Our research goes to work.
# Table of Contents NRRI Semi Annual Report January - June 2012

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Project Highlights
Wood Products and Forestry
NRRI Forest Product’s Program Director, Brian Brashaw, Co-Chaired First Annual Heating the Midwest Conference
In support of creating new and expanded markets for woody biomass, NRRI Forest Products Program Director, Brian Brashaw, co-chaired the first annual Heating the Midwest (HTM) with Renewable Biomass Conference and Expo held in Eau Claire, Wisconsin during April 25-27, 2012. This event was attended by over 175 people and over 25 equipment and energy vendors, it created excellent momentum for expanding biomass use for highly efficient thermal applications. The conference highlights were published in Biomass Power & Thermal, a leading trade journal. Brian Brashaw was also asked to continue serving as chair for the HTM Steering Committee for 2012/13.

NRRI to Initiate Two Important Research Projects on Timber Bridge Inspection & Repair
In cooperation with Iowa State University, USDA Forest Products Laboratory, and HDR Engineering, NRRI will be initiating two important research projects on timber bridge inspection and repair sponsored by the Minnesota Local Road Research Board and the Minnesota Department of Transportation. Minnesota has over 2,500 timber bridges that play an important role in rural transportation and economic development. NRRI is the lead Principal Investigator on the project, “Advanced Inspection Techniques for Minnesota’s Timber Bridges” and the leading subaward for the Iowa State University project “Cost-Effective Repair Techniques for Timber Bridges.” The joint agency and in-kind funding for these projects is over $600,000.

Forest Products Program Purchases Thermal Modification Pilot Plant for Opportunity to Lead in North America
The Forest Products Program has purchased a new thermal modification pilot plant/ laboratory to be installed at NRRI this fall. This new research tool will provide an opportunity to lead the development of this eco-friendly wood modification process in North America.

Positioning NRRI for Leadership Role in Developing International Fenestration Trade Show in Minnesota
In March 2012, Forest Products Program Director Patrick Donahue accompanied a regional wood product industry client to Nuremburg, Germany to attend the world’s leading trade show for the window and door industry -- Fensterbau. This event spurred many new business development and technology transfer opportunities. An especially positive outcome was connecting with the Fensterbau show management who Donahue is working with to establish a similar event to be held in the Twin Cities in the spring 2015.

The Partnerships for Innovation Grant Proposal on Thermal Modification Research for Engineered Wood Materials Receives Strong Support
Matthew Aro submitted a National Science Foundation grant proposal for a “Partnerships for Innovation” (PFI) grant. The proposal, “PFI: Thermal Modification Research for Engineered Wood Materials,” received strong support from the USDA Forest Products Laboratory and APA – The Engineered Wood Association. Other project partners include both regional small businesses and a large multi-national wood products business. This proposal was accepted for National Science Foundation funding for a two-year period.

NRRI Forest Products Program Creates Advisory Group to Lead the Commercial Development of Wood-Frame Housing Systems Developments
The NRRI Forest Products Program has seen tremendous and renewed interest in its work in the development of ready-to-assemble housing technology. Its technology demonstration video (on YouTube) has over 125,000 views. In an effort to move the technology into commercial development,
Program Director, Patrick Donahue established a small but very active advisory group that includes seasoned professionals with expertise in business start-ups and automated housing technology. The group has been positioning the technology to capitalize on new opportunities for (1) establishment of business(es) focused on providing the technology, and (2) for implementation of a prefabricated housing factory.

**NRRI’s Poplar Genetics Program has Breeding Activities Producing More than 10,000 New Genotypes**
The NRRI’s Poplar Genetics Program has had one of its most successful seasons with breeding activities producing more than 10,000 new genotypes. This material will serve as the foundation for the field testing program.

**NRRI Scientist Invited Speaker at SunGrant Conference – New Orleans**
Bill Berguson has been invited to present the results of the SunGrant Regional Feedstock Partnership Poplar Team’s activities at a national conference entitled “Science for Biomass Feedstock Production and Utilization” to be held in New Orleans in October. Bill Berguson and Bernie McMahon are co-authors on a paper to be published as part of the proceedings of this conference describing the results of a collaborative national poplar breeding and field testing program. This work is sponsored by the U.S. Department of Energy through the national SunGrant Program.

**Peat Industrial Products**
**Peat-Based Media For Waste Water Treatment**
Igor V. Kolomitsyn is leading an NRRI Industrial team to develop environmentally beneficial peat-based products that can replace chemical treatments for agricultural and remediation purposes. The team has focused on development of an environmentally friendly chemical procedure for producing a peat granular product - APTsorb III. New funding has been secured to further develop the technology that will lead to manufacture of peat-based products for purification of waste water.

**Energy**
**EDA Rare Earth Elements**
The work on the Rare Earth Element project started with compilation and review of publications of the Minnesota Geological Survey and the Minnesota Department of Natural Resources, Division of Lands and Minerals reports for the geochemical and/or mineralogical occurrences of rare earth elements. The rare earth minerals monazite and xenotime were both identified. This research continues. Two newly graduated geologists, Ms. Sara Chlebecek (UMD Geology Dept.) and Ms. Sara Post (Colorado School of Mines) were hired to assist with field collection of samples and to process samples for polished thin sections and geochemistry. Mark Severson, John Heine, and Steven Monson Geerts are also collected samples.

**Geothermal Energy**
The geothermal energy project, supported by the Office of Energy Security (Dept. of Commerce) completed the final report and new heat flow map of Minnesota. This new heat flow map illustrates that Minnesota “down under” is not as cold as the previous heat flow map illustrated. Areas in Otter Tail and Wilkin counties, and in Pipestone, Murray, Rock, and Nobles counties, show increased heat flow at a shallower depth of 6.5-7 km versus previous estimates of 10 kilometers, which makes these areas prospects for geothermal energy production. Using additional resources from the Association of American State Geologist and Department of Energy, additional granitic samples are being collected and processed for determination of radionuclides and thermal conductivity at the University of North Dakota-Grand Forks. These additional sample points will be integrated into the new revision of a heat flow map of Minnesota by Dr. William Gosnold.
Advancement in Dry and Wet Torrefaction Processing at CMRL
CMRL has completed dry torrefaction research work evaluating the production of bio-coal from our woody biomass resources in northeastern Minnesota. A calcining kiln was converted to a dry torrefaction processing unit to accomplish the research at CMRL. Bio-coal products were successfully produced having various levels of organic carbon content as a result of being processed at various time and temperature combinations. Biomass torrefaction research has now been extended to evaluate wet torrefaction processing of woody and agricultural biomass feed stocks. Bio-coal products were also successfully produced using this wet torrefaction methodology.

Environmental Chemical
Aqueous Sulfate Reduction Project for MN Taconite Operations
NRRI/CMRL is partnering with Clearwater Layline LLC to develop new sulfate reducing bioreactor modular technology to accomplish sulfide reduction levels being specified by State environmental regulators for taconite tailings basin waters and basin discharges. The project goal is to produce an aqueous sulfate reduction of greater than 95%, with relatively low cost modular technology produced with recycled materials.

Minerals
Severson continues to log drill core (>50% time) for Teck American in Babbitt.

Severson and Heine also completed a report regarding the geochemical results for the Sixmile Lake Area (funded by Mn/DOT). (See Addendum to NRRI report NRRI/TR-2012/20.)

New Millennium Iron Project Concentrator Flowsheet Test Work
A bulk sample of 50 tons of crude iron ore from the New Millennium Iron’s future iron operation in Labrador, Canada, is being upgraded using a number of concentrator flowsheet designs to evaluate the optimum mineral processing equipment configuration. A KHD High Pressure Grinding Rolls (HPGR) unit is being tested as part of the initial crushing and grinding configuration. The flowsheet designs are being evaluated in continuous flow pilot scale operations at CMRL. Mineral characterization of the magnetite ore was also conducted.

American Institute of Steel Industries (AISI) Project Update
The Coleraine Minerals Research Laboratory conducted a study for AISI to evaluate and assess the quality of Direct Reduced Iron (DRI) pellets achieved from deep bed roasting of green agglomerates in a specifically designed furnace. A series of tests was conducted to understand the heat transfer and kinetic characteristics for metallization in a deep bed for potential scale-up. The objectives of these tests were to produce DRI pellets with characteristics more closely related to the proposed commercial furnace and to evaluate pellet volume and quality as it transitions the bed.

Minnesota Taconite Operations
CMRL continues to assist the Minnesota taconite operations with process airflow surveys. Assistance is provided to work with Mr. Marty Hanninen of Metcom Consulting to conduct the surveys. Goals of the surveys are to measure all inlet and out process airflows to optimize specified furnace parameters or overall induration furnace performance. CMRL also continues to assist Minnesota taconite operations with improvements in their concentrator flowsheet designs and equipment upgrades.

CMRL Provides Mineral Processing and Pyrometallurgical Research Assistance to New Mining Operations on the Mesabi Iron Range
CMRL is providing mineral processing and pyrometallurgical research assistance to new mining operations in northeastern Minnesota, including Essar Minnesota and Magnetation.
Dust Reduction Work for DRI Operations
As a result of CMRL’s dust reduction research work, Nucor Steel is installing equipment in their new HYL direct reduction facilities being built in New Orleans, to apply dust suppressants recommended by CMRL. Significant DRI dust reduction has been measured at electric arc furnace facilities as a result of the application of the dust suppressant product developed at CMRL. A patent has been applied for covering the type of chemistry and spray system design for use of this dust suppressant.

Upgrading MN Mesabi Iron Range Lean Ore Stockpiles
NRRI and CMRL have been interested in finding uses for our MN Mesabi Iron Range lean ore stockpiles for a number of years and are now pursuing a variety of iron ore upgrading techniques to add value to these iron ore resources. CMRL has hired a MN-based sonic drilling company to drill several of these lean ore stockpiles to obtain representative samples of the inside of these 5–10 million ton piles. Tests are ongoing to produce a variety of value-added products at the lowest cost.

Mining Cluster Grant Projects
The Department of Commerce’s Economic Development Administration has granted $800,000 in research funding to support a number of mining research projects focused on developing value-added products from our valuable mineral resources in northeastern Minnesota. The grant specifically provides research funding for taconite by-product aggregate usage, rare earth element potential, titanium dioxide hydrometallurgical development, non-ferrous hydrometallurgical development, and lean iron ore recovery from Mesabi Iron Range stockpiles.

NRRI Pellet Fines Reduction System Upgrade
CMRL has refined the design of its Pellet Fines Reduction System (FRS) to include abrasion-resistant AR400 steel chevron lifters fastened across the entire width of the conveyor belt technology, as well as specialized urethane-coated conveyor belt carrying wheels supporting the return belt under the machine. In addition, a cylindrical fines chute was fabricated out of Linatex rubber to contain fines coming off the top of the Fines Removal System and to deposit them near the base of the unit. Finally, a small conveyor belt is being positioned under the larger FRS belt to carry away fines coming off the returning belt. The newly modified system will be tested at a northeastern Minnesota taconite operation during the fall of 2012.

Peat
Significant progress continues to be made on the wetland banking project at the Fens Research Facility (Fens) during the first half of 2012. Management of the Fens for peatland restoration (wetland banking, wetland mitigation) continues to meet objectives given in the governing document (Bank Plan) for the wetland banks. The Minnesota Board of Water and Soil Resources (BWSR) approved an additional ten acres of restored wetland, triggering a $150,000 contractual payment (joint powers agreement) by BWSR to NRRI. The Iron Range Resources and Rehabilitation Board (IRRRB) has revenue sharing rights to portions of the Fens. Consequently, for the payment, revenue sharing calculations were made that itemize “after cost” distribution of revenues between IRRRB and the University of Minnesota (UM). After lengthy negotiation, the University of Minnesota and the U.S. Army Corps of Engineers (Corps) agreed to a mitigation banking instrument (MBI) which brings to a close the active wetland banking activities at Wetland Bank I at the Fens. A similar document is expected to be signed during the fall of 2012 for Wetland Banks II and III.
Great Lakes Coastal Wetland Monitoring
Our objective is to assess the biotic condition of all the major coastal wetlands of the Great Lakes, United States, and Canadian shorelines.

Building on the indicators developed for U.S. EPA by the Great Lakes Coastal Wetland Consortium and the Great Lakes Environmental Indicators grants, the current project is assessing the baseline biotic condition of all major coastal wetland complexes along the coasts of the Laurentian Great Lakes. Biotic communities to be assessed include birds, frogs, fish, aquatic invertebrates, and aquatic macrophytes, along with supporting water quality and habitat. During this five-year project, coastal wetlands around the Great Lakes are being sampled and assessed by crews based in Duluth, Green Bay, Michigan/Indiana, New York, Windsor, and eastern Ontario.

The NRRI GIS lab created a site-selection system that is being used by all collaborators across the Great Lakes to virtually review and select sites appropriate for sampling in each year. There were 1039 sites selected for the five years, with approximately 208 sites selected for the first year of sampling.

In the first year of sampling, 2011, NRRI fish/bug/veg crews visited approximately 35 sites, sampling 23, while bird/amphibian crews tried to access around 50 sites and were able to sample 37. Progress was reported at a Great Lakes coastal wetlands meeting in Traverse City, Michigan, in August 2011 and at the 2011 State of the Lakes Ecosystem Conference in Ohio in November. Lead researchers are starting to delve into the data collected last summer to calculate indicators of wetland condition, verify that these indicators work across all the types of wetlands encountered across the Great Lakes, and 'tweak' indicators that need to be adjusted so that they accurately indicate wetland condition.

Crews spent this winter entering and quality checking data, and identifying aquatic macroinvertebrates. The database system that supports the entire project and holds and serves all of the data was built by NRRI GIS laboratory staff. Presently, crews are starting to gear up for the 2012 field season. This includes using Google Earth to investigate sites and to find safe access points, rounding up field gear, and will soon include selecting field crews.

Stressor Gradients and Spatial Narratives of the St. Louis River Estuary
The St. Louis River estuary, the mouth of the largest contributing United States watershed to Lake Superior, is simultaneously an EPA area of concern and a National Estuarine Research Reserve. The estuary is a complex mosaic of high quality aquatic and riparian habitat intermingled with areas of heavy industrial use and effluents from an urban landscape. Communities surrounding the estuary are actively developing land use plans that will determine their future environmental and socioeconomic health, and it is important that decision makers have access to data, tools and technologies that provide for socially and ecologically sound decisions. This project used geospatial analyses to derive a watershed-based human stressor gradient, incorporating factors such as population and road density, point source density, and land use. The resulting stressor gradient was used as a basis for sampling water quality, and plant and macroinvertebrate communities, with the intent of quantifying relationships between land-based stressors and aquatic ecosystem indicators.

The stressor gradient also served to structure a series of ‘spatial narratives’ – human stories of the estuary developed through interviews and research. The narratives target key issues of the estuary, such as shipping, fishing, and restoration. The interviews and science materials are interwoven to create web-based vignettes that illustrate the complexity and multiple perspectives within large-scale social, economic, and ecological systems. To help present these stories, the narratives also incorporate augmented reality games – mobile-phone based ‘geo-quests’ that use the device’s GPS capabilities to
trigger audio or video at key locations. Further communication and education tools include land and ship-based geo-tours of the estuary, science-based geocaches, and an open geospatial data archive. Results of this study are intended to help citizens and decision makers understand and help prioritize monitoring, restoration, and remediation activities, and enhance public awareness and understanding of this unique environment. The science and stories of the estuary are available at www.stlouisriverestuary.org.
Center for Research and Applied Technology Development
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
Data on all Red Pine thinning experiments has been collected and summarized. At this time, Red Pine experiments show little difference among treatments in total stand volume growth post-thinning. While results are preliminary, if trends continue, these experiments point to significant flexibility in Red Pine with respect to thinning treatment providing greater flexibility to landowners in stand management. The MFPRC poplar research continues with the evaluation of parent populations of P. deltoides for use in the breeding program. Older flowering collections of pure-species parental stock were sexed and the degree of flowering evaluated. Arrangements have been made with project cooperators from the Pacific Northwest and South for procurement of flowering materials to supplement the NRRI breeding program.

Current Activity
A total of 10 of the intended 13 Red Pine thinning field studies have been set up and thinned by project cooperators. The remaining three sites have been measured and marked in preparation for thinning by MFPRC cooperators. Analysis of field data to date show little difference among thinning treatments except for reduced post-thinning growth in some of the more intensive thin-from-below treatments. Additional sites to enhance the existing Red Pine productivity database were selected during the quarter and will be measured in the fall. Hybrid poplar research continues with cooperative testing of a rapid method for screening of new genotypes for susceptibility to Septoria disease, a significant stem canker disease. This work is being done in conjunction with North Dakota State University and Verso Paper. Yield studies were maintained and new coppice trials were initiated in an existing five year old study containing multiple clones at a denser spacing. Over time, this study will produce unique data on production of coppice poplar and variation of yield among poplar genotypes.

Principal Investigator(s)
William Berguson

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**Total** $1,275,000

**Start Date:** 10/28/2004       **End Date:** 06/30/2012       **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 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 Duluth-NRRI, GreenWood Resources (Portland, Oregon), Mississippi State University, and ArborGen LLC (Summerville, South Carolina) 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
Activities during the quarter include collection of data on all large-scale genetics tests, clone trials, and yield blocks included in the SunGrant network of research sites. We collected data on 14 clone trials, 14 yield block tests, 3 large-scale family field trials, and 2 spacing trials. Based on analysis of clone trial data to date, a subset of superior clones is becoming evident with a new group of clones being propagated for evaluation in larger, single-clone yield blocks. Yield block tests show that new clones developed by NRRI are meeting and, at some sites, exceeding yields of the currently available commercial standard, NM6.

Current Activity
Breeding research continues at NRRI with cross pollinations being completed during the quarter and the flowering female branches have continued to mature and produce seed. Seed harvest and sowing is underway. A total of 105 successful crossing attempts have been made with a very high number of P. deltoides x P. nigra parentage producing viable seed. While not yet complete, we have a total of 9,538 and 2,539 seedlings of P. deltoides x P. nigra and P. deltoides x P. deltoides, respectively, for a total of 12,077 new seedlings. This is the largest set of new P. deltoides x P. nigra material produced by our program, roughly 2.5 times that produced in other years with similar effort. Populus nigra collections were sampled and exchanged in 2011 among the participating groups in the Feedstock Partnership (i.e.: NRRI, ArborGen, GreenWood Resources, and Mississippi State University). The newly exchanged materials were established in nurseries at various locations in 2012.

Principal Investigator(s)
William Berguson

Project Sponsor(s) | Amount | Account | Active
--- | --- | --- | ---
South Dakota State Univ-(USDOE-Prime) | 603,759 | 3014-10414-00012404 | 01/01/2009 09/30/2013
Total | $603,759 | | |

Start Date: 01/01/2009  End Date: 09/30/2013  Project ID: 1571
Objective
To develop a modular agglomeration system which transforms delicate corn stover fibers into highly absorptive free flowing granules, uniquely capable of displacing inefficient clay type absorbents in the marketplace.

Background
Oil and coolant drips, leaks and spills from vehicles, machines, oil transfer units, and other business activities account for 36 percent of petroleum waste that is polluting US surface water, ground water, surface soil, and sub soil (U.S. Dept. of the Interior Minerals Management Service). The usual cleanup method of these spills on a hard surface is the use of clay or diatomaceous earth which are inefficient or polypropylene sorbents which are more efficient but are made from petroleum and present their own disposal problems. Antidotal evidence indicates that as much as 60-70 percent of the clay based sorbents sold are disposed improperly. Research performed by the University of Minnesota Duluth, Natural Resources Research Institute (NRRI) in cooperation with Clean Plus, Inc. has demonstrated the use of corn stover fiber as a highly absorbent medium for oils and other harmful fluids. Tests at NRRI have shown corn stover absorbs over five times more oil, on a pound for pound basis, than clay based sorbents.

Previous Activity
Challenges were encountered on the green strength of the agglomerates. Up-scaling from the 20 and 36 inch disc agglomerator to a 7 ft disc was found to be too abrasive for effective agglomerate survival. Retention time on the 7 ft disc subject the agglomerates to significant attrition forces and was found to abrade the particles before they could exit the disc. Attempts to improve green strength with binder dosage and pre-heating were unsuccessful. As a result, the team altered the agglomeration approach to incorporate minimum-distance-of-travel with a two tier agglomeration system. This allows the agglomerates to form in the center tier and migrate to the second tier where they freely exit at minimal travel length. This necessitated the use of two 36 inch discs, each with a center tier, operating in parallel from a single plate feeder. This duel disc set-up has yielded a capacity of approximately 500 lbs per hour. Future plans are to double this capacity by adding a second dual disc set-up which may bring the capacity up the target level of 1,000 lbs per hour.

Current Activity
The delicate nature of the two part binder system was significantly overcome with the use of two 36 inch discs operated in parallel. This minimized retention time on the disc with less abrasion to the delicate corn stover particles. The team then shifted its focus to the drying stage where significant progress was made. The team improved the up-scale drying factors from Phase I from 0.74 to 9.8 lb/hr/ft2 by increasing inlet drying temperature from nominal 130°F to 490°F. This effectively reduced the predicted drying area from 1300 to just over 100ft2. The CPI fluid bed dryer, was converted to downflow-fixed-bed configuration and successfully achieved ~200 lbs/hr.

Principal Investigator(s)
Brian Brashaw
Timothy Hagen

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Start Date: 09/01/2010  End Date: 08/31/2012  Project ID: 1662
Developing Thermal Verification Guidelines for Firewood

Objective
The objective of this project is to improve the current temperature monitoring process for heat treating firewood by developing the necessary background data that can be used to develop thermal verification guidelines that are primarily based on the kiln heating conditions to supplement the data from the firewood samples.

Background
Heat sterilization is currently the most practical and official treatment to kill Emerald Ash Borer (EAB) in infested ash firewood. To stop further spread of EAB, the USDA Animal and Plant Health Inspection Service (APHIS) has enforced a heat treatment process for the U.S. firewood industry to heat sterilize all hardwood firewood before it can be shipped out of infested areas. Yet, many firewood producers have had challenges implementing the heat treatment process in firewood operations due to a lack of sufficient heating facilities and a reliable temperature monitoring system. Significant operator errors were also found to occur in the current monitoring process. The purpose of this project is to improve the current heat treatment process by developing generic thermal verification guidelines that are primarily based on kiln conditions, eliminating most operator errors that exist in current heat treatment practices. This project will be conducted by a multidisciplinary team that include university and federal laboratory researchers, state wood products specialists, USDA APHIS Plant Protection and Quarantine officers, and field regulatory staff from several states.

Previous Activity
We have identified several potential Minnesota cooperators to help our project team acquire the needed data on temperature profiles of firewood and the control temperatures and humidity of the kilns used for drying firewood. Price Firewood of Cloquet, Minnesota has purchased and is installing a new kiln that will be used in this project. A previous cooperator, Green Thumb, has also agreed to allow the project team to acquire data.

Current Activity
Several heating trials were conducted at Savannah Pallet in cooperation with Price Firewood. This resulted in the collection of data that will be used to develop strategies for assessing the use of kiln controls as a secondary measurement technique. Due to the off-season nature of firewood, there was no work completed during the spring and summer of 2012, additional testing will be completed with several cooperating firewood producers.

Principal Investigator(s)
Brian Brashaw
Timothy Hagen

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Start Date: 07/01/2010   End Date: 06/30/2012   Project ID: 1601
Development of Torrefied Wood as a Biofuel

**Objective**
To develop the densification parameters for a mixed hardwood/softwood wood species torrefied to a specification of 30 percent DSL at 300°C.

**Background**
Effective use of biomass requires pretreatments to allow material to be used without significant modification of existing combustion systems. Ideally, pretreated biomass should have properties that allow the materials to be deployed in a manner similar to fuels currently used. One such pretreatment technology is torrefaction. Torrefaction is a thermal process in which biomass is heated in an oxygen deprived atmosphere at temperatures of 270° to 300°C. Torrefaction requires a biomass combustor in combination with a dryer placed upstream of a reactor capable of heating to 300°C in an oxygen deprived atmosphere. The combustor provides heat for the process by combusting a fraction of the solids exiting the dryer, while remaining solids from the dryer enter the torrefaction reactor. This environment drives off volatiles, thereby changing the nature and properties of the product.

**Previous Activity**
Torrefaction is an emerging industry. The NRRI has focused on the densification properties of torrefied wood chips. The project focuses on both pelleting and briquetting. Most tree species available in Minnesota respond favorably to torrefaction. In general, 70 percent of the mass is conserved, while retaining 90 percent of the wood energy content. Dry Solids Loss (DSL) through torrefaction was found to be a significant indicator of how easily the materials respond to grinding. Uniformity of particle size was found to be a critical parameter for successful torrefaction. However, the densification properties were found to be favorable in a narrow range spanning from 20-30 DSL range, but deteriorate significantly beyond 35 percent DSL. The deterioration of the lignin causes reduced binding quality. Although compaction pressures at 2,000 bar at 200°C with grind specification of 100 percent less 50 mesh have yielded acceptable briquette quality, the surface wetability for the briquettes continues to be an ongoing challenge. The key challenge is to produce acceptably durable briquettes that characteristically do not re-wet appreciably, shed water when placed in a large pile outdoors, and do not appreciably loose their integrity or durability through time when exposed to moisture. Large outdoor storage trials are planned of both pellets and briquettes.

**Current Activity**
Two tons of torrefied micro chips, made from mixed hardwood/softwood species and torrefied to a specification of 30 percent DSL at nominal 300°C were provided by Sylva Corporation. The material was successfully hammer milled in the NRRI pilot plant at three times the normal throughput of dry wood chips. The resulting finely divided material was split into two samples - one for pelleting trials at NRRI Duluth and one for briquetting trials at NRRI Coleraine. Pilot pelleting and briquetting trials are on-going with this material.

**Principal Investigator(s)**
Timothy Hagen

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**Start Date:** 07/01/2010  **End Date:** 06/30/2012  **Project ID:** 1594
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 Guitar were 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. Preliminary testing was completed with thermography, showing some potential for identifying cracks.

Current Activity
There was minimal activity during this reporting period due to other priority project activities for NRRI. The project received an extension from the sponsor until 6/30/2013.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s) | Amount | Account | Active
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USDA Forest Service | 50,000 | 3002-10414-00008448 | 07/01/2009 06/30/2012

Total | $50,000

Start Date: 07/01/2009   End Date: 06/30/2012   Project ID: 1552
Grand Log Homes

Objective
To fully develop the Grand Log technology by developing the production process, producing enough product to complete performance testing, constructing a demonstration site, and producing trade show booth and sales samples which will lead to the start-up of a manufacturing plant in northern Minnesota by the end of 2011.

Background
Grand Log Homes™ has developed the Grand Log™, which combines the durability, authenticity, and curb appeal of solid logs with greater energy-efficiency, stability, and remodeling options, along with less weight and much lower life-cycle costs. The Grand Log™ hybrid log technology is the culmination of original NRRI research and maintenance field data from more than 160 North American installations of a veneered foam-core log siding.

Grand Log Homes™ will compete in the 4+ billion dollar log home marketplace with more than 55 years of battle-tested product design, engineering, product commercialization, manufacturing, construction, and sales experience. This marketplace includes log home package sales, large diameter log siding sales, and log installation revenues. Grand Log Homes™ will focus on the log home, hospitality & upscale rustic construction industries, in addition to the architectural, governmental, and vacation homeowner segments of the marketplace.

Previous Activity
Prototype samples of the original concept drawings for the Grand Log™ were created and used to develop parameters for manufacturing 12 ft lengths during regular production. A prototype assembly jig was conceptualized, developed, and tested using 4 ft lengths. Several improvements were noted and completed. Also evaluated were adhesive requirements, application methods, and placement during assembly. Adjustments were made by the inventors in the design of the product to improve assembly and reduce waste during production. An on-site visit to a potential component milling company was conducted in June 2011 to assess the potential for toll manufacturing during 2011.

