Quarterly Report

April - June

2000

NATURAL RESOURCES RESEARCH INSTITUTE

Our research goes to work.

NATURAL RESOURCES RESEARCH INSTITUTE
QUARTERLY REPORT

TABLE OF CONTENTS

GENERAL

Dr. Donald R. Fosnacht has joined NRRI as its Director of the Center for Applied Research and Technology Development. Don obtained his B.S. and M.S. degrees in minerals engineering from Columbia University in New York and his PhD in metallurgical engineering from the University of Missouri in Rolla. He brings a broad research and management experience to NRRI from a 20-year association with Inland Steel and a President of his own company, Steel Profitability Consulting, Inc.

CENTER FOR APPLIED RESEARCH AND TECHNOLOGY DEVELOPMENT

Ultrasound scanning of hardwood lumbers

Perceptron Inc. completed the fabrication of their first ultrasound scanning system for hardwood lumber. This equipment, built in Brainerd, Minnesota, is capable of identifying drying related defects such as splits, checks, honeycomb, and collapse and should provide a substantial positive economic impact on the hardwood lumber processing industry. NRRI has been significantly involved in the implementation of this technology with Perceptron and the USDA Forest Products Laboratory. NRRI introduced several key Minnesota manufacturers to this technology and equipment during the past quarter.

Maple trusses

Pitched chord trusses were manufactured from undervalued hardwood lumber (hard maple) at Kylmala Truss in Duluth. These were the first modern commercial trusses to be manufactured from this species grouping. Testing results showed that the hard maple trusses were 24 percent stronger and 10 percent stiffer than equivalent designed and grade matched trusses from spruce-pine-fir (SPF) lumber. Further pitched chord testing will focus on red maple, species combinations and high moisture maple. Similar groups of parallel chord trusses will also be manufactured and tested. This project is significant because it focuses on large volumes of undervalued hardwood lumber that could be used for structural applications.

Hybrid poplar research

The Minnesota Hybrid Poplar Research Cooperative breeding program has successfully completed 160 crosses for the 1999-2000 breeding season. Also, six MHPRC field tests were established to evaluate new hybrids and determine growth increases resulting from fertilization.

Environmental review of proposed peat harvesting operation

NRRI and the Minnesota DNR Environmental Review and Assistance Unit completed the state Scoping Environmental Assessment Worksheet (EAW) in April and distributed it for review. A public meeting was held in Big Falls, Minnesota, to discuss the adequacy of the EAW and receive comments. NRRI, MDNR, and Berger Horticultural Products, Ltd. staff gave presentations describing the project and review process. Based on comments, a Final Scoping Decision document will be issued in July, which will serve as a guide for preparation of the Environmental Impact Statement.

Characterization of potential commercial peat site

Aitkin Agri-Peat, Inc. personnel completed field preparations on about ten acres at the Spencer bog for a test harvest conducted on June 8. Approximately 100 cubic yards of peat was vacuum harvested from the site and transported to the Aitkin Agri-Peat operation near McGregor, Minnesota, for

screening. The peat appears to be of suitable quality; however, additional physical and chemical analyses will be conducted early next quarter before a final decision is made to develop the bog.

Mining Symposium

The University cooperated with the Minnesota Section Society of Mining Engineers in conducting the 61st Annual Mining Symposium at the Duluth Entertainment and Convention Center on April 12 and 13. The theme of the conference this year was a review of the history of the taconite industry. There were some 36 presentations in the University portion of the program, many dealing with the evolution of processes and equipment over the approximate 45-year history of the industry. Approximately 400 people attended the conference.

Treatment of Duluth Harbor sediments

Equipment was assembled at Coleraine Minerals Research Laboratory for the demonstration of a size segregation process for the treatment of Duluth Harbor sediments. This equipment will be transported and reassembled at the sediment impoundment area of the harbor and operated intermittently for about three months this summer/fall.

Meetings update

A meeting was held on May 19 with the Permanent University Fund (PUF) Minerals Research Advisory Committee to discuss and later vote on PUF research proposals for July 2000 funding. An annual Iron Ore Cooperative (COOP) Research Committee meeting took place at Iron World on May 25, where presentations were made describing the status of COOP projects throughout the taconite industry. Six presentations were made by Coleraine Minerals Research Laboratory staff. Meetings of the Iron Mining Association and Minerals Coordinating Committee (MCC) were held on June 8 and June 19, respectively, to discuss availability of minerals research funding from various sources. A follow-up meeting of the MCC with minerals company general managers is scheduled for mid-September.

LTV plant as a potential copper-nickel-precious metals site

With the announced closing of the LTV Steel plant in Hoyt Lakes, there has been increased interest by Cleveland-Cliffs, who has an option on the property, concerning the copper-nickel resources of the Duluth Complex. Cleveland-Cliffs is reviewing the copper-nickel data to determine whether or not it might be feasible to use the existing mill site for processing copper-nickel ores. Prior to LTV's announcement, the high price of platinum-group metals (PGM) also contributed to the continued, increased interest in the Duluth Complex Cu-Ni-PGM mineralization by several companies.

CENTER FOR WATER AND THE ENVIRONMENT

Peatlands and soil warming

Peatlands have been removing carbon dioxide from the atmosphere since deglaciation and storing it in partly decomposed peat. Although they occupy about 3% of the earth=s surface, peatlands contain 1/3 of all the carbon in the soils of the world. Peatlands therefore control the global carbon cycle far out of proportion to their land area. Almost all peatlands are in latitudes higher than 45EN, which is where global warming is anticipated to be greatest. Warming could speed decay rates, thus releasing the stored carbon back into the atmosphere as carbon dioxide or methane, and even more powerful greenhouse gas.

Peatlands are occupied by bogs and fens, two different plant communities. Bogs are in domed portions of peatlands and are composed mainly of *Sphagnum* mosses and ericaceous shrubs such as leatherleaf,

bog rosemary, and Labrador tea. Fens are in wetter portions of peatlands and are occupied mainly by sedges and other grass-related species. We have been artificially warming and draining bog and fen communities to determine how they may respond to the expected global warming in the next several decades. After five years of warming, bogs gain carbon in accreting peat, but the amount of carbon gain decreases as the water table is lowered. On the other hand, fens lose carbon as the peat decays, and more carbon is lost as the water table is lowered. We therefore need to know the distribution of bogs and fens worldwide to predict their role in the global carbon cycle. These results also suggest that maintaining high water tables and not draining peatlands may be a management strategy for partly controlling carbon dioxide concentrations in the atmosphere.

Development of ecosystem bioindicators

Streams are intimately coupled to the terrestrial landscape through hydrology. Land use, riparian zones, geomorphology, soil types, and surficial geology have direct affects on stream ecosystems. Our goal is to identify indicators of stream ecosystem integrity that incorporate information about stream biota, habitat, and the terrestrial landscape. NRRI used Geographic Information Systems to quantify landscape attributes for thirty six watersheds in southeastern Minnesota. Scientists concurrently measured a number of habitat, water quality, and biotic variables that describe stream ecosystem structure and function. Currently we are using direct gradient ordination and multiple regression techniques are being used to develop predictive models that relate stream biota to reach scale and watershed scale factors.

Water on the Web - Year 3 update

For the past three years a group of lake researchers and educators from the U. of Minnesota-Duluth=s Education Department, the Natural Resources Research Institute, Minnesota Sea Grant, Hennepin Parks and Apprise Technologies have been deploying a new sampling device called RUSS (Remote Underwater Sampling Station developed by Apprise) in a set of lakes and bays in northern and central Minnesota. The sites range from small to large, relatively shallow to deep, unproductive to highly eutrophic, and include residential, agricultural and forested watersheds. *WOW* ***(http://wow.nrri.umn.edu)*** is a National Science Foundation-funded initiative to develop web-based high school and college-level science curricula around real-time, environmental lake data.

Since its inception in 1998, several thousand students have used *WOW* and its materials and during the past year introduction and training sessions on using *WOW* have been provided for more than 200 teachers. *WOW* web resources generated more than 13,000 page requests per month since the 1999-2000 academic year got into full gear. A variety of lessons use the data bases (several hundred thousand values to date) for science and math classes at several levels. They can be used on-line or downloaded. The site also includes a limnology primer with glossary and useful links, and summaries of the lakes=s behavior to date. The data section provides data visualization tools and related water chemistry, climate and watershed data (GIS tools included). *WOW* lessons teach students the basic fundamentals of science based on real-time data, train teachers in advanced technology, including GIS, remote sensing, instrumentation, and use of the Internet, and aims to improve communication and cooperation among local industry, agencies, and educational institutions. The goal is to equip students with real-world skills they can use in college and beyond.

See also the related *LAKE ACCESS* website at ***http://wow.nrri.umn.edu/access***, funded by the Environmental Protection Agency to deliver real-time water quality and interpretive information on Minneapolis metropolitan lakes to the public to help public feedback be more easily included in the decision making process. WOW received a University of Minnesota Technology Enhanced Learning Award in 1999 and *WOW & LAKE ACCESS* together received the Year 2000 Web Page Gold Award from the National Association of Natural Resource Extension Professionals. The sites will also be accessible via kiosks at the Science Museum of Minnesota and the new Great Lakes Aquarium.

CENTER FOR ECONOMIC DEVELOPMENT, NRRI BUSINESS GROUP

Project Summary

The Business Group worked with 67 clients during the quarter. Twenty-eight new projects began this quarter. Fifteen projects were completed. Five clients obtained financing totaling $622,669 that will allow them to start or expand their businesses:

- One business obtained funding to relocate to a larger facility and to purchase additional equipment. The business has provided auto repair services to its customers for many years and now intends to also become a major regional engine remanufacturer. Five new jobs are projected.

- The second business obtained funding to purchase equipment and supplies to expand its floor coating business. The business applies a protective sealant coating to concrete surfaces. One new job is projected.

- The third business obtained funding to buy equipment to expand a sawmill and add another product. Five new jobs are expected to occur because of the expansion.

- The fourth business obtained funding to develop a new car wash system. No new jobs are expected, but the funding should retain 4 existing jobs.

- The fifth business obtained funds to supplement the start-up capital it obtained during the last quarter. The owners learned that they needed to purchase another vehicle in order to service all of its customers. The company provides dumpster service to residential and commercial customers. One new job has already occurred.

Idea evaluation grants

There were two MTI Idea Evaluation Grants awarded during the quarter. The Business Group is working on these two projects in conjunction with the NRRI Machine Shop:

- One inventor received a $7,000 grant to develop a prototype of a new product to be used by duck hunters. The NRRI machine shop is working on the prototype. The Business Group is assisting with market research and assessment of commercial viability. The inventor is providing about $24,000 in cash and in-kind match.

- Another inventor received a $7,000 grant to develop a prototype of a medical device. The project is in three phases. The NRRI machine shop is working on the technical feasibility on the prototype. The Business Group will be working on the business plan, if a marketable device can be designed. The inventor is providing about $7,100 in cash and in-kind match. In addition, the inventor will be paying for materials.

Information Technology

The Center has partnered with the IRRRB "do IT" program to create the "21st Century Arrowhead Initiative." The initiative is designed to assist businesses with the task of adopting new technologies that uniquely fit their operation's needs. The process involves on-site counseling with a trained counselor, assessment of the company's needs, development and implementation of solutions, and training of company personnel. This program is a one-year pilot project and will assist companies in

the Taconite Tax Relief Area. Two half-time specialists have been added to the CED staff to work on this program.

Marketing assistance

Seven clients received assistance from student marketing teams. The students were enrolled in Dr. Rajiv Vaidyanathan's "Advertising and Marketing Communications" courses spring semester. The students developed advertising and marketing strategies for the clients. Each team made a formal presentation to its client.

Publications

Each month the Center issues two publications. The Arrowhead Business Advisor is published in the Murphy-McGinnis newspapers in Duluth, Virginia and Hibbing. The Arrowhead Business Advisor has a circulation of about 70,000. ENTER is published in the Duluth News Tribune and has a circulation in excess of 50,000. During this quarter, six CED clients were featured in articles in the Arrowhead Business Advisor. The NRRI greenhouse and prototype shop were topics of articles in ENTER.

Business forums

The Center, in partnership with the School of Business and Economics, is sponsoring a series of Business Forums. The second of five sessions for this year was held in May. Dr. Hakan Ylinenpaa from Lulea University of Technology in Sweden presented the results of his research in a presentation titled "Competence Development in Small Firms." Dr. Ylinenpaa had studied small companies in Sweden and Russia. During his stay in Duluth, he broadened his research to include Minnesota companies. Many CED clients were included in his research. The third forum was held in June. The topic was "Work-Family Conflict." The session was presented by Dr. Steve Rubenfeld and Dr. Gary Stark. Both are faculty members in the School of Business and Economics. Their research dealt with expectations that graduating students have with respect to workplace flexibility and conditions. The forums are open to the public.

Entrepreneurial awards

The 8th annual Joel Labovitz Entrepreneurial Success Awards were held May 31, 2000 at the Holiday Inn Duluth Waterfront. Fifteen companies were nominated for awards in a variety of categories. Winners of this year's awards and the categories were:
Emerging Entrepreneur: Banana Bear Day Care (Duluth), Tammy Korhoven, owner; Mature Entrepreneur: Samson Harness Shop, Inc.(Gilbert), Bernard Samson and Susan Samson, owners; Start-Up Entrepreneur: Betty's Pies (Two Harbors), Carl Ehlenz, owner; David A. Martin Entrepreneurial Leadership Award: Mary Mathews, founding president, Northeast Entrepreneur Fund, Inc.; and The ENTER Category: McKie Splints (Duluth), Ann McKie, owner. Over 175 people attended the event which was co-sponsored by the Center for Economic Development, Park State Bank, Iron Range Resources and Rehabilitation Board, Duluth News Tribune, and KDLH Channel 3.

NRRI Business Group

PROJECT WORK

NRRI Business Group worked with 67 different clients this quarter (compared to 63 last quarter).

- 45 clients are manufacturers who are starting or expanding their businesses.
- 6 clients are inventors; 4 who want to manufacture the products and 2 who intend to license the invention.
- 9 clients have technology-related businesses (software, hardware and/or e-commerce).
- 3 are minerals/mining related.
- 4 are service businesses.
- 29 projects involved start-up businesses.
- 38 projects involved expansions of existing businesses.
- 28 projects are new this quarter.
- 52 projects are continuations of projects started in an earlier period.
- 15 projects were completed.
- $622,669 of financing was approved for 5 of the completed projects. 12 new jobs are expected to occur from these five funded projects.

    - 1 business obtained funding to relocate to a larger facility and to purchase additional equipment. The business has provided auto repair services to its customers for many years and now intends to also become a major regional engine remanufacturer. Five new jobs are projected.

    - 1 business obtained funding to purchase equipment and supplies to expand its floor coating business. The business applies a protective sealant coating to concrete surfaces. One new job is projected.

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- The completed projects also had the following outcomes:

    - 1 client is a business owner who is working on a plan to create another business. He requested assistance with cash flow projections. He received instruction for a Business Group counselor and learned to complete the projections himself. His project is moving forward but he has not asked for any additional assistance.

    - 1 client was nominated for a Joel Labovitz Entrepreneurial Success Award. The Business Group worked with the client to prepare the nomination materials.

    - 1 client worked with the Business Group a number of years ago when she was expanding her business and needed additional capital. She recently restructured her business. Her lenders suggested that she return to CED to prepare cashflow projections to confirm the business' ability to service its existing debt.

- 1 client requested help preparing a business plan so he could attract equity financing. The plan was completed but financing was not obtained.

- 1 client requested assistance with company image, pricing, and improving the profitability of the company. The work was completed.

- 1 client requested assistance with market research. A survey of regional manufacturers was conducted on behalf of the client and the results were presented to the company.

- 1 client needed help with distribution of its clay products and wooden toys. The Business Group researched the industry and helped the client understand how similar products are being distributed by other companies. The Group also identified a person who can serve as a mentor for this client.

- 3 clients did not return to CED for further assistance.

- Business Group clients are in a variety of industries.

  - 9 are in the wood products industry.
  - 4 are in clay or minerals related industries.
  - 10 are in the food industry.
  - 5 are in recreational products.
  - 12 are in other manufacturing industries.
  - 3 are in printing.
  - 10 are in computer technology.
  - 3 are in fabric/clothing manufacturing.
  - 5 are in some aspect of the construction industry.
  - 2 are developing medical devises.
  - 4 are service businesses.

- Business Group clients requested and received assistance in the following areas:

  - 37 - Business planning
  - 39 - Financing or financial projections or analysis
  - 22 - Marketing, sales or pricing
  - 7 - Production or manufacturing issues
  - 5 - Management issues
  - 3 - Licensing or development of inventions
  - 1 - Research and development

- The Business Group worked in conjunction with NRRI scientists and staff on 13 projects.

  - 8 projects with CARTD
  - 5 projects with the Machine Shop

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Center for Applied Research and Technology Development

Progress Report for April-June 2000
Table of Contents

PEAT HORTICULTURAL 751

Horticultural Peat Development Aitkin Agri-Peat, Inc.

Objective The overall goal of this project is to locate and secure a suitable horticultural peat resource for Aitkin Agri-Peat consistent with the quality at their current operation, and initiate the environmental review and permitting process

Background NRRI was recently approached by Aitkin Agri-Peat Inc., an established Minnesota peat company, with a request to help them locate a suitable peatland for development to substantially augment their current operation. Aitkin Agri-Peat currently has a 185-acre horticultural peat operation near McGregor, Minnesota, which produces high quality bulk peat, used regionally at horticultural nurseries and in golf course construction. Plans are to establish a bagging plant to produce peat in compressed bales of various sizes in order to expand their sales to the national golf course and retail product markets. Based on current and future demand for their peat, the company estimates they will eventually require up to an additional 1,000 acres of horticultural quality peatland. This expansion would initially provide an estimated 10 to 12 seasonal jobs and two full time positions, with additional job creation in spin-off industries such as trucking.

