount</b>	<b>Account</b>	<b>Active</b>
MN Board of Water and Soil Resources	15,000	3005-10422-00009516	03/19/2009 06/30/2011
MN Board of Water and Soil Resources	14,000	3005-10422-00009514	03/19/2009 06/30/2011
<b>Total</b>	<b>\$29,000</b>		

**Start Date:** 03/19/2009

**End Date:** 06/30/2011

**Project ID:** 1569

---

## Survey of Beaver Ecology in Grand Portage National Monument

---

### Objective

Improve knowledge of beaver in Grand Portage National Monument.

### Background

Baseline characteristics of the beaver population in Grand Portage were established in a 1987 study, which was originally intended to be a comprehensive comparison of beaver populations in national parks in and near Lake Superior. We will trap beaver with Hancock live traps in 2008 and 2009. Trail cameras will be deployed on paths used by beaver to move from the pond to trees, which will be cut in fall 2008 and 2009. We will use 0.025 ha circular plots to determine tree species composition around beaver ponds, and interpret a historical series of aerial photos for pond occupancy.

### Previous Activity

We did much of the field work; measuring trees, distance to foraging, and setting out trail cameras. Data collected to date will result in a good update of beaver status on the Boardwalk pond in the Grand Portage National Monument.

### Current Activity

Analysis and writing are currently being done.

### Principal Investigator(s)

Ronald Moen

### Project Sponsor(s)

USDI National Park Service

### Amount Account

18,985 3002-10430-00000804

### Active

06/05/2008 09/30/2010

**Total** \$18,985

**Start Date:** 06/05/2008

**End Date:** 09/30/2010

**Project ID:** 1544

---

## Synoptic Mapping of Native Plant Communities of the Laurentian Mixed Forest

---

### Objective

#### Background

By analyzing similarities between Land Type Associations in the northern forests of Minnesota we will identify a set of plant survey data from beyond the Aitken target area which can be used to augment mapping of Native Plant Communities in the Aitken target area.

#### Previous Activity

Some preliminary data collection has been completed (Land Type Association attributes for clustering). A framework for the rest of the project has been laid out.

#### Current Activity

Land Type Associations (LTAs) are landscape units commonly used in landscape analysis. They are aggregated into sub-sections, sections, and provinces. DNR forest plans are often generated at the sub-section level.

We have applied cluster analysis (data analysis techniques which group things by degree of similarity) to find sets of LTAs with similar attributes (elevation, soils, slope, percent wetland). These clusters should improve Native Plant Community mapping by allowing expensive plant survey data to be pooled among similar LTAs.

#### Principal Investigator(s)

George Host

Terry Brown

#### Project Sponsor(s)

M DNR

Amount	Account	Active
27,894	3005-10424-00006899	11/18/2008 06/15/2010
<b>Total</b>	\$27,894	

**Start Date:** 11/18/2008

**End Date:** 06/15/2010

**Project ID:** 1530

---

## Vegetation Characterization and Conifer Regeneration Strategies for the Grand Portage National Monument

---

### Objective

Identify sites on the Grand Portage National Monument where white pine is most likely to succeed, work with park staff to develop and implement regeneration strategies.

### Background

The major natural resource management goal of the Grand Portage National Monument is to restore the trail corridor to conditions that existed during the fur trade era, or approximately 200 years ago. At this time, white pine (*Pinus strobus*) was a major species in the landscape, growing in concert with red pine or as supercanopy trees in mixed forest conditions. Due to turn of the century logging, the advent of white pine blister rust, and the reduction in the occurrence of natural wildfires, the numbers of white pine are now considerably reduced in the landscape.

This project will identify areas where restoration and enhancement actions are the most likely to succeed. These areas will then receive site specific recommendations for conifer restoration.

### Previous Activity

We spent several weeks in summer 2009 sampling plots in the Grand Portage National Monument. In each plot we recorded overstory and ground flora information, along with coarse woody debris, soil profile information, and counts of white pine seedlings. We also used the rapid worm assessment protocol to check for presence of invasive worm species.

Data were entered in fall 2009 and analyzed over the winter.

### Current Activity

Site-specific prescriptions for white pine restoration or enhancement of white pine regeneration or recruitment were developed. The analyses consists of four interrelated steps: 1) A classification and ordination of the summer 2006 Great Lakes Network vegetation sampling; 2) Spatial modeling to prioritize sites base on existing and newly derived spatial data layers; 3) Field sampling to quantify site-level attributes, including canopy, understory, forest floor, and soil characteristics; and 4) Integration of the above factors to prioritize sites and recommend silvicultural treatments.

The ordination, spatial modeling and field evaluations were integrated to generate a matrix of silvicultural options for restoring white pine on the Grand Portage National Monument. Information from the spatial analysis was used to rank sites based on their need for pine reestablishment, regeneration or recruitment based on landscape factors. Other important factors not present in spatial datasets were used to develop treatment guidelines for various phases of white pine restoration. The map and the matrix can be used together to evaluate the suite of options available, from simple maintenance of existing white pine stock to more complex and costly efforts to restore white pine under existing hardwood canopies.

The final report was submitted to Grand Portage in August 2010.

### Principal Investigator(s)

George Host

### Project Sponsor(s)

USDI National Park Service

### Amount Account

35,646 1648-189-6321-00

### Active

06/01/2007 09/30/2010

### Total

\$35,646

**Start Date:** 06/01/2007

**End Date:** 09/30/2010

**Project ID:** 1480

---



## Assessing the Condition of Great Rivers using Benthic and Planktonic Algal Indicators

---

### Objective

The U.S. Environmental Protection Agency Environmental Monitoring and Assessment Program has embarked on a comprehensive survey of Great Rivers in order to provide tools the states need to better manage and protect these important national resources. This survey will assess the health status of the Missouri, Mississippi, and Ohio Rivers using indicators of water quality, sediments, algae, plants, insects, and fish. The Natural Resources Research Institute's task in this project is to develop indicator tools from the algae, collected from hundreds of sites throughout the Great Rivers system. A variety of algal based tools will be developed for use by environmental managers and agencies.

### Background

The Natural Resources Research Institute is developing indicator tools from algae, collected from hundreds of sites throughout the Great Rivers system. Indicators will be available to track ecological quality using periphytic and phytoplanktonic assemblages. These indicator approaches will support future monitoring and paleoecological programs, and be used to identify and verify reference locations in rivers.

### Previous Activity

We have nearly completed four years of the Great Rivers-algae project.