Current Activity
Log siding materials were produced using a 16 ft long manufacturing jig and clamping system in order to produce samples for product testing and market development. This included participation in an industry trade show.

Key design improvements were completed and additional samples were routed and assembled at NRRI. These samples were used to finalize the design and produce final materials that will be used to complete the construction of a carriage home.

A project extension was requested and granted until 12/31/2012. During this time, additional R-value insulation testing and durability testing will be completed. Business planning support will also be provided, in cooperation with the Itasca Economic Development Corporation.

Principal Investigator(s)
Brian Brashaw
Victor Krause

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Start Date: 01/03/2011   End Date: 05/12/2012    Project ID: 1651
Integrated Acoustic Assessment Technologies for Optimal Wood Products and Wood Biomass Utilization

Objective
The objectives are to: (1) Develop economic assessment models that incorporate wood quality, carbon and bioenergy values along with end markets for use with acoustic-based nondestructive assessment technologies; (2) Identify implementation strategies and guidelines for use with standing trees, stems, and logs for regional application across the varied forest cover types; and (3) Develop a nondestructive approach to accurately determine wood density for individual species within a localized forest stand.

Background
The University of Minnesota Duluth has been at the forefront in the development of robust nondestructive evaluation (NDE) technologies capable of predicting the wood properties of trees, stems, and logs, and assessing the value of stands and forests. In this project, the University of Minnesota Duluth will collaborate with the College of Menominee Nation and the USDA Forest Products Laboratory to evaluate previous data sets and conduct an assessment of standing timber in Wisconsin to provide advancements and refinements of acoustic assessment technology to ensure that these methods will be successfully implemented for managing wood quality, assessing the forest value, and ensuring efficient use of woody biomass.

Previous Activity
A project team meeting was held at the College of Menominee in Keshena, Wisconsin. A technical review of acoustic technologies and a hands-on demonstration of the log tool (Hitman 200), standing tree tool (STS 300), and resistance micro drill was provided. This provided needed context to the use of these tools to assess standing trees and logs during the project. The Forest Products Laboratory and NRRI prepared and submitted a draft report that included a literature review on the use of nondestructive inspection as a means to predict quality and specific gravity of trees, logs, and lumber. A field trial was completed in October on approximately 30 white pine trees and 45 sugar maple trees.

Current Activity
The data from the field trial was analyzed to identify the range of acoustic properties for white pine and sugar maple trees, and the logs that were cut after harvesting. The resulting data showed that there was a wide range of acoustic velocities in these materials, reflecting wide variety in wood quality. The data is being further compared with the log scaling data to develop several thresholds that could be used to effectively sort this material prior to processing in the woods or at the sawmill.

A presentation and discussion of the data to date was given to the senior staff at Menominee Tribal Enterprises and for students and staff at the College of Menominee Nation. The final report will be prepared in the next reporting period.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s)
College of Menominee Nation/(USDA Prime)

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Start Date: 10/01/2010   End Date: 09/30/2012   Project ID: 1610
Forest Products

Midwest Gypsum, Inc

Objective
To develop the densification and processing parameters for a turkey bedding formulation made of pelletized gypsum, paper, and wood.

Background
This project seeks to develop the optimal formulation and densification parameters for a turkey bedding made of recycled wallboard, paper, and wood. Successful completion of this project will provide the technical and economic data required for a new Minnesota start-up company - Midwest Gypsum. The company has identified a critical need for developing value-added markets from recycled gypsum wallboard, which has also been identified by the Minnesota Pollution Control Agency as a target product for recycling as compared to the more traditional landfilling disposal method. U of M Poultry Science is a valuable participant in the project and will conduct preliminary cage and larger scale pen trials to evaluate the potential of the new bedding.

Previous Activity
This is a new project. No previous activity to report.

Current Activity
Three cubic yards of recovered gypsum wallboard was obtained in partnership with AA Roll-Off, a local waste hauler and recycler, headquartered in Superior, Wisconsin. The wallboard was initially ground through a RotoChopper grinder equipped with a 4-inch screen. The recovered material was collected into a dump trailer and transported to NRRI where it was screened into three size fractions: + 5/8 (paper), 5/8 x 8 mesh (granules), and - 8 mesh (fines). The paper fraction was further processed through a hammermill to knock off additional fines adhering to the paper. The granular fraction was of ideal size to be used as is in further cage trials. The fines were pelleted as 1/4 inch pellets and were used in cage trials as well. Each fractional cut represented about a yard of recovered material. The paper fraction was eliminated as a bedding material because of severe caking. The screened granular material and the pelleted material appeared to offer the best performance for further scale up in 4 ft x 8-ft pen trials. The initial results are quite encouraging from both a processing and performance standpoint and may provide a viable market outlet for clean, recovered gypsum wallboard.

Principal Investigator(s)
Brian Brashaw
Timothy Hagen

Project Sponsor(s)  Amount  Account  Active
J & J Knight Foundation  16,805  3001-10412-00029817  08/15/2011  12/31/2012
Blandin Foundation  7,852  3001-10412-00029815  05/15/2011  12/31/2012
Total  $24,657

Start Date: 08/15/2011  End Date: 12/31/2012  Project ID: 1679
**North American Thermowood Standard Industry Development**

**Objective**
NRRI is organizing an industry forum at the USDA’s Wood Education and Resource Center to identify the key components for a technical standard for the North American thermally-modified wood industry. The standard will provide a tool for both the hardwood and softwood industries to develop consensus on a comprehensive technical standard for engineers, builders, product designers, wood product manufacturers, and architects to specify thermally-modified wood for a variety of construction applications that demand high performance. The standard will be based on accurately referenced ASTM standards or equivalents.

**Background**
The NRRI will develop an industry forum at the Wood Education and Resource Center in Princeton, West Virginia, to identify the key components for a technical standard for the fledgling North American thermally-modified wood industry. The near-term result is that the outputs from the forum – identification of the steps necessary to develop a consensus for North American technical standards for thermally-modified wood – will be published in key industry trade journals. The results will be also disseminated through industry trade association memberships. The ultimate outcome of the project will be that key industry stakeholders carry forward the work of the forum and conduct the steps required to establish a North American technical standard for thermally-modified wood.

**Previous Activity**
The forum was scheduled for April 26, 2012. We have established the electronic media necessary to promote and execute the forum, which will be both live audience and webinar based.

The project has gained the cooperation of Dr. Matthew Lietch of Lakehead University, Thunder Bay, Ontario who will be responsible to increase the Canadian contribution to the effort.

**Current Activity**
Due to a number of scheduling conflicts we rescheduled our forum to October 25, 2012. A project extension was granted by the Forest Service.

The forum save the date poster is well-designed and distributed to people who may be interested in coming. Our speakers who are going to give presentations about their specialty are all confirmed. We will be getting some financial support from sponsorship. Our website is finished and has already had 1900 visits. On the website, all the detailed information about the forum is available for potential attendees to download. We have two options to register for the forum. The early-bird registration forms which were for people that showed interest in coming to the previously scheduled forum and for our speakers’ organizations. We want to make sure those people have reserved seats. The other option is online registration, open to anyone that may want to register for the forum.

**Principal Investigator(s)**
Patrick Donahue

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Total: $10,140

**Start Date:** 07/01/2011  **End Date:** 06/30/2012  **Project ID:** 1666
Old Globe Reclaimed Wood Company - NRRI Product Development Fund

**Objective**
To develop a new line of commercial flooring using Old Globe White Pine feedstock.

**Background**
Old Globe Reclaimed Wood Company owns the world’s single largest source of old growth Eastern White Pine, the 1887 Globe Elevator sitting on the edge of the Duluth-Superior Harbor, has an estimated 6 million board feet. The company has made a large effort to manufacture and sell commercial flooring from the reclaimed Eastern White Pine. Customers are strongly attracted to the rustic appearance of the wood. However, customers note that the wood is quite soft and lacks the hardness, long-term durability, and wear characteristics desired for restaurant, bar, and certain specialty retail applications. The project goal is to develop an extremely durable and high-value acrylic-impregnated Eastern White Pine flooring with a specific focus on commercial restaurant, bar, and specialty retail applications.

**Previous Activity**
White pine was sourced from the company and remanufactured into flooring lamellas at NRRI in the wood prototype laboratory. This material has been sent to several vendors who commercially process wood into acrylic hardened materials. The project retained lamellas and began processing internal samples with various readily available industrial chemicals. We have reached out to local coating supplier Van Technologies for solutions. In addition to the commercial flooring application we discovered several simple new products that fit the Old Globe branded products program; thermally modified white pine garden tiles, table/desk top, and small ready-to-assemble structures. We will create prototypes of all as an expanded project scope.

We have engaged the local architectural design community to help in creating furnishing designs with the materials.

**Current Activity**
The infusion of white pine with acrylic resins has proven to be more difficult than originally conceived. The sawn lamellas have been sent to two manufacturers of acrylic enhance flooring with poor results. It appears that acrylic hardened white pine flooring will not be a realistic new market for Old Globe Reclaimed Wood Company.

However, as will many projects, the unexpected results create good opportunities. In the case of Old Globe Reclaimed Wood Company, this is exactly the case. The company continues to get great press – in fact was featured on the history channel show "Axe Man." This national press coverage has created new confidence for this fledgling business.

The concept of an Old Globe Furniture brand appears to be gaining momentum. This initiative has created spin off opportunities for others in the region who are positioned to craft furniture from this unique local resource. Even though the project is complete we are certain this company will continue to be an active NRRI client.

**Principal Investigator(s)**
Patrick Donahue

**Project Sponsor(s)**
John S and James L Knight Foundation

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**Start Date:** 09/01/2011  **End Date:** 04/30/2012  **Project ID:** 1664
**Forest Products**

**Ryan’s Rustic Railings and Furniture - NRRI Product Development Fund**

**Objective**
To develop ready-to-assemble versions of Ryan’s Railing current furniture.

**Background**
Ryan’s Rustic Railings, Inc., (RRR) has manufactured rustic motif staircase systems and furniture for more than a decade. The business has continued to grow steadily, but has seen a more recent reduction in sales because of the slowing second-home market. Despite the drop in sales, the company is positioning itself to grow and is in the process of constructing a new building, which will triple its manufacturing and raw material inventory space. This project’s aim is to exploit RRR competitive advantage by developing ready-to-assemble rustic furniture products which utilize Knapp GmbH’s timber construction connector technology.

**Previous Activity**
The project purchased a small-specialized swing band saw to manufacture prototypes. The band saw has been sited at Ryan’s factory to enable more efficient prototyping. The project has begun to redesign rustic log furniture with an internal ready-to-assemble connector method. The difficulty of the task of designing connector interfaces with round materials has proven to be challenging. We have broadened our connector hardware focus to include other systems. In addition we have engaged the local architectural design community to help with expanding the focus of Ryan’s designs to include a more urban chic design focus.

**Current Activity**
We attempted to create a ready to assemble package of round post lodge style furniture using a system of Knapp, their internal plate connection system. The challenge of joining round post wood-to-wood connection using plate connections proved too difficult.

As an alternative NRRI scientist configured a new method of assembly by fabricating off-the-self materials. This new system not only provides a method for packaging but also provides a method where a single person can assemble the large heavy units.

The client has been aggressively pursuing new/used production equipment, purchasing an entire production facility, which was being dismantled and relocated to Cook, Minnesota. Even though the project funding has expired, NRRI will complete the market development task to demonstrate the new product features to a major home center.

This client has a great deal of potential to grow manufacturing jobs. These jobs are converting a logging resource directly to a customer product. They maintain a high degree of added value. The manufacturer is committed to continued growth and investment. This company will be a long term NRRI client.

**Principal Investigator(s)**
Patrick Donahue

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**Start Date:** 09/01/2011  **End Date:** 05/31/2012  **Project ID:** 1665
**Objective**
The goal of this project is to provide training and hands-on production process improvements that allow Top That! to increase their production efficiency and reduce manufacturing waste, resulting in increased capacity and ability to service additional customers in 2011.

**Background**
Top That! By Loni is a small custom sewing company based in International Falls, Minnesota that specializes in the production of custom boat canvases and alteration and repair services for both business and consumers in International Falls and the surrounding area. Top That! was a Labovitz Award Winner in 2008 in the Micro-Entrepreneur category.

**Previous Activity**
Training on lean manufacturing including identification of production waste, 5S, cellular manufacturing, total productive maintenance, and quality production principles was completed. This training included development of a current and future value stream map for Top That!, and determination of shop floor improvements that would help to reduce waste and maximize value-added production. Along with Top That! staff, shop floor improvements were implemented during a blitz project on-site. This included the construction of a new sewing table and the expansion and relocation of another sewing table. New storage was created for necessary tools and materials. Work benches were reduced in size to allow for more efficient work processes and ease in location of tools. An on-site project was scheduled for July 2011 to help with additional production improvements.

**Current Activity**
An on-site continuous improvement project was conducted in August 2011 to fabricate new and additional organized storage for incoming small sewing projects. This unit has openings for 17 individual projects, plus additional space for storage above, and tall project storage along the side. Mirrors were mounted in two locations in the shop to allow employees to see customers entering the building from both access locations. Additional easy access storage was created for commonly used items. A waste evaluation was revisited on one sewing area and additional materials and items were removed to improve efficiency in the area. Repairs and additions were made to the sewing tables deemed necessary since the previous visit.

The owner reported to NRRI in the final assessment that the improvements made in her manufacturing shop have increased the amount of sewing that can be completed daily, improved the organization of the shop, and allowed for the hiring of additional staff. The owner has credited NRRI will helping her make key improvements to support the growth of her business.

**Principal Investigator(s)**
Brian Brashaw  
Victor Krause  

**Project Sponsor(s)**  
Blandin Foundation

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Start Date: 01/03/2011  
End Date: 05/12/2012  
Project ID: 1650
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, new technologies need to be explored which can provide as-built records at a faster rate 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
A final report on the 3D laser scanning of six historic covered bridges was completed and provided to the USDA FPL. This report noted the following conclusions: (1) 3D laser scanning can be used to rapidly scan historic covered bridge structures. (2) Post-processing of the scan data requires experience and skill to cost-effectively create as-built documentation. (3) A 3D scanner can be used to create a range of outputs that include point cloud scans, parametric images, and 2D and 3D AutoCAD® drawings. For historic covered bridges, this information can be used for a variety of purposes including as-built documentation and structural assessment, while also providing detail on the land topography adjacent to the bridge.

Current Activity
The background developed by the NRRI project team provided the stimulus to successfully apply for the 2011 University of Minnesota Infrastructure Investment Initiative (I3), resulting in the purchase of a 2011 3D laser scanner that will allow the project team to investigate and demonstrate other potential applications. The project sponsor also added an additional $18,000 to the project for this purpose. These funds were used to complete the scanning of a historic bridge located in Amnicon State Park, located 10 miles East of Superior, Wisconsin. In this project, the new scanner was used to complete the assessment, the data was imported into AutoCAD, and the process documented for use in inspection procedures of historic structures.

Principal Investigator(s)
Brian Brashaw

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Start Date: 07/28/2009   End Date: 01/31/2012   Project ID: 1570
Forest Products

Wolf Wood Inc. - NRRI Product Development Fund

Objective
To develop houseware products with thermally modified wood.

Background
The goal of this project is to provide Wolf Wood, Inc. with the technical knowledge, expertise, and market intelligence required to begin manufacturing niche kitchenwares using thermally modified wood and be a catalyst that allows Wolf Wood, Inc. to develop other thermally modified wood products, including wood window and door components, millwork, outdoor furniture, and wood flooring.

Previous Activity
One highlight to report is the purchase of a thermally modified wood laboratory by Wolf Wood, Inc. This laboratory will be leased by and operated by NRRI in Duluth. This is a significant step forward in the development of other thermally modified wood applications for our region. The laboratory has the capacity to process lumber and composite panels in small lots in lengths up to eight feet. It has been designed to simulate the three major thermal modification methods.

This positions NRRI and Wolf Wood, Inc. to develop additional niche applications with full scale market development samples. The laboratory is being built by IWT-Moldup and will be installed in late summer of 2012.

Current Activity
The project outcome has identified methods to manufacture solid lumber feedstock into edge glued and finger joint thermally modified wood components. The key development is the know-how to bond solid wood prior to the thermal modification.

The project investigated both single component and two component polyurethane systems. The single component systems products were 100 percent liquid at room temperature whereas the two component systems consisted of a base resin and catalyst.

Hardwood and softwood lumber was converted into prototype products, followed by a thermal modification schedule with a maximum temperature of 190°C.

The prototypes were tested for bond line strength. The single component systems failed whereas the two component systems maintained nearly 95 percent of their original bond line strength properties.

Our research shows at least two suppliers of two part systems would be candidates for production processing. This is extremely encouraging for future product development work in thermally modified products. The ability to convert solid lumber into bonded components prior to modification changes the production flow model – making the modification processing far more competitive.

Principal Investigator(s)
Patrick Donahue

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Start Date: 08/15/2011     End Date: 05/12/2012     Project ID: 1663
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. 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
The book on wood utilization options was completed in draft form. The initial chapter focused on the material properties of ash and other affected species. 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 challenge 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.

Current Activity
This project was extended until 9/30/2012 to allow for completion, editing, and peer review of the final chapter on wood product options. The title of the manual is: Wood Utilization Options for Urban Trees Infested by Invasive Species. It focuses on emerald ash borer, gypsy moth, asian longhorned beetle, and thousand cankers disease. The following chapters are included in the manual:

1. Overview of Invasive Insects and Utilization Options for Hardwood Species
2. Basic Wood Properties of Hardwood Species Affected by Invasive Insects
3. Market and Utilization Options for Ash Logs, Lumber, and Other Products Affected by EAB
4. Heat Treatment of Wood for Invasive Forest Pests

The final manual will be printed in September 2012.

Principal Investigator(s)
Brian Brashaw

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Start Date: 07/01/2009    End Date: 09/30/2012    Project ID: 1573
Objective
To determine and understand the parameters required to gasify alternative biomass fuels. Examples include herbaceous biomass such as corn stover, prairie grass, or wheat grass, woody biomass such as hardwoods and softwoods, and/or mixes of herbaceous and woody biomass.

Background
The NRRI Coleraine Minerals Research Lab (CMRL) has been conducting biomass gasification research since June 2007. For much of this time, the primary feedstock consisted of relatively homogeneous hardwood woodchips, yet there are many potential sources of gasifier feedstock that are not merely one kind of woody biomass. Northern Minnesota has an abundant supply of woody biomass, but in other parts of the country, woody biomass is not as readily available. Many places have, on the other hand, abundant herbaceous biomass. To be able to utilize this feedstock, it is required to conduct research into how to gasify these potential fuel sources.

Previous Activity
Research was planned to determine and understand the parameters required to gasify alternative sources of biomass. Literature research was to be done as the first step in determining the state of the art. Feasibility of using woody and non-woody feedstock mixes will also be investigated.

Current Activity
CMRL has contacted the manufacturer of the Biomax25 biomass gasifier for potential hardware/software upgrades and training on advanced gasification techniques. On-site training was determined to be cost prohibitive. However, training at the Community Power facility in Littleton, CO, may be an option. These opportunities are being evaluated.

Principal Investigator(s)
Richard Kiesel

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Start Date: 09/01/2008    End Date: 12/31/2012    Project ID: 1670
Biotechnology Initiative

Torrefied Biomass as a Partial Replacement Fuel for Taconite Induration

Objective
To conduct a series of roasting tests to determine the parameters required to produce a biomass char applicable to Minnesota mining industry combustion systems.

Background
Torrefaction of biomass is an effective method to improve the grindability of biomass to enable more efficient co-firing with fossil-based fuels. It can then be used as a complete, or more likely partial, replacement for coal in pulverized coal facilities.

Previous Activity
Tests were conducted in a pilot scale roasting kiln set up at the Coleraine Minerals Research Laboratory (CMRL), designed to process 4-20 lbs/hr of biomass feed materials. Bio-char products were characterized according to carbon, ash, and sulfur content. Further evaluation was conducted using a specialty Thermal Gravimetric Analysis (TGA) that was designed to accommodate significantly larger samples of bio-products for temperature-weight loss characteristics, ash analysis, and product gas characterization. To efficiently use biomass char as a fuel for taconite induration, energy content of by-product gas must also be utilized. Characterization of off-gas was used to determine further application as a fuel to either conduct the torrefaction process or as a supplement to the current burner combustion system. The calciner torrefier was used to generate enough torrefied wood samples for chemistry, calorimetry, ash chemistry, TGA, and grindability studies. Three different temperatures were chosen to represent severe, moderate, and mild torrefaction. Temp setpoints of 300, 275, and 250 degrees Celsius correlated with dry solids losses (DSL) of approximately 32%, 28%, and 18%, respectively. Calorimetry and grindability tests on 10%, 20%, and 30% replacement tests with coal showed an increase in grindability, energy density, total carbon content, and ash content. Gas analysis was conducted using online gas analyzers and gas chromatography. The permanent gas portion of the off-gas consisted mainly of carbon dioxide and carbon monoxide, whereas the condensable portion consisted of a numerous amount of compounds.

Current Activity
This study shows that torrefied biomass has the potential to be used as a partial replacement fuel for taconite induration on processes capable of utilizing solid fuels with similar characteristics to common coals. The blending of bio-coal resulted in an increased fuel energy density with an associated increase in total carbon content. System mass and energy balances showed that the torrefaction process increases the energy density of the solids fuels produced from torrefaction disproportionately with respect to the resulting off-gases. This project is complete and a final report has been submitted.

Principal Investigator(s)
Matthew Mlinar
Richard Kiesel

Project Sponsor(s)  Account  Active
MN DNR  35,737  3005-10417-00014215  05/01/2010  06/30/2011

Total  $35,737

Start Date: 05/01/2010  End Date: 06/30/2012  Project ID: 1630
**Product Development Support, Minnesota Mining Cluster - The Next Generation of Innovation**

**Objective**
To provide applied research and development support with product development or improvement and processing design and efficiency to five companies, averaging $20,000 per investment. Each project is expected to provide a combination of in-kind and/or cash match to expand the effort and to ensure that the entrepreneurs and small businesses are intimately involved in a hands-on manner in the initiative.

**Background**
NRRI, together with its partners in the Minnesota Mining Cluster (MMC), will search out entrepreneurs and small business suppliers/vendors and assist them with new product development, product improvement and processing efficiencies to help them either start new businesses or expand existing businesses, with the goal of job creation and new investment within the cluster. NRRI has found that prospective partners have unique needs.

**Previous Activity**
The existing Product Development Fund (PDF) program procedures will be utilized for this piece of funding, and an application has been developed to meet the parameters of the Economic Development Association portion of the funding. Preliminary discussions are being held with internal NRRI Center for Applied Research and Technology principal investigators to discuss potential projects.

**Current Activity**
NRRI and the UMD Center for Economic Development (CED) made site visits to two potential NRRI clients, as a result of the survey conducted by the UMD CED. There appears to be at least one project that would be related to lean manufacturing. It is anticipated that a couple of applications will be submitted in the last half of 2012.

**Principal Investigator(s)**
Pamela Sarvela  
Steven Hauck

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**Start Date:** 10/01/2011  **End Date:** 09/30/2013  **Project ID:** 1688
Development And Commercialization Of A Biorefinery For Processing DDGS In Biofuels And Other Value-Added Products

Objective
To develop and optimize parameters of DDGS processing into value added products at lab scale and pilot scale industrial conditions with a subsequent commercialization of the value added products.

Background
Laboratory of Chemical Extractive at the Natural Resources Research Institute (NRRI, UMD) developed new process of DDGS processing into value added product - biofuels (biodiesel and ethanol), zein (corn protein) and high protein feed product HPDG. Project Co-PI Douglas Tiffany conducted a preliminary analysis using economic models that combine our proposed biorefinery with existing ethanol plant capital costs and performance. Results from this model show significant economic improvement from implementing our technology compared to that of current ethanol plants, as well as competitive technologies for processing DDGS. Successful proposal to Minnesota Corn Research and Promotional Council and Minnesota Corn Growers Association was based on this background. The main idea of this work was to provide pilot scale research and development process in cooperation with industrial partners for project commercialization.

Previous Activity
Technology of processing DDGS into value added products was discovered at NRRI’s Laboratory of Chemical Extractive and patented in 2011 (UMN Assignees, Krasutsky, P. A. US Patent app 20070089356, April 26, 2007). This technology was the basis of our proposal to Minnesota Corn Growers Association. The goal of this work was to move the DDGS processing from laboratory scale to pilot industrial scale with industrial partners Crown Iron Works and GlycosBio.

Current Activity
Research and Development from July 2011 to December 2011 was performed in cooperation with Crown Iron Works (Roseville, MN) using their pilot equipment for extraction on-site at Crown Iron. Pilot scale tests confirmed results achieved at the Laboratory of Chemicals Extractive (NRRI, UMD). The next step will be devoted to pilot scale development of the process of DDGS oil transesterification in cooperation with Crown Iron Works and bioconversion of soluble in cooperation with GlycosBio.

Principal Investigator(s)
Pavel Krasutsky

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Start Date: 03/23/2011      End Date: 09/01/2012      Project ID: 1658
Chemical Extractives

Processing DDGS into Biofuels and Other Value-Added Products - Pilot Development and Commercialization

Objective
To develop and optimize parameters to process DDGS into an array of value-added products at lab, bench, and pilot scales with the subsequent commercialization and marketing of the value-added products.

Background
Minnesota’s corn ethanol industry produces millions of tons of a lower value co-product called Dried Distillers Grains and Solubles (DDGS) that is marketed as a feed product. It has been determined that the components of DDGS can be selectively extracted yielding a liquid fraction (oil and solubles) and a solid fraction (a higher protein distillers grain).

Previous Activity
This work led to laboratory scale development of the process of DDGS extraction, oil separation and oil transesterification into biodiesel B100. Laboratory pilot scale equipment became available for demonstration. Samples of final products: (1) high protein distillers grain (HPDG), (2) biodiesel, and (3) zein, were prepared for tests. Analyses of samples were conducted with the use of Gas Chromatography/Mass Spectrometry (GC/MS), high performance liquid chromatography (HPLC), and nuclear magnetic resonance (NMR). Work on industrial scale pilot development was in progress. An invention disclosure was submitted to the University of Minnesota's Office of Technology Commercialization (OTC).

Current Activity
Research & Development during January - June 2012 was directed towards optimization biodiesel synthesis process using DDGS extract. Two approaches were explored: (a) batch process of biodiesel synthesis with the use of different heterogeneous and homogeneous catalysts, and (b) continuous process with the use of heterogeneous and homogeneous catalysts. It has been discovered that process(b) is more efficient than homogeneous catalysts. Optimal parameters – solvent-to-oil ratio, temperature and retention time in reaction zone – have been determined. The process of extraction has been provided on 25 lbs of DDGS from new supplier. The content of ethanol was determined by NMR spectra and by GC/MS analysis: oil, 80-85 percent; free fatty acids, 15-20 percent. A sample of oil was obtained and used for the process of transesterification with ethanol. A sample of solubles was transferred to GlycosBio for optimization of the process of bioconversion.

Principal Investigator(s)
Pavel Krasutsky

Project Sponsor(s) 

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Start Date: 07/01/2010  End Date: 06/30/2013  Project ID: 1595
Hydrothermal Processing of Biomass Materials

Objective
To conduct research that relates to processing of renewable fuels so as to improve the useful quality of biomass fuels by means of hydrothermal treatment. Exploration is planned regarding various kinds of biomass, including forestry, agricultural products, and energy crops, in bench top scale hydrothermal processing experiments, followed by characterization of the obtained products.

Background
The term "Hydrothermal Processing" means exposure of material to elevated temperature in water media. During past provisional research, it was found that wood, grass, and other lignocellulosic materials, being hydrothermally processed, show significant loss of weight while retaining up to 95% of the initial fuel value. Compared to the more common Torrefaction (TM) process, the hydrothermal process shows the same effects at more mild conditions. Hydrothermally processed biomass products are friable, almost odorless, and show higher bulk density, lower equilibrium moisture and ash content. This makes hydrothermally processed biomass an effective and manageable fuel for heat/power processing, residential heating, and other applications.