Previous Activity/Results NRRI personnel met with Aitkin Agri-Peat, Aitkin County Growth, Minnesota DNR (MDNR), and property owner Russ Sampson to discuss possible development of the Spencer Bog located near Aitkin, Minnesota, and to determine permitting requirements. Aitkin Agri-Peat tentatively agreed to develop the bog contingent on the peat quality meeting their product standards. Site preparation, including surface vegetation removal and initial tillage, was initiated in preparation for test harvesting to be conducted later this spring.

Principal Investigator(s)
Kurt Johnson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$30,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5400880

Progress/Results
Aitkin Agri-Peat personnel completed field preparations on about ten acres at the Spencer bog for a test harvest conducted on June 8. Approximately 100 cubic yards of peat was vacuum harvested from the site and transported to the Aitkin Agri-Peat operation near McGregor, Minnesota, for screening. The peat appears to be of suitable quality, however, additional physical and chemical analyses will be conducted early next quarter before a final decision is made to develop the bog. NRRI, MDNR, and Aitkin Agri-Peat personnel also conducted a preliminary tour of three other potential peat harvesting sites. Peat resource and ownership information for these sites was also gathered by NRRI and MDNR staff and presented to Aitkin Agri-Peat. NRRI provided Aitkin Agri-Peat with an electronic moisture meter to better regulate the percent moisture of their peat to produce a more consistent product.

Horticultural Peat Development Berger Horticultural Products, Ltd.

Objective As before, the overall goal of this project continuation is to facilitate the development of the Pine Island Bog in Koochiching County for horticultural peat production.

Background As part of two previously funded MTI projects, "Pine Island Bog Horticultural Peat Development" (1996-97) and "Pine Island Bog/Koochiching County Technical Assistance" (1997-1998), NRRI was instrumental in bringing Berger Horticultural Products Ltd., a large Canadian peat company, to Koochiching County, where they now are in the process of developing the 800-acre Pine Island Bog near Big Falls, Minnesota. The development will eventually employ about 20 individuals, for the most part on a seasonal basis that would complement the winter logging jobs in the area. In addition to the jobs at the peat plant, estimates are that 10 individuals would be employed in the trucking industry and another 15 in pallet making operations in support of this new industry. Berger and Koochiching County have requested that NRRI continue to assist them in the ongoing pre-development environmental review and permitting process. This would include help in completing permit applications and providing information to consultants hired to complete the Environmental Impact Statement (EIS). Logistical support for subsequent site visits, surveying, and peat sampling has also been requested.

Previous Activity/Results NRRI, Koochiching County Land Department, and Koochiching Soil and Water Conservation District personnel met in mid-February to finalize locations to be used for the Pine Island Bog plant site and peat storage areas. Property to be included in a County/State of Minnesota land exchange was also identified. Information for a revised EAW was prepared by NRRI and submitted to the Minnesota DNR Environmental Review and Assistance Unit in late-February. The completed EAW will be distributed for review next quarter. NRRI and Koochiching County personnel have begun work on completing the Combined Project Application Form required by the U.S. Army Corps of Engineers for the Pine Island Development. Completion of this form will coincide with the EAW distribution and review next quarter.

Principal Investigator(s)
Kurt Johnson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$34,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5400885

Progress/Results
NRRI and the Minnesota DNR Environmental Review and Assistance Unit completed the state Scoping EAW in April and distributed it for review. A public meeting was held in Big Falls, Minnesota, to discuss the adequacy of the EAW and receive comments. Presentations describing the project and review process were given by NRRI, MDNR, and Berger staff. Based on comments, a Final Scoping Decision document will be issued in July, which will serve as a guide for preparation of the Environmental Impact Statement. NRRI and Koochiching Soil and Water Conservation District personnel completed the Combined Project Application Form for the Pine Island Development and submitted it to the U.S. Army Corps of Engineers in April. The Army Corps will issue a public notice and solicit comments on the project in early July.

PEAT HORTICULTURAL **505**

Densified Peat Products Phase I & II

Objective This project seeks to commercialize the production of a densified peat granule for horticultural use.

Background The NRRI, in collaboration with a major peat company, has identified the process and formulation steps for producing densified forms of peat meeting specific proprietary performance standards. This project has moved into the commercialization phase. This phase of the project includes transferring the technology to the industrial sector, purchasing equipment, trial production, test market and trial sales, pre-commercialization business analysis and production start-up, and market launch.

Previous Activity/Results The manufacturing line was started-up and several tons of granules were supplied to customers for field testing and verification of performance. Sustained runs over several days were completed in which capability was identified. The line can produce granular peat with optimal microbial activity, pH, size and handlability. Two bottlenecks were identified which prevented the line from running at full capacity; both were equipment related and were resolved quickly. The conditioning station was calibrated and found to deliver the proper dosage proprietary additives. The conditioning station allows customized blending for several types of products. A new dryer was installed and found to operate efficiently throughout several sustained runs. A computer program was developed in which the system material balance is varied over a wide range of recycling, input and operating conditions, which allowed single inputs into the process to be varied in spreadsheet format. The program provided significant insight on the migration of various additives used in the process, the efficacy under which they improve performance and quality, and the cost implications associated with their use. Optimizing the conservation of dry solids throughout the plant is a continuous and ongoing function. The recent acquisition of a computerized monitoring system which tracks energy consumption and temperature will help to assure that future quality and energy standards are met. In addition, any improvements in plant operating efficiency can be easily traced with the monitoring system.

Principal Investigator(s)
Timothy Hagen
Thomas Malterer

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$48,500
Minnesota Technology, Inc. (MTI)	$79,300

Start Date 7/1/98 **End Date** 6/30/00

Project No 5499575

Progress/Results
Efforts to meet the demand for peat granules for the early spring planting season fell short this quarter. Equipment was not procured or readied in time to meet an early April delivery of about 200 tons of granules. However, approximately twenty-two (22) tons of granules were produced and shipped for field trials to be held in early fall of 2000. These trials will verify performance in the field. Customers found the peat granules to have the required specification of size, handalibility, microbial activity and pH. The only concern at this time is the density specification for the product. Customers have requested that the density of the peat granules be raised from their current 35 lb/ft3 to 40 lb/ft3. Trial runs to confirm the possibility of achieving this level of densification are now in progress. The acquisition of a more efficient screen and re-trofitted water circuit greatly improved the efficiency of the process line. Efforts are now in full swing to meet the fall planting season.

Development of a Model Code for Onsite Wastewater Treatment Systems

Objective The objective of a model performance-based code is to provide a flexible structure that can be used to customize comprehensive management programs designed for onsite wastewater systems to perform specific and measurable requirements established to protect public health and the environment.

Background Current Minnesota Rules Chapter 7080 that regulates onsite treatment systems is largely prescriptive. Unfortunately, the prescriptive design alternatives permitted are not suitable for many of the site conditions encountered in northeast Minnesota. As a result, unsewered development in areas of the region is prohibited and many existing systems on developed properties are not in compliance. Without acceptable alternatives in the code, economic hardships are created and economic development inhibited. The demand for effective systems on properties where Chapter 7080 designs are not permitted is high. Alternative technologies and design approaches exist that could provide acceptable onsite treatment. However, Chapter 7080 lacks sufficient flexibility to adopt such systems. The code has provisions for construction of "experimental" or "performance" systems, but adequate guidance for permitting systems appropriate for specific sites is lacking. To achieve sustainable development that allows economic development in northeast Minnesota without sacrificing public health and environmental quality, a performance-based code is necessary. Without it, costly central sewerage is the only other option.

Previous Activity/Results Ten regional workshop meetings were held in January-February 2000 to solicit support and input to the development of the model performance code for onsite sewage treatment systems. The meetings were held with the following regional groups: 1) Koochiching County Commissioners and staff, 2) St. Louis County contractors, 3) Cass County and Itasca County staff, 4) Beltrami County ISTS Task Force and staff, 5) Carlton County Commissioners and staff, 6) Lake County staff and contractors, 7) Aitkin County staff, 8) Arrowhead Water Quality Management Team, 9) Cook County staff and Commissioners, 10) IRRRB/NLTA Technical Advisory Committee, and 11) Northern Counties Land Use Board. Comments of the meetings were tabulated and a draft outline of the model performance code is under development. Several of the participating counties have pledged a financial support of $5,000 and in-kind staff support of this locally driven initiative in support of a model performance code.

Principal Investigator(s)
Barbara McCarthy

Project Sponsor(s)	**Amount**
St. Louis County Health Department	$60,000

Start Date 1/11/00 **End Date** 6/30/01

Project No 5400897

Progress/Results
Subchapters 1 and 2 of the model code were drafted and are being reviewed by the IRRRB/NLTA Technical Committee. External Sales Agreements with seven counties in northern Minnesota were developed. Each county is contributing $5,000 towards the development of the model code.

WASTEWATER TREATMENT 936

Onsite Sewage Treatment Alternatives: Performance, Outreach and Demonstration

Objective The objective of this project is to continue to monitor the performance of the alternative wastewater treatment systems at the Northeast Regional Correction Center (NERCC), to provide educational programs, to compile an inventory and assessment of the performance of some existing performance-based systems, and to demonstrate the use of performance-based technologies in the five MPCA regions of the state.

Background Approximately 27 percent of Minnesota's residents depend upon onsite sewage systems for the treatment of wastewater. This project is part of a multi-industry/local, state, and federal agency effort to design, construct, and monitor the performance of alternative wastewater treatment systems, including aerobic tanks, constructed wetlands, drip technology, peat filters, sand filters, pre-engineered modular filters (a peat filter and a textile filter with polishing sand filter) standard trench system, and gravel-less trench system.

Previous Activity/Results This is a continuation of the project "Development of Alternative On-Site Treatment Systems for Wastewater Treatment: Phase III Assessment of Recirculation Systems" funded from July 1997-June 1999. Although the winter of 1999-2000 was one of the warmest on record, the lack of snow cover contributed to freezing of several systems, including drip dispersal, constructed wetlands, and drainpipes from systems located at shallow depths in the soil. Presentations summarizing research results were recently made at: the Minnesota Onsite Sewage Treatment Contractor Association Convention in St. Cloud, Minnesota; the Wisconsin Onsite Disposal Association Convention in Wausau, Wisconsin; the Aitkin County contractor meeting; the Itasca County contractor meeting; and the Minnesota Rural Water Cooperative meeting. A new publication by R. H. Kadlec, R. Axler, B. McCarthy, and J. Henneck titled "Subsurface Treatment Wetlands in the Cold Climate of Minnesota" was completed and submitted for publication In Advances in Ecological Sciences, U. Mander, Editor, Constructed Wetlands for Wastewater Treatment in Cold Climates. A Masters Thesis titled "Seasonal Pathogen Removal by Alternative On-site Wastewater Systems" was completed by Jonathan Pundsack.

Principal Investigator(s)
Barbara McCarthy

Project Sponsor(s)	**Amount**
Legislative Commission for MN Resources (LCMR)	$141,748

Start Date 7/1/00 **End Date** 6/30/01

Project No 5400901

Progress/Results
The systems at NERCC and Grand Lake continued to be monitored and maintained during the spring 2000. The systems that experienced freezing problems were put back on-line. The textile filter was modified by insulating the drainpipe with 2-inch polystyrene and heat tape from the textile filter to the trench sump vault. The air-intake on the blower was routed to a heated box that houses the units water meter. The pressure manifold for the trenches was insulated and the orifices on the drainfield pipe were oriented down. The textile filter has operated successfully since these modifications were completed. Several tours of the NERCC facility were held, including a tour for Commissioner Karen Studders and staff from the Minnesota Pollution Control Agency and Iron Range Resources and Rehabilitation Board, representatives from the companies Bord na Móna and Minnesota Sphagnum, Inc., and a tour for a wastewater class from Vermillion Community College (Ely, Minnesota). A presentation regarding the NERCC systems and other systems in northeast Minnesota was made at the North Shore Wastewater Annual Conference at Superior Shores, Two Harbors, Minnesota. Several meetings were also held with industry representatives to discuss possible improvements to systems, including Geoflow, Inc., San Francisco, California, and North American Wetland Engineering, Forest Lake, Minnesota. Staff from NRRI are also serving on a New Technology Committee organized by the MPCA. A number of alternative systems in Aitkin and St. Louis County, including sand filters and a textile filter, were evaluated by NRRI to determine general operational reliability and overall performance. Approximately 20 systems will be evaluated this summer as part of the LCMR project.

Commercialization of Containerized Peat Filters

Objective The objective of this project is to provide start-up assistance to Minnesota Sphagnum Inc. (MSI) in the fabrication of Bord na Móna's Puraflo® peat biofilters at their facility, and to continue monitoring the performance of the Puraflo® systems at the Northeast Regional Correction Center (NERCC), in order to provide and distribute a basic understanding of the performance of these systems, and work with Bord na Móna in commercializing their technology.

Background Approximately 27 percent of Minnesota's residents depend upon onsite sewage systems for the treatment of wastewater. This project is part of a multi-industry/local, state, and federal agency effort to design, construct, and monitor the performance of numerous alternative (alternative to mounds) wastewater treatment systems, including peat filters, sand filters, constructed wetlands, drip technology, aerobic treatment units, recirculating containerized peat filters, and textile filters.

Previous Activity/Results NERCC systems (peat filters, sand filters, constructed wetlands, and standard trenches) were completed in the Fall of 1995. Pressure compensating drip technology was added in the Fall of 1996. NRRI developed a partnership between Bord na Móna and MSI, and Puraflo® biofilters containing MSI and Irish mediums were added to NERCC during the Summer of 1998. A setback during the 1998-99 winter resulted in switching from recirculation to intermittent mode, and the reconstruction of the MSI modules, including a module containing a mixture. The systems at NERCC have operated successfully since, and continued to be monitored. In the commercialization of Puraflo® peat biofilters in Minnesota, an attempt is underway to certify additional contractors in the installation of Puraflo® systems. Several installers from the region, who had previously attended a Puraflo® training workshop at NRRI, were contacted with the offer that NRRI will coordinate their first installation with Bord na Móna. Hopefully this will provide sufficient incentive to complete the certification process to become a Puraflo® installer.

Principal Investigator(s)
Stephen Monson Geerts
Barbara McCarthy

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$37,500

Start Date 7/1/99 **End Date** 6/30/00

Project No 5400890

Progress/Results
In regards to previous efforts put forth in gaining additional contractors interested in becoming certified installers of Puraflo® peat biofilters, no activity was experienced this quarter, most probably due to a lack in demand for the systems' specific application, i.e., small lot size, lake property, tight soils, etc. On April 13, Joe Walsh (former president) and Robert Turner (acting president) of Bord na Móna's North American operation, attended a meeting in Duluth, Minnesota, which included a tour of several lake property applications of Puraflo® peat filtration systems, the NERCC facility, and Minnesota Sphagnum Inc. The Puraflo® peat biofilter systems at NERCC have operated successfully over the past year since the MSI modules were reconstructed and both systems were switched to intermittent mode. The systems continued to be monitored for wastewater contaminants and pathogenic organisms. Fabrication of Puraflo® modules containing MSI peat is currently on hold, pending further performance data from NERCC.

WASTEWATER TREATMENT 661

Performance of Containerized Textiles and Peat Biofilters as Alternative Wastewater Treatment Systems

Objective The objective of this project is to evaluate the performance of two, pre-engineered containerized alternative wastewater treatment systems and compare them to the existing standard and alternative systems at the Northeast Regional Correction Center (NERCC). If the performance is acceptable, this project will work with the companies in the commercialization of their systems.

Background Approximately 27 percent of Minnesota's residents depend upon onsite sewage systems for the treatment of wastewater. This project is part of a multi-industry/local, state, and federal agency effort to design, construct, and monitor the performance of numerous alternative wastewater treatment systems, including aerobic treatment units, constructed wetlands, drip irrigation, peat filters, sand filters, recirculating containerized peat filters and a textile filter, and standard technology.

Previous Activity/Results NERCC systems (constructed wetlands, peat filters, sand filters and standard trenches) were completed. Two Bord Na Móna Puraflo® biofilter systems were installed, one containing a proprietary Irish peat, and the second containing a Bord Na Móna specified proprietary Minnesota peat from Minnesota Sphagnum Inc. (MSI). A setback during the 1998-99 winter resulted in changing to intermittent mode, and the reconstruction of the MSI modules, including a module containing a mixture. An Orenco recirculating textile filter and polishing sand filter, with a reduced area shallow trench system using pressure distribution (without rock), were constructed at NERCC under OSI direction. Freezing problems during the 1999-2000 winter resulted in the insulation of many of the textile filters components.

Principal Investigator(s)
Stephen Monson Geerts
Barbara McCarthy

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$70,700

Start Date 7/1/98 **End Date** 6/30/00

Project No 5499875

Progress/Results
The Puraflo® systems have operated successfully over the past year since the modules containing MSI medium were reconstructed, and both systems were changed over from recirculation to intermittent dosing mode. In summary, both the Irish and MSI mediums achieved secondary treatment standards for TSS (25 mg/L) and BOD (30 mg/L) during summer and winter operation. The Irish medium also met secondary treatment standards for fecal coliforms (200 cfu/100 ml) during summer operation. The systems continue to be monitored for wastewater contaminants and pathogenic organisms. The textile filter system was brought back on line in mid-May, upon the complete thawing of the dispersal system. Modifications were made to the textile filter system including: insulation and electrical heat tape on the drainpipe from the polishing sand to the dispersal sump, redirecting the blower intake to the heated solenoid box, insulation around the dispersal manifold, and redirecting the orifices down on the dispersal laterals to promote drainage of the laterals upon dosing. The textile filter has been operating successfully since mid-May.