Four articles from this project have been published or are in review:

- Reavie ED, Jicha TM, Angradi TR, Bolgrien DW, Hill BH. 2009. Algal assemblages for large river monitoring: comparison among biovolume, absolute and relative abundance metrics. *Ecological Indicators*.
- Sgro et al. Development of new rapid-assessment indicators using river algae, and comparing these indicators to approximately 20 indicators currently in use worldwide.
- Kireta et al. Development of a weighted-averaging model to infer environmental quality using periphytic and phytoplanktonic algae from the Great Rivers.
- Kireta et al. Determination of the appropriate data structure for Great Rivers algae indicators. For instance, should we be using relative abundance of species? Biovolumes? Relative biovolumes? Density? Other considerations include comparison of species- and genus-based indicators.

### Current Activity

We have completed the Great Rivers-algae project.

Four articles from this project have been published or are in review:

- Reavie ED, Jicha TM, Angradi TR, Bolgrien DW, Hill BH. 2009. Algal assemblages for large river monitoring: comparison among biovolume, absolute and relative abundance metrics. *Ecological Indicators*.
- Sgro GV, Reavie ED, Kireta AR, Angradi T, Jicha, TM, Bolgrien, DW, Hill BH. 2010. Comparison of diatom-based indices of water quality for mid-continent (USA) Great Rivers. *Environmental Bioindicators*.
- Kireta et al. Development of a weighted-averaging model to infer environmental quality using periphytic and phytoplanktonic algae from the Great Rivers.
- Kireta et al. Determination of the appropriate data structure for Great Rivers diatom indicators. *Journal TBD*.

### Principal Investigator(s)

Euan Reavie

### Project Sponsor(s)

	Amount	Account	Active
Environmental Protection Agency	535,199	1628-189-6289-00	10/01/2005 09/30/2010
<b>Total</b>	<b>\$535,199</b>		

**Start Date:** 10/01/2005      **End Date:** 09/30/2010      **Project ID:** 1397

---

## Data for Discovery and Decision-making: Lake Superior Streams

---

### Objective

This project continues funding for the LakeSuperiorStreams.org project via the NOAA/Minnesota DNR funded Lake Superior Coastal Program. Its goal is to improve environmental literacy and decision-making in regard to regional water resource issues by providing online public access to real-time water quality data and other relevant data and interpretive information.

### Background

LakeSuperiorStreams.org provides an easy access web portal for the public to understand the environmental, public health and regulatory issues related to north shore stream condition and its relationship to the coastal waters of Lake Superior as affected by land use management.

### Previous Activity

Remotely operated flow and water quality sensors generated on-line, animated data sets for stations on the trout streams: Tischer, Chester, Kingsbury, Miller, and Amity, the WLSSD discharge, and a nearshore Lake Superior buoy operated by the UMD Large Lakes Observatory for summer and fall 2009. A prototype web 'mashup' using Google Earth mapping utilities was developed for the lower St. Louis River and St. Louis River estuary and historical water quality data can now be accessed and visualized via our online, interactive data animation tool. Data from other recent (2008-09) north shore stream projects is now accessible in user-friendly formats via the website. The website continued to display information serving the needs of regional communities and agency partners representing the Superior Regional Stormwater Protection Team and to provide water-related information via a bulletin board 'What's New' section. Website activity has remained at a level of ~ 400-500,000 requests per month with peak activity in spring and fall when schools are in session.

### Current Activity

Stream gauging stations were operated through fall, winter, and spring 2008-2009. Data from the MPCA /South St. Louis SWCD Knife River TMDL study for three sites from 2006-2009 were acquired for the period 2004-06 and from WLSSD for historical water quality data from sites along the lower St. Louis River. Data from a new UMD Large Lakes Observatory nearshore buoy was imported and temperature profile and related meteorological data can be viewed in real-time at a 10-minute frequency via our data animation tools. A prototype map-based data viewer was developed for citizen stream and lakes monitoring program data.

### Principal Investigator(s)

Cindy Hagley  
George Host  
Richard Axler

### Project Sponsor(s)

	Amount	Account	Active
MN's Lake Superior Coastal Program	89,862	3013-10423-00000651	08/14/2008 06/30/2010
<b>Total</b>	<b>\$89,862</b>		

**Start Date:** 08/14/2008      **End Date:** 06/30/2010      **Project ID:** 1526

---

## Duluth Residential Stormwater Reduction Demonstration

---

### Objective

Determine whether property-owner-based stormwater reduction practices are effective in reducing peak stormwater runoff in Duluth due to the cold climate, clay soils, and surficial bedrock.

### Background

We propose to demonstrate the effectiveness of residential best management practices (BMPs) at reducing stormwater runoff problems for Lake Superior tributaries. We will install residential BMPs in a subwatershed in an older residential neighborhood and compare the runoff to that of a similar control subwatershed without stormwater BMPs. The neighborhoods identified for the program are located in the Lester-Amity stream system that is on the Minnesota 303(d) list for turbidity. Tributaries receiving the runoff from the targeted neighborhoods/subwatersheds are being severely eroded by high peak flows and deliver highly turbid water to Amity Creek. Water flow, temperature, and turbidity measurements will be taken within storm sewers in both subwatersheds before and after BMP installation, requiring three full field seasons of work. Flow, temperature, and turbidity data from storm sewer flow will be posted and interpreted on the educational Lake Superior Streams website, as will final results. Resident knowledge of runoff issues, solutions, and responsibilities will be evaluated at the beginning and end of the project. Results from this demonstration project should be applicable throughout the Great Lakes.

### Previous Activity

During summer 2009 stormwater BMPs were provided for about 22 properties in the area chosen for treatment. These included planting (and protecting from deer) more than 250 trees and shrubs with wildflowers between to reduce yard space for folks to mow; 5 rain gardens; 22 rain barrels; 6 rock-filled sumps; and aeration on 20 yards. Most of the work was done by the Minnesota Conservation Corps youth and young adult crews, supervised by Center for Water and the Environment scientists, Duluth utilities department, Barr Engineering, and South St. Louis Soil and Water Conservation District personnel. MCC personnel also dug several long trenches, re-dug a stormwater ditch, and installed five ditch checks to improve and clean up stormwater flow.

### Current Activity

Monitoring equipment (flow, temperature, conductivity, and turbidity) was installed in the three neighborhood storm sewer systems again for the ice-free season of 2010. These data will be compared to the pre-installation data from 2008 to determine how much stormwater runoff has been reduced from the treatment street properties.

In addition, two rain garden workshops were taught during summer 2010, with the construction of one additional rain garden for each workshop. There were approximately 15 participants in each workshop and they helped plant the rain gardens.

Rain gardens constructed in 2009 look very good and appear to be functioning well.