Previous Activity
This is a new project.

Current Activity
Hydrothermal processing advanced a suitable method for fabrication of highly effective solid fuels from wet slurries, farm wastes, waterweeds, etc. Lab tests have been done at variable temperature, pressure and load ratios in order to find the best conditions for carbon and energy recovery. The proper process temperature was found to be 250-260 deg. C for woody biomass and 240-250 deg. C for herbaceous materials and farm wastes. The resulting solid fuel product (Biocoal) shows a higher heating value of 23 kJ/g (kilojoules/gram) and above, and can easily be fired in coal-burning furnaces and boilers, or be briquetted/pelletized for residential heating.

Principal Investigator(s)
Andriy Khotkevych
David Hendrickson
Donald Fosnacht
Richard Kiesel

Project Sponsor(s)  | Amount | Account | Active
-----|--------|---------|--------
PUF Mineral Endowment | 110,000 | 1750-10417-20090-100001 | 01/09/2012 06/30/2013

Total  | $110,000

Start Date: 01/09/2012   End Date: 06/30/2013   Project ID: 1680
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 300ft. or 100m, which eliminates all but one of the previous data points.

Previous Activity
Over 800 sites were searched for wells to probe. Fifty-eight wells were probed that were reduced to 36 new data points. Radionuclide data collection was completed. Downhole temperature data, radionuclide data from granite samples, and thermal conductivity data from 180+ samples were used to produce new heat flow data. The new map illustrates warmer temperatures at shallower depths, less than the 10kms required to find 150 deg C water. In portions of Otter Tail and Wilkin counties, the depth to 150 deg C occurs at about 7.0-7.5kms. In the southwest Minnesota counties of Murray, Nobles, Pipestone, and Rock, these temperatures were found at a depth of about 8.0-8.5 km. Additional sample collection is needed to refine these data to see if shallower depths might produce these temperatures.

Current Activity
A final report was submitted to the Office of Energy Security and was accepted. It is available on the NRRI Minerals website. Additional funds from the American Association of State Geologists-DOE still remain. These funds will be used to process additional samples for thermal conductivity and radionuclide analyses. Unanalyzed samples from the previous project, and new samples collected during the new EDA REE project will be processed and sent to Dr. William Gosnold at the University of North Dakota Grand Forks for additional analyses, with the data to be added to the National DOE Geothermal Database and also sent to the National Heat Flow database at Southern Methodist University (SMU) in Texas.

Principal Investigator(s)
Donald Fosnacht
Steven Hauck

Project Sponsor(s)

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Start Date: 11/02/2009     End Date: 06/30/2012     Project ID: 1580
**Energy**

**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**
Catalysts for conversion of syngas to liquid fuels were made on a base of the local mineral ilmenite. Processing of these catalysts, identified as polymetallic ferrotitanates, is cost and labor saving, and is comprised of clinkering ilmenite with sodium or potassium carbonates, followed by water leaching the clinker. The named catalysts were found to be suitable for the conversion of syngas to hydrocarbons, which is known as the Fischer-Tropsch reaction. A systematic study proceeded with conversion of low-hydrogen (below 50% H2) blends, since this composition is typical for syngas obtained from biomass. It was also found that CO2/H2 blends can be converted to hydrocarbon mixtures over the named catalysts. The effects of temperature, pressure and dope metal additives, and certain kinetic studies as well, have been explored on a regular basis. During 2011, research progressed in the area of testing other types of mining and industrial materials as potential catalysts for syngas conversion.

**Current Activity**
Study has continued in regard to exploration of Direct Reduced Iron (DRI) as a source of syngas conversion catalysts. Two common brands of DRI have been tested in the process, with various temperatures, pressures and dope metal additives. It was found that conversion of syngas to hydrocarbons on DRI-based catalysts was possible, with a 65–90% conversion factor per single pass in a fixed-bed gas reactor. Compared to the ilmenite-based catalysts, the DRI-based ones show about the same activity level, but much better mechanical properties. It was also found that conversion of syngas on the DRI-based catalysts leads to higher yields of the liquid fraction of hydrocarbons, as compared to the high weight (waxy) products. The current stage of the project includes scale-up simulations and searching industrial partners for commercialization.

**Principal Investigator(s)**
Andriy Khotkevych
David Hendrickson
Richard Kiesel

**Project Sponsor(s)**

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**Start Date:** 02/29/2008  **End Date:** 12/31/2012  **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 (Cu/Ni) 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
The autoclave was being refurbished. When the update is completed, it was planned that work would start on making the necessary concentrate for leaching tests. When sufficient concentrate becomes available, autoclave leaching tests will be conducted. Following the leaching tests, the PGMs (Platinum Group Metals) in solution will be precipitated with a sodium sulfide addition. It is anticipated that essentially all the mercury will also precipitate as mercury sulfide.

Current Activity
CMRL’s autoclave has been rebuilt and is now ready for leaching test work to be conducted to evaluate the addition of sodium sulfide to PGM concentrates to look for mercury reduction. Additional mercury measurements will be made as Minnesota Cu/Ni ores are processed as part of NRRI’s EDA Mining Cluster Grant. A mass balance will be developed for mercury distribution throughout the various processing stages.

Principal Investigator(s)
David Hendrickson

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Start Date: 02/09/2005   End Date: 12/31/2012   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 (CMRL) will be injected as dry sorbents into the 75 megawatt (MW) unit’s 250,000 cubic foot/meter (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 Permanent University Trust Funds (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 flue gas slip stream from Unit 4 at Minnesota Power's Boswell Generating Station in Cohasset, MN. 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 CMRL to design an efficient dry sorbent injection system, ensuring good gas-sorbent contact.

Previous Activity
New chemical oxidation and/or nano-solid sorbent mercury removal technologies were planned in 2011 so as to accomplish a full scale mercury reduction test in 2012. Wet scrubbers were being phased out of pollutant control technologies for coal fired power plants, so our research emphasis has been focused on mercury reduction technologies applied to bag house fly ash removal techniques.

Current Activity
Full-scale mercury reduction tests have not been advanced pending the development of low-cost, efficient, dry mercury sorbents. New mercury sorbents have been prepared which can be separated from flyash and which could compete with marketed brominated activated carbon injection into dry baghouse systems, such as those being injected on Boswell’s Unit 3 generator. Tests are being conducted at CMRL to gauge the mercury removal efficiency of these sorbents in simulated stack gas streams, as well as their ability to be regenerated. After a successful sorbent is fully tested and regenerated, full scale tests on Boswell’s Unit 4 generator will be conducted.

Principal Investigator(s)
David Hendrickson

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Start Date: 04/10/2007       End Date: 12/31/2012       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**
When the necessary equipment is available, work will begin to determine if bromine salts added to green balls can increase mercury oxidation. Bromine salts were procured. The mini-pot was down for repairs. When the pot has been repaired, it is planned that green balls with and without bromine salts will be produced and fired.

**Current Activity**
New baseline data has been generated using CMRL’s state-of-the-art Ohio-Lumex On-line Speciated Mercury Analyzer, linked to the stack gas discharge of our new pilot scale pot grate pelletizing simulator, to accurately simulate and measure the volatilization of mercury during the induration cycle for straight grate and grate kiln pellet plant furnaces. Tests indicated that lower silica concentrates that were balled and fired, volatilized far less mercury than higher silica concentrates that were balled and fired. Tests will now progress to evaluate the addition of halide salts to concentrates, to measure the potential oxidation of mercury by halides added to concentrates prior to balling, using the pot grate system linked with the On-Line Mercury Analyzer.

**Principal Investigator(s)**
David Hendrickson

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**Start Date:** 02/09/2005   **End Date:** 12/31/2012   **Project ID:** 1378
Environmental Chemical

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
NRRI engineers and technicians met and conducted on-line continuous speciated mercury analysis baseline testing at Minnesota taconite operations. Additional baseline testing was planned for the fall of 2010. NRRI researchers were also chosen in conjunction with researchers from the University of North Dakota’s (UND) Energy and Environmental Research Center (EERC) to participate in mercury removal research for taconite operations. Preliminary test work will be conducted at CMRL, followed by larger scale tests using pellet plant stack gas emissions. In-plant research work was planned at several Minnesota taconite operations using mercury reduction techniques developed at EERC. A new pulse jet bag house pilot scale system was being installed on the 250 cfm slip stream that we have developed from Boswell Unit 4 on the wet scrubber feed stream. Research efforts were to focus on elemental mercury reduction for bag house technology, which follows new mercury reduction technology installed on Boswell Unit 3.

Current Activity
As reported in project 1378, CMRL’s On-Line Speciated Mercury Analyzer has been linked to the pot grate induration simulator to evaluate mercury removal for Minnesota taconite operations. Successful mercury removal technologies developed at CMRL could then be tested at full scale in actual taconite operations on a single pelletizing line.

Principal Investigator(s)
David Hendrickson

Project Sponsor(s)  Amount  Account  Active
PUF Mineral Endowment  350,000  1896-783-1228-00  04/10/2007  06/30/2013

Total  $350,000

Start Date: 04/10/2007   End Date: 12/31/2012   Project ID: 1477
Environmental Remediation

Erie Pier Dredged Material Beneficial Use Study

Objective
(1) Identify landowners willing to participate in demonstration projects and receive fine grained dredged material for restoration demonstrations.
(2) Evaluate the cost and feasibility of using rail transportation to move Erie Pier fine grained dredged material to potential recipient sites.
(3) Provide monitoring and results analysis of vegetative health, plant diversity and control of purple loosestrife for demonstration sites.
(4) Evaluate the effectiveness of using microwave technology to sterilize seeds contained in Erie Pier fine grained dredged material.
(5) Conduct a laboratory and field assessment of the stamp sand area near Gay, Michigan, within the context of this location being a potential recipient site for navigation channel material from the Duluth-Superior harbor and/or Erie Pier for establishing stamp sand-stabilizing vegetative cover.

Background
The University of Minnesota Duluth Natural Resources Research Institute (NRRI) is working with the U.S. Army Corps of Engineers (COE) to evaluate beneficial use of Erie Pier fine grained sediment dredged from the Duluth-Superior harbor and stored at the Erie Pier facility located in Duluth Minnesota. The Erie Pier facility will reach its engineered design capacity within the next five years. Consequently, finding small, medium, and large-scale sites for beneficially reusing the materials stored at Erie Pier is an important goal. The current study is evaluating potential beneficial uses for the sediment within approximately a 60-90 mile radius of Erie Pier, in part as it relates to mine land usage. The project was several components that will address the objectives listed previously.

Previous Activity
Two more sediment re-use demo projects took place in 2011: 1) at the former Atlas Cement site in Gary-New Duluth, and 2) at the Northland Country Club. Two more studies were added to the overall project: 1) Microwave Treatment of Purple Loosestrife in Erie Pier Sediments, and 2) Stamp Sands from Gay, Michigan, the purpose of which is to evaluate the potential of reclaiming copper from the stamp sands. Work has begun on both.

Current Activity
Site monitoring resumed. Project planning meetings and communications continued for developing future project tasks and funding. A scope of work was submitted for additional funding support for the current project. The add-on will support activities planned for Hibtac. Additional funding is in the works for NRRI to administer for covering material transport costs. Discussions with the COE’s Duluth Area Office and potential contractors are ongoing, with the goal of arranging a back haul of byproduct Mesabi rock to the Duluth area. The project is coordinating with Tom Levar and the Minnesota Mining Cluster Biomass project. It is looking more likely that transport of material will start during late summer/early fall 2012. Another scope of work was submitted for expanded work at the Atlas Cement site. A project progress/status report is in preparation that summarizes all project activities to date.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

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Start Date: 01/24/2011       End Date: 12/31/2012       Project ID: 1612
Sediment for Biomass, Minnesota Mining Cluster - The Next Generation of Innovation

Objective
To conduct field trials of varieties of cellulosic feedstock on mineland tailings basins and other marginal lands using readily available soil amendment materials: clean sediments dredged from Duluth-Superior Harbor amended with treated municipal wastewater/biosolids. The objective is to conduct field-scale (>3-acres) research at one or more host taconite mines (or other brownfields/marginal lands location). Ultimate products will be: 1) identification of the most appropriate cellulosic feedstock species; 2) an assessment and proof-of-concept demonstration of overall waste and energy management planning and recycling in the region so long as sediment disposal challenges and mine land reclamation needs remain; and 3) energy development opportunity. Project findings would be applicable to other areas around Minnesota and the Great Lakes region, including tailings basins, gravel pits, brownfields, and other marginal lands.

Background
Marginal and unproductive mining lands, including iron mine tailings basins and stockpiles which no longer have economic mineral value to be recovered, have enormous potential to act as plantation sites for growth and production of cellulosic feedstock such as hybrid poplars and switchgrass. Large-sized basins and stockpiles and their location within active mining areas make them especially attractive targets for large-scale biomass plantation development that minimizes environmental impacts. However, the physical properties and relatively sterile nature of these sites requires adding supplemental soil-like materials and nutrients to support plant growth.

Previous Activity
This is a new project.

Current Activity
Logistical planning for moving material from Duluth Harbor to mine sites is underway. The plan of action includes four elements: Species, Site, Substrate and Spacing. The goal is to demonstrate sustainable biomass productivity from vegetation management of minelands. Focus has been on site selection and acquisition of plant materials.

1) The U.S. Steel Keetac tailings basin near Kewatin, MN, was selected and confirmed for one experimental field site. Discussions are continuing with another mining company for a second study site on the Mesabi Iron Range to complete the desired two-site design.

2) Acquisition of plant materials continued, including selection/sourcing/purchase of alder species and other shrubs from vendors. These are bareroot stock, unlike the hybrid poplar and willows which will be planted as containerized (i.e. rooted cuttings). All plant materials were delivered in the spring (bareroot stock) to be held in dark refrigeration and/or moved and temporarily planted until final deployment.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

Project Sponsor(s)
US Dept of Commerce

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Total $100,000

Start Date: 10/01/2011  End Date: 09/30/2013  Project ID: 1677
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. It was planned that a new electrical engineer at the Coleraine Minerals Research Laboratory (CMRL) would begin assembling the components for bench scale testing, and that the unit would be tested in manual mode prior to advancing to a PLC operating mode. Project work was completed for developing an automated filter cake drying system based upon housing a large-capacity scale in the base of a convection-type drying oven in order to create an automated high capacity moisture balance for measuring filter cake moisture. Filter cake samples as large 2,000 grams were analyzed to a 2-sigma accuracy of 0.02% moisture. Discussions with Minnesota taconite operations favored a more automated on-line filter cake moisture analysis system, therefore design progressed on such a unit. The planned design incorporates diversion of filter cake samples off production conveyor belts onto a weigh belt scale system equipped with banks of heaters to accomplish dynamic weighing, drying, and reweighing of the filter cake sample. New weigh belt equipment affords accurate measurement of filter cake moisture on moving belt systems. A new Permanent University Trust Fund (PUTF) project will be created to demonstrate this new advancement in technology.

Current Activity
The project has been completed and the final report is being written. Currently a Minnesota taconite operation is being sought to provide a site to install an NRRI filter cake moisture analysis system design, which incorporates diversion of filter cake off production belts to a weigh belt system equipped with banks of heaters to accomplish dynamic weighing.

Principal Investigator(s)
David Hendrickson
Kyle Bartholomew
Richard Kiesel

Project Sponsor(s) | Amount | Account | Active
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PUF Mineral Endowment | 88,800 | 1896-783-1060-00 | 02/01/2002 06/30/2011

Total | $88,800

Start Date: 02/01/2002   End Date: 12/31/2012   Project ID: 1181
Minerals, Ferrous

Coleraine Lab Standards

Objective
To establish new laboratory standard samples for regulation of standardized procedures and calibration of equipment and instrumentation.

Background
The previous lab standard was collected and prepared in 1986, and is commonly referred to as the Coleraine 9-barrel standard. Several barrels of fired pellets were collected from a local taconite plant and were screened to remove fines, resulting in nine barrels of +1/4” pellets. These pellets have served as a lab standard for almost 25 years, and we are now down to the last 5-gallon pail. Fired pellet standards are routinely run to ensure that equipment and procedures are reliable.

Previous Activity
Two fired pellet and one iron ore concentrate standard were collected and prepared as follows: 1) acid pellet, 2) flux pellet, and 3) acid concentrate. The pellets were split and blended to ensure that each barrel collected was identical and that they were representative of each other. Each barrel of pellets was then analyzed to ensure that the sample was reliable and uniform. Fired pellets were tested using ASTM, ISO and lab standardized procedures to establish an acceptable statistical mean and standard deviation. This was done for each pellet sample to establish both an acid and a flux pellet standard. Essentially the same technique and procedure were used on the iron ore concentrate. It was split, blended, mixed and analyzed using a standardized set of screens to ensure that it was uniform and reliable. Fired pellet samples were collected, split and analyzed. Baseline data were recorded, and data were analyzed for full determination of statistical mean and standard deviation. Final metallurgical quality test results for ISO 4695, Fired Pellet Reducibility (R40) were in progress. A scale bias noted on the R40 test resulted in delays to complete the testing. The equipment has been calibrated, and verification of the test parameters is being analyzed for consistency.

Current Activity
The ISO test furnaces have been calibrated and the data reporting function has been modified to accommodate the new spreadsheet format for data reports. The fired pellet sample for fluxed pellets was found to contain too much variability to be established as a lab standard. An additional sample will be collected, blended, representatively split and tested. ISO furnace testing for the acid pellet sample is in progress.

Principal Investigator(s)
Richard Kiesel

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Total $47,000

Start Date: 11/19/2010   End Date: 12/31/2012   Project ID: 1636
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 Program Director, Dr. E. Caner Orhan, began work at the Center during March 2010. It was planned that he would be introduced to the Center's version of USIM PAC and to taconite industry contacts. It was necessary for him to become familiar with the Center's previous work so that he would be able to demonstrate proficiency in modeling the various concentrators on the Iron Range. 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. Work began on well-known and robust equipment models that had not previously been included in USIM PAC, to integrate them into the software. This would enable re-evaluation and cross-checking of predictions made by USIM PAC's built-in models. New concentrator models were developed for new, potential magnetite ore mining operations. Dr. Orhan left the University of Minnesota in February 2011 and returned to Hacetteppe University in Ankara, Turkey.

Current Activity
The concentrator modeling center is being advanced by CMRL’s Mineral Processing Acting Deputy Director. The Deputy Director has previously conducted concentrator modeling work using USIMPAC modeling software. Models are being developed to improve concentrator circuit performance for Minnesota taconite operations and other iron ore operations in North America.

Principal Investigator(s)
David Hendrickson
Kyle Bartholomew

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Start Date: 07/16/2006      End Date: 12/31/2012      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 MetalRecovery, sited at the Coleraine Minerals Research Laboratory (CMRL), and tile formation and annealing in other equipment at the same site, also provided by MetalRecovery.

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
Coal boiler fly ash and bottom ash were used as alternative fluxes for the taconite tailings. Melting of taconite tailings with the plasma furnace was continued at CMRL for research and development of both solar and non-solar tile purposes. Differing melting techniques, feed mixes, and tile shapes were researched for future commercial application. Tile slumping occurred from previously manufactured pieces. A large number of small-scale pours were also conducted to allow for greater flexibility of input parameters and speed of testing. New feed additions included granite and autocatalysts.

Current Activity
NRRI provided continued technical support and analytical services to the startup venture, Accents Elegance, as they work toward commercial production of consumer products using the taconite tailings materials and processing methods developed as part of this project.

Principal Investigator(s)
David Hendrickson
Donald Fosnacht
Kyle Bartholomew
Lawrence Zanko
Matthew Mlinar
Richard Kiesel

Project Sponsor(s)  | Amount  | Account  | Active
--- | --- | --- | ---
PUF Mineral Endowment | 284,396 | 1896-783-1241-00 | 04/28/2008 06/30/2013
Total | $284,396 |

Start Date: 04/28/2008  |  End Date: 12/31/2012  |  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
Data analysis for quenching of fired pellets using halogenated water 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 effects of fluorine and chlorine on agglomeration was planned. Greenballs were to be prepared with varying levels of halogen concentration in the balling water. Minipot firings would be used to determine if a measurable effect on physical pellet quality is detectable. Statistical analysis, using z-score as a discriminator, was performed on halide data. A fully replicated designed experiment allowed for an estimation of test variability. Variability was low enough to allow for screening-level conclusions. Agglomeration and firing tests were scheduled.

Current Activity
No further work has been completed on this project. The agglomeration and fired pellet testwork will be completed in the second half of 2012. Greenballs will be prepared with process water doped with levels of flourine and chlorine containing compounds to determine any influence on green agglomerate strength and fired pellet quality.

Principal Investigator(s)
Kyle Bartholomew
Richard Kiesel

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Start Date: 06/01/2003    End Date: 12/31/2012    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 (600-800ºC). The CO2 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; 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. The NRRI-Coleraine Pot Grate Furnace was upgraded with a new combustion system and blower, PLC (Programmable Logic Controller) control, PC-based data collection, flow control/measurement for natural gas, airflow, and oxygen, digital pressure and oxygen measurement, and full temperature recording capabilities.

Current Activity
Both mini-pot and full pot grate furnace testing are complete. Preheat firing temperature was increased 50 F to simulate the addition of preheat burners. Results were compared to a standard baseline cycle. Increasing preheat temperature in mini-pot tests with the low-level limestone addition shows a significant increase in fired pellet compression, with less of an influence on the high level addition rate. Further data analysis on pot grate test results and a full report are in progress.

Principal Investigator(s)
Richard Kiesel

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Start Date: 02/09/2005    End Date: 12/31/2012    Project ID: 1391
Environmental Study of Airborne Particulates on the Mesabi Iron Range, Northeast Minnesota

Objective

To characterize particulates associated with 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

From July-December 2011, laboratory analysis of particulates continued, utilizing transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and electron back scatter diffraction (EBSD), as did analysis of lake sediment samples. Quality control evaluations of laboratory datasets continued. A GIS-compatible database with these results was developed and continues to be modified. Report writing and revising continued, and the development of a communications plan was initiated.

Current Activity

From January to June 2012, laboratory analysis of particulates using TEM, SEM, EDS, and EBSD continued, as did lake sediment sample analysis. Quality control evaluations of laboratory datasets was nearly completed. Additional side-by-side testing of the micro-orifice uniform dispersion impactors took place at the University of Minnesota Department of Mechanical Engineering. Report writing and revising continued.

Principal Investigator(s)

George Hudak
Steven Hauck

Project Sponsor(s)  

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Start Date: 07/01/2008   End Date: 12/31/2012   Project ID: 1539
Objective
To: (1) produce a geological resource estimate of the oxidized taconite ore in the area of the Canisteo, Danube, Morrison, Walker, Fletcher, Hunner, King, Jennison, and Buckeeye mines (Sections 25, 36, R25W, T56N and Sections 20, 29, 30, 31, R24W, T56N) in Itasca County, and (2) make the data available in a Geographical Information System (GIS) format that can be used by industry, Itasca County, the State of Minnesota, and local towns and townships for use in future land-use planning.

Background
A current Permanent University Trust Fund (PUTF) project is compiling data on the Judd, Sally, Plummer, Holman-Cliffs, Homestead, Diamond, and Arcturus mine areas located northeast of this proposed study area. Approximately 20 to 30 years ago, there was a great deal of activity aimed at determining the occurrence and quantity of oxidized taconite in both Minnesota and Michigan, as well as evaluating alternative schemes for its exploitation. Currently, there is no mining on the western end of the Mesabi Iron Range in Itasca County, but there has been and are many other uses, i.e., boating, water resource management, other construction, that will directly affect the availability of these oxidized ores in the future. These oxidized taconite, or non-magnetic ore reserves, could become economically beneficial in the future with new mineral processing and mining techniques and with lower stripping and blasting costs. The study will provide these data in a GIS format to local, county, and state agencies that are involved with land-use issues and will allow them to become more aware of the mining potential of the area. Thus, it is hoped that these various entities will use the data to make informed land-use decisions for the western Mesabi Iron Range.

Previous Activity
No work was done on this project due to commitments to complete other projects.

Current Activity
Final processing and modeling of the data are being conducted to finish this project and final report.

Principal Investigator(s)
Steven Hauck

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Start Date: 07/01/2000    End Date: 12/31/2012    Project ID: 962
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 number of state and federal grant proposals were written and submitted. Grant funding was received from the 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), the U.S. Dept. of Energy (DOE), and the MN-DNR/Iron Ore Co-Op. A number of new contacts were established in order to submit grants from a collaborative of research organizations and corporate research groups.

Current Activity
A number of Federal, State, University, and International grant proposals were submitted to gain future research funding in the areas of mineral processing, pyrometallurgy, environmental remediation, and renewable energy. NRRI received $800,000 in research funding from the Department of Commerce’s Economic Development Agency to advance mineral development in Minnesota by developing a Mining Cluster for the U.S. New searches are being conducted to seek additional grant funding on a national and international basis.

Principal Investigator(s)
Andriy Khotkevych
Dave Englund
David Hendrickson
Kyle Bartholomew
Matthew Mlinar
Richard Kiesel

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Start Date: 02/09/2005   End Date: 12/31/2012   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
The new PI directing our Concentrating Modeling Center has initiated work on advancing the current hydroseparator model in USIMPAC concentrator modeling software to make it apply in our Minnesota taconite flowsheets.

Current Activity
The new PI who will be advancing work for our Concentrator Modeling Center is Kyle Bartholomew. He plans to order a USIMPAC software developers kit and license to be able to construct new concentrator models. The new models will be useful to Minnesota taconite operations to evaluate the operating efficiency of their concentrator unit processing circuits. For hydroseparator modeling, new models will be developed to incorporate the ability to add magnetic fields to feed slurries, as well as particle liberation data. Hydroseparator modeling work conducted by the previous PI will soon be finished and entered into USIMPAC software. Dr. Salih Ersayin will be contacted as a consultant, since he conducted the previous modeling work. Minnesota taconite groups will be contacted to see what new programing work is required, and a paper on our existing models will be presented at the upcoming Duluth SME meeting in April 2013.

Principal Investigator(s)
David Hendrickson
Kyle Bartholomew

Project Sponsor(s)

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Start Date: 02/09/2005    End Date: 12/31/2012    Project ID: 1379
Investigate Ideas for Further Processing of Taconite Coarse Tailings at the Plant Before Haulage and Stockpiling

Objective
NRRI Duluth and Coleraine will work with each taconite facility to assess how and where coarse taconite tailings are produced in the facility’s flow sheet, and to determine if simple physical methods can be used to efficiently, cost-effectively recover one or more gradations from the process stream cost-effectively. Proposed work would include: 1) taconite plant visit and flow sheet evaluation; 2) development of sample collection/recovery strategy; 3) collect sufficient sample for physical, chemical, and mineralogical characterization; 4) suggest possible recovery methods; 5) estimate cost and benefit of implementing recovery methods; 6) summarize results and produce a final report of investigation.

Background
Based on its taconite aggregate investigations to date, the NRRI feels there is an excellent opportunity for generating value-added products on a modest scale at taconite facilities that make use of the full gradation spectrum of taconite coarse tailings. For example, plants that use spiral classifiers to separate fine and coarse tailings are already doing much of what a commercial aggregate washing/screening plant does to recover aggregate products like sealcoat chips, which are a premium-value aggregate product. Depending on the gradation, such products can sell for $15 to $20 per ton, FOB producer. Some specialty friction products, when dried and bagged, can sell for considerably greater amounts, e.g., over $150 per ton.

Previous Activity
Investigation showed that it would take considerable effort and cost to implement a system to recover size-bracketed coarse tailings fractions at their point of generation, especially within taconite plants. An in-plant recovery system would be better suited for designing into a new operation’s process flow-sheet prior to construction, rather than retrofitting an existing one; space constraints and potential disruption of operations would pose challenges. Field sampling conducted by NRRI outside of a taconite facility, however, suggests that selective recovery – e.g., at a tailings basin discharge point – might be a simpler, more flexible, cost-effective alternative. This project also evaluated physical and mineralogical/microscopic properties of the tailings. A final report was in preparation, and should be completed in early 2012.