Alternative Sewage Treatment Demonstration Project

Objective To design, construct and monitor the performance of alternative sewage treatment systems

Background In Minnesota, a large number of onsite sewage treatment systems do not adequately treat wastewater. Many of these systems are failing. Difficult site conditions contribute to this problem, including inadequate lot size and poor soil conditions. Many resorts are mandated to replace them, with few replacement options or with systems that are not affordable. In response to this need, the Iron Range Resources & Rehabilitation Board (IRRRB) and the Northern Lights Tourism Alliance (NLTA) developed a pilot project for the construction and overall performance of alternative wastewater treatment systems at resorts.

Previous Activity/Results Four demonstration projects were completed from 1996 through 1999, including wastewater treatment systems for Burntside Lodge on Burntside Lake near Ely, Minnesota, Dodges Log Lodges on the North Shore of Lake Superior, IRRRB office building near Eveleth, Minnesota, and at Northern Lights Resort on Lake Kabetogama. The Burntside Lodge system was monitored for two seasons, with excellent performance observed. The IRRRB system has been monitored since its construction in October 1998 and is performing as expected. Construction of the wetland/engineered mound system at Northern Lights Resort was completed in July 1999 and is expected to be monitored during the summer 2000. The development of a model performance-based code for onsite treatment systems is currently under development. Several local training sessions on sand filters, peat filters, drip dispersal and control panels have been held over the past few years for area contractors and regulators.

Principal Investigator(s)
Barbara McCarthy

Project Sponsor(s)	**Amount**
Iron Range Resource Rehabilitation Board (IRRRB)	$179,810

Start Date 10/1/94 **End Date** 6/30/00

Project No 5495860

Progress/Results
Two monthly IRRRB/NLTA Technical Committee meetings were held this quarter. A training session for area contractors was held at NRRI in May. Three vendors presented information on various products available through each company. About 50 contractors and local regulators attended the one-day workshop. Two subchapters of the model performance-based code for onsite systems were drafted for review and comment. Final plans are being made for the MOSTCA summer tour, which will be held in Duluth, Minnesota, along the North Shore of Lake Superior on July 22, 2000. Preliminary plans were made for field training in soils to take place in the spring of 2001. Monitoring of the IRRRB wastewater system continued and the system is performing as expected. No problems were encountered. The Northern Lights Resort wetland/mound system was operating successfully during the spring start-up period for this seasonal resort, although the control panel had to be replaced this quarter.

CHEMICAL DERIVATIVES

The New Technology of Birch Bark Utilization

750

Objective The development of marketable chemicals from Minnesota's forests.

Background Minnesota's forest products industries have large capital investments and significant production costs. If unused materials or by-products of the process could be identified as valuable, or as precursors to marketable products, the competitiveness of our regional industries could be significantly improved.

Previous Activity/Results A patent on the use of betulin and its derivatives for treating herpes virus infections was issued by the U.S. Patent and Trademark Office. Three other patents are pending, one on pharmaceutical applications and two on processes for deriving chemicals from birch bark. Based on research in this program, University of Minnesota, Duluth, Potlatch Corporation, and Synertech (A Minnesota Power subsidiary) formed the company NaturTek LLC to develop and market chemicals from birch bark. A new process of inner birch bark tannin manufacturing was developed. General tests on birch bark tannin show its high equivalent quality with well-known marketable tannins such as quebracho tannin, chestnut tannin and pecan tannin. Samples of birch bark tannins were prepared for testing by industrial partners. The method of HPLC analysis of birch bark tannin was developed. Synthesis of new betulin acrylates was developed and characterized by H1-NMR-, IR- and C13-NMR spectra. New polymeric water-soluble derivatives were synthesized from these triterpene acrylate monomers, and samples were prepared for industrial tests. Standards of 9,10-epoxy-18-hydroxyoctadecanoic acid, phloionolic acid, 22-hydroxydocosanoic acid and 22-docosandioic acid were prepared and used for developing a new procedure of natural hydroxyfatty acid HPLC analysis. Samples of birch bark hydroxyfatty acids were prepared for tests. The procedure of triterpenes separation and purification was successfully investigated on the pilot level. Samples of lupeol, betulin and betulinic acid were prepared for tests. New technology on birch bark processing without SCFE was initiated with encouraging results. Dr. Pavel A. Krasutsky was approved as a principal coordinator of a new project on the use of natural products for increasing wear resistance of metals, supported for 2000-2001, by the Science and Technology Center in Ukraine (UCST). A coordinating meeting was held in Kiev, Ukraine. An agreement was signed in cooperation between NaturTek LLC and the Institute of Bioorganic Chemistry and Petrochemistry (IBOCPC) of the National Academy of Science of Ukraine (Kiev). Samples of birch bark fatty acids were transferred to IBOCPC.

Principal Investigator(s)
Pavel Krasutsky

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$70,000
Minnesota Technology, Inc. (MTI)	$100,000
Potlatch Corporation	$134,946
Minnesota Power	$164,934
NaturTek LLC	$280,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5400535

Progress/Results
New non-supercritical technology of birch bark extraction was developed on the scale of 500 ml Soxlet Apparatus. This technology allows selective extraction of major birch products through special pretreatment of birch bark. The quality of triterpenene products was significantly improved. Patentability of this invention demands expanded experiments on higher-scale equipment, which is in progress. Intensive sample preparation, as well as the engineering of the extraction process, requires high-scale pilot equipment for extraction. The construction of a 50l extraction column started at NRRI's Laboratory of Chemical Extractives. New polymeric materials were obtained from birch bark suberinic acids. These natural polyesters are proposed for the Collaborative Research and Development Funding (CRDF) Next Step to Market Program. The proposal "New Polymers from Value-Added Renewable Birch Bark Products" is under preparation in the cooperation between NRRI and the Institute of Macromolecular Chemistry of the National Academy of Ukraine (Kiev). Esters and salts of suberinic acids will be tested in lubricants, cutting materials and pigments, in cooperation with the IBOCPC of the National Academy of Science of Ukraine. Birch bark chemicals and their derivatives are planned as basic materials for two additional proposals to the CRDF Next Step to Market Program. The proposals "New Lubricants from Renewable Birch Bark Products" and "New Coating and Film Materials from Value-Added Birch Bark Chemicals" are in process in cooperation with the Institute of Bioorganic Chemistry (Kiev). NaturTek will be the U.S. private partner required for all above CRDF projects. The technology of birch bark tannin manufacturing was modified, producing a procedure of tannin purification from mixtures with hemicellulose (polysaccharides). Three samples of tannins, as well as spectral data on them, were transferred to the USDA Forest Service Lab for testing. Twenty-five samples were synthesized for biological screening of birch bark chemicals. The Research and Development Division of BASF will test these samples for different kinds of agrochemical activity.

Forest Products Technology Advancement

Objective To work with the forest products industry on sustainable development opportunities

Background This project will complement an ongoing program to help forest products companies in the Upper Midwest and particularly Minnesota. Specifically we will work with existing small and mid-size companies to implement technologies which will help them remain or become more competitive in the marketplace. The planned project initiatives are: wood-based membrane press technology development II; simulation modeling for small wood products companies; green building products assessment and development; and technology assessment and implementation III.

Previous Activity/Results Work plans were developed and all initiatives are ongoing. The wood-based membrane press technology development II project is active and reported individually. As part of a thesis proposal, a simulation model has been developed which has the potential to improve rough mill lumber yield based on scanned image information. Thesis completion is anticipated in Spring 2000. Technology assessment and implementation is ongoing. New activities are added as opportunities are found. We worked with Evergreen Global Resources (EGR), a company that is making panels using a sterilized waste paper mix. We organized and facilitated three regional defect scanning technology workshops that were broadly attended by industry representatives. The presentations covered all commercially available scanning technologies. NRRI staff attended Ligna '99 and focused on the nondestructive defecting technologies that were offered. We're working with Perceptron Inc. in ultrasound technology. Perceptron has sold two systems for locating splits and internal defects. A tour of 2 Minnesota companies was arranged for staff from Perceptron. There was a positive response from both companies to the development of automated defect detection systems using ultrasound, with one exploring a plant trial for evaluating end splits in oak lumber. We completed our analyses of a wetwood trial on green red oak lumber for Perceptron, with good results.

Principal Investigator(s)
Neil Nelson and Christian Edwardson

Project Sponsor(s)	**Amount**
USDA Cooperative Research Service	$218,116

Start Date 3/1/97 **End Date** 2/28/01

Project No 5497010

Progress/Results
Perceptron Inc. completed the fabrication of their first ultrasound scanning system for hardwood lumber. This equipment is capable of identifying drying related defects such as splits, checks, honeycomb, and collapse and may provide a significant positive impact on the hardwood lumber processing industry. NRRI has been significantly involved in the implementation of this technology with Perceptron and the USDA Forest Products Laboratory. The equipment was built in Brainerd, Minnesota. NRRI introduced several key Minnesota manufacturers to this technology and equipment during the past quarter. We're also evaluating a potential panel product made using newsprint (a green building product). Much of this effort has been aided by the knowledge gained in our work with EGR. An important aspect of the product is a specific, narrow range of product density required to meet mechanical and physical properties for the end-use.

FOREST PRODUCTS 752

Wood-based Membrane Press Technology Development

Objective To assist in the development of new process parameters and new products utilizing membrane press technology and wood-based materials, and transfer this know-how to industrial suppliers and end-product manufacturers.

Background Membrane pressing is the process of laminating decorative vinyl or polypropylene films and wood veneer to a contoured surface using a combination of heat, vacuum, and pressure. These products are then used in a wide range of applications from kitchen and bathroom cabinet door fronts to furniture applications. A Friz veneer membrane press was donated to NRRI by Minnesota- based Northern Contours, a leader in membrane pressing. This press was modernized to allow for advanced process control and ease of changing manufacturing parameters. A high volume low-pressure spray system and spray booth were installed to complete the development of the NRRI membrane press technology center.

Previous Activity/Results Specific expertise in membrane pressing technology and associated industry market sectors have been gained through experience with private companies, trade shows, and hands-on work in our Membrane Press Research Center. A variety of projects have been completed for several cabinet companies, adhesive suppliers, and overlay suppliers. NRRI staff attended Interzum '99 and Ligna '99. Specific attention was paid to new developments in laminate technology, adhesives, and pressing equipment. To date, we have worked with 25 companies in our Membrane Press Technology Center.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s) **Amount**
None

Start Date 3/1/97 **End Date** 3/1/01

Project No 5495010/5497010

Progress/Results
Several projects were completed with substantial match funding by private companies. They included:

- Dow Chemical Company
Development of manufacturing parameters for a new decorative laminate.
Provided training for a new Dow engineer on membrane press technology and product performance testing.

- Kleerdex Company
Performance testing of decorative laminate for use in furniture applications.

- HB Fuller Corporation
Adhesive performance testing to determine effect of manufacturing parameters on heat resistance of the adhesive.

- CFC International
Evaluation of heat transfer foil products for use in cabinet door manufacturing.

Forest Products Technology Implementation

Objective To work with the forest products industry on sustainable development opportunities.

Background This project will complement an ongoing program to help forest products companies in the Upper Midwest and particularly Minnesota. Specifically we will work with existing small and mid-size companies to implement technologies which will help them remain or become more competitive in the marketplace. The project initiatives are: modern manufacturing concepts III and technology assessment and implementation IV. These initiatives are inclusive of the wide range of projects we engage in to assist new and existing business.

Previous Activity/Results We have provided industrial engineering assistance to a dimension parts manufacturer in Minnesota. Market and technical assistance to Evergreen Veneer Inc., in Ashland, Wisconsin, has allowed them to begin operations and generate cash flow as they install equipment for the production of a product previously known as Microwood®. Other efforts included selection of new equipment; market development, with analysis and advice for specific niches; and product development, which has resulted in a royalty agreement for a product developed by an NRRI researcher. We provided technical assistance to several Minnesota and Wisconsin forest products companies. We developed, prepared, and presented a training seminar on wood and furniture in an effort to improve manufacturing through a better understanding of wood. The first presentation was customized for Room & Board of Minneapolis. We provided information on forest stewardship, wood basics, life cycle, wood and water, wood finishing, and wood care. NRRI staff have assisted Colonial Craft, Minneapolis, Minnesota, as they started-up a paint line for the window grille sticks that they manufacture. Standard operating procedures were developed, employees were trained, information on equipment was reviewed and the start-up was on time.

Principal Investigator(s)
Neil Nelson
Christian Edwardson

Project Sponsor(s)	**Amount**
USDA Cooperative Research Service	$218,153

Start Date 5/15/98 **End Date** 5/31/02

Project No 5498010

Progress/Results
Funding from this project was used to provide technical assistance to forest products companies in Minnesota, Michigan, and Wisconsin. Many of the companies we help are listed in the Technical Assistance section of the quarterly report. In addition to the general technical assistance we provide, some funds from this project have been used to supplement our current MTI projects. More information can be found in the MTI reports for Crystal Cabinets, Blandin, Colonial Craft, and SunRamps.

Forest Products Innovation and Implementation

Objective The overall objective of the project is to develop private sector forest products opportunities in Minnesota and the Upper Midwest. Specific objectives are to help existing small and mid-size wood products companies remain or become competitive through research and development or by providing specific technical or business expertise.

Background This project will enhance our ongoing program to help forest products companies and associated industries in the Upper Midwest and particularly Minnesota. Project funds are used to work with existing small and mid-size companies to develop, improve, and implement technologies which will help them remain or become more competitive in the marketplace. The project initiatives are: modern manufacturing concepts IV, technology assessment and implementation V, and production of high value biomolecules in transgenic hybrid poplar. These initiatives are inclusive of the wide range of projects we engage in to assist new and existing business. The project builds on ideas used successfully for 13 years by the NRRI Forest Products Program. Over the past five years we have served more than 40 companies per year as clients and strategic partners. Approximately 60% of these companies are entrepreneurs or small or medium-sized businesses. Using funding provided in 5 previous USDA Special Grants we have worked with more than 80 companies. This research collaboration with the private sector has resulted in the formation of new companies, facilitated the growth of others, created new technology and products, and accomplished economic development in the Upper Midwest.

Previous Activity/Results Some funding from this project is allocated for our ongoing investigation of chemical derivatives from birch bark and to the NRRI Biotechnology Initiative. A tissue culture and biotechnology laboratory was set up on the UMD campus and a postdoctoral research associate began working on the project. Eight hybrid poplar clones were established in tissue culture. Technical assistance is provided to Lake States companies on a regular basis to help them improve operations and assess or implement new technologies. Some good examples of technical assistance to Lake States companies are: sawing using thin kerf technology, round rod technology, and micro-veneer technology. The thin kerf technology has led to a new spin-off in geometric window components and mouldings (10 new jobs). The round rod technology has resulted in the purchase of a new mill and a multi-million dollar potential highway guardrail contract. The micro-veneer technology has created a veneer plant that is poised to produce up to 200,000 square feet of veneer per shift.

Principal Investigator(s)
Neil Nelson and Christian Edwardson

Project Sponsor(s)	**Amount**
USDA Cooperative Research Service	$255,396

Start Date 6/15/99 **End Date** 6/30/01

Project No 5499010

Progress/Results
For progress in the area of chemical derivatives from birch bark, refer to the separate report.

Genetic transformation experiments on hybrid poplar were initiated, transformation and expression strategies were refined, and a second postdoctoral research associate was hired in the Biotechnology Initiative.

We continued to work with the Lake States companies involved in sawing using thin kerf technology, round rod technology, and micro-veneer technology to create new markets and company expansions.

A major effort was undertaken to pursue a new design method for ready to assemble (RTA) cabinetry and case-goods. The resulting design will be built using regional manufacturing networks of cabinet shops and cabinet component suppliers. We hope to private label the product to large home centers, manufactured home builders, and multi-family housing contractors. The new designs will strengthen the position of the cabinetry industry across the region and create new added-value wood product job/business opportunities.

In addition we've been expanding our Forest Products Resource Center. This is a collection of woodworking machinery catalogs and brochures from all over the world. The collection has been used many times by staff, as well as the general public to find wood processing technology that can be used in the region.

Agri-Sorb Plant Start-Up Assistance

Objective The primary project objective is to help Second Harvest Cooperative (Freeborn County, Minnesota) in the commercialization phase of AgriSorb™, a corn-based absorbent panel.

Background AgriSorb™ was developed jointly by NRRI and CO-PAK, Inc. The technology has been licensed by Second Harvest Cooperative, who plan to continue the market development with the ultimate goal of establishing a manufacturing facility in southern Minnesota. The primary markets for this product are expected to be in the oil spill maintenance sector. Second Harvest is currently investigating additional markets for these products.

Previous Activity/Results A patent on AgriSorb™ was issued by the U.S. PTO. The technology was licensed by Second Harvest Cooperative from the University of Minnesota on January 1, 1998. Efforts have also concentrated on manufacturing prototype material at NRRI for market development activities. In 1998, NRRI and Second Harvest Cooperative manufactured more than 17,000 sq ft of AgriSorb™ in the NRRI pilot plant. A technology transfer meeting was held to bring Second Harvest up-to-date on the project. Primary discussions focused on the structure of their cooperative, market potential for AgriSorb™, and plant equipment and manufacturing techniques.