### Principal Investigator(s)

Jesse Schomberg  
Richard Axler  
Valerie Brady

Project Sponsor(s)	Amount	Account	Active
City of Duluth (MPCA Prime)	121,482		02/27/2008 06/01/2011
<b>Total</b>	\$121,482		

**Start Date:** 02/27/2008      **End Date:** 06/01/2011      **Project ID:** 1528

---

## Great Lakes Biological Monitoring: Phytoplankton

---

### Objective

The primary objectives of the Great Lakes phytoplankton program are to: 1) collect phytoplankton from the Great Lakes; 2) identify and enumerate phytoplankton, maintaining quality assurance standards; 3) maintain a database of phytoplankton data; 4) interpret phytoplankton data, including evaluation of long-term trends in phytoplankton and food web dynamics; 5) dissemination of data and interpretations through reports, presentations, peer-reviewed journals and on the internet.

### Background

Phytoplankton are known to respond to stressors such as nutrient loading and invasive species. We will take a comprehensive approach to GLNPO's Biological Monitoring program for the Great Lakes using proven sampling and evaluation techniques. New and long-term phytoplankton data will be used to track shifts in the offshore biological community related to natural and anthropogenic influences.

The research will characterize and evaluate phytoplankton communities throughout the Great Lakes. Analyses of these data in concord with long-term sampling data, and other project data (e.g., zooplankton, water quality) will provide interpretations of stressor influences on lake biology. A database of detailed, quality-assured phytoplankton data will be provided for contemporary and future evaluations of Great Lakes condition.

### Previous Activity

All 2007 and 2008 samples have been analyzed and taxonomic databases have been submitted to EPA. Six month-long sampling cruises aboard the R/V Lake Guardian have been completed and we are currently planning for the seventh. Significant efforts have been undertaken to create photographic plates and refine diatom taxonomy using virtual communications among team members and iterative revisions to these plates. We have initiated development of a SOLEC indicator that will use algal monitoring data to track pelagic condition in the lakes. We have also initiated development of an algal flora for the open water assemblages.

### Current Activity

All 2007 through spring 2010 samples have been prepared and 2007 and 2008 data have been submitted to EPA. Seven month-long sampling cruises aboard the R/V Lake Guardian have been completed and we are currently planning for the eighth. We have created a series of photographic plates for algal taxonomy in the Great Lakes, and a detailed database of pelagic Great Lakes algae is under development. We have initiated development of a SOLEC indicator that will use algal monitoring data to track pelagic condition in the lakes.

Several taxonomic workshops and QA/QC sessions were held to ensure taxonomic accuracy for the project.

Sample assessments show that significant changes have occurred in the Great Lakes food web over the last decade. These shifts are being examined for causes and trophic linkages. Three articles from this study are in review.

### Principal Investigator(s)

Euan Reavie

### Project Sponsor(s)

	Amount	Account	Active
Environmental Protection Agency	590,295	1628-189-6315-00	03/01/2007 02/28/2012
<b>Total</b>	<b>\$590,295</b>		

**Start Date:** 03/01/2007      **End Date:** 02/28/2012      **Project ID:** 1487

---

## Minnesota's Water Resources: Impacts of Climate Change - Phase II

---

### Objective

To assess the consequences of past climate trends on aquatic resources we are analyzing hydrologic, water quality, and fish community responses. We propose to expand that study to develop prediction for future climate specific to Minnesota, and then quantify the potential economic impact of climate-induced changes in precipitation and hydrology on the water resource infrastructure, including storm sewers, bridges, water treatment facilities, and shoreline development. Projections of future biotic responses from hydrologic and water quality models will be developed. Lastly, to assist the state's natural resource managers and regulators, we will identify potential hydrologic and aquatic indicators and propose monitoring methods that can be implemented in Minnesota.

### Background

Minnesota's climate has become increasingly warmer, wetter, and variable, resulting in unquantified economic and ecological impacts. More recent changes in precipitation patterns combined with urban expansion and wetland losses have resulted in an increase in the frequency and intensity of flooding in parts of Minnesota with extensive and costly damage to the state's infrastructure and ecosystems. We are examining historic climate records and developing a database of key climatic measures and their variability in a current LCCMR project "Impacts on Minnesota's aquatic resources from climate change."

### Previous Activity

We are in the process of completing compilation of the historic responses to climate, and also identifying subsets of lakes and covariates for these biological response projections. In addition to the down-scaled climate predictions for Minnesota, we have acquired projected 2020 land use data for the seven county metropolitan area.

We have begun to identify data-sets and analytical methods to identify biotic indicators of climate change. We have identified a set of more than 90 data-dense lakes which we will use as our test set to develop indicators. These lakes have the greatest breadth (time-series) and depth (across data types) of records in our accumulated database. A larger subset (up to 500 lakes) will be used for validation, and then projections can be applied state-wide (greater than 4000 lakes).

### Current Activity

Historic responses to climate and covariates for these biological responses are being analyzed. In addition to the down-scaled climate predictions for Minnesota, we have acquired projected 2020 land use data for the seven county metropolitan area. Projected biological responses will be made by extrapolation of historic responses.

### Principal Investigator(s)

Jennifer Olker  
Lucinda Johnson  
Richard Axler

### Project Sponsor(s)

	Amount	Account	Active
MN Legislative Commission on MN Rsrc	78,808	1527-189-6301-00	06/27/2006 06/30/2009
LCCMR	172,860	1527-189-6320-00	07/01/2007 06/30/2010
<b>Total</b>	<b>\$251,668</b>		

**Start Date:** 06/27/2006      **End Date:** 06/30/2010      **Project ID:** 1488

---

## Predicting Impacts of Development on Lake Superior North Shore Streams/GIS Data

---

### Objective

1. To quantify the impacts of development, as estimated by watershed land use and land cover (LULC), on in-stream water quality, habitat, and biota for North Shore Lake Superior watersheds. 2. To quantify the appropriate a) spatial extent, and b) map resolution for detecting LULC impacts on in-stream water quality, habitats, and biota in the Lester and Amity watersheds, a region undergoing moderate urbanization and the focus of a multi-organization collaboration. 3. To determine whether position, connectivity and other spatial attributes of urban and riparian areas influence the predictive power of the LULC data in the Lester-Amity watersheds.

### Background

Natural landscape modification for human use is a major threat to health of Lake Superior's North Shore and the Great Lakes ecosystem as a whole. Tributary streams are increasingly threatened by development as urbanization and rural development place increased pressure on the Lake Superior region's coastal communities. Links between land use and in-stream responses are now well-documented. This study is creating both a moderate resolution land cover classification map from the St Louis River to the Beaver River and a multi-institution historical database covering 28 streams along Lake Superior's North Shore in order to mitigate past challenges and understand the relationships between land use and in-stream responses. Using our higher resolution map we are evaluating how land use spatial position and riparian connectivity affect in-stream responses.