Current Activity
Due to other current and competing project commitments, completion of the final report was delayed. The final report is expected to be completed in the second half of 2012.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

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Start Date: 05/01/2010  End Date: 12/31/2012  Project ID: 1618
**Paired Straight Hearth Furnace Simulation**

**Objective**
To design and construct a furnace with electrical heating, capable of achieving 1600 degrees C in each of two separate zones to accommodate a deep bed of pellets (nominal 120 mm height) and produce Direct Reduced Iron (DRI) under conditions prescribed by the American Iron & Steel Institute (AISI).

**Background**
CMRL will conduct a study for the AISI Paired Straight Hearth (PSH) Furnace Project to evaluate and assess the quality of Direct Reduced Iron (DRI) pellets achieved from deep bed roasting of green agglomerates in a specifically designed furnace to simulate the PSH process. This program is required to understand the heat transfer and kinetic characteristics for metallization in a tall bed for the design and construction of a pilot plant for the potential commercialization of PSH technology. The proposal is submitted in two parts: 1) design and fabrication of the DRI furnace and 2) production and quality assessment of deep bed produced DRI pellets. Objectives of these tests are to produce DRI pellets with characteristics more closely related to the proposed commercial furnace and to evaluate pellet volume and quality as it transitions the bed.

**Previous Activity**
Furnace design was finalized in agreement with AISI and their associated industrial partners for testing the PSH Furnace process. The furnace was then constructed according to the design agreed upon. Furnace installation then took place, and the exhaust and relevant utilities have been properly connected. Refractory curing, hot commissioning and acquisition of raw materials was in progress. Green balls were to be prepared according to the mix specification provided by AISI, using magnetite concentrate and a high volatile bituminous coal for subsequent testing.

**Current Activity**
The initial phase of the deep bed Direct Reduced Iron (DRI) Pelletizing Study for American Iron and Steel Institute (AISI) Paired Straight Hearth (PSH) Furnace project is complete. The project was expanded to include 10 additional tests, with green balls prepared with a bentonite binder. That testing is nearly complete. Final data collection and the final report are in progress. The reporting deliverables include temperature and gas profiling for each 70-minute run, chemical analysis of the pellets, and three-dimensional shrinkage of the sample within the sample crucible.

**Principal Investigator(s)**
Richard Kiesel

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**Start Date:** 11/30/2010  **End Date:** 12/31/2012  **Project ID:** 1641
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
All project tasks were completed by the end of 2011, and a draft final report was prepared. The final report is in prep and will be completed in early 2012, and will represent a collaborative effort from all three project lead organizations: NRRI, MnDOT, and UM-CE.

Results suggest that taconite-based thin lift HMA mixes that also incorporate RAP should be recognized as an environmentally sound and high-quality option for HMA pavement rehabilitation and preservation.

Current Activity
A final technical report, NRRI/TR-2012/04, was submitted to FHWA. The investigators conclude that taconite-based thin lift HMA mixes that also incorporate RAP should be recognized as an environmentally sound and high-quality option for HMA pavement rehabilitation and preservation. Collectively, the material testing results suggest that thinner wear-course pavements made from appropriately designed taconite-based mixes can match or exceed the service life of conventional MnDOT Level 4 mixtures. If extended service life is realized, then taconite fine aggregate could be a cost-effective choice at end-user locations where high-quality local aggregate sources are lacking or absent. These enhanced performance attributes can add intrinsic value to taconite materials and make them more desirable to use and more cost-effective to transport over longer distances, thereby improving and broadening their near- and long-term potential for regional and national highway infrastructure projects.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

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Total $120,000

Start Date: 09/25/2009 End Date: 06/30/2012 Project ID: 1579
Recovery of Iron Values from Lean Ore Stockpiles from Past Mining Activities in the MMC, Minnesota Mining Cluster - The Next Generation of Innovation

Objective
To conduct research regarding recovery of iron values from lean ore stockpiles remaining from past mining activities in the Minnesota Mining Cluster (MMC) area.

Background
MMC has been producing iron ore for over 100 years. Over this period, piles of “lean ore” containing from 27% to 50% iron have been generated and stockpiled across the TAA (Taconite Assistance Area). The Minnesota DNR has tracked the generation of these stockpiles and tonnages on public lands that will soon be made available. In addition, significant volumes of material are also held by private interests across the TAA. This represents an enormous underutilized iron resource that has great value under current iron ore market conditions. Preliminary testing of this resource indicates that substantial amounts of magnetic taconite can be recovered through new processing. Potential world-wide markets exist for this upgraded material, and the processor network existing within the MMC could be utilized to recover this iron and market the products once the technology is fully proven.

Previous Activity
This is a new project.

Current Activity
From the time period January 1 through June 30, 2012, the Coleraine Minerals Research Laboratory (CMRL) worked with a sonic-drilling method contractor to obtain drillcore samples from a lean ore stockpile located north and west of Nashwauk, MN. In March 2012, the drilling contractor collected mostly 4-inch and some 6-inch drillcore samples from four different drillholes spaced throughout the lean ore stockpile. The total depth drilled was 270 feet, and the amount of drillcore recovered for processing and analysis at CMRL was 120 feet. During April and May 2012, core samples from the four drillholes were characterized by visual and chemical analysis methods. An NRRI geologist recorded visual and handheld magnetic susceptibility meter results for each 4-ft core box interval collected. In June 2012, characterization work continued on the individual core interval samples from drillholes 3 and 4. Each core interval sample was dried and then split in half. One half was saved "As-Is," and the other half was crushed using a bench scale jaw crusher followed by a gyratory crusher, to pass 6-mesh size. A sample of the minus 6-mesh from each core interval was submitted to the CMRL Chem Lab for Total Iron (Fe) analysis. Additional work in June 2012 was performed with the 10- to 22.5-ft core interval from drillhole 3. The minus 6-mesh sample from this core interval was used to establish operator settings for the bench scale Eriez High Intensity Magnetic Separtor (HIMS) and for the Carpco HIMS for future core sample tests.

Principal Investigator(s)
David Hendrickson
Paul Mack

Project Sponsor(s)                      Amount     Account                   Active
US Dept of Commerce                   124,999     3002-10417-00028241         10/01/2011  09/30/2013
PUF Mineral Endowment                 125,000     1750-10417-20090-000282    10/01/2011  09/30/2013

Total                                  $249,999

Start Date: 10/01/2011    End Date: 09/30/2013    Project ID: 1684
Objective
To document the detailed stratigraphy of the Biwabik Iron Formation (BIF) with regard to bedding type changes in the various iron-formation submembers, and to document the effects of metamorphism by the Duluth Complex in order to spatially establish more up-to-date lines that separate specific metamorphic zones.

Background
There are very few publicly-available drill cores of the Biwabik Iron Formation (BIF) from the eastern Mesabi Iron Range. While this area has been extensively drilled by the mining companies, there are only four holes that are available to the public. However, the core from 68 drill holes (over 20,000 feet of core drilled by United States Steel Corp.) from this same area has recently been obtained from the RGGS Land Company in Virginia, MN. This core will be used to conduct a detailed stratigraphic study of the BIF, as well as a study of the metamorphic effects to the BIF by the nearby Duluth Complex.

Previous Activity
Two cargo containers and appropriate shelving were purchased. Core was moved from the Virginia, Minnesota, RGGS office to NRRI in Duluth. Drill core logging has been initiated by John Heine and Marsha Patelke. An understanding of the ELFs (Elongated (mineral) Fragments), both horizontally and vertically away from the Duluth Complex, has implications relative to which mined units should be avoided for health-related reasons, and which of the mined waste units could be utilized for potential aggregate materials due to a lack of ELFs.

Current Activity
Two of the RGGS holes have been logged by Patelke and Heine. A drill hole (17700) with known metamorphic minerals was reviewed to establish criteria for recognizing the various metamorphic minerals. This hole is stored at the drill core library of the Minnesota Department of Natural Resources in Hibbing, MN.

Principal Investigator(s)
Mark Severson
Steven Hauck

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Start Date: 12/22/2010       End Date: 12/31/2012       Project ID: 1669
**Minerals, Ferrous**

**Sinter Mix Permeability Test**

**Objective**
To develop a bed permeability measurement device and test procedure for measurement of bed permeability in granulated beds and sinter mixes.

**Background**
Bed permeability is critical to efficient sintering in the steel industry. Sinter pot firing can be minimized (# tests) if granulation for optimum permeability can be established using smaller quantities of material, prior to firing pots. If the total number of pots fired is reduced, sinter programs benefit the client with reduced cost to achieve desired goals in their programs.

**Previous Activity**
Two permeability containers were made and are operational. One is 6” dia x 16” deep, and the other is 3” dia x 8” deep. Both units have been tested and a basic procedure is in place. The advantage of the smaller unit is that it has a shorter test time and less sample is consumed. The larger unit requires 30 lbs of mix, while the small unit requires about 5 lbs of mix. Several test series have been performed. The test appears capable of relating bed permeability through air flow to binder and moisture additions, permitting an optimum set of mix conditions to be defined for maximum airflow. A 3” x 20” cell was fabricated to test deeper beds. Results were recorded but have not yet been analyzed. This project is awaiting additional funding. One interesting point to note is that optimum air flow appears to occur at moisture levels that are too high for sinter beds. This is attributed to the fact that the permeability cell can measure air flow as a function of bed resistance, but does not replicate condensation in the bed that occurs during normal firing conditions. It is anticipated that a correlation can be developed in the future relating optimum permeability moisture to optimum sinter bed moisture.

**Current Activity**
A sinter mix permeability measurement test was developed and used to evaluate two sinter mix blends and two granulation methods. The test was used to distinguish between bed characteristics resulting from moisture and mix composition changes. Two granulation methods were used, an 18-inch balling disc and the standard sinter granulation drum. There were some differences between granulation methods, disc vs. drum. Using the drum has the advantage of being consistent with sinter pot trials. The permeability test is an evaluation of bed void fraction, resistance to flow and granule properties. Knowledge of the relationship between Japanese Permeability Unit (JPU) and moisture content is helpful in determining optimum moisture contents. A final report has been issued. A follow-up program was recommended to evaluate more sinter blends which would demonstrate test sensitivity to blend composition.

**Principal Investigator(s)**
Dave Englund

**Project Sponsor(s)**

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**Start Date:** 10/27/2010  **End Date:** 06/30/2012  **Project ID:** 1637
Systematic Survey & Characterization of Amphibole

Objective
The objective of this project is to physically, mineralogically, and chemically characterize amphibole and phyllosilicate minerals that may become airborne particulates during processing of potential Duluth Complex ores and associated waste rocks. This will be accomplished by scientific evaluations utilizing a wide variety of techniques including petrography, scanning electron microscopy, and transmission electron microscopy.

Background
Ongoing and potential future activities involving mining Duluth Complex ore and associated waste rocks requires a need to identify and characterize elongate particles of silicate minerals that may become airborne as fine particulates. Exposure to elongate mineral particles of phyllosilicate and inosilicates (in particular, asbestiform amphiboles) have been historically linked to lung disease. Late stage deuteric alteration of the mafic minerals (for example, pyroxene and olivine) of the Duluth Complex has produced hydrous secondary amphibole and phyllosilicate minerals in the rock. At the present time, the detailed mineralogy, mineral chemistry, and mineral morphologies of these minerals are not well defined.

Previous Activity
Petrographic studies have been completed and are currently being compiled. Results from the MLA analyses have been received and are currently being compiled and evaluated. Elutriation analysis results are pending.

Current Activity
Elutriation results have been received. MLA analyses continue to be evaluated. Databases have been and continue to be updated with newly obtained data. Report writing has commenced.

Principal Investigator(s)
George Hudak
Mark Severson
Stephen Monson Geerts
Steven Hauck

Project Sponsor(s)  Amount  Account  Active
MN Department of Natural Resources  102,000  3005-10416-00014315  02/19/2010  06/30/2011

Total  $102,000

Start Date: 02/19/2010  End Date: 12/31/2012  Project ID: 1613
Objective
To evaluate the low-grade stockpiled hematite ore and hematite tailings available from past mining operations on the Mesabi Iron Range, and to ascertain the ability to upgrade the iron in the ore and tailings for production of value-added iron products from these materials.

Background
Millions of tons of hematite low-grade ore stockpiles and coarse tailing material containing 35-40% iron are available from iron ore plants that operated in past decades on the Mesabi Iron Range. Since these ores and tailings are already crushed and ground to a size which can be used directly in mineral processing concentrator flowsheets, operating costs are minimal to turn these low-grade materials into value-added hematite concentrates containing 65-66% iron and 4-5% silica. Flowsheets need to be developed to attract corporate operators to build low-cost concentrating facilities in northeastern Minnesota to recover these valuable iron resources.

Previous Activity
Several lean ore stockpiles in northeastern Minnesota on the Mesabi Iron Range have been sampled on a preliminary basis to gain experience in the type of processing required to upgrade the iron units to an acceptable grade for use in Minnesota taconite operations. One lean ore stockpile near Nashwauk, MN, has been chosen to act as a representative unit, which will be drilled to gain quantitative data to describe the ore types found in the pile as well as the iron distribution throughout the pile. Sonic drilling was scheduled to commence the week of March 19, 2012. Drill core samples were to be brought back to Coleraine for analysis and mineral evaluation.

Current Activity
In order to evaluate iron upgrading techniques, representative lean ore stockpile samples were taken by drilling the piles using sonic drilling techniques. Major Drilling, a Minnesota-based drilling company, was commissioned to drill lean ore stockpiles from a western Mesabi Iron Range location near Nashwauk, MN, and an eastern Mesabi Iron Range location near Hoyt Lakes, MN. Drill core samples from these two locations were brought back to the Coleraine Minerals Research Laboratory for analysis. The two Iron Range locations provide quite different ore types. The western location contained primarily hematite ore with a smaller portion of magnetite, while the eastern location contained primarily magnetite ore. Samples containing hematite ore are being evaluated using wet and dry high intensity magnetic separation, flotation, and magnetic roasting techniques to upgrade the iron content. Samples containing magnetite are being evaluated using low intensity magnetic separation and flotation to upgrade the iron content.

Principal Investigator(s)
David Hendrickson
Paul Mack

Project Sponsor(s)  Amount  Account  Active
PUF Mineral Endowment  125,000  1750-10417-20090-100001  02/19/2011  06/30/2013

Total  $125,000

Start Date: 02/19/2011  End Date: 12/31/2012  Project ID: 1638
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
Successful adjustments were made to the formulation, allowing the licensee to proceed with preparing pallet-sized batches for field trial usage by MnDOT and others. In September of 2011, the licensee participated in a main-line (I-94) field installation at MnDOT’s MnROAD facility, and had good success with mechanized mixing of larger batches of the repair compound. UMD student and NRRI employee, Will DeRocher, observed the installations. NRRI continued to facilitate interactions between the licensee and potential long-term suppliers of taconite materials. Expanded field trials will continue into 2012.

Current Activity
Significant progress was made on making beneficial adjustments to the formulation, confirmed by laboratory testing conducted by Will DeRocher. Further testing and field trial evaluations will take place during the summer of 2012 via a new project funded by the Center for Transportation Studies/MnDOT.

Principal Investigator(s)
Donald Fosnacht
Lawrence Zanko
Steven Hauck

Project Sponsor(s)  

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Total $1,976,000

Start Date: 07/01/1999  End Date: 04/30/2014  Project ID: 1392
Objective
The program will focus on near-term implementation projects that introduce aggregate materials to targeted markets in project-sized quantities, value-added commercialization opportunities, and promising avenues of taconite-based applied research. The program includes:
• Conducting an accelerated aggregate material qualification/certification program;
• Development and deployment of mix and pavement designs using high quality taconite aggregate materials in their upper wear courses; • Production of value-added products derived from coarse taconite tailings, such as high friction bridge deck and airport runway surfacing aggregates; • Further development and implementation of innovative concepts, products and technologies such as: taconite-based pothole/paving compounds and pursuing microwave-based technologies for all-season pothole and pavement repair; energy-absorbing materials for possible defense applications; and UV, solar, and geothermal heating and energy storage. This project area is highly dependent on private sector/private sector and private sector/public sector interactions, negotiations, and timetables. Collaboration with private and public sectors at local, state, and national levels will be a key for implementing these activities and leveraging project resources.

Background
Construction materials and value-added aggregate by-products and co-products from mining have potential for economic development and immediate job creation in Northeastern Minnesota. Expanding the use of (and deriving value from) these byproduct and co-product materials is one leg of a three-legged strategy for long-term economic stability and competitiveness of iron ore mining and steel-making industries. This strategy also contributes to sustainability in that it maximizes resource utilization while contributing to reduced energy consumption.

Previous Activity
This is a new project.

Current Activity
The following areas/activities are being investigated/pursued by NRRI: (1) Value-added friction aggregates: NRRI continues to work closely with a local entrepreneur whose goal is to become a specialty friction product supplier for regional and national paving needs, as well as a producer of other sized specialty products. The production facility would be located near the taconite byproduct sources on Minnesota’s Mesabi Iron Range. The entrepreneur has begun ordering equipment. (2) Pavement repair materials and technologies: Development and testing of products (road repair compounds) and technologies (e.g., microwave) are underway. (3) Cement manufacturing: Laboratory testing has shown that taconite tailings would work as a raw material replacement for several cement makers on the Great Lakes. Discussions continue regarding next steps and potential scale-up of testing. (4) Frac sand potential: Preliminary testing has been performed. (5) Other product development: Interest has been shown in two different value-added products that require silica.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

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Start Date: 10/01/2011    End Date: 09/30/2013    Project ID: 1674
Comparative Performance Study of Chip Seal & Bonded Wear Course Systems Applied to Bridge Decks and Approaches

Objective
To provide a comparative evaluation of the performance of several polymeric chip seal (PCS) and ultra-thin bonded wear courses (UTBWC) applied to bridge decks, including sealing and corrosion protection attributes afforded to the deck, as well as improved safety due to increased friction and retention of deicing chemicals as provided by the overlayer. Yearly reports and a final report summarizing this comparative evaluation will be the products of this work.

Background
Recent development and commercialization of various polymeric chip seal and ultra-thin bonded wear courses poses several key questions with respect to the widespread application of these to bridge deck surfaces. Choices must be made among those available in the absence of data allowing for sound comparative assessment. Primary concerns focus on the following performance characteristics: 1) Materials quality and performance quality of materials in a given system, including both the sealing material (e.g. polymer in a PCS system) and the aggregate component; 2) Skid resistance afforded by the overlay system, evaluated by friction measurement over the first few years of service life; 3) Improved safety provided by higher friction as manifested in accident reduction at the application sites; 4) Effectiveness of the sealing component to reduce or eliminate chloride ingress into the deck as a consequence of the use of deicing chemicals; 5) Examination of issues relating to moisture trapping at the seal coat/concrete interface which may cause premature degradation of the concrete, and; 6) Cost/Benefit considerations as related to the above.

Previous Activity
The project was put on hold in the second half of 2011. The former project PI (from UMD) withdrew from the project, and NRRI recommended that a new PI (Prof. Eshan Dave) from UMD's Department of Civil Engineering take over the project. Discussions between UMD, NRRI, and MnDOT took place in late 2011, with agreement that a revised/amended project work plan and timetable would be submitted to MnDOT in early 2012.

Current Activity
Following further discussions and meetings with MnDOT in early 2012, a revised/amended project work plan and timetable were submitted to MnDOT in April, and were approved. A project planning meeting took place at NRRI with Prof. Eshan Dave on May 23. NRRI activities will continue through the summer and fall, some of which will be coordinated with Prof. Dave.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

Project Sponsor(s)
MN Department of Transportation

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Total $31,790

Start Date: 07/08/2010      End Date: 12/31/2012      Project ID: 1616
Modification of the NRRI Pellet Fines Removal System to Provide More Durable Wear Parts to Improve the Physical Availability of the Unit to Minnesota Taconite Operations

Objective
To provide improved wear parts for the NRRI pellet fines removal system (FRS) to allow the belt to be operated at feed rates of 300-350 tons per hour, 24 hrs per day, to remove pellet fines and chips without needing to replace chevron lifter bars on the belt surface for at least 3-month intervals.

Background
An NRRI pellet fines removal system was previously developed at CMRL, which efficiently removed taconite pellet fines and pellet chips without using vibrating screen components. The pilot scale apparatus was scaled up into a full-scale operating unit, which was mounted on a trailer that could be transported to Minnesota taconite operations or blast furnace steel plant operations for full-scale testing. Tests were initially run at a Minnesota taconite operation, and results showed excellent separation of pellet fines and chips from whole pellets. Chevron-shaped rubber lifters fastened to the flat belt surface were key to the separation process. However, they exhibited excessive abrasive wear, requiring replacement after every 25,000 tons of pellet processing. Tests were run on a variety of high wear resistant materials, which showed that chevrons made of AR400 steel gave the least abrasive wear from the pellets. This is a continuation of previous work reported under Project Tracking #1309, PUTF Fines Removal System.

Previous Activity
New AR400 lifters were bolted up through the rubber belt to hold them securely using Flexco conveyor belt clips. Once the older rubber chevron lifters were replaced with the new AR400 steel chevron lifters, taconite pellet fines removal tests were to be conducted at a Minnesota taconite operation to prove the wear capability of the new chevron design, to prove the new design of the carrying belt wheels, and to measure the efficiency of pellet fines removal at pellet feed rates of 300-350 tph. Tests were run at one of the operating Minnesota taconite facilities, with results showing greater than 90% removal of minus 1/4-inch fines from pellet feeds. NRRI began working with an international conveyor belt manufacturer located in Minnesota to establish a manufacturing and marketing group responsible for selling the NRRI-designed Pellet Fines Removal System to worldwide markets.

Current Activity
A number of modifications have been completed on the NRRI Pellet Fines Removal System. Wear resistant AR400 steel chevrons have been installed across the entire width and length of the 4-foot wide by 26-foot long Flexowall conveyor. Four urethane-coated belt-carrying wheels have also been installed to support the return belt under the system. A cylindrical rubber chute has been installed at the top of the conveyor to contain the fines being removed from the pellets and to deliver them to the ground. Additionally, a small conveyor belt is being installed under the belt to carry away fines discharged off the return belt. The NRRI FRS will be tested at a Minnesota taconite operation to evaluate design modifications at a pellet feed rate of 350 tons per hour in the fall of 2012.

Principal Investigator(s)
David Hendrickson
Richard Kiesel

Project Sponsor(s)  Amount  Account  Active
PUF Mineral Endowment  52,335  1750-10417-20090-100001  08/25/2010  06/30/2013

Total  $52,335

Start Date: 08/25/2010  End Date: 12/31/2012  Project ID: 1633
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 Keweenawan-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
Polished thin sections (28) have been reviewed, and the abundance of poikilitic olivine in the majority of the rocks was poorly underestimated during mapping. However, this only affects the name given to the rock in the field and will be corrected in the final report. The economic potential of the Cloquet Lake intrusion remains low, based solely on the limited rock outcrops found and sampled during the field season. These data suggest that any Cu-Ni-PGE targets within the intrusion will be based on either geophysical criteria or on glacial till sampling results.

Current Activity
Writing of the first draft has been initiated. No new conclusions have been reached.

Principal Investigator(s)
Mark Severson
Steven Hauck

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Start Date: 09/01/2004   End Date: 12/31/2012   Project ID: 1358
Objective
To 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., oxide fraction, and identify 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.

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 identify 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
The final report was expected to be completed in early 2012.

Current Activity
Summaries of both wet hi-intensity magnetic separation (WHIMS) and mineralogical analyses follow: WHIMS showed that separation is not sufficient to recommend WHIMS as a method to concentrate olivine from copper-nickel flotation tailings. Six samples of Duluth Complex tailings were examined to determine general mineralogy. All six samples have similar bulk mineralogy, consisting of plagioclase feldspar, olivine, pyroxene and sheet silicates. Scanning Electron Microscopy (SEM) showed additional oxide and sulfide mineral phases. Due to current and competing project commitments, completion of the final report was delayed. The final report is expected to be completed in the second half of 2012.

Principal Investigator(s)
Lawrence Zanko
Steven Hauck

Project Sponsor(s) | Amount | Account | Active
--- | --- | --- | ---
MN Department of Natural Resources | 15,000 | 3005-10416-00014395 | 07/08/2010 06/30/2011
PUF Mineral Endowment | 15,000 | 1750-10416-2090-100000 | 09/25/2009 06/30/2013
Total | $30,000 | | 

Start Date: 09/25/2009   End Date: 12/31/2012   Project ID: 1577
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
To date, the data indicate a large diffuse train of total gold grains strongest in northern and central Minnesota, decreasing to the south. When viewed in conjunction with the pristine and modified gold data, both of which are associated with materials closer to the origin of the gold, we see a more defined pattern in north-central and east-central Minnesota. Silver has a pattern similar to the total gold grains, which makes it difficult to use these indicators for locating source areas. Both pristine and modified gold grains seem to be more useful for that purpose. The 63-micron fraction geochemistry has a number of anomalies, which are associated with known mineral occurrences. Copper, nickel, palladium, and, to a lesser extent cobalt, chromium and gallium, anomalies are associated with areas of known Volcanogenic Massive Sulfide (VMS) and Duluth Complex mineralization. Zinc shows a stronger affinity for the VMS terranes, while titanium is more closely associated with the Duluth Complex. There is a moderate manganese anomaly associated with the manganese occurrences in the Emily District of the Cuyuna Range. Work is progressing on the final report.

Principal Investigator(s)
John Heine
Steven Hauck

Account

Project Sponsor(s) | Amount | Account | Active
--- | --- | --- | ---
MN Department of Natural Resources | 74,700 | 1663-187-6586-00 | 08/10/2006 06/30/2008
PUF Mineral Endowment | 95,000 | 1896-783-1223-00 | 07/16/2006 06/30/2010
**Total** | **$169,700**

Start Date: 08/10/2006   End Date: 12/31/2012   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 (SG). While performance was promising, the previous researcher was concerned regarding clogging of the heavy mineral discharge hardware. Existing magnetic separators are designed to remove magnetite out of the tailings stream, while sending both liberated magnetite and middlings on to further processing, but they don't separate pure magnetite away from the middlings. However, if this can be done with a Falcon, the combination of devices could produce a returning mill feed stream consisting of middlings. As the net mill feed tonnage is reduced, 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
The Falcon increased the SG of each size fraction presented. Integration into existing flowsheets requires addition of a size separation: the high SG discharge stream contains liberated, fine magnetite and unliberated coarse particles; 22% of feed to the unit reported as high SG, and over 23% of this stream assayed at below 5% silica. Removing fine liberated material from the circulating load in the ball mill circuit increases circuit capacity and reduces overgrinding. Circuit modeling could estimate grinding circuit capacity increases that may be attainable. Test results showed that the Falcon concentrator units could be used as a final concentrating step in Minnesota taconite operations. However, capital costs for the number of units required on each concentrator mill line would not make the technology worthwhile as compared to a final screening step.

Current Activity
Work continues on assembling data and developing a final report from the Falcon Concentrator investigations conducted by former PI Tom Larson.

Principal Investigator(s)
Kyle Bartholomew

Project Sponsor(s)          Amount  Account          Active
PUF Mineral Endowment         40,000  1896-783-1208-00  02/09/2005  06/30/2006

Total                     $40,000

Start Date: 02/09/2005      End Date: 12/31/2012      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
The second draft is currently being edited, and the finalized report should be available to the public in approximately March 2012. Several more items regarding private data, that were never turned in to the state, were obtained during the report period and will be included with the final report. One item of particular interest showed that gold grains are abundant in the till in the Wilson Lake area of Itasca County. These data, coupled with ongoing drilling to the southwest of Wilson Lake (at Lost Lake) suggest that there is a good potential for locating a gold deposit, associated with an Archean iron-formation trend, in northwestern Itasca County. Historical data also strongly suggest that the trace of the Vermilion Fault has the best potential of hosting a gold deposit in the Mud Creek Road area of St. Louis County.