Principal Investigator(s)
Brian Brashaw

Collaborator(s)
Chris Edwardson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$16,000

Start Date 7/1/97 **End Date** 6/30/00

Project No 5498225

Progress/Results
Second Harvest renewed an effort to market AgriSorb through regional automotive and farm machinery dealers. A list of agri-fiber manufacturing plants was compiled and submitted to Second Harvest. These plants could serve as toll manufacturers of AgriSorb. Several discussions were held with the University of Minnesota Patents and Technology Marketing Department to review Second Harvests commercialization schedule.

FOREST PRODUCTS 641

Utilization Of Tamarack as a Small Sawlog Resource

Objective To determine if tamarack logs can be converted directly into a solid wood product. The project will process tamarack 6-12" diameter logs into products (semi-trailer flooring planks, kitchen cabinet doors, and furniture table tops) which will be evaluated for application performance, for market acceptance, and for economic feasibility.

Background Tamarack grows slowly on marginal sites but also grows relatively fast and in larger merchantable diameters on better drained sites throughout northern Minnesota. This regional resource is often available for winter-cut harvest but is more often excluded from timber sales and/or left standing due to low to nonexistent demand by all major primary wood using industries. Very little is known about processing this resource, providing a unique research task. The conversion process has the potential to create jobs and allow resource managers to harvest an underutilized timber resource.

Previous Activity/Results A number of semi-truck flooring static bending samples were tested with disappointing results. Log to product options developed were: large logs into lumber (and re-sawn veneer), medium size logs as possible OSB furnish, and small logs into rustic furniture stock and bark products. The best utilization for tamarack appears to be processing directly into round applications, such as rustic furniture components and log home interior trim, log homes, and industrial uses. This conclusion was made while assisting several northern Minnesota companies research and acquire new European round rod machine technology. The result is a new plant being built in Orr, Minnesota. Several machines were ordered based on our input. One new machine to peel tamarack and cedar logs into posts was delivered in early July and was set up at an existing site in Orr, Minnesota. The addition of the round rod machine creates a unique manufacturing work center to better utilize the existing tamarack log resource. The project outcome is different than envisioned in the original proposal, but the result is the same: increased utilization of tamarack, simultaneously creating new manufacturing jobs in northern Minnesota with new manufacturing technology. Another new application, the use of tamarack in a new tri-ply flooring product is continuing with other funding sources.

Principal Investigator(s)
Patrick Donahue

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$28,500

Start Date 7/1/97 **End Date** 6/30/00

Project No 5498301

Progress/Results
The project has been completed and closed.

NDE of Hardwood Log Quality

Objective To evaluate the relationship between nondestructive evaluation (NDE) parameters and the resulting material properties and yields of hardwood logs.

Background This project is the first project of an informal nondestructive evaluation (NDE) cooperative between the USDA Forest Products Laboratory (FPL), Pennsylvania State University (PSU), and the Natural Resources Research Institute (NRRI). This type of relationship will bring varied perspectives and experience on the use of NDE by the forest products industry in the Lake States and the Appalachian region. During the past several years the FPL, PSU, and NRRI have had several informal cooperative projects through third parties. These have included the development of ultrasonic stress grading of green veneer and technology implementation projects with Sonic Industries to commercialize ultrasonic hardwood systems.

Previous Activity/Results Pulse-echo NDE techniques were used to evaluate hardwood logs at Kretz Lumber Company in Antigo, Wisconsin. This technique introduces a longitudinal compression stress wave into the log through a sledgehammer impact on one end of the log. This stress wave travels through the log from end to end, reflecting back and forth. A transducer then monitors the reflection of the wave and determines the speed and energy loss. This information has been used successfully on softwood logs.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s)	**Amount**
USDA Forest Service	$9,122

Start Date 9/11/98 **End Date** 9/30/00

Project No 5499227

Progress/Results
Red maple logs were located for use in this project. They will be purchased from Savanna Pallet in McGregor, Minnesota. NDE of the logs and sawing have been scheduled to occur in July in Madison at the FPL. This is in conjunction with the Annual State Foresters meeting which will be held in Green Bay, Wisconsin.

Hardwood Lumber I - Joist Manufacturing

Objective To evaluate the use of undervalued hardwood lumber for use in manufacturing wood I-joists.

Background This project is part of a study to provide a technical basis for converting undervalued hardwood lumber into high value structural components. In cooperation with Northern Hardwoods of Houghton, Michigan, the USDA Forest Products Laboratory, Michigan Technological University, Qualtim Technologies, and Superior Wood Systems, the NRRI is participating in this study of sugar maple, red maple, yellow birch, and aspen lumber. The other primary focus is to qualify hardwood lumber for use in residential and light commercial trusses.

Previous Activity/Results Superior Wood Systems of Superior, Wisconsin, is a manufacturer of wood I-joists and is the primary project cooperator for the I-joist phase of developing structural products from undervalued hardwood lumber. Approximately 1,000 board ft of machine stress graded (MSR) hardwood lumber was obtained using an e-computer at Northern Hardwoods. This material was then used to manufacture wood I- joists at Superior Wood Systems. A presentation was prepared on the use of hardwoods for structural applications and was presented at the 1999 Annual Forest Products Meeting in Boise, Idaho. This presentation outlined the broad project and focused on the performance testing of truss plates and wood I- joists. The conclusions of the project to date are that we have achieved adequate structural performance for both trusses and I-joists, and these products can add substantial value to low grade hardwood lumber.

Principal Investigator(s)
Brian Brashaw

Collaborator(s)
Michigan Technological University, USDA Forest Products Laboratory

Project Sponsor(s)	**Amount**
USDA Forest Service	$13,618

Start Date 9/21/98 **End Date** 9/30/00

Project No 5499228

Progress/Results
No activities occurred during this quarter.

Advancing Technology to Manufacturing Trusses from Hardwood Lumber

Objective To manufacture residential and light commercial trusses from hardwood lumber and perform structural testing to demonstrate their suitability for commercialization.

Background This project is part of a study to provide a technical basis for converting undervalued hardwood lumber into high value structural components. In cooperation with Northern Hardwoods in Houghton, Michigan, the USDA Forest Products Laboratory, Michigan Technological University, Qualtim Technologies, and Superior Wood Systems, the NRRI is participating in this study of sugar maple, red maple, yellow birch, and aspen lumber. The other primary focus is to qualify hardwood lumber for use in residential and light commercial trusses. To date, the following milestones have been met: Lumber strength properties were determined. Preliminary drying schedules were determined. Metal truss plate assemblies have been manufactured and tested. I-joists have been manufactured and tested.

Previous Activity/Results Pricing information was collected for the manufacturing of prototype trusses by Kylmala Truss in Duluth. Truss manufacturing and testing documentation was identified and reviewed to govern truss design, manufacture, and testing.

Principal Investigator(s)
Brian Brashaw

Collaborator(s)
Michigan Technological University, USDA Forest Products Laboratory

Project Sponsor(s)	**Amount**
USDA Forest Service	$15,000

Start Date 9/28/98 **End Date** 4/30/00

Project No 5499229

Progress/Results
Hard maple and spruce-pine-fir (SPF) lumber was graded and sorted for use in manufacturing 4/12 pitched chord trusses. Six trusses were manufactured from each species at Kylmala Truss in Duluth. No problems were noted during manufacturing. Destructive testing of these trusses was completed and witnessed by the Executive Director of the Wood Truss Council of America. The hard maple trusses were 25 percent stronger and 10 percent stiffer than the equivalently designed and matched SPF trusses. Additional truss sets are scheduled for manufacture and testing throughout the summer. Southern yellow pine, red maple, red maple/SPF, and high moisture hard maple pitched chord trusses will be manufactured. Each of the pitched chord truss groups will then be replicated as parallel chord trusses.

FOREST PRODUCTS 656

Development of New Products and Markets for Woodline Manufacturing

Objective To develop new products and markets for Woodline Manufacturing to better use available resources and equipment.

Background Woodline operates two manufacturing plants in Minnesota, a sawmill in Onamia and a hardwood dimension and moulding plant in Eveleth. At the sawmill they have both a circular mill and a band mill. They would like to develop a plan to better use locally available hardwood resources of oak, ash, and basswood. Woodline has been making significant investments in the sawmill since they purchased it in November 1997. They would also like to develop products which better utilize the materials they currently process, as well as several log-to-finished products which would use all the facilities.

Previous Activity/Results July 5, 1998, only five days after the project began, Woodline lost their band mill to a multi-million dollar fire. The project start-up was delayed. We assisted Woodline in developing a new product which utilized hardwood residue. We developed a series of basswood products from the local log resource. We also helped Woodline test new materials for an existing industrial application for the door industry and assisted in market research on a new Woodline-designed product. The new product utilizes low grade thick basswood boards. These boards are processed by using a method that is different than those typically used. This new product will be used as a core for laminated mouldings for the millwork and picture frame industry. We had 4,000 board feet of basswood logs from Central Minnesota sawn into our raw material input and placed on kiln sticks.

Principal Investigator(s)
Patrick Donahue
Brian Brashaw

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$23,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5499232

Progress/Results
The material sawn was dried and processed in components. The material yield loss was extremely high, making the new product concepts uneconomical. In addition to the basswood log study, we provided custom programming to update an order entry program that we had originally developed a number of years ago. The final report is currently being prepared for this project.

Value Added Agricultural Based Panel Products for Phenix BioComposites

Objective To partner with Phenix BioComposites in the development of value added agricultural residue based panel products and to provide market research for the products developed.

Background Phenix BioComposites manufactures Environ™ a unique composite product used in furniture, plaque, flooring, and paneling applications. Environ™ is a mixture of soybean flour and recycled newsprint with additives such as stabilizers, dyes, and adhesive. In many applications, Environ™ is laminated to a particleboard substrate. Phenix has marketed Environ™ as an environmentally friendly product, and they are not satisfied with the current substrate choices. In response, they have embarked on the development of a particleboard made from soybean stalks and wheat straw. Developing a value-added product would enable Phenix to be competitive in the particleboard market place.

Previous Activity/Results The installation of equipment needed for this project and other particleboard work was completed. Our hammermill was tested on straw to determine particle size distribution from various screens. Our large, three deck (four sorts) Rotex screen was commissioned. NRRI personnel met with the Phenix Technical Director in December 1998 to discuss the project direction. Following that meeting, a plan was developed for product development related to wheat straw. NRRI personnel began to work on the requested research, primarily completing improvements to our screening system, but in March learned that matching funding was very uncertain. At that time generic market research was begun which focused on required product attributes for panels in various market segments. This work was viewed as being applicable not only to Phenix, but to future efforts to attract other similar business start-ups in Minnesota. Limited effort was expended on determining required panel attributes (including some product testing) for market segments, primarily cabinet, furniture, and millwork applications. We believe the work that has been completed is important and will be applicable to secondary manufacturers who might purchase ag-based panels in the future.

Principal Investigator(s)
Christian Edwardson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$12,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5499234

Progress/Results
The project was stopped six months ago due to lack of financial support from the cooperator. This was a function of their desire to pursue R&D internally. Phenix Manufacturing is now operating a $25 million agricultural-based particleboard plant in Mankato. Chris Edwardson had the opportunity to tour the plant in December 1999. The operation was fully functioning and they appeared to be making a quality panel product.

FOREST PRODUCTS 769

Product Development and Process Improvement for Northern Contours

Objective To provide Northern Contours with continued technical support for their manufacturing operations, to assess new materials and develop processing parameters and to provide new product development.

Background Northern Contours is a cabinet and furniture component manufacturer based in Fergus Falls, Minnesota. They use thermoforming technology to manufacture kitchen and bathroom cabinet doors using wood composites and decorative vinyl or veneer laminates. NRRI and Northern Contours have had a long-term relationship since the company was established in 1992. They donated a thermoforming membrane press to the NRRI which became the cornerstone of our Membrane Pressing Technology Center.

Previous Activity/Results Previous activities with Northern Contours have included materials evaluation, performance testing, training, development of quality control procedures, development of manufacturing standards, presentations to sales staff, new product development and technology assistance. NRRI has functioned as a key component of Northern Contours research and development department.

Principal Investigator(s)
Brian Brashaw
Patrick Donahue

Project Sponsor(s)	**Amount**
Northern Contours	$124,200

Start Date 10/1/98 **End Date** 9/30/01

Project No 5499235

Progress/Results
This project is externally funded and covered by a nondisclosure agreement. Only general information will be reported. Specific questions regarding project activities should be directed to Brian Brashaw or Pat Donahue, principal investigators. Activities during the quarter have focused on developing and testing a line of custom cabinet doors and performance testing of adhesives and decorative laminates. Two presentations were presented at the Annual Sales Meeting during May. One focused on providing information on the heat performance of kitchen appliances and how Northern's products perform when exposed to heat. The second presentation reviewed the differences between membrane pressing (vacuum and pressure) and strictly vacuum forming. A tour of new ultrasound scanning equipment was arranged. This technology may have future applications in Northern's rough mill. General technical support was provided as Northern continues to evaluate pricing/performance issues of the materials used for manufacturing thermofoil components.

Northern Contours Order Entry and Production Control System

Objective The primary objective of this project is to develop a new order entry and production control system that will allow Northern Contours to more completely understand their cost structure. This will improve long term profitability and competitiveness for the company. A secondary objective is to prepare a feasibility study for development of a veneer sheet optimization program that they will tie into the order entry system. We believe that a real time system could significantly improve veneer yield, increase production, and improve profitability.

Background Northern Contours, in Fergus Falls, Minnesota, has three operating divisions. The Veneer Division is a supplier of veneer raised panels for the cabinet, interior door, and exterior door industry. Currently, the company uses three computer software programs, requiring multiple manipulations to run the business. The system is complex and needs to be simplified and developed to provide more and better business decision making information. Part of making better decisions will be software additions that will allow the product to be tracked from the raw board into shipping. Reports will be generated for supervisors to show bottlenecks. It will be useful for giving customers ship dates and will provide cost analysis information for each process step. We will also plan for the future development of a veneer sheet optimization program to integrate into the system. An optimization program will allow Northern Contours to provide shorter lead times to their customers and provide close to just-in-time delivery by reducing the high and low inventory levels that customers currently experience.

Previous Activity/Results The focus of this project was re-defined because of priority changes within Northern Contours. The project timeline will be the first six months of 2000.

Principal Investigator(s)
Christian Edwardson
Steven Kossett

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$15,616

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400211

Progress/Results
As part of the project redefinition, further improvements were made on the order entry and production control system at Northern Contours Hardwood Division. A spreadsheet-based database query system was developed which allows reports to be generated showing the amount of sales by customer, product type, and species. These reports are typically generated on a monthly basis; however, they can be generated for any time period. Also, a system to determine the quantity of lumber used for each purchase order is under development. Computations were developed and implemented to compute the board foot requirements for each part that is produced in a door assembly. These board foot quantities are listed on reports generated for each incoming purchase order.

FOREST PRODUCTS 774

Laminated Truck Flooring for Industrial Hardwood Products

Objective The objective of this project is to develop a new lighter weight, stronger, lower cost composite wood truck flooring.

Background Industrial Hardwood Products, in Red Wing, Minnesota, operates a laminated hardwood truck flooring plant. Laminated "board" flooring is manufactured in 1-foot wide planks that are 2 to 4 inches thick depending on the application. This is a very competitive industry, with many manufacturers trying to develop new products. Board strength is important in the trucking industry and any new product must meet current TTMA standards. However, weight is also very important because a lighter truck has fuel cost advantages. Therefore, a lighter weight board will give a supplier, such as Industrial Hardwood Products, a competitive advantage.

Previous Activity/Results Four competitor truck decks were tested in the July-September 1999 quarter to learn current industry "standards." Funding for this part of the study was provided directly from the project cooperator. A laboratory evaluation of Industrial Hardwood Products oak and maple flooring was completed. Full scale deck evaluation of oak has also been completed. Following this test, the dynamic load test equipment required extensive repair and maintenance due to cracked welds and fatigue in aluminum. The square tube tracks were also replaced with solid steel. We evaluated two truck floor decks to compare oak and hard maple. The dynamic test load data, with laboratory evaluations were provided in a confidential report to the client. Additional laboratory evaluations have been completed to assess several product configurations proposed by Industrial Hardwoods.

Principal Investigator(s)
Christian Edwardson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$15,700

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400212

Progress/Results
We completed evaluation and reported results of the dynamic and laboratory tests for two truck floor decks. The results were used to help design a proprietary deck which we will test in the next quarter - this will complete the project. Our laboratory evaluations of several product configurations proposed by Industrial Hardwoods were concluded.

SunRamp Solutions Product Development

Objective The objective of this project is to give SunRamp Solutions, Inc. continued assistance in the development of skate ramps for the roller sport industry. Specific activities will focus on technology transfer of their Mini-Wave™ ramp and with product development for the SunRamp-Wave™ and Eighth-Pipe™ ramps.

Background SunRamp Solutions, Inc. of Duluth, Minnesota, has partnered with NRRI to develop high performance, durable skate ramps for use with skateboards, roller blades and trick bikes. A previous project was funded through Minnesota Technology, Inc.'s (MTI) NRRI grant program in fiscal year 1999. This included the design of the ramp and material selection for the laminates, wear surface and transition boots. Prototypes were manufactured and extensively tested. A manufacturing process was outlined. Each of the components will be manufactured by external vendors and the final assembly of the ramp will be completed by SunRamp Solutions. A business plan has been completed.