### Previous Activity

We completed a high resolution land use classification from 2007 Landsat TM satellite data for the North Shore of Lake Superior extending from Duluth to Beaver Bay. Multi-institution historical water quality, habitat, and invertebrate data have been summarized for 28 north shore streams. In 2008, water quality, biological, and physical habitat data were collected on nine streams in the Duluth area and added to the historical database. Additional work has been conducted to assess the potential impact of development on ecosystem functions, including stream metabolism (the balance of gross primary production and respiration), nutrient spiraling, and stream temperature. All three of these projects are being conducted as part of master's degree program at the University of Minnesota Duluth.

### Current Activity

The remaining government agency historical data sets are being added to the North Shore database. Empirical models assessing the influence of data resolution and land use assessment methods will follow. Currently we are using GIS distance weighting methods to determine if land use spatial location influences in-stream responses. In short, distance weighting functions give land uses whose flow paths are closer to the stream, greater influence. We are processing the remaining biotic samples which will then be used in conjunction with the existing data to develop predictive models similar to those described above for the water quality data.

### Principal Investigator(s)

Jeremy Erickson  
Lucinda Johnson

### Project Sponsor(s)

MN Sea Grant

### Amount Account

134,644 1001-189-1033-00

### Active

07/01/2007 09/30/2010

**Total** \$134,644

**Start Date:** 07/01/2007

**End Date:** 06/30/2009

**Project ID:** 1522

---

## Research Development Testing and Evaluation Facility for Ballast Treatment in the Great Lakes Region

---

### Objective

The Great Ships Initiative (GSI) is a innovative collaboration whose objective is to end the problem of ship-mediated invasive species in the Great Lakes-St. Lawrence Seaway System, including through independent research and demonstration of environmental technology, financial incentives and consistent basin-wide harbor monitoring.

### Background

The near-term objective of the GSI is to significantly accelerate research, development and implementation of effective ballast treatment systems for ships that visit the Great Lakes from overseas. To that end, the GSI has established research capabilities at three scales—bench, land-based, and shipboard. Each scale is dedicated to addressing specific evaluation objectives, with protocols as consistent with the International Maritime Organization (IMO) and federal requirements as practicable.

NRRI's role in the GSI is to test candidate ballast water systems to ensure they are able to meet the IMO's criteria for mortality of the microorganisms carried in ballast water.

### Previous Activity

Significant development and testing of the land-based testing facility has been completed over the last three years. This past summer we completed testing of the first candidate system, and the final report from that testing has been submitted to the vendor and regulating agencies. Three additional treatment systems are in line for testing in summer 2010.

Substantial efforts have been allocated to determining appropriate methods for assessing whether treatment systems are effectively killing organisms. The first article establishing a new method for assessing phytoplankton mortality in ballast water has been submitted to the Journal of Great Lakes Research (Reavie et al.).

### Current Activity

Last summer we completed testing of the first candidate system, and the final report from that testing has been published (<http://www.nemw.org/GSI/GSI-LB-F-A-1.pdf>). 2010 efforts are in progress, and preliminary testing of a candidate lye (NaOH) treatment system is complete. Two additional treatment systems (developed by Alfa Wall) are in line for testing this summer.

Efforts have been allocated to determining appropriate methods for assessing whether treatment systems are effectively killing organisms. The first article establishing a new method for assessing phytoplankton mortality in ballast water has been published in the Journal of Great Lakes Research (Reavie et al.).

### Principal Investigator(s)

Euan Reavie

Project Sponsor(s)	Amount	Account	Active
University of Wisconsin Superior	30,000	1673-189-6311-00	01/22/2007 12/31/2007
University of Wisconsin Superior	17,497	1673-189-6323-00	12/01/2007 05/31/2008
Northeast Midwest Institute	249,932		06/01/2008 12/31/2010
<b>Total</b>	<b>\$297,429</b>		

**Start Date:** 01/22/2007      **End Date:** 12/31/2010      **Project ID:** 1469

---

## Restoring Impaired Lake Superior Tributaries: Stormwater BMP Evaluation, Education, and Outreach

---

### Objective

Our primary goal is to coordinate with local agency remediation/BMP projects and the existing Chester, Kingsbury, Tischer, Amity and Poplar Creek/River automated water quality monitoring and public education effort carried out by the LakeSuperiorStreams.org project to demonstrate their effectiveness at reducing stormwater runoff problems as indicated by upstream-downstream and before-after water quality and biological monitoring.

### Background

Urban Duluth streams are generally similar to the less developed watersheds of the North Shore with >70% forested, similar geology and hydrology, and in the case of Amity in particular, the potential for increased development pressure. Therefore, Duluth's streams can serve as pilot-watersheds for evaluating restoration, mitigation and planning strategies for use in protecting more pristine, but developing, North Shore streams.

### Previous Activity

1) Graves Road Creek restoration -lower Amity Cr. We have worked with the city of Duluth to develop a project including new culverts, flow rerouting, bank slope reductions, and sediment stabilization. Survey and design elements were outlined by city engineers, with construction and implementation targeted for 2009. This ~400 ft project will replace and extend old concrete culverts on the steepest, critical clay banks sections; to prevent further headcutting; stabilize the clay sloughing on the other creek sections, and engineered rip rap to prevent further scour; address side channel headcutting and erosion on a side creek just above present culvert location. The engineering design is in progress via funding from the Weber Stream Restoration Initiative and an extensive baseline data set of upstream-downstream water quality, habitat and invertebrates has been developed; 2) We are sampling upstream and downstream of a sediment trap installed in Miller Cr. in 2004 behind Miller Hill Mall to evaluate its performance. Sediment depth has also been determined throughout the trap and it will be re-surveyed if we can locate original engineering drawings; 3) Upper Amity Cr bank stabilization. Engineering designs are being developed to stabilize two eroding bluffs with anticipated implementation in 2009. NRRI has sampled for water quality, and benthic invertebrates below the funding to generate a year of intensive baseline water quality, suspended sediment levels and turbidity, and biological monitoring data to assess project results and cost-effectiveness.

### Current Activity

#### Principal Investigator(s)

Dan Breneman  
Richard Axler

#### Project Sponsor(s)

MN Pollution Control Agency

#### Amount Account

103,553 1662-189-9023-00  
Total \$103,553

#### Active

02/01/2007 06/30/2011

**Start Date:** 02/01/2007

**End Date:** 06/30/2011

**Project ID:** 1511

---



## St. Louis River Watershed Streams and Lakes: Water Quality Biological Monitoring

---

### Objective

The overall project goal is to develop complementary (same year) physical, biological and chemical data sets for a range of Minnesota Pollution Control Agency-prioritized streams and lakes in northeast Minnesota and to process and/or compile historical, but modern, water quality and biological data into the overall state database.