Current Activity
The final report (170 pages) has been completed and has been distributed to the appropriate state agencies and to people that contributed exploration materials, and/or personal memories, regarding gold explorations in Minnesota. The report has also been posted on the NRRI website.

Principal Investigator(s)
Mark Severson
Steven Hauck

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Start Date: 09/25/2009         End Date: 06/30/2012         Project ID: 1576
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
A Minnesota sulfide ore head sample was crushed and blended. Initial grinding tests have been conducted to determine proper grind times. Additional collector and frother reagents have been procured. It is anticipated that Denver bench scale flotation machines will be cleaned and rebuilt in early 2012. Bench-scale flotation circuits including roughing, scavenging, cleaning, and recleaning will be conducted in the next period.

Current Activity
Three different sulfide collectors were tested at bench-scale to evaluate performance. Grind time and flotation time were also evaluated. This information will be used to run a bulk rougher flotation test to produce enough concentrate for cleaner and scavenger testing.

Principal Investigator(s)
Kyle Bartholomew

Project Sponsor(s)  
PUF Mineral Endowment  

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Total $71,144

Start Date: 08/25/2009  
End Date: 12/30/2012  
Project ID: 1556
Non-Ferrous Hydromet, Minnesota Mining Cluster - The Next Generation of Innovation

Objective
To recover non-ferrous and precious metal resources from Minnesota Mining Cluster (MMC) mineral deposits using hydrometallurgical processing methods, which avoid the use of high cost autoclave reactor vessels. The conditions for high recovery of metals will be established, and the costs for implementation will be estimated based on the data produced.

Background
Base and precious metal ore mineral deposits in Minnesota require beneficiation to produce a concentrate for further refinement into metals. This project will explore mineral processing routes to make these concentrates, and alternative hydrometallurgical routes for refinement of the concentrates into metals. Conditions for atmospheric pressure oxidation and leaching will be explored, along with conditions for copper solvent extraction, precious metals leaching, precious metal solvent extraction, iron precipitation from copper raffinates, and nickel and cobalt precipitation.

Previous Activity
This is a new project.

Current Activity
Activity this period includes setting up a service agreement with Process Research Ortech to conduct hydrometallurgical processing of non-ferrous concentrates produced at the Coleraine Minerals Research Laboratory (CMRL), preparation of a bulk head sample from a Minnesota copper-nickel bulk sample, investigation of required grinding to achieve liberation, rougher flotation testing to evaluate alternative collectors and processing conditions, and setup of a novel column flotation apparatus.

Principal Investigator(s)
Kyle Bartholomew

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Start Date: 10/01/2011       End Date: 09/30/2013       Project ID: 1683


**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% Cr2O3 in saprolite in a drill hole drilled into a Keweenawan ultramafic body in Stearns County.

**Previous Activity**

The decision was made to use the new Mineral Liberation Analyzer (MLA) technique to evaluate the polished thin sections. A short list of samples was under consideration for analyses, and the list will be reduced upon selecting the specific techniques to be used in the next quarter. It was planned that the project would continue in the next quarter by sending off samples for MLA analyses. Data would then be compiled, and a report will be written that will also include petrographic descriptions of the polished thin sections, along with conclusions on the various types of chromium mineralization.

**Current Activity**

Initial costs for analyses with the Mineral Liberation Analyzer came in high. Research on its capabilities for this project needs to be refined. Additional petrography was completed on some of the remaining polished thin sections. Work on both aspects will continue in the next quarter.

**Principal Investigator(s)**

Mark Severson
Steven Hauck

**Project Sponsor(s)**

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**Start Date:** 02/01/2002  **End Date:** 12/31/2012  **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 -decades-long decline in the teaching of geologic mapping skills in U.S. colleges and to provide advanced training to professional geologists.

Previous Activity
FIELD CAMP: The 5th annual Precambrian field camp was held July 10-Aug 20, 2011 with 22 students from 17 different schools. WORKSHOPS: A professional workshop typically held in the fall was not scheduled during 2011 because of the national Geological Society of America convention held in Minneapolis in October. Hudak and Miller were cochairs of the field trip committee that recruited a docket of 40 offered trips and served as editors of the guidebook. Miller was also chair of a special topical session on the Midcontinent Rift, which included 23 talks. STUDENT SUPPORT: For the Fall 2011 semester, Ben Brooker and Matt Chaffee were supported with PRC graduate research assistantships. FUNDRAISING: By the end of the 2011 calendar year, the PRC raised a record $136,200 from corporate and individual members.

Current Activity
FIELD CAMP: Planning and promotion was conducted for the 6th annual Precambrian field camp to be held July 8-Aug. 17; by early February, 24 students from 18 different schools had registered for the camp. WORKSHOPS: Planning and promotion was conducted for a Professional Workshop to be held Oct. 1-3 in the Twin Cities on the topic of Silica Sand Resources in Minnesota and Wisconsin. The workshop is being co-organized with the Twin Cities SME subsection. STUDENT SUPPORT: Three UMD graduate students, Ben Brooker, Matt Chaffee, and Chris Gosniack were awarded with PRC graduate research assistantships during the Spring 2012 semester. OUTREACH: The PRC played a major organizational role in putting on the 15th annual Minnesota Minerals Education Workshop held June 19-21 at Winona State University. The workshop was attended by a record 96 K-12 earth science teachers from across the state. FUNDRAISING: Membership donations for the first half of 2012 lagged a bit from the record pace of 2011, but we hope to pick up the pace to exceed our goal of $100,000 for the year.

Principal Investigator(s)
Dean Peterson
Donald Fosnacht
George Hudak
Jim Miller

Project Sponsor(s)  Amount  Account  Active
PUF Mineral Endowment  150,000  1896-783-1226-00  07/18/2006  06/30/2010

Total $150,000

Start Date: 07/18/2006  End Date: 12/31/2012  Project ID: 1432
Objective
The purpose of this project is to conduct a multi-disciplinary geological and geochemical assessment of a variety of rock types in Minnesota for potentially economic rare earth elements (REE) mineral deposits.

Background
China controls upward of 95% of the world production of rare earth elements. Recently, they have curtailed exports of these elements, which are considered to be important critical and strategic minerals to the U.S. Based upon the reduction in Chinese exports, there has been increased exploration worldwide for rare earth elements. Minnesota has favorable geology that may contain rare earth element mineralization.

Previous Activity
This is a new project.

Current Activity
Literature research on rare earth elements in Minnesota was conducted to determine if there were any known rare earth element-bearing minerals in Minnesota or anomalous rare earth element geochemistry available. For example, the minerals monazite and xenotime were located in the literature in glacial till studies and/or microscope studies. Also, a rare earth-bearing pegmatite along Highway 53 was reported on at a recent meeting. Based upon the above information, two recently graduated geologists were hired to work with NRRI geologists to collect additional rock samples from a wide variety of igneous and metamorphic rocks. About 85 samples were collected during this period. They will be prepared for making polished thin sections and for extensive whole rock, trace element, and rare earth element geochemical analyses at a commercial laboratory.

Principal Investigator(s)
Steven Hauck

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Project Sponsor(s): US Dept of Commerce

Amount: $100,000

Start Date: 10/01/2011

End Date: 09/30/2013

Project ID: 1675

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
The first draft was about 80% complete and was expected to be finalized before summer 2012. Data suggest that while massive sulfide occurrences are common to the area, there are two areas/belts that have historically returned some mildly interesting zinc values (up to 4% Zn). These two areas will be highlighted in the report, with a conclusion that any future exploration work should be limited to these areas. The highest gold values (up to 2ppm) are associated with the Hero massive sulfide deposit (with no significant base metal concentrations). While some of the gold values at Hero are impressive, the majority of the samples from this deposit do not contain significant gold, and its potential remains low.

Current Activity
The first draft report has been completed and has been submitted for editing. Conclusions generally remain the same as stated in the previous semi-annual report. However, an isolated drill hole to the immediate east of the Hero Deposit contains four consecutive intervals with >450 ppb gold. This same hole also contains 2.75 ppm gold, which is the most anomalous value for the entire area. This hole has also been highlighted in the conclusions.

Principal Investigator(s)
Mark Severson
Steven Hauck

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Start Date: 09/01/2004  End Date: 12/31/2012  Project ID: 1356
Objective
To recover titanium oxide (TiO₂) from iron titanates using hydrometallurgical processing methods to produce high quality titanium-bearing products for metals and pigment production. The process will be tested under laboratory and simulated pilot conditions. Necessary processing conditions for potential commercialization by future mine operators will be defined, and product quality of both titanium and iron-bearing products will be quantified.

Background
Pigment-grade titanium dioxide (TiO₂), used in many energy-saving products, is predominately produced from titanium-rich slag imported from Canada. Conversion of slag to TiO₂ is environmentally challenging due to high energy use and deep well injection of the iron chloride byproduct. The project objective is demonstration of an alternative, low-energy, environmentally-friendly combined mineral processing and hydrometallurgical process to generate TiO₂ and high-value byproducts from Minnesota titanium ore (ilmenite). The outcome of the project will be a credible demonstration of product quality and process capability providing a path to reduce U.S. dependency on foreign sources of titanium dioxide, increase energy efficiency of the TiO₂ production process, reduce environmental burden, allow development of U.S.-owned mineral resources, and provide high quality U.S. employment opportunities.

Previous Activity
This is a new project.

Current Activity
Activity this period included setting up a service agreement with Process Research Ortech to conduct hydrometallurgical processing of ilmenite concentrates produced at the Coleraine Minerals Research Laboratory (CMRL), cleanup of the wet pilot plant area near the spiral concentrator circuit, establishing titanium analytical procedures in the CMRL analytical laboratory, and evaluation of previous ilmenite concentrator flowsheets used at CMRL. Next steps will be to coarse screen and crush the existing ilmenite pile at CMRL to ¾” topsize to allow for processing in the CMRL rod mill prior to spiral circuit concentration.

Principal Investigator(s)
Kyle Bartholomew

Project Sponsor(s) | Amount | Account | Active
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US Dept of Commerce | 137,499 | 3002-10417-00028239 | 10/01/2011 09/30/2013
PUF Mineral Endowment | 137,500 | 1750-10417-20090-000282 | 10/01/2011 09/30/2013

Total | $274,999

Start Date: 10/01/2011 | End Date: 09/30/2013 | Project ID: 1682
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 personnel assisted Premier with mercury level calculations for their MPCA Discharge Monitoring Reports. All readings were within regulatory limits. Work on the proposed Wright Bog environmental review and permitting process will resume in 2012.

Current Activity
NRRI staff have continued work on the proposed Wright Bog horticultural peat operation, including creating GIS maps of the site and mining layout, determining discharge flows, designing sedimentation basins, organizing all information previously collected, and filling out the required State and Federal regulatory applications. Work on the permits will be ongoing throughout the coming months.

Principal Investigator(s)
Kurt Johnson
Steven Hauck

Project Sponsor(s)
Minnesota Technology, Inc.

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Start Date: 07/01/1999  End Date: 12/31/2012  Project ID: 1074
Objective
To develop cost effective methods for creating functional mitigation wetlands in abandoned borrow areas that meet regulatory permit requirements and are an integral part of road construction projects.

Background
Wetland impacts are often an inevitable consequence of road construction requiring compensatory mitigation. Northeast Minnesota still retains more than 80 percent of its pre-European settlement wetland acreage presenting very few opportunities for traditional mitigation such as wetland restoration. Abandoned borrow areas that have been excavated for road construction materials are one of the few remaining areas that can serve as wetland mitigation sites within the impacted watersheds. In a previous project “Wetland Mitigation in Abandoned Gravel Pits” a demonstration site was established to evaluate techniques for creating fresh meadow, shrub swamp, wooded swamp, and bog wetlands in abandoned gravel pits. Preliminary results are encouraging, but continued monitoring is needed to determine long-term success. This project would continue monitoring for the existing demonstration site wetlands for an additional three years. The effect of established treatments such as donor soil and seed mixes on native plant cover, species richness and diversity will be the primary focus, with special attention to monitoring and control of invasive plant species. Additional vegetation monitoring will also be conducted on other mitigation sites within the U.S. Trunk Highway 53 reconstruction corridor to evaluate their progress. The overall goal of the project is to develop cost effective methods for creating functional mitigation wetlands in abandoned borrow areas that meet regulatory permit requirements.

Previous Activity
Task 3 was completed to determine treatment effects and vegetation changes over time. Vegetation surveys were conducted. Water level monitoring was conducted biweekly throughout the frost-free period. An annual summary report including water level and vegetation monitoring data was completed. Wetland plant communities were outlined at each mitigation site using GPS. Monitoring photos were taken at photo reference points established by MnDOT. A Technical Advisory Panel meeting was held in October to discuss progress to date on the project, reporting requirements, and future plans.

Current Activity
Biweekly monitoring of water table wells on all mitigation sites was initiated after the spring thaw and has been ongoing throughout the summer months. Willow shrub height and survival was measured on Mitigation Site 5, and the same was done for Tamarack and Black Spruce on Mitigation Site 3. Vegetation surveys will be completed for all 11 mitigation sites in July. Data recording and analysis are ongoing.

Principal Investigator(s)
Kurt Johnson
Steven Hauck

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Start Date: 03/25/2011      End Date: 08/31/2014      Project ID: 1628
Peat, Horticultural
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. Construction (2009) and establishment of monitoring sites followed the same process as that for the 2002 and 2005 agreements.

Current Activity
The U.S. Army Corps of Engineers (Corps) approved Wetland Bank I (established in 2002) and the Corps and NRRI subsequently signed a Mitigation Banking Instrument (MBI) for perpetual care of the Bank Site. An MBI is in the final stages of review for Wetland Banks II and III (established in 2005). The UM Office of General Counsel (OGC) and Real Estate Office (REO), along with NRRI, are doing the review. In spring and early summer 2011, intensive vegetation and water table monitoring were done on Wetland Banks IV and V (established in 2009). In May 2012, BWSR gave approval for the deposit of 10 acres of NWC for Bank IV. NRRI continues to meet all agreement requirements for these banks, including the control of invasive species. Wetland Bank IV and Wetland Bank V (both established in 2009) are progressing well as functioning restored peatlands. Routine maintenance was done on the facility and equipment as the field season began.

Principal Investigator(s)
Thomas Malterer
Steven Hauck

Project Sponsor(s) Amount Account Active
MnDOT 1,344,258 1026-10415-20090-1000004086 05/01/2001 06/30/2011
MN Board of Water & Soil Resources 1,828,136 1026-10415-20090-1000004086 05/01/2001 06/30/2011
Total $3,172,394

Start Date: 05/01/2001  End Date: 09/30/2013  Project ID: 1367
Development Of Peat-Based Media For Waste Water Treatment

Objective
To develop environmentally beneficial peat-based products that can replace chemical treatments for agricultural and remediation purposes.

Background
Peat is partially decayed vegetation that accumulates in wetland bogs. Approximately 15 percent of Minnesota is covered with this valuable resource. Peat has been investigated by several researchers as a sorbent for the capture of dissolved metals from waste streams. Utilization of peat and other biomass materials for treatment of waste water containing heavy metals is gaining more attention as a simple, effective and economical means of pollution remediation. Besides being plentiful and inexpensive, peat possesses several characteristics that make it an effective media for the removal of dissolved metal pollutants. Drawbacks of using peat are its low mechanical strength, high affinity for water, poor chemical stability, tendency to shrink and/or swell, and leaching of organic compounds. American Peat Technology, LLC, partnered with NRRI to develop environmentally beneficial peat-based products that can be used for purification of agricultural and industrial waste water. Developed peat products should overcome the major drawbacks of parent peat material, and should also either inherit parent peat properties to absorb heavy metals or else have additional chemical and physical properties that will be useful for agricultural and remediation purposes.

Previous Activity
Newly developed peat granules underwent a series of performance tests. Increased absorption activity and capacity were observed for absorption of the following heavy metals: cobalt, copper, nickel, zinc, cadmium, manganese, and lead. A specification spreadsheet for newly-developed peat granules was developed, and an Intellectual Property Disclosure Form for a newly developed technology to produce a peat granular product was submitted to the University of Minnesota's Office for Technology Commercialization. This disclosure was accepted for patent application filing on behalf of the inventors. APTsorb III is the brand name for the newly developed peat granules to treat industrial waste water. Additional funding was secured.

Current Activity
Newly developed APTsorb III peat granules underwent a series of column performance tests to measure absorption capacity. The sorption capacity of APTsorb III depends on the flow velocity of waste water that has to be in the range of 0.1–0.4 m/hr to reach up to 10 mg/g for Cd. Elemental analysis of APTsorb III was completed. Results demonstrated that the peat material passed the required Toxicity Characteristic Leachate Procedure test and can be used in industrial waste water treatment applications. Another batch of APTsorb III (400 lb) was produced in the batch-type process. The next phase of research has been initiated. New funding has been secured to further develop the technology.

Principal Investigator(s)
Igor Kolomitsyn

Project Sponsor(s) | Amount | Account | Active Start Date: 11/13/2009 End Date: 12/31/2012 Project ID: 1614
-------------------|--------|---------|----------|----------|-------------------|----------|-------------------|----------|-------------------|----------|
Total | $137,700 |
Personnel

Mathew Aro graduated from the University of Minnesota’s President’s Emerging Leaders Program at the University of Minnesota – Twin Cities, June 2012.

Matthew Aro entered graduate school at the University of Minnesota – Twin Cities in pursuit of a Ph.D. in Natural Resources Science and Management.

Patrick Donahue completed his required coursework in pursuit of his Masters of Science in Engineering Management.

Scientific Meetings/Presentations

Bill Berguson gave a presentation of the SunGrant Regional Feedstocks Partnership Poplar Woody Crops Research Program at the annual SunGrant contractors meeting in Indianapolis, Indiana. Bill Berguson is the national lead for the SunGrant Poplar Program and presented a summary of all national research activities ongoing in poplar under the program.

Bill Berguson gave a presentation of biomass sources, wood energy, and potential production of liquid fuels from biomass to the Arrowhead Growth Alliance in March 2012.

Brian Brashaw presented a paper entitled “Nondestructive Technology Options for Improving Management and Utilization of Trees, Logs, and Lumber,” as an invited speaker at the Shifting Seasons: Great Lakes Forest Industry, Products and Resources Summit, June 6-7, 2012 in Keshena, Wisconsin. This Summit was sponsored by the College of Menominee Nation Sustainable Development Institute.

Tim Hagen gave a presentation entitled “My Family’s Successful Transition from Propane to Wood Pellets” at the 2012 Heating the Midwest Conference and Expo in Eau Claire, Wisconsin, April 25-27, 2012.


Publications


Victor Krause. 2012. A confidential report was issued to Northern Contours, Inc. Natural Resources Research Institute Technical Report Number NRRI/TR-2012/05.

Victor Krause. 2012. A confidential report was issued to Northern Contours, Inc. Natural Resources Research Institute Technical Report Number NRRI/TR-2012/06.


Tim Hagen. 2012. A confidential report was issued to the USDA/SBIR. Natural Resources Research Institute Technical Report Number NRRI/TR-2012/08.
Tim Hagen. 2012. A confidential report was issued to the USDA/SBIR. Natural Resources Research Institute Technical Report Number NRRI/TR-2012/09.


Outreach

Quality One Woodworks, Hastings, Minnesota: Patrick Donahue completed a consulting project for Quality One Woodworks. The project assessed new product development opportunities for the outdoor kitchen market.

Biovation LLC, Mankato, Minnesota: Patrick Donahue began a consulting project for Biovation LLC to assess the durability of bio-based laminates.

Forest Products Society Upper Mississippi Valley Chapter: Patrick Donahue began his second year as Chairperson of the Forest Products Society Upper Mississippi Valley Chapter. A key outcome for the past year was the development of an upcoming international conference in St. Paul, Minnesota entitled “North American Wood Window and Door Symposium.” In addition, Donahue received a grant from the University of Minnesota’s Initiative for Renewable Energy and the Environment in support of his research assistant Miss Wen Chen to develop promotional and marketing materials in support of this event.

Midwest Technology Services, Carlton, Minnesota: The NRRI provided technical assistance for wood pellet manufacturing in regards to available species mix and quality, equipment condition, and a general assessment of plant layout. A future product development fund was discussed pending approval of the insider group and specific financial constraints. This opportunity continues to evolve.
KBM Resources Group, Thunder Bay, Ontario: KBM Resources Group markets a tall oil pitch used in the suppression of dust releases from mine tailings. KBM Resources contacted NRRI in regards to using tall oil pitch as an enhanced binder and hydrophobic aid for wood pellets. Preliminarily, tall oil pitch does appear to show some binding and hydrophobic character, but larger pelleting trials are needed to define the activity of the binder further. Various funding avenues are being investigated to pursue this opportunity further.

M E Elecmetal, Duluth, Minnesota: The NRRI was recently invited on a tour of the ME Foundry in Gary New Duluth. The foundry has faced increased costs for casting sand caused by increased demand from the hydrofracturing industry and currently has an ongoing effort to find a cost effective replacement of Zircon sand. Options for recovering the zircon sand from the standard silica sand was discussed and a small sample of recycle sand was obtained from the facility. XRF results showed Zircon present at ~26 lb/ton and is likely recoverable with either a dry or wet side gravity separation technique. The NRRI is trying to build on this opportunity further by demonstrating a laboratory separation technique and then submitting a proposal to ME through the Mining Custer Fund.

Northern Contours Inc., Fergus Falls, Minnesota: Performed assessment of long term humidity exposure on door corner joints. Performed corner joint strength testing. Performance evaluation of laminates and coatings was provided.


Price Firewood: Cloquet, Minnesota: Site visit to kiln at Savannah Pallet in McGregor, Minnesota. Evaluated the process and measured temperatures in a partial load of firewood through a pallet kiln cycle. Provided feedback on use of pallet kiln cycle for firewood treatment.


BTD Powder Coatings, Inc., Brainerd, Minnesota: Evaluated materials for scratch, mar, and abrasion performance according to NRRI and ASTM standard tests.

Ferche Millwork, Rice, Minnesota: Evaluated materials to determine possible causes for failures in wood veneer wrapped door jambs.

Biovation, Mankato, Minnesota: Performed scratch, mar, abrasion and impact testing on various materials according to NRRI and NEMA standard tests.

Van Technologies, Duluth, Minnesota: Provided information on the hot foil industry. Designed modifications to bag-sealing equipment used as test device for evaluation foil transfer onto coated specimens.

Stephanie Beard, University of Minnesota: Provided overview of UV reflective coatings on glass that help prevent bird strikes. Suggested commercially available materials and evaluation methods for improving the performance for her project.

Cirrus Design, Duluth, Minnesota: Conducted resin flow testing as part of the Cirrus quality assurance program.
Agristrand Composites, LLC, Mankato, Minnesota: Produced laboratory samples of various density particleboard panels in support of testing and marketing activities as Agristrand nears start-up of their particleboard plant. The testing provided key manufacturing parameters and the samples were used to generate market interest.

The Barrel Mill, Avon, Minnesota: NRRI staff provided information on potential markets for wood residues created during manufacturing of wood barrels.

White Cedar Shingles, Superior, Wisconsin: NRRI staff provided unique market ideas to White Cedar Shingles on potential markets for the cedar residues created during production.

Verso Paper Company, Alexandria, Minnesota: NRRI assisted Verso Paper Company staff in evaluation of the hybrid poplar genetic improvement program and selection of clones for commercial application in central Minnesota.

Michigan State University, Michigan: NRRI assisted Michigan State University by providing plant material for poplar field trials at various locations in the Midwest.

**Facilities**

The forest products program has purchased a new thermal modification pilot plant/laboratory to be installed at the NRRI this fall.

The NRRI greenhouse is currently being used to produce seedlings resulting from the 2012 breeding. The controlled climate facility was used during early 2012 to pre-treat cottonwood female plants as part of the breeding program.

Metrohm Compact 881 Compact Ionic Chromatographic Pro System was purchased and installed for anions and cations analysis. This system will be used in the new project for sulfate analysis.

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

**Personnel**

In May 2012, Research Fellow Matthew A. Mlinar left the employ of the Coleraine Minerals Research Lab. Matt’s focus at CMRL was on supervising the biomass gasification projects and in renewable energy and power/controls. His research contributions will be sorely missed.

Fred Kiesel, Bruce Sodahl & Isaac Hudson were hired as temporary summer employees to assist with work on numerous and diverse CMRL research projects.

Sara Chlebecek, graduate of UMD Geology Dept. and Sara Post, graduate in geological engineering, Colorado School of Mines, were hired in June 2012 for the EDA Mining Cluster project: Rare Earths Elements in Minnesota.

Matt Chaffee, graduate of UMD Geology Dept., was hired to assist the NRRI Particulate Project with the School of Public Health-NRRI Lung Health study.

**Scientific Meetings/Presentations/Papers**

P. Mack was the moderator for the HPGR (High Pressure Grinding Rolls) short course at the April 17, 2012, SME Conference at the DECC in Duluth, Minnesota. This involved introducing the short course topic and the course instructors.

D. Fosnacht, S. Hauck, G. Hudak, M. Severson, and M. Patelke attended the Prospectors and Developers Association of Canada (PDAC) meeting held on March 4-7 in Toronto, Ontario, Canada. They helped staff the State of Minnesota booth. Minnesota was one of only two U.S. States (Alaska) represented at this international meeting of 30,369 attendees.

On January 20, L. Zanko visited and toured the National Center for Asphalt Technology (NCAT) test track and laboratory in Auburn, Alabama, met with NCAT engineer Dr. Michael Heitzman, and discussed current testing of taconite friction aggregate being conducted at NCAT, and potential future testing related to NRRI's taconite aggregate activities.

L. Zanko participated in the 91st Transportation Research Board (TRB) annual meeting from January 22-26, to attend technical sessions and committee meetings (including the Mineral Aggregates Committee meeting), to meet with transportation researchers and professionals, and to communicate with Minnesota congressional staff. L. Zanko is a member of the Mineral Aggregates Committee, and is in communication with Richard Meininger at the Federal Highway Administration (FHWA) regarding a Call for Papers and for organizing a 2013 and/or 2014 TRB session on, “Recycled Materials and Byproducts.”

L. Zanko also attended the TERRA Pavement Conference in St. Paul on February 9, 2012.


Training

J. Heine attended a week-long gOCad training workshop in Toronto, Canada, in May.

J. Oreskovich attended the Water Resources Application of LiDAR Data Workshop - March 14-15, 2012 – Brainerd and Web-based:
• Mapping & GIS Analysis Supports Decision-Making - UMN-TV Live Broadcast - April 10, 2012 (1 Hr.)
• Webinar: Choosing a Silica Analytical Laboratory - Industrial Minerals Association - May 24, 2012 (1.5 Hrs.)
• Webinar: Technology Transfer and Training Resources for Mining Sites - EPA - June 13, 2012 (2 Hrs.)

T. Levar and C. Maly attended 40 hour Hazwoper Training at Lake Superior Community College, and S. Post was recertified after 1 day of training.

All NRRI MSHA training is up to date.

Field Trips
Institute on Lake Superior Geology (ILSG), Thunder Bay, Ontario, Canada, May 16-19, 2012
G. Hudak, Geology of the Shebandowan Mine Area
G. Hudak, M. Patelke, and M. Severson, Musselwhite (Gold) Mine Trip
S. Hauck, North American Palladium’s Lac des Iles Mine Trip
S. Hauck, Midcontinent Rift Intrusions
M. Severson, Geology of the Sibley Peninsula

Geological Association of Canada/Mineralogical Association of Canada, Annual Meeting (GAC-MAC)

Society of Economic Geologists

Publications/Awards
The University Innovations Award Ceremony was held March 8, 2012, organized by the Office of the Vice President for Research, R. Timothy Mulcahy. It celebrates University researchers who have been issued patents and whose intellectual property was licensed during the preceding fiscal year. NRRI researchers awarded for both patents and licenses in FY 2012 were: Matthew Aro, Donald Fosnacht, David Hendrickson, Timothy Kemp, and Richard Kiesel

Patents: Rodney Bleifuss, David Englund, Andriy Khotkevych, Pavel Krasutsky, Lawrence Zanko

Licenses: Lawrence Zanko

Coleraine Technical Reports


Economic Geology Group Technical Reports


Economic Geology Group Posters


Facilities
At the Duluth location of NRRI, a Metrohm Compact 881 compact Ionic Chromatographic Pro system was purchased and installed for analysis of anions and cations. Initially, this system will be used for sulfate analysis. The equipment investment was $30,000.00.