Previous Activity/Results This project continues the development work begun on the FY 1999 project. We will focus on helping the company sell ramps, develop a manufacturing process and quality control procedures, and develop additional ramp designs. SunRamps launched their first product design, "The Wave," during the 1999 National Park and Recreation Association trade show in Nashville, TN. They also displayed their products at the US Military Park and Recreation show in Nashville and the Minnesota Park and Recreation Annual meeting in Mankato, MN. The product was well-received and SunRamps is focusing on developing markets for the products. Additional prototype ramps were fabricated. The designs were then provided to SunRamps vendor for developing costing information. This increases the number of ramp designs to three. SunRamps has begun aggressive sales efforts. Direct mailings were made to Park and Recreation Directors in the seven county area around Minneapolis and St. Paul. A new web site was developed with the potential for e-commerce. Approximately 20-30 visits are being made to this site daily. The second product offering, "The Breaker" and the third product, "The Launch" were prototyped and were placed in Duluth parks for feedback from the users. A web site was developed and launched in addition to KSTP's story that ran nationally. We have continued to provide development work on material selection, manufacturing techniques, and market development.

Principal Investigator(s)
Brian Brashaw and Patrick Donahue

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$20,000
Minnesota Technology, Inc. (MTI)	$16,000

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400231

Progress/Results
We've continued to provide marketing support as SunRamps tries to establish a market. Feedback has been positive, but their potential customers are requesting additional shapes before they commit to orders. Therefore, the Breaker ramp mold was purchased by SunRamps. We also completed prototype testing of the Launch ramp which is ready for development of a mold pending the arrangement of financing. A revised business plan has been prepared and the NRRI business group is working with SunRamps to obtain additional funding. The cooperator is working to develop distributors across North America and has continued to sell ramps. The largest contracts to date have been from military bases. A proposal was prepared for continued funding through the NRRI Minnesota Technology Inc. (MTI) grant program.

FOREST PRODUCTS 761

Development of a Rot Detection System for Trees

Objective The objective of this project is to develop a field-friendly method for identifying rot (decay) in standing trees. The primary goal for the project cooperator, Blandin Paper Company, is to develop equipment and testing techniques to identify rot in balsam fir and spruce trees. We will target this equipment to be forester-friendly, able to be widely used with minimal training, weather hardy and be able to give results that can be quickly summarized as part of the overall forest site evaluation.

Background Blandin Paper Company is a member of the UPM-Kymmene Group, and depends on the highest quality, rot-free pulpwood they can obtain for use in making groundwood pulp for making lightweight coated printing papers. A technique for identifying rot before cutting the trees would aid their forestry staff in obtaining high quality pulpwood.

Previous Activity/Results During the summer of 1998, a preliminary investigation was completed by NRRI and the USDA Forest Products Laboratory in Blandin"s wood yards and forests to determine if ultrasonic stress waves could be used to identify rot. The work in the wood yard provided decay threshold values for use in standing timber. In the forest, two trees were cut to verify the presence of decay. Twenty-five log sections were provided to the NRRI for evaluation of several equipment systems. Preliminary analysis showed that it was possible to identify the presence of decay using several NDE technologies.

Principal Investigator(s)
Brian Brashaw

Collaborator(s)
Bob Ross, USDA Forest Products Laboratory

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$15,700

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400240

Progress/Results
One of the ultrasound equipment systems was used to evaluate standing timber on five different locations. We were able to correctly identify the presence and extent of decay on at least 80 percent of the trees sampled. A portable ultrasound system was ordered for further evaluation. This system meets many of the size and portability requirements. This system is manufactured by the same company that provided the system used to date in this project.

Redevelopment of the R-50 Cabinet Door

Objective The objective of this project is to help Crystal Cabinet Works, Inc. develop veneered cabinet door technology to supplement their solid wood cabinet and drawer fronts. Specifically, we will focus on Crystal's R-50, a solid wood design that they eliminated from their product offering 3+ years ago due to shrinkage and warpage issues after installation.

Background Crystal Cabinet Works, Inc. is a Minnesota-based custom manufacturer of high end cabinetry for the entire home. They are currently ranked as the 17th largest wood-based cabinet company in the United States, with sales over $50 million. The focus of this project will be to develop alternate manufacturing techniques and prototypes for their R-50 door style. Efforts will focus on building this door from dimensionally stable fiberboard or particleboard with decorative wood veneer overlays. It is expected that this product will be manufactured using several technologies including CNC routing, flat pressing, and membrane pressing. The quality and aesthetic requirements for this product will be high, to fit Crystal Cabinet Works' reputation for high end cabinetry.

Previous Activity/Results Several prototype solid wood doors were manufactured and provided to Crystal for review with positive feedback. Veneer door prototyping began and is ongoing. Additional prototype doors were manufactured for dimensional stability testing. These doors were placed into a humidity room and allowed to equilibrate at 40 percent RH which would simulate indoor winter humidity levels. The humidity was then increased to 80 percent to simulate summer conditions. The new door design showed excellent improvement over the previous design.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$6,500

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400241

Progress/Results
Humidity testing showed that we were able to manufacture an extremely dimensionally stable door that met the visual requirements imposed by the cooperator. Crystal Cabinet Works purchased Design Line Cabinets in late Spring. This acquisition has forced Crystal staff to place this project on hold until the end of the summer. Crystal is interested in working out a manufacturing agreement with Hill Wood Products to introduce the replacement R-50 next spring. A final report was prepared for the cooperator.

FOREST PRODUCTS 775

Paint Line and New Window Grille Development

Objective The objective of this project is to provide Colonial Craft with technical assistance for a grille paint line that they will begin operating in the second quarter of 1999 and to provide product development assistance with the development of new interior and exterior window grilles.

Background Colonial Craft is a Minnesota-based manufacturer of hardwood mouldings, window and door grilles, and picture frames. They have manufacturing facilities in St. Paul, Minnesota; Luck, Wisconsin; and Opelika, Alabama. Activities for the proposed project include assistance with a window grille paint line and the development of new window grilles. Colonial Craft is assuming control of the grille paint line from Artistic Finishes during the second quarter of 1999. This paint line is at Colonial Craft's St. Paul plant, and is currently operated by Artistic Finishes. This project will give Colonial Craft technical expertise and experience to make the ownership/operation transition smooth. Areas of assistance will include process and equipment layout, development of quality control and standard operating procedures, and employee training. The focus of this project is to provide assistance with the development of new lower cost window grilles that meet strict customer requirements. This product development is being driven by customer demand and the need for Colonial Craft to respond proactively to market needs. Desired assistance will include substrate selection, manufacturing methods and material, and product performance testing.

Previous Activity/Results An analysis of the paint line was completed prior to Colonial Craft's assumption of operation. Standard operating procedures were developed and customized. Detailed quality control procedures were developed and implemented. Recommendations on quality assurance equipment were prepared. The spray controls were re-engineered and fabricated in conjunction with Colonial Craft's personnel.

Principal Investigator(s)
Brian Brashaw

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$15,700

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400242

Progress/Results
Testing has been ongoing on a new window grille that Colonial Craft is developing for their primary customer, Andersen Windows. Several site visits to NRRI were completed by Colonial Craft and Andersen Windows staff to witness testing and discuss testing results. Two final reports were completed on the performance of window grille fasteners. Additional testing of window grille components has been scheduled for early July. A new subproject was initiated to review alternate coating lines for window components. A proposal was prepared for continued funding through NRRI's Minnesota Technology, Inc. (MTI) grant program.

Development of RTA Cabinets and Furniture

Objective To develop a series of specialized industrial woodworking components which are targeted at the Ready To Assemble (RTA) furniture market. Begin marketing these components and at the same time design an RTA kitchen cabinet product line. Generate finished-goods prototypes which will be offered to selected national home centers. If offered goods show market promise, further funding will be sought to carry forward a narrowly defined market research project.

Background The RTA (ready-to-assemble) furniture industry has seen tremendous growth over the past two decades. One company, Mill's Pride of Waverly, Ohio has very successfully adapted RTA processes and product concept to the kitchen cabinet industry. It is the intent of this project to design new RTA components which can be offered to RTA furniture manufacturers. At the same time we will design an RTA kitchen cabinet line similar to Mill's Pride and follow the product development process through industrial market research. The product line could eventually be produced using a strategy which organizes a regional manufacturing network. Two outcomes are targeted. The first is to expand several Northern Minnesota manufacturing firms into new products using fresh design options being developed for the RTA furniture business. The second is to determine the feasibility of the concept of creating an RTA kitchen cabinet product line with components supplied by a regional manufacturing network.

Previous Activity/Results Analyzed Mill's Pride product line. Several major product line weaknesses were identified and new methods prototyped to create an improved product. We were successful in obtaining extensive wholesale price information for the RTA furniture industry, which gives the project key market information for evaluating feasibility. Developed new product concept for building face-framed ready to assemble cabinetry. The new concept is important because all other RTA cabinet products on the market today use "European 32 MM assembly methods and hardware." In the US cabinet market, (which includes assembled and ready to assemble) 32 MM designs account for only 16 percent of the sales, while framed cabinets account for 84 percent of the sales. This new concept produces only framed cabinet designs.

Principal Investigator(s)
Patrick Donahue

Collaborator(s)
Rosandich Wood Products, Virginia, Minnesota, Hill Wood Products, Cook, Minnesota

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$20,000

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400243

Progress/Results
An invention disclosure for the new RTA cabinet product was filed with the University of Minnesota, Office of Patent and Technology Marketing. After a patent search it was identified that the possible patent claim was already used in another unrelated but relevant US patent. The product can be produced but not patented. A Minnesota based cabinet and counter top company has expressed a high level of interest in building and boxing the RTA cabinet. A Minneapolis businessman has expressed strong interest in marketing and distributing the RTA cabinet. Additional funding and investors will be sought out to complete necessary market research prior to ramping up into production.

FOREST PRODUCTS 763

Hot Foil Transfer to Timberline Furnishings

Objective To transfer hot foil stamping technology to a furniture manufacturer with two plants, one in Southern Minnesota and one in Northern Minnesota, providing new product line(s).

Background Jon and Sue Denney have successfully purchased and turned around two financially-distressed furniture manufacturers in out-state Minnesota, developing them around into growing businesses. The Denney's first purchase was Conestoga Furniture in Mountain Lake. The business, which makes high-end country orientated furniture, is in a rural predominantly Mennonite community, where tradition of furniture building crafts is strong. The second business, purchased two years ago and five years after Conestoga, was Timberline Furnishings, in Grand Rapids. The Denney's have hired a North Carolina designer to help develop the appearance of their future product lines. We can help both businesses with product engineering and process development to quickly position their new products into the market.

Previous Activity/Results We defined and developed new woodworking technology relating to adhesive use and application, which were immediately implemented by Timberline Furnishings, lowering their manufacturing cost. They purchased several new pieces of product equipment based on this development work. We have helped them double the outputs of both the glue clamps and hot press by the introduction of new adhesive technology. We have also helped them improve their sanding and finishing processes in both plants. Much of this work has been driven by a new contract to Timberline from Room and Board Furniture Stores. We have been building prototypes using hot foil technology. These new products all utilize new and improved hot foil transfer technology. These materials and methods are not widely used by Minnesota manufacturers, but they offer this small multi-plant company an opportunity to compete against much larger national manufacturers. Timberline furnishings currently produces higher-end solid wood furniture for the Dayton department stores. They may have an opportunity to build a line of TV stands for their mass market chain using the hot foil technology. This technology provides a higher-end look using composite wood fiber board substrates.

Principal Investigator(s)
Patrick Donahue

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$15,000

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400244

Progress/Results
We completed our primary project goal of developing furniture prototypes using hot foil transfer technology and composite fiber board. The prototypes are being shown to two top regional retailers. Both have expressed early interest in the new product concept, and the prototypes will allow these potential customers to fully evaluate the advantage of this new technology for new product lines. The project objective of transferring the technology has been clearly met; however, it may take months to see if the work results in any new jobs. Meanwhile, Timberline continues to grow with very strong sales via a dot.com furniture retailer. Both the Mountain Lake plant and the Grand Rapids plant are near capacity, with some machining centers running around the clock.

Cryogenic Tempering Woodworking Machine Tooling

Objective To determine if computer controlled cryogenic tempering of machine tool steel improves the wear resistance of woodworking knives, saw blades, and router bits, in cooperation with Diversified Cryogenics, a Minnesota company in the business of cryogenic tempering of metals.

Background For years it has been reported that exposing steel to cryogenic temperatures results in the material becoming significantly harder. This effect is reported to be a cost effective method of extending the life of any metal under wear conditions. This study is a series of experiments that looks at a number of real world applications. The experimental design will create results that can quantify the level of improved wear resistance.

Previous Activity/Results The largest hardwood lumber user in the U.S., Bruce Flooring, ran a side by side comparison of treated versus untreated molder knives. The mill trial was completed in the second quarter of '98. We analyzed the results to date and unfortunately the field-collected data did not provide us enough information to make any conclusions. Due to insufficient data developed in earlier industrial plant trials it was decided to run experiments in the NRRI wood prototype shop. We conducted the first round of a detailed experiment in our wood shop lab to determine the treatment effectiveness. On MDF, the first material attempted, we found no significant difference in blade resistance between cryogenically treated blades and controls. We ran the same comparison with finger jointed pine lumber. We have not been able to determine whether this method is effective in extending the life of woodworking machine tooling.

Principal Investigator(s)
Patrick Donahue

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$7,000

Start Date 9/1/97 **End Date** 6/30/00

Project No 1197042

Progress/Results
The project has been completed and is closed.

FORESTRY 654

Minnesota Hybrid Poplar Research Cooperative Program

Objective To produce genetically superior cottonwood and hybrid poplar trees, improve cultural practices, increase yield and provide technical assistance to Cooperative members and the public.

Background This project builds upon previous research done on hybrid poplar production on farmlands in Minnesota. The goal of current research is to develop new hybrids and management practices, assess yields of commercial-scale plantations, and assist landowners in proper establishment of hybrid poplar. Over 400 hybrids of Eastern Cottonwood, European Black Poplar, Black Cottonwood, and other species are being tested in studies across Minnesota. NRRI, along with other agencies, is continuing to develop hybrid poplar as an alternate crop for Minnesota's farmers and provide additional wood supplies to Minnesota's forest products industries.

Previous Activity/Results Breeding is underway with over 150 crosses being made at the NRRI greenhouses. F1 crosses being made this year are comprised of P. deltoides females and P. maximowiczii and nigra males. At this time, the percentage of successfully pollinated flowers appears to be relatively high and seed development is progressing well. A number of P. deltoides X (P. deltoides X maximowiczii) backcrosses are being done in an attempt to increase resistance to Septoria canker in those clones having P. maximowiczii parentage. Plans for the upcoming field season include planting of new genetics tests at three field sites in northern and central Minnesota and refertilization of nutrition research sites at eight locations throughout the state.

Principal Investigator(s)
William Berguson

Project Sponsor(s)	**Amount**
Agricultural Utilization Research Institute (AURI)	$391,000
Agricultural Utilization Research Institute (AURI)	$516,639

Start Date 10/19/99 **End Date** 6/30/01

Project No 5400625

Progress/Results
Tests were planted in May at three Minnesota sites to evaluate growth rates and disease resistance of 38 families that were produced in the 1996 and 1997 breeding seasons. Clones of open-pollinated (wild) cottonwood collected in Minnesota were also planted in replicated field tests. A collection of pure-species P. maximowiczii and P. nigra was established at three sites to serve as a source of pollen in future MHPRC breeding. Large block yield tests were planted this year to measure growth and verify yield gains of four promising clones, two pure P. deltoides clones and two P. deltoides X maximowiczii hybrids, under near commercial conditions. Significant increases in yield over commercial clones are expected. As of the 2000 planting season, a total of 16 fertilization studies have been established by the MHPRC. Seven fertilization studies slated for reapplication of fertilizer in 2000 have been completed. Three new fertilization tests were established in northern and central Minnesota to determine optimal dose and frequency of fertilization and evaluate interactions between weed control and fertilization. Field tests to evaluate herbicide effectiveness and phytotoxicity were installed at two sites. Seed continues to be harvested from crosses made in 2000 in the MHPRC breeding program. A minimum of 100 seedlings in each of 70 families are expected. Seedlings from January 2000 breeding in the NRRI greenhouse will be outplanted in nurseries this fall to begin field testing.

Enhancement and Assessment of Forest Productivity

Objective To develop techniques to increase productivity of Minnesota's forest resource.

Background Minnesota's forest products industry accounts for a large share of the state's economy. Approximately $4 billion in economic activity are generated annually by the forest products sector in Minnesota. In the recent past, the forest products industry in the state has increased production capacity, several plants being improved and new plants constructed. Commensurate with these expansions, demand for wood fiber statewide has risen from approximately three million cords in 1985 to over four million cords currently. Thus, the forest products industry has contributed significantly to the expansion of job opportunities and the economy of the state during the past decade. The purpose of this research project is to participate in cooperative projects with the forest products industry to improve forest productivity through analysis of growth rates in natural stands and development of management methods to improve productivity.

Previous Activity/Results An additional 25 stands were measured on cooperator's lands and these data were input into our database of aspen growth. A total of 61 stands are contained in our dataset including data collected previously from aspen thinning research sites and those collected as part of this project. Using the current set of stands, we evaluated stand volume over time assuming various merchantability criteria. As expected, the selection of top-diameter standards greatly affects merchantable volume, particularly on these relatively young stands. We are in the process of adding 30 more stands to our dataset during the upcoming quarter. Analysis of this complete dataset will be done and results of our analysis published in the annual report. This project was developed as a two-year project with the first year's work focusing on size-density relationships (stand stocking) and the second year concentrating on stand growth rates. To prepare for the second-year research, we collected increment cores on several stands to evaluate the feasibility of measuring growth increment using cores and digitizing growth rings.