### Background

Water quality, biological, and habitat data are critical for identifying status and trends that may reflect short and long-term water resource impairments in response to impacts at local, regional, and global scales such as urbanization, agriculture and forestry practices, invasive species introductions, atmospheric deposition, and climate change. Ideally, since field collections are costly, sampling designs and types of assessment data are best selected by considering multiple benefits and efficiencies. NRRI is assisting the MPCA in assessing the condition of St. Louis River watershed lakes (14) and streams (34) by collecting intensive water quality information and summer habitat, macroinvertebrate (bug) and fish data.

### Previous Activity

This is a new project.

### Current Activity

Fourteen lakes were sampled five times each during the ice-free growing season of May through October (2009) for a suite of core and advanced water quality parameters; 2) 22 MPCA-selected St. Louis River stream sites and 12 additional NRRI stressor gradient selected SLR stream sites were sampled 10 times over the course of the 2009 ice-free season and a suite of field and lab samples were analyzed and submitted to the MPCA; 3) the 34 streams were surveyed once in summer 2009 for macroinvertebrates (bug), fish, and habitat assessment; 4) bug analysis are ongoing. The 12 stressor gradient selected sites were chosen from across a GIS-based anthropogenic stressor gradient delineated from major sub-basin within the St. Louis River watershed from a previous project. This will enable us to directly compare two different assessment processes and sampling protocols across a range of conditions in the watershed.

### Principal Investigator(s)

Dan Breneman  
Lucinda Johnson  
Richard Axler  
Valerie Brady

### Project Sponsor(s)

MN Pollution Control Agency

### Amount Account

302,067 3005-10423-00009742  
Total \$302,067

### Active

05/13/2009 06/30/2011

**Start Date:** 05/13/2009

**End Date:** 06/30/2011

**Project ID:** 1542

---

## Volunteer-Assisted Water Quality/Biological Monitoring of North Shore Superior Streams

---

### Objective

Collect intensive water quality, stream invertebrate (bug), and habitat data to help the Minnesota Pollution Control Agency assess the condition of more than 20 Lake Superior basin trout streams.

### Background

The overall project goal is to develop complementary physical, biological and chemical data sets for a range of agency-prioritized streams to process and/or incorporate historical, but modern, biological data into the overall state database. Major objectives are: 1) Historical water quality and invertebrate data from ~ 30 North Shore stream sites sampled from the late 1990s through 2007 will be screened, further analyzed where necessary, and entered into STORET/EDA. These efforts also included substantial water quality, flow, and habitat data, and sampling of other biota (fish, diatoms). Some data was recently used for the Knife River TMDL, but additional processing is needed for it to become truly useful. Water quality data is also available from the same studies using certified methods/labs and from the LakeSuperiorStreams project (3-4 urban streams at >20/yr), that would also be entered into STORET; 2) Sample 12 Superior basin streams intensively for flow, TSS, turbidity, nutrients and other parameters and establish CSMP sites for 12 sites in 8 priority streams; 3) sample benthic invertebrates at 13 Superior basin stream sites coordinated with 2008/2009 water quality sampling for North Shore and St. Louis River tributaries (Obj 2) or performed independently by MPCA, the Flute Reed River Partnership, or the St Louis River Citizens Action Committee. This proposal is based on discussions with MPCA and Minnesota DNR staff regarding priority basin watersheds and the need for concurrent physical, chemical, biological, and geomorphic stream data over a gradient of stressor indicators.

### Previous Activity

A quality assurance project plan was developed and can be loaded or viewed on the LakeSuperiorStreams.org website. Biological monitoring and stream habitat evaluation field observations were completed in 2008.

### Current Activity

Midge larvae were processed from EPA archived samples and slide mounted in early 2009. Identification of midge larvae to the appropriate taxonomic levels is 100% completed. Remaining macroinvertebrate and stream reach habitat data have been compiled undergoing final quality assurance/quality control for submission to MPCA. All water quality field and lab data for 2008 and 2009 were completed and submitted to STORET/EDA. These data are being re-formatted for user-friendly access via the LakeSuperiorStreams.org website. Historic data from previous University and EPA-Mid Continent Ecology Division in Duluth MN have been compiled and will be submitted in 2010. All North Shore water quality data are also being classified as to their hydrology at time of sampling by examining field notes, nearby flow gauging stations, and weather.

### Principal Investigator(s)

Dan Breneman  
Richard Axler  
Valerie Brady

Project Sponsor(s)	Amount	Account	Active
MN Pollution Control Agency	229,533	1663-189-6325-00	04/07/2008 06/30/2010
<b>Total</b>	<b>\$229,533</b>		

**Start Date:** 04/07/2008      **End Date:** 06/30/2010      **Project ID:** 1519

---

## Weather and Water: Combining Broadcast Meteorology and Stream Data Animations to Protect Superior

---

### Objective

### Background

Coastal communities across the northern Great Lakes are increasingly facing 'tipping points' – points at which trout can no longer live in a stream due to thermal stress, beaches become unswimmable due to fecal coliform violations, or streams require development of TMDL remediation strategies because they have exceeded threshold turbidity levels. Lake Superior is particularly sensitive to increased pressures related to development of primary and secondary homes and the associated problems of stormwater management.

The intent of this proposal is to deliver information on stormwater and other Lake Superior issues through broadcast media. Broadcast meteorologists typically have the broadest and most in-depth science backgrounds of news staff and are also trained to communicate science to the general public. Since weather (rainfall amount and intensity; snowfall; air temperature; wind in regard to lake mixing) is one of the strongest drivers of runoff amount, quality, and seasonal and year-to-year variability, meteorologists have great potential to educate the public about water pollution in the context of their routine forecasts and explanations.

### Previous Activity

We held numerous meetings with Northland's NewsCenter staff, and storyboarded several ideas for upcoming feature stories.

### Current Activity

We recently worked with Northland's NewsCenter meteorologist Jeff Edmundson to produce a two-part story on runoff, focusing on the Amity Creek restoration project. The story aired July 13 and 14, 2010.

A future story on potential impacts of climate change is under development.