NRRI’s Coleraine Minerals Research Laboratory (CMRL) received a rebate in the amount of $16,029.00 from Minnesota Energy Resources for insulation improvements on two of its 1950’s era buildings. The Wet and Dry Pilot Plants, which have more than 11,600 sq. ft. of working space, had an exterior insulation applied to their roofs to increase the insulation R value from R-1 to R-20.4. Energy savings is expected to be over 3,244 MMBtu/year, with a 1.4 year simple payback. The rebate was facilitated by P. Hanson, K. Bartholomew, D. Hendrickson, R. Oberton, and N. Johnson. This is the first stage of CMRL’s commitment to reducing its energy and electrical consumption.

CFD Modeling Center Equipment Upgrade at CMRL
Two Dell T7500 workstations were purchased, each machine containing dual six-core processors, for a total parallel processing system of 24 processors. These two machines have a combined memory capacity of 96 GB. The addition of these workstations greatly enhances the Computational Fluid Dynamics (CFD) Modeling Center’s capabilities to model more complex furnace designs and heat recovery systems for our Minnesota taconite operations, DRI furnaces, and Nodular Reduced Iron (NRI) furnace systems.

KHD High Pressure Grinding Rolls Unit Installation at CMRL
A pilot scale High Pressure Grinding Roll (HPGR) unit was installed at CMRL. It is produced by Klöckner-Humboldt Deutz (KHD) of Germany, and has a nominal 50-ton/hr capacity feed rate, 90 cm roll diameter, 25 cm roll width, and a pressure rating of 40 bar. Many new mining operations around the world are evaluating the benefits of installing HPGR units in their crushing and grinding circuits to provide significant energy savings in grinding. CMRL is using the KHD unit for pilot testing in crushing and concentration circuit design.
Center for Water and the Environment
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 Forests 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
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 six 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 14C 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)  Amount  Account  Active
Univ of Delaware (USDA Prime)  16,223  3014-10424-0002871  09/01/2008  08/31/2011
US Dept of Agriculture  3,568  3002-10424-00026321  08/01/2010  07/31/2012
Total  $19,791

Start Date: 09/01/2008  End Date: 07/31/2013  Project ID: 1565
Objective
The project is a coordinated effort to determine whether it is possible to slow or prevent a decline in northeastern Minnesota’s moose population. Public outreach and education will be accomplished with a website that provides information on moose in Minnesota and allows the public to report moose sightings. The Minnesota Zoo in Apple Valley will develop an on-site informational kiosk about Minnesota moose and zoo educators will help develop a curriculum for teacher workshops to be held both at the zoo and at the Boulder Lake Environmental Learning Center near Duluth. We will schedule 25 public moose presentations per year. The project combines research and education to increase public understanding of Minnesota moose now and in the future.

Background
Moose are one of Minnesota’s most prized wildlife species. In less than 20 years moose in northwestern Minnesota declined from over 4,000 to fewer than 100. The northeastern Minnesota moose population, with over 7,000 moose, may be beginning a similar decline. Higher mortality in radiocollared moose is correlated with warm temperatures. Satellite collars will track moose in northeastern Minnesota and collect GPS locations day and night 365 days a year. Specific habitats needed by moose will be identified using the satellite collars. Spatial distribution and availability of habitat types will guide identification of specific sites for enhancement, protection, or acquisition. Development of habitat guidelines will help private and public land managers provide the best possible habitat for moose.

Previous Activity
This is a new project.

Current Activity
This is one of four current GPS collar projects. In January of 2011, we deployed collars on 64 moose that will collect GPS locations every 20 minutes and send the locations via the Iridium satellite cell phone network to the PI. Activity and air temperature is also monitored on the collar.

This is the first project in the world to take locations frequently enough to monitor an animal’s movement 24 hours a day, 7 days a week. We expect that it will provide insight into landscape use by moose, management activities that could benefit moose, habitat selection in cool and hot weather, and information on calving by moose.

The Minnesota Zoo completed updating the existing moose display with new graphics that cover basic moose biology, explain historical trends in moose populations in Minnesota, and present findings from this project. A new moose sculpture was acquired by the zoo with other funding.

Principal Investigator(s)
Ronald Moen

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Start Date: 07/01/2010    End Date: 06/30/2013    Project ID: 1586
ECOSYSTEM STUDIES - Land Resources

Lowland Conifer Bird Species in Agassiz Lowlands

Objective
Gather information on breeding bird populations in the Agassiz Lowlands section of Minnesota.

Background
This is a short term project primarily focused on the June 2011 breeding season.

Previous Activity
This is a new project.

Current Activity
Breeding bird data were gathered from a series of lowland coniferous sites identified by the Minnesota DNR in Grand Rapids. These sites were in stands of various age classes, cover types (e.g., black spruce, tamarack, and white cedar), and site quality. Counts were all completed by June 30, 2011. A report will be sent to the Minnesota DNR with the results of the surveys. These surveys will form the basis on decisions regarding future work in the Agassiz lowlands subsection, especially in the context of future logging within these vast lowlands.

Principal Investigator(s)
Annie Bracey
Gerald Niemi

Project Sponsor(s)                          Amount        Account                      Active
MN DNR                                    3,000         3005-10429-00024060             05/15/2011  06/30/2011
MN Department of Natural Resources         29,289        3013-10429-00031482             05/14/2012  03/30/2014
MN DNR/Federal Funds                      36,341        3013-10429-00030419             05/14/2012  03/30/2014

Total                                     $68,630

Start Date: 05/15/2011   End Date: 03/30/2014   Project ID: 1645
Mapping Native Plant Communities of Minnesota’s Forest Lands

Objective
Mapping of the native plant communities for Minnesota’s Laurentian Mixed Forest based on the Minnesota DNR Ecological Classification System.

Background
The Minnesota Forest Resources Council's Landscape Program recognizes several distinct regional landscapes, formed by integrating the natural physiographic and climatic regions of the state with social and economic objectives. These landscapes have served as focal points for regional planning efforts involving multiple groups of stakeholders. While the landscape regions have unique issues and potentials, they all have common data needs. Foremost among these is an assessment of landscape potential, which is required to formulate desired future conditions.

This project will:
1) Integrate a suite of geospatial data layers to create native plant community maps of the Drift and Lake Plains and Western Superior Uplands ecological sections, with a spatial resolution similar to the Minnesota-Ontario Peatlands and Northern Superior Uplands native plant community maps and based on the Department of Natural Resources classification of native plant communities.

2) In support of the landscape committee planning efforts, summarize acreages of native plant communities at the system and class level by ownership (MFRC 2010); provide other reports in consultation with committee members.

Previous Activity
This is a new project.

Current Activity
We downloaded and processed the newly available soil series data from the Natural Resources Conservation Service. We also acquire the plant relevee database, which provides ecological descriptions for 3000+ sample points across northern Minnesota. Finally, we summarized geomorphic, topographic and other relevant geospatial data to develop an input data set to test against the native plant community relevees.

Analyses are underway - the end product will be a synoptic map of native plant communities for the Minnesota Drift and Lake Plains and Western Superior Uplands, which will complete the native plant community classification for the entire Laurentian Mixed Forest within Minnesota.

Principal Investigator(s)
George Host
Mark White
Terry Brown

Project Sponsor(s) | Amount | Account | Active
--- | --- | --- | ---
MN Dept of Natural Resources | 20,000 | 1663-189-6195-00 | 06/05/2000 09/30/2000
MN-Department of Natural Resources | 25,000 | 1663-189-6216-00 | 01/01/2001 06/30/2001
MN Department of Natural Resources | 9,500 | 3005-10107-00029462 | 05/30/2012 06/30/2013
Total | $54,500 |

Start Date: 06/05/2000    End Date: 06/30/2013    Project ID: 947
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 U.S. 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
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.

Current Activity
During the winter of 2011, data gathered during 2009 and 2010 were summarized. Many qualified bird observers were identified, primarily graduate and undergraduate students at the University of Minnesota. Breeding birds were sampled in over 700 townships with over 2,000 point counts from May 27 to July 15, 2011. Because these data collection efforts were recently completed, they have not yet been analyzed. These data are currently being double-entered and error-checked to insure accurate information. Species observations will also be scrutinized by several experts to insure that they are correct.

Principal Investigator(s)
Annie Bracey
Gerald Niemi

Project Sponsor(s)  Amount  Account  Active
LCCMR  101,000  3015-10429-00000576  07/01/2008  06/30/2010
Legislative Comm on MN Resources  161,000  3015-10429-00019124  07/01/2010  06/30/2012
National Audubon Soc (MNDNR prime)  97,100  3006-10429-00030942  05/15/2012  05/14/2013
Total  $359,100

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
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 2013 field season.

Current Activity
Field season for 2012 has been completed.

Principal Investigator(s)
Annie Bracey
Gerald Niemi

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Total $1,083,109

Start Date: 05/01/1998   End Date: 12/31/2012   Project ID: 420
Objective
Our goal is to use a multi-pronged approach to reduce the introduction and spread of invasive earthworms through rigorous quantification of the relative importance of different vectors of introduction for earthworm species, develop and test the effectiveness of management recommendations for resource managers to limit the spread and introduction of earthworms, and 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.

Background
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.

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. 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.

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.

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
Protocol-based internet searches and knowledge, attitudes, and practices (KAP) studies of potential target audiences were finished in 2010.

A KAP study has been developed and was delivered at five conferences this year.

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; workshops are now being scheduled; several hundred new citizen-based data points have been added to our database across the Great Lakes region.

Current Activity

Principal Investigator(s)
Cindy Hale

Project Sponsor(s)
Legislative Comm on MN Resources

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Start Date: 07/01/2009   End Date: 12/30/2012   Project ID: 1545
Reducing Human-mediated Spread of Non-native Earthworms

Objective
The long-term goal of this integrated proposal is to substantially reduce the rate of spread of damaging, invasive earthworms in northern hardwood forests.

Background
Specifically, this project will quantify the effect of bait labels on bait disposal behavior in the population of anglers. Anglers visiting fishing resorts and anglers purchasing bait at bait shops will be the two sample groups, and behavior will be measured directly by counting the number of containers placed in a bait disposal bin at the resorts, and indirectly through written surveys in both groups. We will use this information to estimate the consequent reduction in human-mediated spread of earthworms into hardwood forests which will be directly related to the benefits of using bait labels.

Previous Activity
The experiment continued in summer 2011, with an effort to increasing response from angler surveys.

Ryan Huffmeier, NRRI, conducted a survey of boat landings within a 15-mile corridor of Highway 53 from Virginia to Cook, Minnesota. The intent of the survey was to quantify degree of earthworm impact in forests adjacent to the landings, along with a characterization of forest overstory and ground-flora composition and an assessment of forest soils. Virtually all sampled boat landings showed presence of earthworms.

Current Activity
We began a modeling project to predict levels of earthworm invasion based on geospatial data, including distance to boat landings, campgrounds, and other sources for colonization, along with abiotic factors such as soil type, slope and aspect. The project will test statistical models against predictions derived from simple tesselation and kriging methods. The predictions will be evaluated in Fall 2012 with field visits.

We also conducted a project to how different phases of colonization relate to distances from boat landings. Colonization did decrease with distance, with heavy nightcrawler infestations found within the first few hundred meters of the boat launch, with progressively decreasing densities to relatively low levels at 1000 m.

Principal Investigator(s)
Cindy Hale
George Host

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| Total | $50,000 |

Start Date: 02/01/2010   End Date: 01/31/2013   Project ID: 1649
Restoring Moose Foraging Habitat in Lake Superior Upland

Objective
Restore moose foraging habitat in Lake Superior upland.

Background
Moose populations in the western portion of the Lake Superior watershed may be declining. Annual mortality rates of adult cows are much higher than in other moose populations. We will restore over 200 acres of moose foraging habitat. We will also evaluate moose use of previously restored foraging habitat, and test how moose wearing GPS collars use restored sites, and how far moose will move from thermal cover to forage. Funds will only be used for habitat restoration and measuring moose use of restored habitat because the GPS collar project is funded by the Legislative-Citizen Commission on Minnesota Resources.

Previous Activity
We did contracts to restore about 200 acres of moose foraging habitat and monitored browse intensity at several sites in northeastern Minnesota.

Current Activity
The habitat restoration on Lake County forestry land was accomplished in December 2010 and January 2011. In midwinter we measured browsing intensity and sampled bites in areas where GPS collared moose were foraging. This measured the actual forage availability to moose on the landscape. This spring when the snow was gone we measured overall browse removal in the winter on some of these sites as well as other sites. The net effect was that browse removal was locally higher than expected, and there were other areas with relatively low browse removal.

Principal Investigator(s)
Ronald Moen

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Start Date: 08/16/2010  End Date: 09/30/2013  Project ID: 1608
ECOSYSTEM STUDIES - Land Resources

The North Shore Data Consortium: Acquiring and Distributing High-Resolution Geospatial Information

Objective
To create the North Shore Data Consortium - a group of local and regional government and industry officials with the goal of collaborating on the collection and use of high-resolution spatial data, including LiDAR.

Background
There are strong local and regional interests in the acquisition and distribution of high-resolution spatial data needed for land use planning, natural resource management, and environmental assessment. Included among these data are LiDAR imagery, which provides very high resolution (0.5 to 1 m) digital elevation models, high resolution digital aerial photography products and derivative products such as hierarchically structure watersheds, topographic moisture indices, and refined wetland classifications. We propose to create the North Shore Data Consortium, with the purpose of developing specific funding strategies and timelines for collecting LiDAR and contemporary high-resolution aerial photography for the region. The Consortium will develop memoranda of understanding among local, state and federal agencies and interested NGOs to provide for data sharing and leveraging of funds for contracting LiDAR acquisition. The NSDC will also identify data gaps and future data needs. To ensure compatibility with statewide data standards, we will work closely with the Digital Elevation Committee of the Governor’s Council on Geographic Information Systems.

Previous Activity
The NSDC collectively wrote a letter to the Minnesota DNR providing a rationale for accelerating LiDAR data collection, currently scheduled for 2012, to spring 2011. This request was approved by the state’s Digital Elevation Committee in August, and LiDAR flights were conducted in spring 2011.

Current Activity
NOAA coastal LiDAR data were acquired from their Digital Coast website and incorporated into the NRRI GIS laboratory database. G. Sjerven created a number of images for locations along the coast and compared LiDAR bathymetry with other datasets. Several artifacts in the data were identified, as well as locations where turbidity may result in less reliable depth estimates.

We evaluated LP360 LiDAR processing software (GeoCue Corp); the software is an extension to ArcGIS that integrates point cloud datasets directly into the GIS package, and provides for statistics and basic processing operations (surface, height filters, building identification).

G. Sjerven met with Tim Loesch, Minnesota DNR’s coordinator for state-collected LiDAR data to work out issues related to data distribution issues, including storage needs. We identified hardware needed for data storage and will build the RAID storage system in the next quarter. The initial ‘Block 1’ dataset for the Arrowhead region was downloaded and is being incorporated into the NRRI GIS lab database.

Principal Investigator(s)
George Host
Lucinda Johnson

Project Sponsor(s)  Amount  Account  Active
MN’s Lake Superior Coastal Program  39,137  3013-10424-00007525  09/04/2009  05/31/2012
Total  $39,137

Start Date: 09/04/2009  End Date: 05/31/2012  Project ID: 1568
Western Lake Superior GLISTEN Collaborative Cluster

Objective
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.

Background
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.

Previous Activity

Current Activity

Principal Investigator(s)
Pat Schoff

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Start Date: 01/01/2010     End Date: 05/31/2012     Project ID: 1587
Objective
This project will develop a Web 2.0 application to integrate the long-term information provided in the Coastal Atlas (see Project ID 1597), CoastalGIS, and other sources with real-time related to coastal resources, hazards and habitats. Key data layers will include public access, tourism, transportation and coastal hazards such as beach advisories and rip currents.

Background

Previous Activity
The initial data sets are now posted. We had numerous meetings with project end users to identify the most useful forms of Web 2.0 outputs; Facebook, Twitter, blogs, and wikis all ranked highly.

We evaluated ARIS as one of several prospective application platforms for Web 2.0 delivery. ARIS is an open-source platform that allows development of location-sensitive apps. For example, proximity to a beach with swimming advisories or hazardous sites would trigger the mobile device app to send an alert via SMS of other messaging system.

We compiled an initial list of stakeholders and end-users from local government, non-governmental organization, environmental groups and citizens to identify important information and suitable information delivery mechanisms. This group will convene in the next quarter to provide initial input to the project. One key finding was that users desired the ability to serve as providers (prosumers) as well as consumers of data - we are exploring options to facilitate this.

Current Activity
We worked on upgrading our map sessions to the new ArcGIS version of Internet Map Server, and are seeking to move the application to servers at UMD to allow for faster access speed. We created and are testing code to allow users to submit addresses or other location information, and return user-requested information on the surrounding watershed.

We continued to accumulate geospatial data sets related to North Shore coastal resources to be incorporated into this application; the most recent addition is a map/dataset of the current suite of real-time stream and lake data sensors operated by various agencies, including UMD's Natural Resources Research Institute and Large Lakes Observatories, the USGS, and the Lake Superior National Estuarine Research Reserve.

Principal Investigator(s)
George Host

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**Total** $32,058

Start Date: 09/21/2011       End Date: 12/31/2012       Project ID: 1654
A Whole-lake Assessment of Long-term Human Impacts to Lake Superior

Objective
This study will enable us to track pronounced local and global influences in the Lake Superior depositional basins and build a tangible understanding and awareness of how human activity has and continues to change environmental quality. Our analyses of depositional cores will better describe the effects of local and global stressors and the sensitivity of the lake to these stressors. Analyses of historical trends will be performed in the context of past and current retrospective studies and we will ensure that results are effectively communicated to the public and managing agencies. Our findings will provide support for and encourage sustainable environmental practices and will demand progressive action from policy makers. Better understanding will lead to more informed decision making, balancing potential short term economic benefit with long term ecological degradation.

Background
Lake Superior is the least studied and understood of the Great Lakes in terms of water quality changes and human influence. Lake Superior is unique among the other Great Lakes in size, retention time, lower basin development, and consequently, apparent preservation of water quality. It is the only Great Lake with an aquatic food web that is not considered severely impaired. However, there is evidence that the quality of Lake Superior is changing and, unfortunately, little is known about how human activity is affecting the lake as a whole. We aim to put contemporary data in a long-term context by investigating the paleolimnology of Lake Superior.

Previous Activity
Sediment cores have been collected throughout the Lake Superior basin and these cores have been processed for sediment dating and diatom analysis. Diatom, geochemical, and pollen analyses on sediment samples are ongoing.

Amy Kireta presented the project and preliminary results at the International Association for Great Lakes Research (IAGLR) Conference. Results are being compiled and will be presented at the North American Diatom Symposium in September by Victoria Chraibi (a Water Resources Science graduate student).

Current Activity
Diatom, geochemical, and pollen analyses on sediment samples are ongoing.

Results indicate that Lake Superior underwent some eutrophication in the early 20th century, but since recovered. We are currently assessing paleolimnological shifts from the last decade and correlating changes to those determined through the ongoing pelagic monitoring program. Methods and results are also being compiled for a hands-on exhibit at the Great Lakes Aquarium.

The bulk of this work has been managed by WRS graduate student Victoria Chraibi, and we expect most results will be compiled in fall 2012.

Principal Investigator(s)
Euan Reavie

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Start Date: 07/01/2010   End Date: 06/30/2012   Project ID: 1591
Amity Creek Restoration Project

Objective
Reduce sediment to Amity Creek by improved land cover in riparian areas disturbed by development or legacy impacts, and improved stormwater planning and management tools in two rural townships experiencing continued development pressures, and broader use of stormwater reduction and watershed protection resources available on the regional website www.LakeSuperiorStreams.org.

Background
The turbidity and sediment-impaired Amity Creek watershed was chosen as a demonstration site for various restoration and protection activities. Superior trout streams may be harmed by excess mudiness from soil and grit washing in, and erosion caused by too much water entering the streams too quickly after storms and snow melt instead of slowly seeping into the ground first. This project evolved from the Weber Stream Restoration Initiative (www.lakesuperiorstreams.org/weber) and is a collaboration among NRRI, South St. Louis Soil and Water Conservation District, city of Duluth, MN Sea Grant, UMD geology, and Minnesota Pollution Control Agency. Tasks: 1) remediation/restoration of sediment sources (eroding banks, failing bridges and culverts, gullies/washouts); 2) revegetation/reforestation of disturbed riparian zones; 3) tools for rural stormwater runoff and erosion reduction (model land use/stormwater planning tool for township landowners and development of ditch maintenance manual with training workshops; 4) outreach and education (www.LakeSuperiorStreams.org and Superior Regional Stormwater Protection Team; (5) assessment of activities.

Previous Activity
Established working groups, a quality assurance project plan, and initiated revegetation partnership with Duluth Stream Corps project and South St. Louis Soil and Water Conservation District.

Current Activity
Planted trees at restoration sites; developed GIS database for citywide plantings; set up deer repellent experiment. Reviewed Duluth Township prototype and will update aerial photography, add new LiDAR topography data, add drawing/measurement tools for mapping and stormwater runoff estimation, and options for best management practices. Currently compiling information from existing manuals and published literature from Great Lakes region; formed steering committee that produced draft scope for the manual and scope of work for engineer to write the manual. Operated real-time water quality/flow gauging station in lower Amity Creek and conducted three watershed-wide synoptic surveys during spring runoff and a large rainstorm to identify sediment sources; established high resolution benchmarks for ground Lidar based measurements of bluff erosion rates. Continued stormwater runoff and erosion control information dissemination via the LSS website; redesign of Restoration section in progress.

Principal Investigator(s)
Richard Axler

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Start Date: 06/30/2011       End Date: 09/30/2013       Project ID: 1667
Objective

Two major Amity Creek watershed restoration projects were completed in 2009, and approximately twelve related activities are funded for 2011-2013. In this project, water quality, flow, stream bugs and fish (upstream/downstream and pre- and post-construction) will be assessed to evaluate the performance and cost-effectiveness of the restorations and disseminate this essential information via www.lakesuperiorstreams.org. Although this project specifically covers the Amity Creek watershed, it is relevant to all Lake Superior watersheds in the Minnesota Lake Superior Coastal Program management boundary.

Background

The Weber Stream Restoration Initiative began in 2005 via private endowments to create a partnership of UMD scientists and extension educators, and local, state and federal agencies to restore and protect Lake Superior basin trout streams (lakesuperiorstreams.org/weber). WSRI features 1) a demonstration project targeting turbidity/sediment impaired Amity Creek watershed for multiple restoration activities; 2) mapping landscape stressors to highlight areas of higher erosion risk; 3) using real-time data and on-line interactive visualization tools to help inform and educate a broad group of audiences; 4) disseminating technical and non-technical information from the project and related activities via the website. This project funds 2012 water quality, bug, fish, and habitat assessment activities coordinated with the GLRI project to help assess the efficacy of the suite of restoration projects.

Previous Activity

Water quality monitoring at the restoration sites was conducted through Jan 2012 when ice conditions necessitated sensor removal. Stream habitat, periphyton, and fish and macroinvertebrate communities were sampled in Sept 2011. The streams website was operated making data and other stormwater educational and technical information available to its broad audience.

Current Activity

Lab analyses from fall/spring surveys were completed and data posted on the web. The Amity Creek flow gaging station and automated water quality monitoring sensors were operated and data uploaded to website except for late May 2012 due to vandalism, and after June 19 – July 20, 2012 due to Duluth area floods. This massive rain event of > 10 inches in 24 hours destroyed equipment at all Lake Superior streams gaging stations. Website: 1) a new Amity Restoration web section is in development to feature Amity and other regional watershed restoration projects in the Superior basin; 2) a new DataViewer is being beta-tested to allow for stream to stream and multiple-year comparisons; 3) we continue to highlight BMP information and training opportunities via the WHAT’s NEW section of LSS and posted 35 items targeting technical and non technical audiences. Media presentations were developed to aid discussion of the potential effects of the June floods on area water resources, stormwater issues, and on potential impacts to biological communities in Superior basin tributaries and the western arm of Superior.

Principal Investigator(s)

Richard Axler

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Start Date: 09/14/2011  End Date: 12/31/2012  Project ID: 1656
ECOSYSTEM STUDIES - Water Resources

Developing a Diagnostic Tool for Assessing Excessive Sediment Harm to Stream Communities

Objective
To create an indicator of harm to stream biotic communities due to excessive fine sediments.

Background
A number of north shore streams are on the MPCA impaired waters list because of erosion, sediment deposition, and turbidity problems. Excess sediment deposits reduce habitat space for the aquatic macroinvertebrates upon which fish feed, and make spawning more difficult for gravel-spawning fishes.

Our goal is to develop a suite of metrics using stream macroinvertebrate community condition specific to fine sediment deposition. The end result will be a tool that allows water quality managers to determine if sediments are causing biological impairments in streams. The diagnostic tool will help us determine the amount that excess sediment deposits are contributing to any impairment found when macroinvertebrate communities are sampled, even if sediment amounts are not high when samples are collected. Because this sediment-specific tool will be developed using standard invertebrate sampling methods, it can be used to re-evaluate historic datasets for streams of interest. Including historic data will give us an idea of how much sediment deposition contributed to past stream problems, and whether the severity of these effects has changed over time.

Previous Activity
Sediment sampling was completed at all sites five times across a permanent transect at each riffle at each site to track how sediment sizes and embeddedness changed over the course of the summer after various sizes of storm events. The data collected included precipitation amount, current velocity, bankfull width, turbidity, temperature, pH, conductivity, and dissolved oxygen. The stream bed grain size distribution was measured using a Wolman Pebble Count in conjunction with percent composition in sediment size classes in 0.25 sq. m quadrats across the transect. Percent embeddedness was also estimated within each quadrat. Additionally, a sediment sample was collected to determine the size composition of fine sediments (sands, silts, and clays). We collected macroinvertebrate samples at all 22 stream sites between mid-August and the end of September.

Current Activity
Streams covered a range of embeddedness, from not at all embedded, to 25% embedded. The Wolman pebble count and quadrat size classification were compared and used to find the median grain size. The size distribution is one of the sediment characteristics that will be linked to macroinvertebrate traits. Unfortunately, the two different methods used to measure stream substrate size do not compare well with each other, indicating that they cannot be used interchangeably.

Invertebrate samples have been identified, and Chironomidae (non-biting midges) have been identified to genus to help us find good indicators of sediment problems.

Work currently centers around identifying traits that invertebrates may have that would make them sensitive to excessive sediment. We are moving into the statistical analysis phase of this project.

Principal Investigator(s)
Valerie Brady

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Start Date: 08/16/2010    End Date: 12/31/2012    Project ID: 1622
Objective
To develop an ecological design for restoring the Fish and Wildlife Service’s 40th Avenue West and 21st Avenue West Projects.

Background
The lower 21 miles of the St. Louis River, the largest U.S. tributary to Lake Superior, form the 4856 ha St. Louis River estuary. Despite the effects of more than 100 years of industrialized and urban development as a major Great Lakes port, the estuary remains the most significant source of biological productivity for western Lake Superior, and provides important wetland, sand beach, forested, and aquatic habitat types for a wide variety of fish and wildlife communities.

The St. Louis River Alliance Habitat Plan identified several sites within the area of concern with significant habitat limitations. The 40th Avenue West site was identified by a focus group within the SLRA Habitat workgroup as a priority for a remediation-to-restoration project.