Principal Investigator(s)
William Berguson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$29,784

Start Date 7/1/99 **End Date** 6/30/01

Project No 5400628

Progress/Results
A comparison of our 61 measured stands in our dataset and the average density of stands represented in normal yield tables shows close agreement between the two with respect to stand density. This indicates that stand volume on aspen sites in Minnesota may be similar to that shown in normal yield tables (Gevorkiantz and Brown tables). Given this result, harvestable volume in the future will likely be higher than is currently the case in older, less-dense stands. In order to expand the geographic range of our dataset, 30 more stands were measured during the quarter in addition to the 61 stands measured as of March 1999 to bring the total number of stands in our dataset to 91. Analysis of stand density in this complete dataset are currently being done and will be reported in the annual report. Analysis of growth rings from increment cores collected from a subsample of stands showed that correlations between incremental growth rates in the early years (age 11-15) of stand development and later years (age 15- 25) are relatively high. Based on this result, we expect that we will be able to characterize the growth potential of aspen sites at a relatively young age. The combination of incremental growth data to be collected in 2000/2001 and our analysis of stand stocking levels currently being done will allow us to develop a very detailed understanding of stand development and growth in regenerating aspen. This information will be valuable to assess the potential productivity of the aspen resource in the state and estimate future stand volume.

FERROUS MINERALS 515

Weakening of Taconite in Small Scale Explosive Tests

Objective To better define and quantify the effects of blast design on energy required for grinding and on magnetite liberation.

Background Mine blasting is the most cost effective process in taconite particle size reduction. However, the effects of blasting variables on comminution and on magnetite liberation must be quantified to justify additional costs in blasting that can reduce overall taconite processing costs.

Previous Activity/Results A set of 63 rock pieces from the Minntac West pit was randomly divided into three groups. Group 1 was for reference, Group 2 was shot with one strand of detonating cord taped to one side, and Group 3 pieces were shot with two strands of cord taped to opposite sides. Testing was completed, bond grindabilities were calculated for all grinds, comparative graphs were constructed, and data interpretation for the final report was nearly complete.

Principal Investigator(s)
Harlan Niles

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$58,400

Start Date 1/1/98 **End Date** 6/30/00

Project No 5698108

Progress/Results
Evaluation of the size reduction and metallurgical characteristics of the samples tested indicates that there was not sufficient proof that additional explosives provide weakened structural integrity or improved liberation. A final report has been promised to the Iron Ore Cooperative Research Committee by July 1, 2000.

Process Modeling of Pellet Induration Furnaces

Objective To develop a 3-D computational fluid dynamics (CFD) model of Minntac cooler.

Background CFD provides a means to model fluid flow heat transfer and gas/solid chemical interaction in pellet induration systems. Process models of furnaces, ducts, coolers, etc., can then be used to optimize physical configurations and define better operating strategies.

Previous Activity/Results A total of nine in-plant tests were conducted on Line 6. Operating data were collected and analyzed. A statistical analysis of the data showed a good correlation between plant operation and the MEDUSA/CFD model.

Principal Investigator(s)
Dave Englund, Richard Davis

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$119,542

Start Date 2/2/98 **End Date** 6/30/00

Project No 5698112

Progress/Results
This project has been completed and a final report will be issued by July 1. Results have shown that it is possible to improve line productivity by changing cooler fan operating conditions. Results also indicate a significant increase in productivity may be possible by installing a wall in the cooler. Production could increase by as much as 94,500 LTPY.

FERROUS MINERALS 627

Development of a Generalized Production Scheduling (Mine Planning) Methodology for Open Pit Iron Mining Operations

Objective To develop an optimum open pit mine production scheduling methodology based on the concept of fundamental trees.

Background Production scheduling for a mine is one of the most important steps in mine planning. It is becoming more and more critical to obtain an exploitation schedule of a deposit such that the lowest costs are achieved along with meeting other desirable attributes, i.e., ore blending, equipment capacity, mining, concentration, pellet production capacity, metallurgical quality, and pit slope limitations. Although the need to plan and operate an iron mine with an optimum production schedule has been obvious for some time, the methods used to obtain such a schedule have not been. There is not a single, mathematically proven optimum mine production scheduling methodology that is widely accepted and used today. The methodology to be developed will be based on "fundamental trees" and mathematical programming that can be applied to long and short range planning. A fundamental tree is defined as the smallest number of blocks, which can be economically mined as a unit. The basic problem is to develop an efficient methodology to quickly determine fundamental trees. Mathematical programming will then be used to obtain the optimal schedule. Also included will be the development of input and output interfaces between the mathematical programming model and mine planning and design software such as the Medsystem.

Previous Activity/Results The new algorithm developed to construct fundamental trees was tested and evaluated. During initial investigations for a proof, a mixed integer programming model for constructing fundamental trees was developed. The rationale for this was that it would be easier to show that the mixed integer model produced the correct fundamental trees and then either use this to construct the trees, if it was the most efficient method, or show the previous algorithm produced the same results. During this investigation, a linear programming model to construct fundamental trees was also developed and being validated.

Principal Investigator(s)
Thys Johnson

Collaborator(s)
Dr. Kadri Dagdelen, Colorado School of Mines

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$90,000

Start Date 7/1/97 **End Date** 6/30/00

Project No 5698120

Progress/Results
The two most reliable methods for defining fundamental trees appear to be: (1) the intuitive network model (INM) based on fundamental tree properties and network logic, and (2) a linear programming formulation. Both methodologies have been successfully tested and evaluated on 2-D examples. A fundamental tree has three main properties: (1) minimum connections between ore and waste blocks within its cone, (2) has positive value, and (3) doesn't violate the slope constraints. Based on these three properties, linear programming (LP) model appear to provide the fundamental trees in all deposit examples tested. The next step is to mathematically prove that the INM model will provide fundamental trees within all relevant scenario 3-D block models. To do this, the relationship between LP model and INM model will be developed and theory of LP will be used to carry out the proofs. The research focus will then move towards obtaining optimum yearly schedules for a given iron ore mine that meets production requirements as well as the blending constraints based on underlying fundamental trees.

Digital Mine Model and Statistical Evaluation

Objective To assist Minnesota Iron & Steel Company (MIS) by statistically evaluating and mathematically reconciling, if necessary, MIS's historical and newly generated geologic, geochemical, and metallurgical data so that it has the best available information for continuing its direct reduced iron (DRI) and steel project in Nashwauk, Minnesota—in effect, assist MIS in its ongoing due diligence program.

Background MIS is a new company based in Nashwauk, Minnesota, that plans to produce steel from direct reduced iron (DRI) from Minnesota taconite. The company is planning to use the reserve of the Butler Taconite operation, which closed in 1984. The taconite mined at MIS's operation will be used to produce DRI at a new on-site facility.

Previous Activity/Results The final report is near completion and will be sent to MIS and Dr. Barnes for review when complete.

Principal Investigator(s)
Steven Hauck
Lawrence Zanko

Collaborator(s)
Dr. Randal Barnes (UM-Twin Cities), Mr. Richard Patelke (MIS)

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$29,000
Minnesota Iron and Steel Company	$7,500

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699130

Progress/Results
The final report for this project has been completed in draft form and a copy sent to MIS for review. Overall, the report showed that MIS's data were of sufficient quality. The report's data evaluation and statistical analyses give MIS additional independently produced information (and tools) that can be used by MIS or its contracted consultants for several applications, including ongoing feasibility study work, digital resource and reserve estimation, and mine modeling.

FERROUS MINERALS 628

Computational Fluid Dynamics (CFD) Special Problem Assistance

Objective To use these funds for basic training and learning charges of general nature. This should diminish as experience with software increases.

Background There have been several projects funded related to improving pellet plant operation using computational fluid dynamics (CFD) modeling of fluid flow and heat and mass transfer in portions of the induration/cooling system. To date, the cost of learning the capabilities of the computer software and developing solutions to unusual problems encountered during implementation has been borne by the project itself. The Coleraine Minerals Research Laboratory (CMRL) is attempting to become the center of expertise for these modeling calculations for iron ore pelletizing, and since it is important to keep costs for this type of project competitive, it would be advantageous to have a project where unusual learning costs could be charged. The probability for encountering these types of "learning charges" will diminish as the users become more familiar with the software.

Previous Activity/Results Pellet circular grate FORTRAN code was modified with input from AEA Technology Engineering Software to simulate straight grate operation.

Principal Investigator(s)
Dave Englund

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$40,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699134

Progress/Results
There is no activity to report for the quarter. These funds are used only on an "as needed" basis to solve problems that fall outside the scope of normal project development.

Development of a Computational Fluid Dynamics (CFD) Model for the Pot Grate Tests

Objective To develop a CFD model capable of simulating heat transfer, moisture evaporation, and magnetite oxidation in pot grate tests.

Background The pot grate test is used to develop information on the firing of pellets and generate samples for quality measurements. Since these tests are expensive to conduct and there are a number of variables that could be investigated, it is felt that the use of a CFD modeling capability would permit the screening of variables and assist in choosing a more optimum set of test conditions.

Previous Activity/Results A variety of firing conditions on controlled pellet size distributions were explored with the pot grate to obtain basic CFD modeling information. A continuation project was approved through June 30, 2000.

Principal Investigator(s)
Dave Englund

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$80,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699135

Progress/Results
There is no activity to report for the quarter.

FERROUS MINERALS 630

Drum Magnetic Separator Model Development

Objective To develop a mathematical relationship between the equipment parameters, operating conditions, ore characteristics, and drum magnetic separator performance. The magnetic separator is the "work horse" of the magnetic taconite concentration process and is, therefore, a very important model to develop to permit computer simulation of the process.

Background The Iron Ore Cooperative Research Committee decided to establish a Taconite Concentrator Modeling Center at Coleraine. The advisory committee to the Center has chosen to license a modeling and simulation software package marketed by BRGM of France. Out of necessity, one of the first models to be developed by the Center should be that of magnetic separators. There are a large number of potential operating variables. It is proposed that Permanent University Trust Fund (PUTF) money be used to initiate an investigation into the effect of several of the more important variables on separator performance. This could then be supplemented with taconite company funds to look at other variables.

Previous Activity/Results The plans to obtain a loaner, cut down Eriez drum magnetic separator fell through, but initial plant sampling tests were initiated at Minntac as an add-on to one of their process line material balances. A detailed analysis of the samples taken around the various stages of magnetic separation at Minntac was performed. This data, along with other historical data, will be used to develop an improved model to be incorporated into the USIM PAC program.

Principal Investigator(s)
Ronald Wiegel

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$60,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699136

Progress/Results
There were two sets of samples taken from each of the stages of magnetic separation in the Minntac plant (cobber, rougher, finisher, and cleaner). Samples of separator feed and concentrate and tailing samples from each drum in a stage were taken together with overall separator tailings. There were measurements of percent solids and size distributions, and Davis tube (DT) tests were made on individual size fractions with assays for total Fe, Satmagan Fe, and SiO2 on DT concentrates and tails where appropriate. This data will be summarized in a report issued in July 2000. It will be added to data already available from the old LTV magnetic separators as part of the collection of data from which to obtain a gradually evolving model for simulation work.

Geological Resources of Oxidized Taconite Ore in the Vicinity of the Judd, Sally, Plummer, Holman-Cliffs, Homestead, Diamond, and Arcturus Properties: A Pilot Study

Objective To: 1) produce a geological resource estimate of the oxidized taconite ore in the area of the Judd, Sally, Plummer, Holman-Cliffs, Homestead, Diamond, and Arcturus properties (Sections 13, 14, 15, 16, 21, 22, 23, and 24, of 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 At current mining rates, magnetic taconite ore reserves on the Mesabi Iron Range will last for much more than 50 years. However, these reserves will eventually be depleted or uneconomic to mine, and other portions of the Mesabi Iron Range will be mined. About 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 beneficiation schemes for its exploitation. This research led to the construction of the Tilden Mine in Michigan. Currently, there is no mining on the western end of the Mesabi Iron Range in Itasca County, but there have been and are many other activities, i.e., boating, water resource management, and 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 economic in the future with new mineral processing and mining techniques and with lower stripping and blasting costs.

Previous Activity/Results Thirty drill holes (14,280 feet of core) were relogged from the 20,000-series holes that were drilled by U.S. Steel during 1959-1961. Four major stratigraphic members (Upper/Lower Slaty and Cherty members) were identified as well as nine stratigraphic submembers. At least three of these stratigraphic units were correlative throughout the area and, therefore, can be utilized as datums to provide structural-control and ore grade-control. Several 19,000-series and 21,000-series drill holes were also checked for the presence of these three stratigraphic units. Detailed cross-sections that display geological and ore-grade controls were being constructed.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Mark Severson, Julie Oreskovich, Larry Zanko, Harlan "Pete" Niles

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$65,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699137

Progress/Results
Preparation of 13 cross-sections (1 inch = 100 feet) was completed. Portrayed in each cross-section is a distribution of specific geologic submembers within the iron-formation. This distribution is important for resource calculations because the submembers show a "pinch and swell" nature. Only paper copies of the cross-sections have been prepared to date; they will be digitized in AutoCad in the near future. Also, a coding system for the various geologic submembers has been established for resource calculation purposes.

FERROUS MINERALS 632

Mercury Removal From Combustion Gases Using Iron Oxide

Objective To determine the type and size of iron oxide that will best remove mercury from a combustion gas stream. Small scale furnace tests will be performed to determine: 1) the species of mercury (Hg0 or Hg+2) that deposit on the iron oxide; 2) the amount of mercury that can be deposited on iron oxide; 3) the type of iron oxide which best reacts with mercury; and 4) the optimum temperature for mercury deposition on iron oxide. The subsequent removal of the iron oxide dust would result in the removal of mercury from the combustion gas stream.

Background The phenomenon of mercury deposition on iron oxide particles was discovered by the Coleraine Minerals Research Laboratory (CMRL) during mercury-material balances performed at four Minnesota taconite facilities and funded by the LCMR and MPCA. Development of a process leading to decreased mercury emissions and, thus, resultant decreased mercury deposition to Minnesota lakes and streams is desirable.

Previous Activity/Results Several furnace tests were run using mercury chloride, mercury sulfide, and mercury metal with and without magnetite filters. It was determined that magnetite removes mercury oxide from the gas stream. Recoveries of divalent mercury can be as high as 90 percent when a magnetite filter is present. Leach tests on the magnetite filter indicated that most of the mercury collected by the magnetite filter was mercury oxide.

Principal Investigator(s)
Ronald Wiegel, John Engesser

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$85,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699138

Progress/Results
A confidential report has been issued. A project to study stack emissions at six taconite facilities and correlate the emission-gas chemistry and scrubber-water chemistry to mercury removal (scrubbing) rates has been proposed to and approved by the Department of Natural Resources.

Pelletizing Taconite Concentrate With Lime/Dolomite Hydrate and Starch as a Bentonite Replacement

Objective To test the greenball quality using a combination of pebble lime and starch as a binder, and the fired pellet qualities.

Background Although bentonite is an excellent binding agent, the high silica content would reduce the grade of final products. Limestone and dolomite have been used as additives to produce fluxed pellets. Hydrolyzed lime was known to have binding characteristics, and various tests have been conducted to investigate using pebble lime as both a flux additive and a binding agent. The greenball quality is less desirable than those using bentonite as a binding agent. Adding a small amount of starch to the pebble lime would improve its binding characteristics and produce better green balls.

Previous Activity/Results Balling tests and pot-grate tests were conducted with various conditions. Use of hydrolyzed lime or adding starch-based organic binders both improved the greenball quality. Addition of organic binder resulted in significant physical improvements in fired pellets.

Principal Investigator(s)
Ronald Wiegel, Chuying Wu

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$40,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699139

Progress/Results
A final report is in progress. Test results indicated that the fired pellets improved over various aspects using lime hydrate to substitute the bentonite such as compression strength, low temperature degradation, and reducibility. However, the tumble index showed higher dust with lime hydrate substitute, which contributed to poorer greenball quality. Lime is the inhibitor of most binders except starch-based binders. Adding a half-pound of starch per ton improved greenball quality and consequently the tumble index of the fired pellets.

FERROUS MINERALS **724**

Davis Tube Based Taconite Mineral Liberation Measurement

Objective To develop a reasonably simple and understandable model of taconite liberation based on the standard liberation grind Davis tube test.

Background Previous work found that for 10 of 12 magnetic iron formation sample sets tested from around the world, the size fraction liberation of nonmagnetic waste minerals and their rejection in the Davis tube tailing paralleled what was predicted by an idealized "random liberation model" described by two parameters: ore feed grade and a single mineral grain size.

Previous Activity/Results The random liberation model used in previous work was being expanded to allow a gradation of magnetic content from pure gangue to pure magnetite. A computer program was written and reported on for determining the effective mineral grain size, head grade, and barren waste dilution parameters required to characterize the liberation properties of magnetic taconite ores from Davis tube results on individual size fractions. A second computer program (BASIC) designed to demonstrate the integration of mineral liberation and tumbling mill size reduction was completed. A progress report on this project was initiated. The next logical step is to convert the program into FORTRAN and use the BRGM development kit to incorporate the program into the USIM PAC software for use in modeling/simulating magnetic taconite concentration.

Principal Investigator(s)
Ronald Wiegel

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$65,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600101

Progress/Results
The new program is valid only for those situations where the grinding rates of the two minerals representing values and waste are equal. A modification is currently being made to permit the modeling of the more general case where values and waste can have significantly different grinding rates. This project should be completed in two to three months and will be reported at that time.