### Principal Investigator(s)

George Host  
Richard Axler

### Project Sponsor(s)

MN Sea Grant

### Amount Account

1000-10424-20882-  
\$ 37,000

### Active

04/08/2009 03/31/2011

### Total

**Start Date:** 07/01/2009

**End Date:** 03/31/2011

**Project ID:** 1588

---

## Center for Water and the Environment – Program Notes

### *Personnel*

**Lucinda Johnson** was appointed a one-year term as president of the North American Benthological Society in June. NABS is an international scientific organization with about 1,700 members that promotes better understanding of the biotic communities of lake and stream bottoms and their role in aquatic ecosystems.

**Valerie Brady** was appointed to senior membership status and **Cindy Hale** to member/advising level within the University of Minnesota Duluth's Integrated Biosystems (IBS) Graduate Program.

**Jennifer Olker** received 'honorable mention' for her poster titled, "Atrazine and accelerated pond-drying affect developmental rate and metamorphic size in wood frogs (*Rana sylvatica*)" at the Midwest Society of Environmental Toxicology and Chemistry conference on March 27 in St. Paul, Minnesota.

### *Scientific Meetings/Presentations*

**Euan Reavie** gave an invited talk titled "The Great Ships Initiative: Current efforts in the harbor to evaluate ballast water treatment systems" at the Mid-Continent Ecology Division Technical Seminar Series, at the Duluth EPA lab in March, 2010.

**Patrick Schoff** presented a poster about the Great Lakes Innovative Stewardship through Education Network project at the Science Education for New Civic Engagement and Responsibility Symposium 2010 held in Washington, DC on April 20.

**Richard Axler** gave a presentation to three groups recently on LakeSuperiorStreams.org: Using interactive, on-line animation and graphing tools for visualizing real-time stream data to help improve public understanding of aquatic ecosystems and stormwater issues:

- Water Resources Science Seminar Series, University of Minnesota Twin Cities on April 9,
- 2) Integrated Biosciences Graduate Colloquium, University of Minnesota on April 19,
- 3) Minnesota Sea Grant Advisory Board, April 21.

**Subhash Basak** was the U.S. Chair of the Sixth Indo-U.S. Workshop on Mathematical Chemistry in Kolkata, India, January 8-10, 2010. Basak gave the following presentations at the workshop:

- Addressed the inaugural session of the workshop and discussed the history of the Indo-U.S. Workshop series beginning from its inception in 1998 with the organization of the first event at Visva Bharati University, Santiniketan, West Bengal, India.
- "Mathematical descriptors of molecules and biomolecules: Development and practical applications."
- "Some thoughts on the formulation of Indo-Colombia Mathematical Chemistry project."
- "Strategies of combining chemodescriptors and biodescriptors for predicting bioactivity and toxicity of chemicals."
- "Mathematical Chemistry: A futuristic view," at the valedictory session of the workshop.

In addition, **Basak** also gave an invited lecture entitled "Mathematical chemistry in the protection of human and environmental health" on January 12, 2010, at the Jagadis Bose National Science Talent Search Institute in Kolkata, India.

### *Publications*

**Euan Reavie**, along with four researchers from the National Health and Environmental Effects Research Laboratory of the EPA's Mid-Continent Ecology Division, published the article "Algal assemblages for large river monitoring: Comparison among biovolume, absolute and relative abundance metrics" in *Ecological Indicators*, Vol. 10, pp. 167-177.

Matthew Etterson, **Gerald Niemi**, and Nicholas Danz published a paper titled "Estimating the effects of detection heterogeneity and overdispersion on trends estimated from avian point counts" in *Ecological Applications*, Vol. 19, 2009, pp. 2049-2066.

**Gerald Niemi's** book review of *Wildlife-Habitat Relationships: Concepts and Applications*, 3rd edition, by Michael Morrison, Bruce Marcot, and R. William Mannan (2006, Island Press, Washington, D.C.) was published in *The Auk*, Vol. 127 (1), pp. 239-242.

Kathryn Lenz (University of Minnesota Duluth Department of Mathematics and Statistics), **George Host**, **Kyle Roskoski**, Asko Noormets (Michigan Technological University), and David Karnosky (University of Tartu, Estonia) published an article titled "Analysis of a Farquhar-von Caemmerer-Berry leaf-level photosynthetic rate model for *Populus tremuloides* in the context of modeling and measurement limitations" in *Environmental Pollution*, Vol. 158, 4, pp. 1015-1022.

**Subhash Basak**, **Denise Mills**, Douglas Hawkins (University of Minnesota, Twin Cities) and Apurba Bhattacharjee (Walter Reed Army Institute of Research, Division of Regulated Activities) published the paper, "Quantitative structure-activity relationship studies of anti-malarial compounds from their calculated mathematical descriptors: in the international journal *SAR and QSAR in Environmental Research*, Vol. 21, 2010, pp. 103-125.

### **Outreach**

The Center for Water and the Environment awarded four \$50 awards to participants of the NE Minnesota Regional Science Fair held on Saturday, February 6, 2010 at the University of Minnesota Duluth. There were many well-designed and deserving projects. Award recipients were:

- Timothy Billman, 8th grade, Woodland, "Can global warming affect the survival of freshwater fish?"
- Abby Bosell, 7th grade, Woodland, "Testing for lead in the soil."
- Hannah Peterson, 7th grade, Woodland, "Does grass prevent erosion?"
- Angela Moynan and Marlena Duke, 9th grade, Cloquet High School, "The effect of ibuprofen treated with UV light in clear lake water and tannic stained river water on survival and reproduction."

**Valerie Brady** gave the following talks recently to local community organizations: "The impacts of stormwater runoff on North Shore streams" to the North Shore Rotary Club in Two Harbors in March and "Why rural residents should care about stormwater runoff" to the Duluth Town Board for their annual MS4 Stormwater Meeting in April.

Center for Water and the Environment staff members gave presentations about NRRI and its environmental research to the University of Minnesota's University for Seniors between February and April, 2010. The speakers and presentations were:

- **Lucinda Johnson** and June Kallestad "Tour and overview of the natural Resources Research Institute"
- **Dan Breneman** "The Weber Stream Restoration Initiative"
- **George Host** "Forest for the trees: Current issues in Minnesota's forest ecosystems"
- **Valerie Brady** "Effects of stormwater runoff on Duluth's streams and their critters"
- **Pat Schoff** "The effects of environmental stressors on amphibians"
- **Gerald Niemi** "Are Minnesota breeding birds in decline?"
- **Richard Axler** "Water quality 101: How do Minnesota's lakes and streams 'work'?"