NRRI scientists are working with the SLRA Habitat Workgroup to develop an 'ecological design' that will be used to develop remediation and restoration plans for the 40th Avenue West site.

Previous Activity
At an ecological design meeting a number of end users mapped out five to six remediation scenarios, involved placing islands of different sizes and shape at strategic locations in the estuary, with the intent of reducing wave energy that disrupts establishment of submerged aquatic vegetation.

The scenarios were incorporated into a GIS and are now being used to model potential distribution of emergent, floating-leaf, and submerged aquatic vegetation.

Current Activity
Aquatic vegetation models were completed and applied to the remediation scenarios developed by the habitat committee of the St. Louis River Alliance. Maps and summary data were delivered and are under consideration by the committee.

We acquired and processed wind energy and substrate data for the 21st Avenue West site, and are in the initial phases of modeling aquatic vegetation at that site.

Understanding potential habitat, and the effects of the bathymetric changes, fetch disruption, and substrate alterations presented in the five scenarios, should prove useful for providing data to inform decisions of the St. Louis River Habitat Committee in guiding future restoration efforts.

Principal Investigator(s)
George Host
Lucinda Johnson

Project Sponsor(s) | Amount | Account | Active
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USDI Fish and Wildlife Service | 143,980 | 3002-10426-00019490 | 08/01/2010 06/30/2012
USDI Fish & Wildlife | 194,586 | 3002-10424-00025375 | 08/04/2011 06/30/2013

Total $338,566

Start Date: 08/01/2010  End Date: 06/30/2013  Project ID: 1620
Enhanced Tributary Monitoring to Support AOC and LaMP

Objective
Our project will design, install, and operate two or three monitoring stations, coordinated with two to three more stations to be installed by the new Superior National Estuarine Research Reserve in the St. Louis River estuary area of concern. This is one of five Great Lakes projects funded by GLRI-NOAA to develop remote and real-time water quality and biological monitoring that can be integrated into a Great Lakes wide network of data collection, visualization, and dissemination. The project lead is Dr. Jay Austin at the University of Minnesota Duluth Large Lakes Observatory with assistance from NRRI (R. Axler and J. Henneck).

Background
GLOS has developed the Nearshore/Tributary Monitoring Network as a strategic program designed to 'protect, restore, and manage coastal ecosystems more effectively.' Habitat protection and restoration is a major objective outlined in the Great Lakes Regional Collaboration strategy report, with an ultimate goal of improving wetlands function for up to 1.1 million acres across the region. Meanwhile, threats to ecological sustainability are rapidly increasing, such as the introduction of invasive species and land use transformation across the region. As we work to protect and restore natural ecosystems, more information is needed to better understand the restoration impacts and connections between tributary, nearshore, and open lake areas. Access to increased, comprehensive, and coordinated data about the interactions of these systems can help resource manager and other stakeholders make better informed decisions about how to manage and restore the beneficial uses of these ecosystems.

Previous Activity
A multi-agency/organization technical advisory committee was formed. The first site will be the Superior Entry channel between Allouez Bay and Lake Superior. A station site was identified and mounting design presented to the Army Corps of Engineers and U.S. Coast Guard. Project lead, Jay Austin, ordered instrumentation for the site and G. Clark (Wisconsin Sea Grant) and R. Garano (Lake Superior National Estuarine Research Reserve manager) are helping with siting permits.

Current Activity
Superior Entry station site finally received official approval from the Army Corps of Engineers in June 2012. The mounting frame for the Acoustic Doppler Current Profiler, water quality sonde, thermistor string, and data logger were fabricated in the NRRI machine shop and installed on site in late July 2012. Electrical hookup should occur in early August.

LLO and NRRI have coordinated with the Lake Superior National Estuarine Research Reserve staff to obtain permits from the MN Department of Transportation to mount similar instrumentation on the Blatnik, Bong, and Oliver bridges in the St. Louis River main channel. Mounting brackets were fabricated and the team will jointly operate and maintain the network of stations with the LS NERR ultimately taking full responsibility. NRRI is developing a map interface for users to access all data stations via the Web.

Principal Investigator(s)
Jerald Henneck
Richard Axler

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Start Date: 09/01/2010       End Date: 11/30/2012       Project ID: 1644
Event-based Stream Sampling in Northeastern Minnesota

Objective
Determine pollutant concentrations and annual loads of nutrients and suspended sediments by intensively sampling streams during different hydrologic regimes (base flow, storm events, spring runoff).

Background
The Minnesota Pollution Control Agency's Major Watershed Load Monitoring Program requested assistance from local partners to collect samples and field data at designated stream monitoring sites for the purpose of assessing water quality and calculating annual pollutant loads. This project will generate water quality data for ten stream locations MPCA designated for their 2012 and 2013 open-water sampling seasons (eight by NRRI-UMD and two via subcontract to the North St. Louis Soil and Water Conservation District). The overall project goal is to collect event-based physical and chemical data sets for ten agency-prioritized stream sampling sites in northeast Minnesota for calculating pollutant loads and for incorporation into the overall state database for Minnesota Pollution Control Agency assessment purposes.

Previous Activity
This is a new project.

Current Activity
Field personnel training was done by Minnesota Pollution Control Agency event-based stream sampling staff (coordinated by Stacia Grayson) in sampling procedures and the quality assurance project plan developed by NRRI.

Sampling has occurred throughout spring and summer. Water samples have been analyzed for depth, temperature, dissolved oxygen, specific electrical conductivity, pH, and Secchi tube depth; and in the Lab for TSS, TSVS, lab turbidity, TP, OP, TKN, NO3/NO2-N.

Results have been submitted to the Minnesota Pollution Control Agency on a regular basis.

Principal Investigator(s)
Richard Axler

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Start Date: 03/21/2012   End Date: 06/30/2014   Project ID: 1671
GIS Technical Assistance to Support Great Lakes Sea Lamprey Management

Objective
To develop on-line tools to assist Great Lakes fisheries managers in visualizing and interpreting lamprey data.

Background
Sea lamprey are a long-established invasive species in the Great Lakes, and states and provinces have numerous agencies and efforts to control lamprey populations. Yet no single agency has a mandate to synthesize data on a Great Lakes basinwide basis. The goal of this project is to develop on-line data synthesis and visualization to help managers understand the distribution of lamprey and lamprey control measures. The tool will help target future control efforts, as well as further public education on the lamprey issue.

Previous Activity
This is a new project.

Current Activity
We developed a set of potential map outputs including control agent maps (lampricide, barriers, trapping locations) as well as wounding rates, lamprey observations and telemetry information.

A description for a graduate student research position has been made, which will likely come through the Water Resources Science program, and we are currently contacting potential candidates.

Principal Investigator(s)
George Host

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Start Date: 07/01/2011    End Date: 06/30/2012    Project ID: 1648
GLEI II - Indicator Testing and Refinement

Objective
The GLEI-II project will focus on wetland near shore conditions of the Great Lakes, and consist of five tasks: 1) Refine coastal ecosystem indicators from previous monitoring programs through calibration against updated landscape/land use information within the entire Great Lakes basin, 2) test the temporal and geographic integrity of existing Great Lakes indicators. Determine scores for a suite of metrics from sites not sampled previously, and test the applicability of metrics across the Great Lakes basin, including Canada, 3) test and compare analytical techniques to cross-calibrate indicators from concurrent monitoring programs, 4) evaluate indicators for cost-effectiveness, 5) implement a data collection, analysis, and reporting system for recommended indicators as well as a web-based reporting system that integrates landscape/land use information systems, and 6) create a map of baseline conditions for the Great Lakes basin based on historical and current monitoring information.

Background
A comprehensive basin-scale suite of biological, chemical, and habitat indicators throughout the Great Lakes ecosystems, along with monitoring plans for the long-term measurement, will provide valuable information on Great Lakes. Better understanding the condition of this vast resource is vital to the parties charged with administering the agreement.

Previous Activity
Field data quality control measures and data entry occurred during this reporting period. Fish assemblage information and site-level habitat evaluations were entered into an on-line database and are currently available for summary. Invertebrate related information is usually not available for 18 months after collection, but the laboratory sample processing procedures, along with sediment characterization, are on-going and being updated on the web-site as data are entered.

Analysis key to the refinement of indicators was the topic of conversation during a January 2012 PI meeting in Duluth. Indicator analysis procedures using four primary techniques where tested using GLEI-I datasets and presented at the conference. Critical review and recommendations for further analysis were discussed, and manuscript development was outlined. Standard operating procedure evaluations took place to critically review outcomes of the initial field season. Field logistics and procedural changes were identified for further efforts.

Current Activity
Statistical analysis of structural equation modeling (SEM) using GLEI I dataset was initiated. The structure of models was designed in the impact direction from the first group of land impacts (land use, disturbance, shoreline activities, agriculture and development, water/sediment) to the intermediate groups of water quality and habitat, and finally to macroinvertebrates. Preliminary analysis focused on macroinvertebrates traits as response variables. Dominant factors from principal component analysis of each group were employed in the model development. Seven SEM models have been successfully constructed.

Principal Investigator(s)
Euan Reavie
George Host
Gerald Niemi
Lucinda Johnson
Meijun Cai
Richard Axler
Terry Brown
Valerie Brady

Project Sponsor(s)
Environmental Protection Agency

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Start Date: 08/01/2010        End Date: 01/31/2014        Project ID: 1625
Great Lakes Beach Information Communication System

Objective
To develop real-world and on-line warning systems to alert beachgoers to real-time rip current conditions.

Background
Great Lakes beach users have access to an unprecedented amount of data about beaches, including bacteria monitoring, harmful algal blooms, weather, and water forecasts. All of these pieces of information can help beach users decide if today’s the right day to go to the beach, but nowhere is it synthesized in one place. This project will bring these disparate sources of information together into a single 'beach report.' By assembling all relevant beach information and providing the data in multiple formats that are increasingly accessible through wireless technologies, beach users will have a one-stop shop for finding out critical beach information on the go. This increased convenience will result in fewer beach users swimming during unsafe conditions, and greater awareness of beach safety issues.

Previous Activity
We met with National Weather Service and other project personnel to design a system to retrieve information from their website. We also had numerous design meetings prior to having this alert system go live in June 2011.

Current Activity
We developed a model beach report system capable of synthesizing various sources of digital information from a single beach into a single report, and automatically generating summary notices for distribution to beach users through a variety of formats.

We developed this system for Park Point Beach, but designed it so it could be adapted to other beaches. A main component is the parkpointbeach.org website, which reports rip current, temperature and other key information; it also links to a local webcam on Park Point to show current conditions. The system continuously monitors the National Weather Service and responds when there is a change in rip current forecasts.

We created a Park Point beach Facebook page, which was updated daily throughout the summer season. We also created a Twitter feed that alerts uses to rip currents or beach advisories.

Principal Investigator(s)
George Host
Jesse Schomberg

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Start Date: 08/01/2010   End Date: 05/31/2014   Project ID: 1647
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
Sample assessments show that significant changes have occurred in the Great Lakes food web over the last decade in response to establishment of non-native dreissenids and changing water quality. In particular, algal density and biomass are decreasing basin-wide, with the exception of Lake Erie which shows significant blooms of diatoms in the spring. These shifts are being examined for causes and trophic linkages.

Current Activity
We continue to evaluate changes in the Great Lakes that have followed the collapse of the food web due to establishment of non-native dreissenids and changing water quality. In particular, algal density and biomass are decreasing basin-wide, with the exception of Lake Erie which shows significant blooms of diatoms in the spring. These shifts are being examined for causes and trophic linkages. A new team member (Meijun Cai) has been added to develop relationships between pelagic conditions and stressors. Three articles from this study are recently published:


Principal Investigator(s)
Euan Reavie

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Start Date: 03/01/2007      End Date: 06/30/2016      Project ID: 1487
Great Lakes Coastal Wetland Monitoring

Objective
To assess the biotic condition of all the major coastal wetlands of the Great Lakes, United States and Canadian shorelines.

Background
Building on the indicators developed by the Great Lakes Coastal Wetland Consortium and the Great Lakes Environmental Indicators Project, this project will now assess the baseline biotic condition of all the major coastal wetland complexes along the coasts of the Laurentian Great Lakes. Biotic communities to be assessed include birds, frogs, fish, aquatic invertebrates, aquatic macrophytes, along with supporting water quality and habitat. This project will spend 5 years sampling and assessing coastal wetlands around the Great Lakes using crews based in Duluth, Green Bay, Michigan/Indiana, New York, Windsor, and eastern Ontario.

Previous Activity
The NRRI GIS lab created a site selection system that will be used by all collaborators across the Great Lakes to virtually review and select sites appropriate for sampling in each year. There were 1,039 sites selected for the five years.

In 2011, NRRI fish/bug/veg crews visited about 35 sites, sampling 23, while bird/amphibian crews tried to access about 50 sites, sampling 37. The summer's results were reported at the 2011 State of the Lakes Ecosystem Conference.

Crews spent the winter entering and quality checking data, and identifying aquatic macroinvertebrates. The database system that supports the entire project and holds and serves all of the data was built by the NRRI GIS laboratory.

Current Activity
Lead researchers are starting to delve into the data collected last summer to calculate indicators of wetland condition, verify that these indicators work across all the types of wetlands encountered across the Great Lakes, and 'tweak' indicators that need to be adjusted so that they accurately indicate wetland condition.

Meanwhile, crews have again been in the field for the entire summer sampling coastal wetland sites. This year NRRI fish/bug/veg crews targeted 28 wetlands, while the bird/amphibian crews targeted 50 wetlands. The ambitious step this year involved getting crews safely to Isle Royale to sample 5 wetlands; this included 3 visits per wetland for bird/amphibian crews. The venture was successful (and safe), but provided quite challenging logistically (especially keeping water quality samples cold or frozen).

This fall, crews will be identifying the wetland bugs and entering all data into the database system.

Principal Investigator(s)
George Host
Gerald Niemi
Lucinda Johnson
Richard Axler
Valerie Brady

Project Sponsor(s)

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Start Date: 09/01/2010   End Date: 08/31/2015   Project ID: 1605
Impacts of Land Development and Climate Change on Lake Superior's North Shore Trout Habitat

Objective

1) Characterize the current hydrology of North Shore streams, including precipitation and streamflow trends, water budgets, and the relative importance of different baseflow sources.
2) Characterize current stream temperature regimes in North Shore streams using a combination of deterministic models for select study sites and empirical models for broader spatial coverage. 3) Forecast future streamflow and temperature regimes in North Shore streams based on expected changes in land use and in climate. Short term forecasts can be made based on current trends, and long term forecasts can be made based on available climate and land use change data.

Background

Both land development and climate change are expected to impact aquatic habitat (flow, temperature) in North Shore streams. Changes in land use can impact stream habitat via changes in riparian vegetation, modifications to the stream channel itself, increases in surface runoff rate and volume, and loss of hydrologic storage in surface and ground water. Climate change can impact stream habitat via changes in the stream flow regime due to changing precipitation patterns, including intensity and seasonal distribution, and changes in surface water temperatures due to increases in air temperature and humidity. To develop long-term strategies to address these impacts, state agencies and local watershed managers will need information on both the potential extent of the impacts and the physical mechanisms for the impacts.

Previous Activity

Available historical climate and stream flow data for the North Shore region have been assembled and characterized. A deterministic hydrologic model has been developed that predicts year-round stream flow at weekly time increments, and a deterministic temperature model has been developed to predict current and future stream temperature at daily to monthly time steps. A regional regression model has been developed to relate seasonal stream flow, baseflow, and low flows to precipitation, air temperature, and wetland area fraction.

Current Activity

The mechanistic hydrologic and temperature models have been calibrated for the Baptism River, the Knife River, and Amity Creek. Preliminary projections of future streamflow and temperature in the Knife River have been made using the deterministic flow and temperature models, based on monthly climate increments from the Canadian Global Climate Model ver. 3.1. Climate increments for several other global climate models are currently being assembled. Available DNR stream temperature data for North Shore streams has been assembled, and an empirical stream temperature model is being developed to predict mean July stream temperature based on air temperature and catchment land cover.

Principal Investigator(s)

Lucinda Johnson

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Start Date: 05/26/2011   End Date: 11/30/2012   Project ID: 1643
Lake of the Woods Paleolimnology Assessment

Objective
Lake of the Woods has been placed on Minnesota’s impaired list for nutrients and eutrophication indicators, so the future of the lake has become a high profile concern for the Ontario and Minnesota governments and the lake’s diverse group of stakeholders. Research recommendations and data gaps suggested that improved coordination of monitoring efforts and the construction of a long-term ecological reconstruction for the lake were logical steps in management of the resource. NRRI’s objective in this investigation is to collect sediment cores and use archived materials to provide long-term trends and trajectories of lake conditions for use in resource management.

Background
Lake of the Woods has been placed on Minnesota’s impaired list for nutrients and eutrophication indicators, so the future of the lake has become a high profile concern for the Ontario and Minnesota governments and the lake’s diverse group of stakeholders. Research recommendations and data gaps suggested that improved coordination of monitoring efforts and the construction of a long-term ecological reconstruction for the lake were logical steps in management of the resource. NRRI’s objective in this investigation is to collect sediment cores and use archived materials to provide long-term trends and trajectories of lake conditions for use in resource management.

Previous Activity
This project is getting started. Candidate sediment core locations have been selected, and field work for sample collection will begin this winter.

Current Activity
Field work was complete in March 2012 with the collection of six sediment cores from throughout the lake. These cores have been sectioned and sample preparations for physical, chemical and biological analyses are in progress.

Principal Investigator(s)
Euan Reavie

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Start Date: 06/30/2011    End Date: 06/30/2013    Project ID: 1646
Objective
Assist the Environmental Protection Agency funded, Minnesota Pollution Control Agency directed Lake Superior Beach Monitoring and Advisory program.

Background
The Natural Resources Research Institute was contracted by the Minnesota Pollution Control Agency to carry out the Minnesota Lake Superior Beach Monitoring and Advisory Program for 2010. After the field season ended the agency transferred the program to the Minnesota Department of Health for 2011 and beyond. NRRI was contracted by the health department to operate the www.mnbeaches.org website in 2011 and again in 2012. In 2012, NRRI will reformat the website to suit smartphone and other handheld device applications (apps) being developed by similar beach advisory programs and third party businesses for disseminating such information to the general public. The Dataviewer will be improved by providing more plotting choices including historical trend graphs for each beach site. NRRI will collaborate with health department staff to improve the mnbeaches.org maps for rapidly displaying advisories by adding more information to pop-up balloons (including relevant links to other websites and websections) and converting the Javascript code driving the Google map to use their latest API (Google provides an application programming interface to use their tool on any website).

Previous Activity
Data received from the Minnesota Department of Health are being uploaded onto the www.mnbeaches.org website and notifications sent out by email to dozens of interested parties if health risk criteria are exceeded. We are also a part of a MN Sea Grant project funded via the EPA’s Great Lakes Restoration Initiative called the Great Lakes Beach Information Communication System. G. Host is directing the NRRI component of the project which will develop a model beach report system to synthesize various sources of digital information from a single beach into a single report, and automatically generating summary notices for distribution to beach users through a variety of formats. The system will produce daily beach reports during the recreation season based on automated and manual monitoring data, forecasts/nowcasts, and volunteer data collection, and that if dangerous conditions are reported during the day, an automatic report will be distributed, warning of the changing conditions.

Current Activity
The 2012 monitoring season is in progress in collaboration with the Minnesota Department of Health and data and advisories are being reported on the website.

Our beaches website also became the home for www.parkpointbeach.org, a site developed with GLRI funding and led by MN Sea Grant (J. Schomberg PI) to provide time-relevant information on rip current warnings.

The website was also used by the MPCA and MDH to post drinking water and flood water information to the public in Carlton County following the record flooding that occurred after the June 19-20, 2012 rainstorms.

Principal Investigator(s)
George Host
Richard Axler

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Start Date: 08/16/2010   End Date: 12/30/2012   Project ID: 1624
ECOSYSTEM STUDIES - Water Resources

Landscape Metrics for Coastal Wetland Integrity Indices

Objective
To test existing landscape indicators of coastal marsh integrity that can be incorporated into a coastal wetland monitoring program. Using the same set of coastal marshes selected for the USGS project we will 1) evaluate the ability of individual landscape indicators to discriminate between reference, disturbed, and managed sites, and 2) analyze redundancy among landscape indicators and between landscape and site specific indicators.

Because funds for monitoring are often tight, it is advantageous to maximize the amount of information relative sampling costs in a monitoring program. For example, it would not be wise to monitor more than one variable that conveyed the same information. Thus, one part of developing a multi-metric assessment is to evaluate redundancy among indicators. If there are indicators that are highly redundant, then the variable that is more expensive to monitor or is less useful may be eliminated from consideration.

Background
The National Wildlife Refuge System includes 161 coastal refuges on 1,045,925 acres of coastal marsh. The majority of these marshes have experienced some form of anthropogenic alteration such as oil spills, chemical mosquito control, drainage for mosquito control, salt hay farming, introduction of invasive species, restricted tidal flow, road construction, or channelization. These alterations impact both the intrinsic value of coastal marshes as well as the quality of marsh habitat for the unique wildlife they support.

Tools for the assessment of ecological condition remain underdeveloped for these ecosystems. Such tools are critically needed to guide decisions regarding protection, management, and restoration. The most meaningful and useful assessments of ecosystem condition are based on reliable indicators of ecosystem integrity that are integrative across several spatial scales and levels of biological and environmental organization.

Neckles et al. (2008) listed >50 measurable attributes for coastal marshes that could serve as indicators for coastal marsh condition. USGS is evaluating the response of candidate indicators within coastal marshes on 15 National Wildlife Refuges throughout the Atlantic and Pacific coasts of the U.S. In conjunction with site specific indicators, there is a need to evaluate landscape indicators for this same set of coastal marshes.

Previous Activity
Wetland monitoring was conducted in 13 National Wildlife Refuges, with sampling in reference, disturbed, and managed areas. Landscape data and metrics were acquired or derived across the region. Each was evaluated for redundancy and ability to discriminate across disturbance status.

Current Activity
Landscape metrics were incorporated into analyses and reported for coastal marshes in 15 National Wildlife Refuges. Comparisons of metrics across sites and disturbance status are ongoing.

Principal Investigator(s)
Jennifer Olker
Lucinda Johnson

Project Sponsor(s) | Amount | Account | Active
---|---|---|---
USDI US Geological Survey | 93,052 | 3002-10426-00012660 | 08/01/2009 06/30/2013

Total | $93,052

Start Date: 08/01/2009    End Date: 06/30/2013    Project ID: 1561
Managing the Nations Fish Habitat at Multiple Spatial Scales

Objective
1) To refine empirical and mechanistic models for predicting extent of cold water fish habitat under current land use and climate regimes. Predict oxythermal habitat for coldwater fish species using an empirical model incorporating existing land use, lake morphometry, and climate data.

2) Predict future extents of cold water fish habitat in lakes of the Glacial Lakes region under future climate and land use scenarios. Predict future oxythermal habitat in lakes under changing land use and climate for a large set of regional coldwater lakes using empirical models. Predict future oxythermal habitat for individual lakes under changing land use and climate for distinct lake classes and/or geographic regions using a mechanistic model.

Background
Coldwater fish communities are especially vulnerable to eutrophication and the effects of climate change. Climate warming has the potential to reduce coldwater fish habitat by direct warming and increased hypolimnetic oxygen depletion (Schindler et al. 1996; Stefan et al. 1996; Magnuson et al. 1997; Fang et al. 2004). Deep lakes with large, oxygenated hypolimnions may represent important sanctuaries for coldwater species such as cisco. Projected range reductions for cisco and other coldwater species would allow for the identification of high priority refuge lakes. Once identified, lake watershed protection efforts could be directed at refuge lakes to prevent further anthropogenic impacts.

Previous Activity
Ecoregion-specific regression models to relate land use and climate to annual lake nutrient loading rates have been developed for the Glacial Lakes region using historical land use, climate, and in-lake nutrient data. Preliminary projections of future nutrient loading rates have been completed based on future climate projections from one GCM (global climate model) and future land use projections developed at Purdue University. Future climate data from 2 alternate GCMs have been processed for use as model input. The Minnesota DNR empirical model for temperature/oxygen conditions have been tested for Wisconsin lakes.

Current Activity
The combination of the nutrient loading model and the DNR coldwater habitat model is being used to make future projections of coldwater habitat for 255 lakes in Minnesota, Wisconsin, and Michigan. New land use projections from Purdue University extending to the year 2105 have been incorporated into the nutrient loading model. Coldwater habitat projections are being made for 20-year time increments to 2090, using climate data from 3 GCMs. A sensitivity analysis has been performed to assess which lakes experience the greatest changes for spatially uniform change in land use and air temperature. Statistical methods for summarizing and generalizing the results are currently being developed, including the selection of a spatial scale for summarizing individual lake results and for identifying the most vulnerable regions and types of coldwater lakes.

Principal Investigator(s)
Lucinda Johnson

Project Sponsor(s)  Amount  Account  Active
USDI CESU Coop Ecosystem Study  269,648  3002-10426-00015141  01/19/2010  12/31/2012

Total  $269,648

Start Date: 01/19/2010  End Date: 12/31/2015  Project ID: 1563
Paleolimnology Workplan: Building a Long-term Water Quality Record for the White Iron Chain of Lakes

Objective
The White Iron Chain of Lakes comprises the lower portion of the Kawishiwi watershed, draining an area of 1,200 square miles of northern Minnesota’s Rainy River basin. Water quality in the White Iron Chain of Lakes has been subject to human-induced environmental changes since settlement of the region approximately 150 years ago. By describing in detail impacts caused by past environmental insults, we may be able to predict the impacts of future development scenarios. Our paleolimnological assessment will offer pre-settlement baselines, environmental trends, and the timing and magnitude of changes related to human activities. These evaluations will provide important background and remedial information.

Background
The White Iron Chain of Lakes comprises the lower portion of the Kawishiwi Watershed, draining an area of 1,200 square miles of northern Minnesota’s Rainy River basin. Water quality in the WICOL has been subject to human-induced environmental changes since settlement of the region approximately 150 years ago. By describing in detail impacts caused by past environmental insults, we may be able to predict the impacts of future development scenarios. Our paleolimnological assessment will offer pre-settlement baselines, environmental trends, and the timing and magnitude of changes related to human activities. These evaluations will provide important background and remedial information.

Previous Activity
In 2011, sediment cores were collected from the five scoped locations. These five cores are currently being processed for algal microfossils, geochemistry, pollen, organic and inorganic material and isotopes.

At this time no results are ready, but preliminary data indicate that we have retrieved sediment cores with intact profiles, and so we will be able to reconstruct an unbroken record of changes in the WICOL water quality, terrestrial activities and biological conditions. We continue to confer with various stakeholders via the WICOL Association and Lake County, Minnesota.

Current Activity
Initial results from paleolimnological analyses indicate that gradual changes have occurred in these lakes in response to human activities such as deforestation (and recovery), shoreline development and changes in nutrient flux. These results suggest that the major influence on lake characteristics has been damming, which changed the hydrology. A reduction in biodiversity in lake primary producers suggests some eutrophication, but further data developments are required for more detailed conclusions. We anticipate a more complete story for the WICOL lakes in early 2013.

Principal Investigator(s)
Euan Reavie

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Start Date: 06/15/2011       End Date: 06/30/2013       Project ID: 1655
Prioritizing Wetland Restoration for Water Quality and Habitat Improvement

Objective
To prioritize wetland restoration to select sites that will most likely result in high quality wetlands which will be sustainable in the future and second, to prioritize wetland restoration that will improve water quality and habitat.

Background
Current thinking suggests that wetlands with a catchment area of approximately five times the size of the basin represent the most likely opportunities for reliable and sustainable water quality improvement. However, watershed delineations for individual wetlands require highly resolved topographic data that are not yet available state-wide. Thus, we will use a two-tiered approach to identify at-risk regions within major watersheds and next, for a set of test watersheds across the state, we will identify individual wetland complexes with high potential for performing multiple beneficial functions.