Development of a Kiln Computational Fluid Dynamics (CFD) Model for Pellet Induration Processes

Objective To develop a CFD model of a kiln.

Background The kiln CFD model represents the next logical step in the development of a grate-kiln cooler CFD model sequence. This model will be used to study turbulent flow, heat transfer, and NOx generation in the kiln. When completed, it will be coupled with existing cooler models.

Previous Activity/Results No activities were initiated.

Principal Investigator(s)
Dave Englund

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$65,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5600102

Progress/Results
Work on this project has not yet started.

FERROUS MINERALS **726**

Preparation of a Proposal Related to Ore Blending and Concentrator Performance

Objective To devise a project to improve crude ore blending in the taconite industry. Most of the effort will be to find ways of broadening the knowledge of concentrator and agglomerator operations for mine personnel.

Background Taconite mine geologists and mine engineers have expressed interest in knowing the quantitative mineralogy of various taconite ores as they are treated in the several stages of beneficiation. A Coleraine Minerals Research Laboratory (CMRL) proposal to sample plant beneficiation products and determine their mineral percentages was presented to the Permanent University Fund Committee in 1999 but was not approved. Another proposal is to be prepared after consulting with mine personnel.

Previous Activity/Results No activities were initiated.

Principal Investigator(s)
Ronald Wiegel, Harlan Niles

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$10,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600103

Progress/Results
Work on this project has not yet started. A new proposal has been promised for November 2000 PUF project funding consideration.

Development of a Mathematical Model of the High Pressure Rolls for Magnetic Taconite Comminution

Objective To develop sufficient operating data of the high pressure rolls on taconite to permit the development of a mathematical model that could be incorporated into flow sheet simulations.

Background One of the promising, new size reduction devices for the processing of minerals is the high pressure rolls, which causes particles to break by compressive forces concentrated on a bed of particles. This size reduction device has the potential for achieving size reduction with significantly less energy than consumed by conventional rotating mills. The development of a mathematical model of the rolls would allow its evaluation in various portions of a plant's flow sheet.

Previous Activity/Results Various articles were obtained. Data from previous high pressure rolls tests were compiled and used to test the existing models found in the literature.

Principal Investigator(s)
Ronald Wiegel, Blair Benner

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$50,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600104

Progress/Results
Analysis of existing models indicates that they fit only some of the materials, but do not appear to fit taconite very well. Tests have been run to try to fit the results of the HPR grinding to conventional grinding models for ball milling. The data is currently being analyzed.

FERROUS MINERALS 728

Determination of Breakage Functions for Minnesota Taconites

Objective To determine the breakage function parameters for crude ore and concentrates from several taconite plants.

Background The utilization of the current grinding models requires the determination of the "breakage functions" for predictive modeling. The breakage functions are mathematical parameters used to describe the various sizes of the product from the breakage of a single particle. As the crude ore is ground and upgraded by magnetite separation, it is probable that the breakage functions will also change. To accurately model all of the grinding in a taconite flow sheet, the breakage functions of the feed to each mill need to be known or predicted.

Previous Activity/Results In addition to the breakage function determinations for the rod mill feed, grinding rates were determined for the rod mill feed and the magnetic concentrate and tails produced from the rod mill feed. The magnetic concentrate sample had the highest grinding rate, followed by the rod mill feed. The tailings had the slowest grinding rate. Grinding rates will be determined for the Minntac sample.

Principal Investigator(s)
Ronald Wiegel, Blair Benner

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$75,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600105

Progress/Results
Breakage function determinations have been made on three size fractions from three different ore samples: Minntac rod mill feed, LTV rod mill feed, and a poor liberating ore. While there appears to be considerable variation between the concentrate and tailings parameter values, the parameters tend to be self compensating, so that when they are used in the calculations, the resultant size distributions are very similar.

Balling Circuit Study

Objective To continue searching for an effective means of controlling surging problems in pelletizing circuits.

Background Most of the surging problems occur in the balling drum or disc and are caused by changing moisture content of the filter cake. If an on-line moisture analyzer were in place, it would help control the balling circuit and prevent occurrences of surging. Also, it could reduce the bentonite consumption and provide manpower savings.

Previous Activity/Results The guided microwave moisture meter was set up, and several sets of tests were conducted in terms of moisture, flux addition, and grind. Data was evaluated.

Principal Investigator(s)
Ronald Wiegel, Chuying Wu

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$65,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600106

Progress/Results
Tests were completed. The guided microwave moisture meter rental unit was returned. Data collating and analysis are still under way. Preliminary results indicated that the obstacle for an accurate reading of moisture is sample presentation. The optimal filter cake moisture content for pelletizing is for it to have the densest compaction. However, this moisture level in the filter cake made it difficult to flow. Feeding filter cake to a square chamber with a conventional tubular screw feeder very often leaves a gap on the microwave chamber that distorts the waveform, rendering the information useless. For non-continue based, hand-fed samples, the meter is able to read moisture within a 0.1% accuracy range.

FERROUS MINERALS 730

Oxidized Taconite

Objective To: (1) catalog and evaluate data on the beneficiation of Minnesota oxidized taconite, and (2) determine if the high pressure rolls can significantly reduce the grinding energy necessary to process this type of ore.

Background Minnesota has vast quantities of oxidized taconite that will have to be developed in the first half of the next millennium if Minnesota is to continue to be a major supplier of iron units. While the beneficiation of oxidized taconite has been extensively studied, the information is not readily accessible, and a lot of the information resides in the memories of the people who conducted the research. The majority of these have either retired or died. The high pressure rolls have been shown to reduce the grinding energy for magnetic taconites by about 30 percent. With the increased grinding required for oxidized taconite, the high pressure rolls may allow even more savings.

Previous Activity/Results Initial literature review began.

Principal Investigator(s)
Ronald Wiegel, Blair Benner, Harlan Niles

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$45,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600107

Progress/Results
Over 150 articles have been collected and are being evaluated as to their relevance to the future processing of oxidized taconite.

Bentonite Balling Characteristics Based on Cation Exchange Capacity

Objective To develop a test method that will indicate the binding effectiveness of bentonite clay during greenball formation. A secondary objective is to investigate the impact of antifreeze chemicals on pre-fired pellet quality.

Background Bentonite clay has been used by the taconite industry since the commercialization of the taconite process. It provides unique binding qualities that promote stable greenball formation and adequate greenball strength during drying. However, a simple test to determine the way that bentonite will perform during balling has never been established. Research at the Coleraine Minerals Research Laboratory (CMRL) has indicated that the most significant detrimental factor that affects the binding qualities of bentonite is the presence of divalent cations in the process water. Both greenball and dry ball quality characteristics are negatively affected by the presence of divalent cations. This decrease in the effectiveness of bentonite appears to be due to the ion exchange of sodium in the bentonite with divalent cations in the balling feed moisture. A simple test to determine divalent/cation/exchange capacity of bentonite clay should indicate the binding effectiveness of the clay during greenball formation. Antifreeze agents, such as magnesium chloride or calcium chloride, can also dramatically increase the concentration of divalent cations and thus, inhibit the characteristics of bentonite clay.

Previous Activity/Results Test results illustrated that the present standard water plate absorption test, which is normally performed on bentonite, does not correlate well with ball quality and bentonite binding characteristics. Tests also indicated calcium and magnesium in the balling water hinder the binding characteristics of the bentonite. A laboratory test using calcium chloride solution for bentonite testing correlates very well with ball quality and bentonite binding characteristics.

Principal Investigator(s)
John Engesser

Project Sponsor(s)	**Amount**
USX Corporation	$15,000
Minnesota Technology, Inc. (MTI)	$30,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600108

Progress/Results
The test program has been completed. Final report writing is under way. Among the conclusions are: (1) water plate absorption by bentonite has a poor correlation to greenball and dry ball quality, (2) the results of settling tests using calcium chloride solutions correlate well with green ball drop strength, (3) moisture absorption by bentonite after it has been dried for 2 hours at 105°C correlates fairly well with dry ball strength, (4) sodium salts generally have no detrimental effects on ball quality, (5) calcium and magnesium salts have severe detrimental effects on ball quality, (6) a sodium salt should be used when a freeze agent is necessary (7) addition of sodium silicate, sodium hydroxide and sodium carbonate to the filter cake all improve dry ball quality. Sodium silicate also improves greenball quality.

FERROUS MINERALS 720

Optimizing the Firing Cycle in a Straight Grate and Grate-Kiln System

Objective To determine the optimum temperature for drying, preheating, and firing in the grate-kiln system.

Background Heat exchange on the grate is a function of air temperature and air mass flow through the pellet bed. The higher the temperature, the faster the heat can transfer to the pellet bed. However, the higher the temperature, the less air mass can flow through the pellet bed. There are limits on grate temperature and fan capacity that ultimately limit the production rate. Therefore, the key to increasing the production rate, reducing the fuel consumption, and improving the pellet quality is to optimize the heat delivered to the pellet bed.

Previous Activity/Results Several firing tests were conducted using a split pot to compare conditions of pellets between uniformly sized and mixed sized pellets. Different variables such as temperature, time, and bed permeability were investigated in order to reach optimized conditions.

Principal Investigator(s)
Chuying Wu

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$40,000
USX Corporation	$10,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600109

Progress/Results
A number of small-scale tube furnace weight loss/gain tests were conducted under various conditions. Results will be used to guide the next pot-grate firings.

Minnesota Ilmenite Processing Using High Pressure Rolls

Objective To improve the beneficiation of high-grade ilmenite ore from northeastern Minnesota.

Background There are several oxide-rich deposits in the Duluth Gabbro Complex that are being investigated due to their relatively high titanium dioxide (TiO2) contents. Previous studies indicated that high grade TiO2 concentrates can be produced from these projects. In previous studies, the primary objective was to demonstrate that high-grade concentrates could be produced. The current study will investigate methods of improving TiO2 recovery while maintaining grade.

Previous Activity/Results The one-stage HPR screen undersize was tested in a two-stage spiral pilot plant (rougher-cleaner). The spiral cleaner concentrate was passed through a conventional drum magnetic separator to remove magnetite. The magnetic tails were dried for potential electrostatic testing. Work started on recovering the ilmenite associated with the magnetic concentrate.

Principal Investigator(s)
Harlan Niles, Blair Benner

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$68,000

Start Date 7/1/99 **End Date** 6/30/01

Project No 5600110

Progress/Results
Simple regrinding and magnetic separation of the magnetic concentrate followed by silica flotation of the nonmagnetic portion did not remove sufficient gange to produce a high-grade ilmenite product. These results indicate that a more intensive research program is needed. Project funds have been expended. A report will be issued in conjunction with a project funded by the Permanent University Trust Fund.

FERROUS MINERALS 741

Investigation of Balling Circuit Using Computer Image Analysis System and Batch Balling Study Using Locked-Cycle Method

Objective To study the ball size consist on balling drum circuit using an on-line computer image size measurement device. The focus of this study will be on the size distribution of recirculating fines to detect surging occurrences and investigate ways to prevent it from happening.

Background In common practice of controlling a balling circuit, operators adjust the spray water and watch the reaction in the drum. Any sight changes in feed moisture, bentonite addition, and feed rate could trigger the surging. By closely monitoring the size distribution of the recirculating fines, surging occurrences could be detected early, giving the operator improved control of the circuit. Using this technology to study the recirculating fines would be beneficial for control and also tighten the product ball size range therefore improving induration process and pellet quality.

Previous Activity/Results A Contract for Professional Services was set up with Noramco Engineering Corporation to provide technical assistance in the set-up of the processor, cameras and lighting at the study site.

Principal Investigator(s)
Chuying Wu

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$12,600

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600111

Progress/Results
Due to difficulties in arranging for equipment and manpower, further work on this project has been postponed until July 1, 2000, with expected completion by June 30, 2001.

Geological Resources of Oxidized Taconite, Itasca County

Objective A current PUF project is compiling drill hole, geologic, topographic, iron ore assays, and other data on the Judd, Sally, Plummer, Holman-Cliffs, Homestead, Diamond, and Arcturus mine areas. The objectives of this project will continue this work and provide a more detailed geological resource estimate of the area's unmined oxidized taconite by compiling similar data from Sections 20, 29, 32, R24W, T56N, which includes most of the Morrison, part of the Canisteo, and all of the Danube and Fletcher mines.

Background At current mining rates, magnetic taconite ore reserves on the Mesabi Iron Range will last for more than 50 years. However, these reserves will eventually be depleted or uneconomic to mine and other portions of the Mesabi Iron Range will be mined. Marsden (1977) states that there are approximately 11.7 billion tons of oxidized (non-magnetic) taconite ore, of unknown ore grade, on the entire Mesabi Range. Other estimates suggest 6.8 to 7.9 billion long tons of oxidized taconite are known to occur on the Western Mesabi Iron Range alone (Marsden, 1978; Blake, 1983). 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 beneficiation schemes for its exploitation. Currently, there is no mining on the western end of the Mesabi Iron Range in Itasca County, but there are many other uses, i.e., boating, water resource management, and 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 economic 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 the mining industry and local, county, and state agencies that are involved with land use issues and 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/Results Logging of drill core within the study area was started.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Mark Severson, Larry Zanko, John Heine, Julie Oreskovich

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$25,000

Start Date 9/2/99 **End Date** 6/30/01

Project No 5600112

Progress/Results
A trip was made to the Cleveland-Cliffs research facility in Ishpeming, Michigan, to determine what drill core was available for logging and the condition of the drill. Based upon this visit, a second trip followed in June. Between the two trips, 38 drill holes (6,687 ft.) were logged. The geologic unit information will be coded for use in constructing a geologic model and ultimately determining the geological resources of the project area.

FERROUS MINERALS 619

Chemistry and Physics of Taconite Agglomeration-Phase I, II

Objective To obtain a better understanding of the fundamental phenomena associated with the use of binders in the balling and firing of taconite concentrates into pellets.

Background When the iron ore pelletization process was first developed, bentonite was selected as a binder because of a combination of ready availability and low cost. However, the economics of the process and the types of binders available have changed over the years, so it is worthwhile to re-examine alternative binders. It would be beneficial to develop binders that contribute less silica to the finished pellet, while still containing minimal amounts of other troublesome elements such as sodium, potassium, phosphorus, sulfur, or titanium. There are also some concerns about the cost and future availability of bentonite binders, so it is sensible to identify suitable substitutes and extenders. Most of this project will be carried out at Michigan Tech by Professor Kawatra and graduate students.

Previous Activity/Results The project began with an extensive literature review of the use of pelletizing binders other than bentonite clays. A fundamental study of the binding mechanisms for various binders was also begun. It was determined that mixtures of fly ash and bentonite are incompatible, giving properties inferior to either type alone. Work was under way to determine the effects on oxidation and sintering of iron ore pellets. Test work was completed, and a progress report for Phase I of this project was made a part of the continuation proposal for Phase II. A bibliographic result of an extensive literature review was included along with a more complete description of the planned study of binder mechanisms to be carried out in Phase II. Two papers were presented at the Society for Mining, Metallurgy and Exploration annual meeting in Salt Lake City, in February/March 2000. These papers described why bentonite and fly ash cannot be used together as a pellet binder, and how the bentonite is bonded to the magnetite as determined by SEM imaging.

Principal Investigator(s)
Ronald Wiegel

Collaborator(s)
Komar Kawatra, Michigan Technological University

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$59,133
Minnesota Department of Natural Resources (DNR)	$46,320

Start Date 3/2/99 **End Date** 6/30/00

Project No 5600113

Progress/Results
A proposed third phase to this project has been submitted to the DNR, which will focus on the following: (1) evaluating suitability of the use of plate water absorption standard test as an indicator of bentonite effectiveness in pelletizing, (2) using differential scanning calorimetry to measure the transformation kinetics of magnetite concentrates in the presence of both organic and inorganic binders, and relate this to what happens during pellet drying, firing, and cooling, (3) investigating the formation of a fibrous bentonite-magnetite structure that has been noted in earlier phases of this study when there is intensive, intimate mixing of the constituents, and (4) determining if certain Minnesota clays have the potential of replacing part or all of the bentonite used for binding in balling/pelletizing.

Iron Ore Processing Improvements Through Process Modeling and Computer Simulation

Objective To acquire and become familiar with the use of mineral processing simulation software so as to be able to provide a simulation service to all Minnesota magnetic taconite companies.

Background Taconite companies decided to work as a consortium in supporting a simulation capability at the Coleraine Minerals Research Laboratory (CMRL) through the Iron Ore Cooperative. The Taconite Concentrator Modeling and Simulation Center will be advised by a committee composed of representatives from Cleveland Cliffs, National Steel, U.S. Steel, Inland Steel, the Minnesota DNR, a metallurgical consultant, and a process equipment vendor. Decisions have been made on the type of process simulation software to be licensed, and several related projects on the modeling of drum magnetic separators and the licensing of additional competing simulation software have been approved for funding through the Permanent University Trust Fund.

Previous Activity/Results The Center's efforts concentrated on two fields of mathematical modeling research: (1) the development of a predictive model for simultaneous mineral liberation and size reduction, one of the "missing links" in mineral processing capabilities required for magnetic taconite process simulation, and (2) the development of an inclusive model for magnetic separators. A questionnaire was sent to equipment manufacturers and plant operators so as to determine the most significant variables to be included in the model. Their responses were evaluated. A case study illustrating the existing capabilities of USIM PAC for improving the performance of taconite plants was prepared and presented to plant metallurgists. The Center's eagerness to provide assistance in the use of USIM PAC for the simulation of taconite plants was clearly expressed.