The Center for Water and the Environment hosted the following speakers at Muffin Meetings:

- Barb Elliot, Professor, Family Medicine, Medical School Duluth "Family stories: decision making in advanced dementia"
- John Nieber, Professor, Department of Bioproducts and Biosystems Engineering at the Twin Cities Campus "Contributions of sediment to the Minnesota River from ravines, bluffs and streambanks"
- Mike Kroenke, Coordinator, Sustainable Forests Education Cooperative University of Minnesota's College of Food, Agricultural and Natural Resource Sciences, Cloquet Forestry Center, "Connecting with the UM Sustainable Forests Education Cooperative; new coordinator, new education initiatives"
- Karen Updegraff, Research Scientist, Institute of Atmospheric Sciences, "Proposal preparation"
- Nathan Johnson, Assistant Professor, Water Resources Engineering, Department of Civil Engineering, UMD, "Biological contaminant transformations in aquatic sediment"

- Steve Diamond, Environmental Protection Agency, Mid-Continent Ecology Division, “The environmental implications of nanotechnology“
- William Herb, Research Associate, St. Anthony Falls Laboratory, University of Minnesota, “Stream temperature and flow modeling of Miller Creek

## **NRRI Business Development**

NRRI continues to work with the Office of Technology Commercialization to evolve and develop and/or adapt existing policies and procedures relating to intellectual property. NRRI's intellectual property portfolio is quite large with multiple inventors and stages of development for each disclosure that has been filed. The new model of working through NRRI's Business Group as a liaison to NRRI inventors and management has helped to focus priorities as well as serve as a contact for OTC when it needs input for US Patent & Technology Office (USPTO) office actions. An informal procedure is being drafted to serve as a communication tool for NRRI staff in how to handle intellectual property disclosures. Several members of the OTC staff traveled to Duluth/Coleraine in the spring of 2010 to meet with staff and discuss on-going projects.

### **Intellectual Property Portfolio**

- Biodiesel Technology –This technology has a non provisional patent application and received a first office action to which OTC responded. The PI is Pavel Krasutsky. The base foundation for this technology is that an ethanol plant can improve its economics by extracting additional oil from the Dry Distillers Grain and Solubles (DDGS), thus creating High Protein DDGS and additional byproducts.

A concentrated effort of time was spent in first semester of 2010 exploring different avenues for funding the next stages of development for this technology. NRRI was successful in being awarded \$250,000 from IREE with commitment from IREE to assist NRRI with securing another \$500,000. Collaborative funding meetings have been held with several potential sources. A modified budget has been developed for the IREE funding to move forward with Year 1 of the development work, which is scheduled to begin in Fall 2010. Scopes of work are being developed for a project manager as well as bench scale and industrial pilot scale work with Crown Iron Works. Material Transfer Agreements have also been put in place with two additional companies with interest in different aspects of the technology.

Systemic Plant Conditioning Composition (SPCC) –An Exclusive License Agreement was executed on November 23, 2009 with a small business. The Licensee filed for EPA registration in the spring/summer of 2010 and anticipates going to market in August of 2010. This particular technology has a non provisional patent application filed and is awaiting office action. The technology addresses plant protection through a systemic level approach. Active ingredients are assimilated into tissue and dispersed through the plant. It may have applications for pesticides, insecticides, and fungicides for non-agricultural plants. The principle investigator is Tomas Levar, who has worked with collaborators from the private industry for several years.

- Road Patch –An additional Research Collaboration Agreement was needed with the licensee of this technology in order to optimize the recipe of this technology. This Agreement wasn't finalized until November, 2009, which has slowed down the commercialization aspect of the technology. The company has an existing distribution channel in an eleven state region. The primary principle investigator is Don Fosnacht, but there are several other inventors from NRRI that have contributed to the technology as well. NRRI continues to refine the formulation of the road patch to create the optimum composition for what is called a "cold patch". Research and demonstration projects are anticipated for fall 2010.
- Fines Removal System – NRRI has been working to resolve the wear issues on the chevrons for this technology. After much testing at NRRI's Coleraine Minerals Laboratory, a new chevron material and design has been agreed upon. The potential licensee that NRRI has been working with has manufactured new chevrons for the working prototype and a solution for handling the extra weight of the new chevrons has been identified. A pilot scale test is scheduled for Fall 2010 at the Northshore Mine. This technology had a patent issued on March 25, 2008. The inventors for this technology are David Hendrickson, Richard Kiesel, and Rodney Bleifuss.
- Chemical Derivatives Laboratory – NRRI continues to work with the OTC to sort through birch bark related technologies that it can continue to work with to advance its research. Part of the Nature North intellectual property portfolio (LLC ownership included Minnesota Power, Potlatch Corporation and UMN) was sold to Myriad. Of particular interest is a provisional patent that was filed and captured technologies that were



owned by NRRI and thus should not have been included in the sale. The goal is to drop this provisional patent so that NRRI can continue its program and does not conflict with the intention of the UMN license.

### **NRRI Product Development Fund**

The Knight Foundation and Blandin Foundation granted NRRI a total of \$350,000 for product development initiatives. NRRI applied for the Blandin Foundation and Knight Foundation grant to be able to support the economic development efforts of entrepreneurs and/or small businesses in creating or retaining jobs with product development. NRRI has built an infrastructure over the last 25+ years which can support applied research efforts; however, NRRI is only able to provide a limited amount of technical support without payment for services. NRRI anticipated that entrepreneurs and/or small businesses would be willing to match any contributions from the Product Development Fund with cash and/or in-kind services and materials. A key outcome of the grant is to work with up to 30 businesses that will fully understand their proposed product's market which gives them the ability to evaluate and make a "go/no go" decision based on the on whether the economics of the product support a commercialization effort.

NRRI is on task with the major activities identified in the proposal. At 36 months into the grant period, direct results include private investment by the businesses who have received assistance, new products developed, jobs created and manufacturing efficiencies which have increased sales, payroll, and net profit for our clients, even during the economic downturn of late 2008 and 2009. The Product Development Fund has ten completed projects, two projects in progress and one closed project prior to completion due to scheduling conflicts with the client.

In addition to the investment by Blandin and Knight, each project required a cash and in-kind match. For the \$241,116 awarded through the Product Development Fund, \$777,345 private sector investment has been committed, plus \$56,101 in-kind from UMD Natural Resources Research Institute.

For 2010, there is a balance of \$108,884 for additional projects. NRRI received an extension from Knight Foundation (11/30/2010) and Blandin Foundation (4/1/2011) to develop the five additional projects that are in the application process. These projects account for an additional \$85,000 being reserved, with a balance of \$23,884 available for one or two more projects.