Previous Activity
Activities have focused largely on development of a literature review, detailed work plan, and acquisition of spatial data needed to identify at-risk regions where wetland restoration for the purpose of water quality enhancement will be most beneficial.

Current Activity
A statewide restorable wetlands index model is being developed to locate suitable locations for wetland restoration not already delineated by past projects. The model uses readily available GIS data including a digital elevation model, the SSURGO soils data, and the National Wetlands Inventory. Once statewide LiDar data becomes available, the restorable wetlands index will be refined using the high resolution digital elevation model.

A statewide stressor index is being developed at the lakeshed level (watershed boundaries for lakes greater than 10 acres) using the previously acquired spatial data. The stressor index will aide in restoration efforts by directing managers to either high or low impacted watersheds depending on what their restoration objective is. Because not all landscape stressors affect wetlands evenly the individual spatial data is being weighted based off stressor thresholds determined in past studies, information gathered from Minnesota index of biotic integrity studies, and recommendations from a wetland advisory committee consisting of wetland experts from around the state.

Principal Investigator(s)
Jeremy Erickson
Lucinda Johnson
Terry Brown
Valerie Brady

Project Sponsor(s)
MN Pollution Control Agency

Start Date: 03/14/2011   End Date: 06/30/2013   Project ID: 1627

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

**Objective**
The Great Ships Initiative (GSI) is an 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. NRRI’s task in this effort is to develop, test and apply methods to evaluate the effectiveness of candidate treatments systems in their ability to exterminate algae and protozoans.

**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 Initiative 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 Initiative 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**
Several candidate treatment systems have been tested and several reports to vendors and regulators have been provided (www.greatshipsinitiative.org).

2011 efforts are well under way. We are finishing anonymous testing on 'government furnished equipment' for consideration as a ship-board treatment alternative. Ship-board testing is also under way, and we have been tracking the activities of two Great Lakes ships in order to sample real ballast water and attempt preliminary treatment system activities.

Several presentations related to the project comprised a session at the International Association for Great Lakes Research conference.

**Current Activity**
Candidate treatment systems continue to be reviewed and tested, and several reports to vendors and regulators have been provided (www.greatshipsinitiative.org).

Efforts for 2012 are under way. This year we will be testing several candidate treatment systems for consideration as a ship-board treatment alternative. These tests involve ship-board testing and land-based assessment at the facility in Superior WI. Also, a new study is beginning to determine the propagule pressure needed to actually result in establishment of a new invasive species in the harbor at Duluth/Superior. This work involves a new graduate student, Meagan Aliff, in the Water Resources Science program.

**Principal Investigator(s)**
Euan Reavie

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Total $671,266

**Start Date:** 01/22/2007  **End Date:** 04/30/2015  **Project ID:** 1469
Stressor Gradients and Spatial Narratives of the St. Louis River Estuary

Objective
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.

Background
The St. Louis River estuary, 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.

Previous Activity
Twenty-six locations throughout the estuary were sampled during base flow in 2010 and 2011 and during the end of spring runoff in 2011. Near shore and tributary samples were taken at each site. Additionally, the tributaries of 17 of those sites were sampled during five storm events during summer 2011. The samples were analyzed for dissolved oxygen, pH, conductivity, turbidity, temperature, clarity, color, nutrients, chlorophyll-a, phaeophytin, chloride, and sulfate.

Nitrite/nitrate-N and chloride were significantly correlated with the stressor gradient for all flow regimes in both the tributaries and near shore environment. Total nitrogen, ammonium-N, conductivity, turbidity, clarity, dissolved oxygen and phaeophytin were correlated with more than one flow regime. The stressor gradient appears to be a useful tool in watershed assessment, experiment design and management.

Current Activity
Water Resources Science student Will Bartsch successfully defended his master of science thesis, which studied variation in tributary and nearshore water quality to watershed-based stressors across the estuary. Key findings: there is a strong chloride signal related to human activity; and geomorphic variability between the Minnesota and Wisconsin sides of the estuary must be taken into consideration to quantify stressor effects.

In June we held a two-day teacher/outreach workshop on Barker's Island. The workshop consisted of testing mobile phone and geocaching-based games to teach history and science of the area. The University of Wisconsin-Madison group co-hosted an evening cruise on the Vista Queen on Lake Superior, where participants mingled with scientists and interviewees from the spatial narratives part of the project.

Principal Investigator(s)
George Host
Richard Axler

Project Sponsor(s)  
MN Sea Grant  
Account: 1000-10424-20857-000169  
Active: 02/01/2010 03/31/2013  
Amount: 110,311

Total  
Amount: 110,311

Start Date: 07/01/2010  
End Date: 03/31/2013  
Project ID: 1590
Objective
This project will generate physical and chemical water quality information for three lakes that the Minnesota Pollution Control Agency has included in their list of ‘targeted lakes’ for assessment in the 2011 and 2012 field seasons. NRRI’s Center for Water and the Environment has a long-term interest in identifying status and trends that may reflect short and long-term trends 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.

Background
The Clean Water Legacy Act Surface Water Assessment Grant Program has created funding for local organizations, universities and citizen volunteers to help the Minnesota Pollution Control Agency assess the condition of Minnesota’s streams and lakes. Water quality, biological, and habitat data are critical for identifying status and trends that may reflect short and long-term trends 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 was funded to collect seasonal limnological data from three Superior basin lakes in 2011 and 2012.

Previous Activity
Lakes were sampled five times in 2011 from May through September. All water chemistry analyses have been completed. Field and laboratory data as well as an interim report were submitted to the Minnesota Pollution Control Agency per the project timeline.

Current Activity
Lakes were sampled in May and June 2012 and will be sampled in July, August, and September. All water chemistry analyses for May and June have been largely completed. Field and laboratory data, as well as an interim report, will be submitted to the Minnesota Pollution Control Agency.

Principal Investigator(s)
Elaine Ruzycki
Richard Axler

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Start Date: 03/15/2011   End Date: 06/30/2013   Project ID: 1621
Personnel

Gerald Niemi was elected to a three-year term on the Board of Directors of the Hawk Migration Association of North America. The organization is responsible for documenting the systematic counts and trends of migrating birds of prey across North America.

Jennifer Olker received the Best Student Poster Award for her poster titled “Testicular oocyte presence and severity differs across amphibian species, unrelated to atrazine concentration” co-authored by Lucinda Johnson, Pat Schoff, and Rodney Johnson (EPA MED) at the Midwest Chapter of the Society of Environmental Toxicology and Chemistry meeting held Mar. 21-22 in Minneapolis, Minn.

Olker has been named a Consortium Student Scholar and also received a financial award from the Consortium for Law and Values in Health, Environment and the Life Sciences for her dissertation research on “Atrazine concentration in wetlands and associated landscape factors in the Upper Midwest.”

Andrea Crouse, advanced masters teaching assistant, received the Outstanding Teacher’s Assistant Award from UMD’s Department of Biology on Apr. 26.

Publications


Amy Kireta, Reavie, Gerald Sgro (John Carroll University), Ted Angradi, David Bolgrien, Brian Hill and Terri Jicha (all four of the EPA Mid-Continent Ecology Division) published “Assessing the condition of the Missouri, Ohio, and Upper Mississippi rivers (USA) using diatom-based indicators” in the journal Hydrobiologia, issue 691, pp. 171-188.

Scientific Presentations/Meetings

Cindy Hale was keynote speaker at the Wildlife Diversity Conference held by the Ohio Department of Natural Resources on Mar. 7. Her talk was titled “Dances with Worms: The Great Lakes Worm Watch.”

CWE staff gave the following presentations at the Society for Freshwater Science annual meeting held in May 2012 in Louisville, Ky.: Lucinda Johnson gave a talk titled “A comparison of four analytical methods for deriving bioindicators of condition for Great Lakes research” co-authored by Valerie Brady, George Host, Gerald Niemi, Euan Reavie, Terry Brown, Nick Danz (UW Superior), Jan Cibrowski and Katya Kovalenko (University of Windsor), R.W. Howe (UW Green Bay) and J. Gathman (UW River Falls). Also presented was “Congruency in community thresholds in response to anthropogenic stressors in the Great Lakes coastal wetlands” authored by Kovalenko, Richard Axler, Brady, Brown, Cibrowski, Danz, Gathman, Host, Howe, Johnson, Niemi and Reavie. Johnson, Axler, Brady, Brown, Ciborowski,
Danz, Gathman, Host, Howe, Kovalenko, Niemi, and Reavie presented “Conceptual design and template for development of ecological indicators for the Laurentian Great Lakes coast.” Reavie and S. Juggins (Newcastle University, UK) presented a seminar titled “Calibrating algal indicators: how many samples are enough?” Kovalenko, Axler, Brady, Brown, Ciborowski, Danz, Gathman, Host, Howe, Johnson, Niemi and Reavie presented a seminar titled “Community thresholds in response to anthropogenic stressors in the Great Lakes coastal wetlands.”

CWE staff presented the following at the 55th International Conference on Great Lakes Research in Cornwall, Ontario in May 2012: Reavie and Juggins presented a poster titled “Calibrating diatom-based indicators for the Great Lakes: how many samples are enough?” Johnson, Axler, Brady, Brown, Ciborowski, Danz, Gathman, Host, Howe, Kovalenko, Niemi and Reavie presented a seminar titled “Conceptual design and template for development of ecological indicators for the Laurentian Great Lakes coast.” Kovalenko, Axler, Brady, Brown, Ciborowski, Danz, Gathman, Host, Howe, Johnson, Niemi and Reavie gave a seminar titled “Invertebrate, fish, diatom and bird community responses to anthropogenic stress in the Laurentian Great Lakes coastal wetlands: threshold analysis.”

Reavie and Juggins presented a seminar titled “Calibrating diatom-based indicators: how many samples are enough?” at the Phycological Society of America Annual Meeting in Charleston, S.C. in June 2012.

M.B. Edlund (St. Croix Watershed Research Station), Reavie, S. Schottler, D. Hogardy, N. Wattrus (all three of the St. Croix WRS), N. Baratono (MPCA), A.M. Paterson (Dorset Environmental Science Centre, Ontario) and D.E. Engstrom (St. Croix WRS) presented a seminar titled “Reconstructing a historical phosphorus budget for Lake of the Woods” at the 9th International Lake of the Woods Water Quality Forum in International Falls, Minn., March 2012.

Outreach

Valerie Brady, research associate, served on an EPA STAR Fellowship panel during the week of Feb. 20.

Brady also spoke on WTIP radio, March 25, about Sea Grant’s newly funded research projects for 2012-2014 and in May gave a presentation on stormwater issues for rural townships to the Duluth Township Planning and Zoning Board.

Ron Moen gave a talk to the Tuesday Club at Grand Ely Lodge about Canada lynx in Minnesota on Apr. 3.

Elaine Ruzycki, research fellow, talked about her Sea Grant-funded stream/mercury study on WTIP radio on Apr. 26.

Ryan Hueffmeier and Andrea Crouse, NRRI sustainability committee chairs, staffed a booth at UMD’s and Lake Superior College’s Sustainability Fair in May 2012 to promote research efforts for the sustainable use of Minnesota’s natural resources.
NRRI Business Development
NRRI has a mission to foster economic development of Minnesota’s natural resources in an environmentally sound manner to promote private sector employment. As such, we have a range of stakeholders, from the individual entrepreneur with an idea to very large industry, such as mining and forestry. The NRRI Business Group focuses more on what can be referred to as NRRI’s niche, or providing one-on-one entrepreneur/small business development, including the science behind taking an idea to proof of concept and even to industrial scales. There are two areas that can limit NRRI’s ability to assist the entrepreneur/small business. The first is their limited financial ability to pay for the services we are capable of providing. But, if our scientists believe the idea has merit, preliminary market analysis indicates the idea meets a national need and the economics appear to make sense, we do what we can to help them out and even seek resources on their behalf (Product Development Fund and SBIR/STTR reference below). The second area is the perception of how intellectual property is handled in the event the research has patentable results. The University is a very large organization and has federal and state considerations that are incorporated into standard research agreements. For instance, researchers must have the right to publish their results. While this may be important to professors on a tenure track, the scientists at NRRI focus on transferring the knowledge to entities that have the ability to commercialize the technology (the entrepreneur) and do not have the same need to publish. The NRRI Business Group is doing what it can to work with the various offices throughout the University to develop agreements that capture the essence of what NRRI is about. Our work over the last five years has resulted in several successful research agreements and we continue to explore ways in which NRRI shares in upfront risks as well as shares in the rewards through a royalty structure in the event the client is successful with commercialization (patentable or not). We only win when our client wins. NRRI received word that the UMN would allow NRRI to have special language when working the small business clients around capping any royalties to 5% or less. We are proud of where we have come and strive to make our process more entrepreneur/small business friendly. It is good for the entrepreneur, our region, state, and the United States to collaboratively develop and transfer knowledge and technology. The process takes time, but our experiences lead us to believe it is worth it.

The below activities encompass specific projects activities where the NRRI Business Group provided assistance.

**Intellectual Property Portfolio**

- **Fines Removal System** – a considerable amount of time has been spent working with a potential licensee, the inventors, and a local mining operation to test new chevrons that were designed for the system. It was anticipated that the potential licensee would build one unit some time in 2012 for the mining company that has been assisting NRRI with testing the fines removal system. However, NRRI has not been able to complete the modifications and 30 day pilot trial as of yet.

- **Biodiesel Technology** – A patent was issued for this technology. The principal investigator is Pavel Krasutsky and research continues to demonstrate the economic viability of the technology on the ethanol industry. By calendar year 2013, we should be in a position to develop a commercialization strategy for potential licensees with the UMN Office of Technology Commercialization.

- **Road Patch Technology** – NRRI continues to support the UMN licensee for this technology, providing expertise and connections with organizations such as MN Dot and potential material suppliers. Efforts are focused on assisting the licensee in working with MN DOT to receive certification for the new product. It is anticipated that a small commercial run will occur in late 2012.

- **Chemical Derivatives Laboratory** – The UMN entered into an option agreement for a number of patents related to NRRI’s birch bark technology to an entrepreneur who is very familiar with NRRI and our intellectual property capabilities. The entrepreneur is working with Dr. Krasutsky to assess the potential
market and develop a business plan to attract investors. Work continues between this start-up business, UMN Office of Technology Commercialization, and NRRI.

- Peat Technologies – NRRI’s Principle Investigator Igor Kolomitsyn has been supporting a local peat company on improving the performance of the company’s base intellectual property. Various agreements are in place to fund the research and to jointly file on additional intellectual property that has arisen through the joint efforts. An exclusive license agreement will be negotiated and the company anticipates taking new products to market in the last half of 2012.

NRRI Product Development Fund program –“Small Business Innovation Initiative”

While two of the four projects remain to be completed, NRRI is working to expand the program and stabilize it through additional fundraising as follows:

Objective: Raise $1.5 million to increase the University of Minnesota Duluth’s Natural Resources Research Institute (NRRI) ability to support the regional economy through technical assistance to existing small businesses and emerging entrepreneurs with a three-tier approach:

1. Support small business ideas with access to NRRI’s applied research and technology development capabilities – along the product development continuum.
2. Enhance lean manufacturing education, implementation, and networking for rural small businesses.
3. Create an awareness and support for Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) programs.

Outcome:
- Increased access for small businesses to NRRI’s scientific and engineering staff, laboratories, and technologies.
- Small business creates/retains 300 jobs creating the ripple effect of a stronger economy.
- Private investment of additional $1.5 million cash and/or in-kind effort.
- Increased private sector innovation and commercialization.
- Creation of an applied small business proof of concept center focused on product development and manufacturing assistance.

Opportunity: NRRI’s applied research and development capabilities better prepare entrepreneurs/small businesses to turn business ideas into successful ventures. NRRI and its network of cooperators customize an array of technical, research and support services to commercialize their innovations and strengthen their ability to compete regionally and globally.

For clients with new product ideas that prove economically viable, working with NRRI will allow them to reach the market faster and with less risk. A special emphasis placed on clean, green technology companies. This will include research and business activities in renewable energy, energy efficiency, reuse/recycling and innovations in green building technologies.

Leverage: NRRI is providing a 20% match, up to a maximum of $250,000, for this program. Further, each client receiving support will provide a 1:1 leverage. The $1.5 million program will provide a minimum of an additional $1.5 million in private sector investment through a combination of in-kind, material, and cash contributions.
The following is the current activity related to expanding the program.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Amount</th>
<th>Territory</th>
<th>NRRI Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blandin Foundation</td>
<td>$150,000 (approved)</td>
<td>Rural NE MN – Excluding Duluth</td>
<td>$30,000</td>
</tr>
<tr>
<td>Bremer Foundation</td>
<td>$100,000 (approved)</td>
<td>Within 20 mile radius of Bremer banking communities, rural MN</td>
<td>$20,000</td>
</tr>
<tr>
<td><strong>In Discussion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minnesota Power</td>
<td>$30-$50,000 (Preliminary approval)</td>
<td>MP Service Territory</td>
<td>$6,000-$10,000</td>
</tr>
<tr>
<td>Great River Energy</td>
<td>Pending</td>
<td>GRE Service Territory</td>
<td>Pending</td>
</tr>
<tr>
<td>IRRRB</td>
<td>open to further discussion</td>
<td>IRRRB Territory</td>
<td>Pending</td>
</tr>
<tr>
<td><strong>Other Strategy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review companies in MN that have foundations, learn parameters and make contact.</td>
<td>Based on parameters of program</td>
<td>Based on parameters of program</td>
<td>$1 to every $5 raised.</td>
</tr>
<tr>
<td>Foundation Database – working with UMD to subscribe to database for greater reach.</td>
<td>Based on parameters of program</td>
<td>Based on parameters of program</td>
<td>$1 to every $5 raised.</td>
</tr>
</tbody>
</table>

**Minnesota Mining Cluster** – as part of development of a regional grant application, NRRI’s product development fund received $100,000 to work with mining supply companies on product and/or process development opportunities. A follow-up meeting was held with one of the UMD CED clients, with anticipation that a lean manufacturing application will be forthcoming.

**Marketing Plan**
One of NRRI’s greatest challenges is creating an awareness of who NRRI is, what and how NRRI does what it does, and how to access NRRI’s services. The challenge exists for potential clients as well as various stakeholders, including employees, UMD, UMN, legislators, state agencies, federal agencies, and economic development professionals across the state. In part, this is a result of the complexities of being within the University system while embracing a mission that has economic development at the forefront.

The intent of the marketing plan is to develop strategies for communicating the value NRRI brings to the state, region, and nation on a deliberate, unified basis with current and future stakeholders. NRRI stakeholders include funders, collaborators, and NRRI management and staff. Funders include a diverse portfolio of industry, state, federal, university, tribal, and foundations. Collaborators allow NRRI to leverage resources. Management and staff serve as the agents for demonstrating and as the primary voice for communicating the value NRRI brings to funders and collaborators.
The objectives (purpose) of the NRRI marketing plan is to:
1. Maintain and grow revenue
2. Improve and develop stakeholder relationships
3. Diversify the business/customer portfolio
4. Foster employees’ ability to represent NRRI in unified manner

The intended outcomes are:
1. Increase revenue by “X” percent
2. Improve stakeholder satisfaction
3. Increase number of companies accessing NRRI’s services
4. Consistent, unified message to demonstrate and communicate NRRI’s value.

The overall strategies for meeting the objectives of the marketing plan revolve around a three-phase approach.

Phase I: Planning (SWOT/Service Focus and Goal Setting/Marketing program budget)
Timeline: Current through 12/12
Phase II: Implementing (Obtain resources, develop schedules, execute plan)
Timeline: Current through 6/13
Phase III: Controlling (compare results with plans and action to adjust)
Timeline: Ongoing process – at least yearly evaluations

NRRI has created a greater emphasis on connecting with economic development professionals across the state and well as with the International Economic Development Council. Steps that have been taken to-date include the following:

Deliberate and Intentional efforts to Communicate and Demonstrate NRRI Value:

- **IEDC Award.** Responded to the International Economic Development Council (IEDC) request for projects/programs to compete for Excellence in Economic Development awards. The NRRI’s Small Business Innovation Initiative (Product Development Fund) was selected for the Gold Entrepreneur Award. NRRI received the award at the IEDC annual conference in Houston, Texas on October 2, 2012.
- **IEDC Annual Conference.** As a result of the IEDC Excellence in Economic Development Award, NRRI was given an opportunity to submit a proposal to serve as a presenter during the IEDC Annual Conference and was successfully selected. In five minutes, P. Sarvela will have 20 slides, 15 seconds each, to provide an overview of the program and squeeze some information about NRRI.
- **IEDC Economic Development Journal.** NRRI received a request from the IEDC to write a 2500 word story about our small business innovation initiative. Deadline is September 30, 2012. The intent is to share specifics about the program and how we were able to bring funding together to support technical entrepreneurship with a proof of concept center approach at NRRI. And of course, requesting support for the program.

Outreach with Collaborators
NRRI Business Development with others at NRRI has prioritized outreach efforts with agencies across the state, with the intention of connecting, sharing strategies, and looking for collaborative capacity. Over the last four months, the following have occurred:

**Enterprise Minnesota** – several conversations with Bob Kill around their organizational structure, NRRI’s structure, and our efforts to raise additional money to continue our efforts around support of rural businesses in the areas of lean manufacturing and product/process development. Meeting was scheduled for August 2012 but needs to be rescheduled for some time in September/October, 2012 People involved: M. Lalich, B. Brashaw, D. Fosnacht, P. Donahue, P. Sarvela
Agricultural Utilization Research Institute (AURI) – AURI is like a sister organization to NRRI, except the organization is not within the University Structure, and their focus is on agricultural product/process development. They have a Board of Directors with representation of multiple crop farming associations (corn, soy bean, beet, etc.) While NRRI staff works on various projects with AURI, such as Renewable Energy Roundtable, Poplar Research, etc., it had been sometime since the Executive Directors had a more formal conversation. M. Lalich, P. Sarvela, and Teresa Spaeth (AURI Director) met in Bemidji, MN for a timely discussion. Of specific interest is their concern about the EDA planning grant that NRRI is participating in.

Renewable Energy Proof of Concept Center – Collaboration - NRRI is working with the MN Department of Employment and Economic Development (MN DEED) and Region 5 Development Commission to gain funding from the US Economic Development Administration (EDA) for a planning grant to connect Minnesota resources across the state with Renewable Energy Proof of Concept Center (RePOCC) services. MN DEED arranged for a visit by Region 5 and the US EDA representative for MN and WI in early June. NRRI provided a letter of support for the effort. NRRI committed to generating a list of individuals from within the University of Minnesota that should be included in a roundtable discussion on November 7, 2012.

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.

For the six months of January through June of 2012, 19 businesses with a base in natural resources or energy conservation were provided one-on-one consulting, of those, 11 have services or products relating to alternative energy production, particularly in the use of biomass, efficient heating equipment, or wood pellet production. Three of the businesses are involved with the commercialization and use of by-product stone from the regional mining operations, and one of them has secured contracts from throughout the Midwest and has been featured in regional news stories.

Between January and June 2012, CED continued to assist businesses that would be considered “green” and encouraged sustainability in the appropriate businesses. Over 30 “green” businesses were served in the first half of 2012. The businesses represented alternative energy using solar, wind or alternative fuels, energy saving initiatives, environmentally sustainable products and geo-thermal processes. Some of the current business strategies involve the development and manufacture of bio-fuels, marketing assistance for a sprinkler system that has been successfully used in the preservation of buildings during wild-fires, the development and application of equipment used in the solar energy industry, and a bio-butanol project that was a semi-finalist in the MN Cup.

Additionally, CED has included sustainable business practices into the ongoing business consulting package, including the Student to Business Initiative (SBI) which piloted a new program for students to work with a business to evaluate and enumerate the sustainability measures of the company. The first project was done in the fall of 2011. The report and presentation were very well received by the business that was reviewed, and the students were appreciative of the opportunity to make the presentation and do the appropriate research.
During the first half of 2012 the CED Director coordinated the regional effort to promote the Minnesota Cup Business Plan Competition sponsored by the University of Minnesota, Wells Fargo and the State of Minnesota and spoke with regional groups to encourage participation, particularly in the student division.

One of the NRRI Product Development Fund recipients is also participating in the CED Business Incubator Program and continues to develop numerous business and financial projections with CED staff members. Currently, the business owner is pursuing additional federal licensing in order to manufacture the medical device. This business had been selected as a 2010 semi-finalist in the MN Cup competition and received assistance through CED. With the new investors and financing, this business has continued to explore market opportunities, including product licensing agreements. Another long-standing CED business also participated in the Product Development Fund initiative and gained information to use in manufacturing operations.

During the first half of 2012, the CED continued the implementation of its portion of the federal jobs accelerator grant by surveying the East Iron Range businesses to determine the business needs and how the business could better service the mining industry. The survey results are being shared and community services tailored to the finds. Preliminary partnerships are being developed which will enable the Bois Forte Reservation Business Committee to evaluate their community needs and provide a feasibility analysis for future business opportunities.

The CED partnered in the development of the regional grant opportunity with NRRI CARTD, NE Minnesota Higher Education District, MN Department of Employment and Economic Development Workforce Section, and the Northspan Group. The grant is one of the first developed across three federal agencies in order to promote education, research and small business development as way to grow a regional economy. The objective of the Northeastern Minnesota Mining Cluster is to provide funding for minerals research, workforce development and small business development in northeastern Minnesota in support of the regional mining industry. There were 124 applications for the regional grants and 20 were awarded. One of the 20 awarded is to the Minnesota Mining Cluster which includes CED. The CED portion from the U. S. Small Business Administration (SBA) gives $150,000 in each of two years, with the possibility of four additional years of funding.

The Mining Cluster grant process began in the late fall of 2011 and focuses on providing technical assistance and educational opportunities to entrepreneurs and businesses in the region who directly and indirectly support the mining industry and mining industry cluster. Particular emphasis is being given to provide strategies to businesses owned by women, minorities, veterans, service-disabled veterans, and tribes. Assistance is provided on topics including feasibility analysis, business planning, start-up assistance, stabilization, exporting products and services, loan packaging, cash-flow analysis, marketing, the use of technology and social media, expansion, innovation and intellectual property. In partnership with the other NRRI centers, the CED and the NE Minnesota Small Business Development Center assist businesses in developing new products and bringing those products to market.
**PUBLIC RELATIONS ACTIVITIES**

**Media Progress/Results**

Burrelle’s Luce Clipping Service Media Value = $199,881.33
Television Newscasts Commercial Advertising Equivalent = $1,050

**Total commercial advertising equivalent $200,931.33** (+ $129,000.29 since last report)

Print Newspaper mentions/stories:
- Duluth News Tribune 11
- Minneapolis Star Tribune 2
- St. Paul Pioneer Press 1
- Finance & Commerce (Metro MN) 1
- Small towns/Weeklies 42

Web mentions/stories: 13
Television broadcasts: 2
Radio broadcast: 4
Industry trade journal: 1 (No advertising equivalent)

Social Media
- Facebook (10/2/12) 124 Likes/Fans (+43)
- LinkedIn (10/2/12) 41 members of the NRRI Group (+5)

Print *NRRI Now* Newsletter: 2,134 subscribers (-65)
Electronic *Now* Newsletter: 586 active contacts (+140)
38.8% (-4.4%) Open Rate (Industry Avg. = 20%)

NRRI Website: 14,780 Avg. successful page requests per day (-2,000)

Activity for requested reports:
- Economic Geology Group = 34%
- Great Lakes Worm Watch = 8.45%
- Canada Lynx = 6.99%
- Moose in Minnesota = 6.79%
- CARTD = 6.411%
- NRRI Now Newsletters = 4.73%

**Visibility/Other PR Projects**

Total number of people toured NRRI: 190

Other Public Relations Promotions:
- PR staff assisted with the inaugural Heating the Midwest Conference held in Eau Claire.
- PR staff nominated the Goodwill Mattress Recycling program for an Environmental Initiative Award, which it won.
- PR staff organized and participated in a 4 week class about NRRI and its research.