### **Small Business Innovation Research Program**

The NRRI Business Group has initiated research into understanding the art and science involved with participating in the Small Business Innovation Research (SBIR) program. The SBIR program was created through the Small Business Innovation Development in 1982. The program was developed because the nation's small, high-tech, innovative businesses are recognized as being a significant part of the federal government's research and development efforts. Eleven federal agencies participate in the SBIR program by setting aside a portion of their research and development budgets for SBIR contracts with small businesses. In 2010, the estimated budget is \$2.4 billion. The SBIR program has four principal objectives:

1. To stimulate technological innovation by small business;
2. To increase small business participation in meeting federal Research and Development needs;
3. To increase the commercialization of technology developed through federal R&D;
4. To enhance outreach efforts to ensure that all qualified small businesses are aware the SBIR program and the many benefits it provides.

The SBIR program is a competitive process. Each year, the 11 agencies identify various research and development topics for pursuit by small businesses under the SBIR/STTR program. The topics are then released in a pre-solicitation, allowing small business to discuss topics with experts. The second release is the final solicitation. Contract winners are chosen on competitive merit by an agency's technical and scientific experts ([www.sbir.gov](http://www.sbir.gov)). There are the three phases of the SBIR/STTR Program – each agency has slightly different parameters but in general, the following is true:

- Phase I is a feasibility study to evaluate the scientific and technical merit of an idea and up to \$150,000.
- Phase II is to expand on the results of and further pursue the development of Phase I. Phase II awards are for periods of up to two (2) years in amounts up to \$1 million.

- Phase III is for the commercialization of the results of Phase II and requires the use of private sector or non-SBIR federal funding. Receiving Phase II funding is now more dependent on demonstrating a commercialization plan which will result in Phase III or what's considered a "use-condition" of the technology.

NRRI would like to learn what Minnesota and the NE Minnesota Region can do to help the small business community attract program dollars to advance innovation and thus job creation. NRRI has been successful in helping some of its small business clients write SBIR proposals who have received funding. Further, two Minnesota small business clients participated in the annual SBIR meeting held in Hartford, Connecticut in April, 2010 with NRRI representatives. These companies are exploring possibilities to apply for SBIR as a funding mechanism to contract with NRRI for the applied research services that they need to advance technologies to commercialization.

#### *UMD CENTER FOR ECONOMIC DEVELOPMENT*

##### **Small Business Development Assistance**

The NRRI supports the UMD Center for Economic Development (CED) for small business development assistance to those businesses focusing on the commercialization or conservation of natural resources. The assistance is related to business planning, financial planning, financing plans, marketing plans, ecommerce, etc, which complements the research and development activities at NRRI. During the first half of 2010, 17 businesses with a base in natural resources or energy conservation were provided one-on-one consulting,. Of those, 7 deal with alternative energy production, particularly in the use of biomass or wood pellet production. Two of the businesses are involved with the commercialization and use of by-product stone from the regional mining operations, and one of the businesses was recognized as a recipient of a Labo award at the 18<sup>th</sup> annual Joel Labovitz Entrepreneurial Success Awards in April, 2010.

Between January and June 2010, CED continued to assist businesses that would be considered "green," with the total in the first half of 2010 totaling 34. The industries included alternative energy using solar, wind or alternative fuels, energy saving initiatives, environmentally sustainable products and geo-thermal processes. Some of the current businesses involve the development of bio-fuels, financing and marketing assistance for a sprinkler system that has been successfully used in the preservation of buildings during wild-fires, a plasma gasification project, the bottling of natural, pure water in bottles made of corn, a bio-butanol project, and a researcher who is developing a carbon sequestration process.

One of the NRRI Product Development Fund recipients is also participating in the CED Business Incubator Program and has been working on numerous business and financial projections with CED staff members in order to obtain additional financing which became reality during the last half of 2009. This business was also selected as a semi-finalist in the MN Cup competition and received assistance through CED. With the new investors and financing, this business will be continuing to explore market opportunities, including product licensing agreements in 2010.

CED continues to assist several of the regional businesses that are part of the aviation sector with business planning, marketing and financial support.

Additionally, CED assisted four student teams that participated in the student 2010 MN Cup competition in completing the commercialization model for the team projects. All four team are in the engineering program at Mesabi Community and Technical College.

CED continues to work with one of the regional communities on a solution to a biomass project, and its partnership with the Minnesota Logger Education Program.

## **NRRI Public Relations**

## PUBLIC RELATIONS ACTIVITIES

### Media Progress/Results

NRRI media coverage for the first half of 2010 (January – June) amounted to an official commercial advertising equivalent of \$330,538.79, up substantially from the last half of 2009 by \$228,586.55. In this first half of the year, NRRI was represented in 85 newspaper stories, 56 web stories, and 7 different commercial television news stories. Locally during those six months, the Duluth News Tribune printed 27 stories related to NRRI, which are simultaneously posted on their website (web audience = 74,943). Rural and small town newspapers ran a total of 54 stories related to NRRI, many appearing on their websites. In the Twin Cities, NRRI was part of 6 stories in the Star Tribune and Pioneer Press. NRRI research was also the focus of two magazine articles: *Lake Superior Magazine*, “Freshwater Research on the Great Lakes” and *Farm Journal*, “The dirt on worms.”

New Media: The electronic version of the NRRI Now newsletter (first issue January 2010) is growing slowly, but steadily. It is emailed to subscribers every two months. We’ve had about 50 recipients sign up on their own, and have also had a handful of subscription requests. We now have 243 contacts with a successful “open” percentage of 50 percent. Staff are being encouraged to send this communication tool to colleagues.

The NRRI website receives an average of 10,000 successful page requests per day (up from 7,000 reported in the first half of 2009). The Economic Geology Group is the most active area on our website generating more than half of the activity (54.82%). The Great Lakes Worm Watch (6.17%), Canada lynx (6.04%) and Moose (5.15%) sites are next top active areas.

### Visibility/Other PR Projects

Public Relations staff gave tours to a total of 22 people in the first half of 2010.

Other Public Relations efforts to promote NRRI research and programs included:

- Updated and staffed display at Duluth Days at the State Capitol, March 3.
- PR staff gave a NRRI overview talk to the Altrusta professional organization on March 24.
- PR staff coordinated a talk by CWE Director Lucinda Johnson to the Hermantown Chamber of Commerce on March 26.
- PR staff wrote and directed a short YouTube video about NRRI, working with a UMD student videographer.
- PR staff developed a display for Lake Superior College’s Earth Day festivities.
- PR staff coordinated a tour and visit with researchers for Lois Quam Entenza, wife of gubernatorial candidate Matt Entenza.
- PR staff gave a one hour NRRI overview talk to senior citizens visiting UMD on June 23.
- PR staff attended a Duluth Sister Cities luncheon on June 29 with business/city delegates from Sweden.