Principal Investigator(s)
Ronald Wiegel, Salih Ersayin

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$95,333
Minnesota Department of Natural Resources (DNR)	$61,400
Minnesota Department of Natural Resources (DNR)	$81,600

Start Date 11/1/99 **End Date** 6/30/00

Project No 5600114

Progress/Results
A computer program for predicting simultaneous mineral liberation and size reduction modeling has been completed. Incorporation of the model into USIM PAC simulation software has just begun. PERI, the software vendor, has expressed its willingness to form collaboration between CMRL and BRGM for this purpose. Analysis of the existing data with respect to the development of an inclusive magnetic separator model is about to be completed. Detailed sampling data from four of the taconite plants on the Iron Range have been mass balanced and their performance was analyzed. Files containing a summary of mass balancing and performance analyses are being sent to the respective plant engineers for their review. An initial contact has been established with Inland Steel to carry out detailed sampling in the plant. The data obtained will be used for simulation of the plant. Simulation results will form a basis for changing operating conditions and/or the flow sheet in order to improve plant performance. It is expected that a similar type of work will be carried out in other plants. Data from these studies will be added to the magnetic separator model.

FERROUS MINERALS 872

Effect of Pellet Size Distribution on Bed Permeability and Gas Flow

Objective To define a single bed characteristic that relates pellet surface area and bed permeability with pellet size distribution. This characteristic parameter will be utilized in the Davis induration model to predict how pellet size distribution affects drying, magnetite oxidation, pressure drop, productivity, and fuel consumption during pellet induration.

Background Iron ore pellet induration processes rely on moving large quantities of air through pellet beds to transport heat in the process. Heat exchange between the pellet bed and the air stream is crucial, whether heating the bed or cooling it. Significant amounts of energy are expended by process fans to move air through the system. At times, the fans become limiting factors in production because the volumes of air necessary to transfer heat in the process exceed fan operating capabilities. Bed permeability is a key factor in maximizing air flow at a given pressure drop. It is often argued that bed permeability must increase to improve airflow in the system. The highest permeability (void volume) occurs when all pellets are the same size and perfectly spherical. Permeability for mono-sized spheres is independent of diameter, but as pellet diameter decreases, pellet surface area and resultant drag on the gas stream increase. Pressure drop will increase with drag, and hence, more energy must be expended to move the process gas through the bed. No pellet plant with the current pelletizing equipment can produce a perfect mono-sized pellet product. Bed permeability decreases as the size distribution widens from a single sized product. As permeability decreases and/or bed surface area increases, the volume of air moving through the bed decreases at constant pressure drop. When air flow drops off, heat transfer is reduced, and the efficiency of the induration process is diminished.

Previous Activity/Results No activities were initiated.

Principal Investigator(s)
Dave Englund

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$36,805

Start Date 11/9/99 **End Date** 6/30/00

Project No 5600116

Progress/Results
Work on this project has not yet started.

The Reduction of Fluoride Dissolution During Induration Off Gas Scrubbing

Objective To reduce fluoride dissolution in scrubber water, prevent precipitation problems during filtering, and create more consistent green-pellet quality.

Background Fluoride minerals are volatilized during pellet induration. The fluoride enters the process water stream in the wet scrubbers. Water containing high fluoride concentration creates process and environmental problems. Addition of lime hydrate or pebble lime to the green pellets could dramatically reduce the amount of fluoride that volatilizes during induration. The soluble fluoride that is present in the green pellets will react with pebble-lime or lime-hydrate and form calcium fluoride prior to green-pellet drying. Calcium fluoride has a volatilization temperature that is much higher than pellet-firing temperatures. Therefore, any soluble fluoride present in the green pellet will be contained in the fired pellet and will not report to the induration off gas. This will reduce problems in filtering and balling created by calcium fluoride precipitation.

Previous Activity/Results Filter cake samples were collected from two taconite plants. The filter cake samples and the lime hydrate used for balling were being analyzed for fluoride.

Principal Investigator(s)
John Engesser

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$17,000

Start Date 11/9/99 **End Date** 6/30/00

Project No 5600117

Progress/Results
Filter cake from two taconite plants was obtained. Samples of each filter cake were processed into greenballs containing various amounts of bentonite, limestone, and/or lime hydrate. The pellets were heated to temperatures ranging from 800°C to 1200°C in a horizontal tube furnace. The fired-pellet samples and the greenball samples are presently being analyzed for various chemical constituents. Fluoride volatilization will be calculated based on the difference between the greenball fluoride content and the fired-pellet fluoride content.

FERROUS MINERALS 934

Annual USX Research Budget - CY 2000

Objective To provide ongoing research support to the USS Minntac concentrator and agglomerator by providing technical support through bench scale and pilot plant testing and regular consultation sessions.

Background The Coleraine Minerals Research Laboratory (CMRL) has provided research support to the USS-Minntac taconite operation for several years. Pilot plant and bench scale work at CMRL has helped Minntac implement several flow sheet improvements including fine screening, on-stream silica analyses, flotation, and fluxed pellets.

Previous Activity/Results A slightly different approach was taken to the design and selection of projects that USX feels are problem areas and where CMRL feels it can be of technical assistance. Work centered on projects related to the effect of recirculated water chemistry on flotation and balling, the development of test data for a ported kiln evaluation, and the development of an improved bentonite quality test related to greenball strength.

Principal Investigator(s)
Blair Benner, John Engesser, Dave Englund, Harlan Niles, Ronald Wiegel, Chuying Wu

Project Sponsor(s)	**Amount**
USS Minntac	$180,000

Start Date 1/1/00 **End Date** 12/31/00

Project No 5600118

Progress/Results
The water chemistry testing, both in the laboratory and for short periods in plant demonstrations, is nearing completion, with results mandating significant process changes to the plant. Other work for Minntac has been aimed at solving short duration metallurgical problems.

Spruce Road Exploration Program

Objective INCO, through its US subsidiary, American Nickel & Copper Company, Inc., and Wallbridge Mining Company entered into a joint venture to evaluate footwall copper deposits in the Spruce Road area that would be similar to footwall copper deposits in the Sudbury, Ontario, nickel camp. One or two drill holes will evaluate the footwall copper potential.

Background INCO (International Nickel Company) began exploring for copper-nickel deposits in the Duluth Complex in the 1960s. During their exploration, they defined two ore deposits, Spruce Road and Maturi. These ore deposits are considered to be sub-economic, i.e., the grade of the deposit is not rich enough to predict a profit under current economic conditions. However, with the advent of the discovery of "footwall copper deposits" in the Sudbury, Ontario, nickel district, similar exploration targets in the Duluth Complex are considered to have exploration potential. In 1998, INCO, through its US subsidiary, American Nickel & Copper Company, entered into a joint venture agreement with Wallbridge Mining Company, of Lively, Ontario, to test the footwall copper potential in the Spruce Road and Maturi areas where INCO still retains its U.S. Forest Service mining leases. Wallbridge Mining Company is the operator and plans to drill one or two drill holes within the area.

Previous Activity/Results Wallbridge Mining Company's drilling program was suspended until fall 2000. Only minor technical assistance was provided to Wallbridge in preparation for the next drilling program.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Larry Zanko, Mark Severson, Bill Jahn, John Heine

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$7,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 1198027

Progress/Results
Wallbridge issued an initial public offering (IPO) to raise funding for their future projects, which includes this project. No work was done on this project during the quarter. Work should continue in the fall with the start of their drilling program.

NON-FERROUS MINERALS 613

Evaluation of a New PGE Exploration Method

Objective This project will evaluate the usefulness of sampling glacial material, over portions of the Duluth Complex, as an aid in exploring for Platinum Group Elements (PGE).

Background Previous studies of PGE mineralization in the Duluth Complex have shown that many of the mineralized zones often contain chemically distinct chromium-rich spinels, hercynitic spinels, and other specific heavy minerals. However, much of the Duluth Complex is covered by glacial deposits, and thus, exploration for "hidden" PGE deposits is dependant on blind drilling programs, or drilling adjacent to known PGE occurrences. In other glaciated areas of the Canadian Shield, heavy mineral sampling of the glacial drift has been shown to be an effective exploration tool. This is because glaciers have the capability of grinding up the bedrock and mineralized zones and mixing the material as the glacier advances. As the glacier melts, or retreats, this material is further modified by melt water that concentrates heavy minerals. In theory and practice, the chemistry of any anomalous heavy minerals can then be followed back "up ice" to a source area that contains anomalous mineralization—especially if the glacial heavy minerals exhibit a specific chemical signature that is associated with known PGE mineralization. Since much of Minnesota is covered by glacial drift, any new technique that can explore for "hidden" PGE mineralization by using the overlying material could potentially aid in finding additional ore deposits.

Previous Activity/Results Work by Great Lakes Exploration, Inc. (GLE) and subcontractors continued on this confidential project.

Principal Investigator(s)
Steven Hauck, Mark Severson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$44,000

Start Date 7/1/98 **End Date** 6/30/00

Project No 5699208

Progress/Results
Work on this confidential project is continuing by GLE and subcontractors. A subcontractor's contract was extended to June 15, 2000, to complete additional work without an increase in cost.

Birch Lake Drill Hole Research Project

Objective The purpose of this project is to gain further knowledge on the extent and nature of the Birch Lake platinum-group element (PGE) occurrence by investigating the geology, petrology, and sulfide, oxide, and PGE mineralogy in the newly drilled core holes BL-98-1 and BL-98-W1.

Background The Birch Lake prospect is located in the South Kawishiwi Intrusion (SKI) of the Duluth Complex. Like the Bushveld Complex of South Africa, which hosts most of the world's major known platinum deposits, the Duluth Complex is a large body of mafic to ultramafic igneous rocks. PGEs are strategic and critical materials of national significance. Ongoing research at NRRI has been concerned with defining the processes that produced the elevated PGEs in the SKI and specifically, in the Birch Lake area. The PGE unit is defined by Severson (1995) as the U3 Unit (Ultramafic 3 Unit) of the SKI. Anomalous PGE values are associated with the U3 Unit throughout the SKI; however, more elevated PGE values occur in the U3 Unit at Birch Lake and in drill hole BL-98-1. The elevated PGEs in the U3 Unit are associated with sulfides, with both chromium-rich (Cr-hercynite, Cr-magnetite) and chromium-poor massive oxides, and oxide-rich ultramafic layers. PGE ratio data also support a magmatic reef-type environment of formation. Data of Severson (1995) suggest that the Birch Lake area is positioned near a north- to northeast-trending fault zone(s), i.e., Birch Lake Fault.

Previous Activity/Results A draft report was written and submitted to the IRRRB. Additional research for this confidential project will continue in the next quarter.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Steven Monson Geerts

Project Sponsor(s)	**Amount**
Iron Range Resource Rehabilitation Board (IRRRB)	$18,000

Start Date 1/5/99 **End Date** 12/31/00

Project No 5699209

Progress/Results
Six polished thin sections from various geologic units were selected for microprobe analyses. Sample sites were photographed and annotated. The samples have been sent to a microprobe laboratory in the Twin Cities. Additional samples will be selected in the future.

Petrographic Characteristics of the Birch Lake PGE Ores

Objective To: (1) Identify the platinum-group minerals (PGMs) in drill holes, and their respective wedges, BL-99-1, BL-99-2, BL-99-3, and BL-98-1, and (2) Describe the petrological relationships between the PGMs and the sulfides, oxides, and silicates and the relationship between the various PGM phases present.

Background Altoro Resources of La Paz, Bolivia (a Vancouver, B.C.-based company), and their joint venture partner, the Beaver Bay Joint Venture of Minneapolis, have been exploring the Birch Lake area of the Duluth Complex in St. Louis County for platinum-group elements (PGEs). After several years of drilling and 16 drill holes and wedges, the partnership has defined several zones of PGM mineralization that may be economical to mine if future drilling has the same encouraging results. To date, limited research has been conducted to identify the specific PGMs that are present within the ore zones, and to describe the relationship between the surrounding silicate, sulfide, and oxide minerals that comprise the ore zones. The existing information is presented in two Finnish theses and a few brief confidential reports. Altoro Gold estimates a potential resource at their Birch Lake prospect of 4.2 million tonnes grading 3.09 g/t Pt-Pd-Au, 0.66% Cu and 0.22% Ni (420,000 ounces PGE + Au), which was calculated on the basis of six drill hole intersections defining a zone 400 m wide, 800 m long, and open along strike to the north and to the east. Altoro Gold has a five year option to acquire a 100% interest in the property for staged payments totaling US$500,000 and 200,000 common shares and staged work commitments totaling US$3 million. A retained 5%-15% net profits royalty can be purchased by Altoro for US$2 million. (Data Source - Altoro Gold web page - http://www.altoro.com/profile_f.htm). Altoro Gold is planning to drill another drill hole in June 1999 (BL-99-3).

Previous Activity/Results Altoro Gold withdrew from this exploration project, but this confidential project will be picked up by its partner.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Mark Severson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$22,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600201

Progress/Results
Impala Platinum of South Africa has picked up the project. The project should start in the next quarter with a revised work plan.

Pre-Assay Sample Preparation and Geological Studies to Produce a Drill Indicated Ore Reserve for PolyMet Mining's Copper-Nickel NorthMet Deposit in St. Louis County, MN

Objective The NorthMet mining project must produce a feasibility study that includes: (1) assay data for deposit grade calculations and reliable drill hole correlations, (2) specific gravity data for reliable tonnage factor calculations, and (3) geologic control of ore and waste rock and a digital database for ore reserve calculations for mine planning needs.

Background The NorthMet deposit is one of several large copper-nickel deposits within the Duluth Complex in St. Louis and Lake Counties. PolyMet Mining Corporation (PolyMet), a Vancouver Stock Exchange registered company headquartered in Golden, Colorado, has been examining the NorthMet copper-nickel deposit in St. Louis County since 1989. PolyMet, formerly named Fleck Resources, Inc., recently renamed US Steel's Dunka Road copper-nickel deposit the NorthMet deposit. The NorthMet project is PolyMet's primary asset and the single focus of the corporation's multi-year, multi-million dollar development efforts. Fluor Daniel Wright, a mining consulting company, previously calculated an open pit potentially mineable geological resource of 808 million metric tons of ore, grading 0.432% copper, 0.437 g/mt palladium, 0.116 g/mt platinum, 0.109% nickel, 0.061 g/mt gold, 1.5 g/mt silver, and 0.006% cobalt, which was based on 4,200 assays from 102 drill holes. This open pit tonnage is contained within a global mineral resource estimated at 1.45 billion metric tonnes at similar metal grades.

Previous Activity/Results Many of the objectives for this project were completed. The bottoms of all the drill holes at the Dunka Road (NorthMet) deposit were relogged. The data were used to construct maps that depict: (1) the configuration of the basal contact, (2) rock types present at the basal contact, and (3) the presence and configuration of miscellaneous units beneath the basal contact. Over 1,600 samples from 22 holes were selected for geochemical analyses. Over 600 samples from 19 drill holes were collected for specific gravity determinations. Sawn core from CMRL was delivered to Lerch Brothers in Hibbing for additional processing.

Principal Investigator(s)
Steven Hauck, Harlan Niles

Collaborator(s)
Mark Severson

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$47,150
PolyMet Mining Corporation	$28,000
Minnesota Technology, Inc. (MTI)	$10,850

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600203

Progress/Results
The final report for this project has been completed in rough draft form and has been submitted for review. The report describes results pertaining to: (1) collection of 1,760 drill core samples for sawing and geochemical analyses, (2) collection of 1,039 core samples for specific gravity (density) determinations, (3) preparation of 26 cross-sections that exhibit the overall geology, and (4) the spatial locations of specific geologic units within the deposit (eight plates).

NON-FERROUS MINERALS 782

Comparative Geology, Stratigraphy, and Lithogeochemistry of the Quartz Hill, Eagles Nest, and Five-Mile Lake VMS Occurrences, Western Vermilion District

Objective This project will use detailed outcrop mapping, petrography, core logging, rock property data, and geochemistry at each volcanogenic massive sulfide (VMS) prospect, in conjunction with the Minnesota Geological Survey (MGS), to better characterize each prospect and identify both regional and more localized volcanological and hydrothermal alteration patterns that may point to mineralization.

Background Preliminary studies in the Western Vermilion District (south and west of Ely, Minnesota) indicate that the Archean-aged Eagles Nest and 5-Mile Lake prospects represent Noranda-type (Noranda District, Canada, mines) VMS systems, while the Quartz Hill prospect represents a Mattabi-type (Mattabi deposit, Sturgeon Lake, Canada) VMS system. The presence of Noranda-type and Mattabi-type VMS systems, as well as possible epithermal (low temperature) gold mineralization, suggests that the Vermilion District may represent a region of significant polymetallic mineralization.

Previous Activity/Results Work on this VMS project focused on collection of magnetic susceptibility data and specific gravity samples from drill core, and logging of the drill core. Magnetic susceptibility measurements were run on 11 drill holes, and 37 specific gravity samples were collected. Logging was completed on five drill holes from the Quartz Hill area, two drill holes from the Five Mile Lake area, and one from the Eagle's Nest area. A meeting was set up with Dr. George Hudak, UW-Oshkosh Geology Department, to plan the field activities for next summer.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Mark Severson, John Heine

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$95,000

Start Date 10/1/99 **End Date** 6/30/01

Project No 5600204

Progress/Results
The field mapping season began in late-June. Consultant, Dr. George Hudak (UW-Oshkosh), two students, and John Heine began cleaning and locating outcrops and relocating previous company grids in the Five Mile Lake area. Geologic quadrangle scale maps were made from Mr. Dean Peterson's (UMD Department of Geological Sciences) recent ArcView compilation of the geology. These maps are being used as base maps for the mapping. An additional map was made at a larger scale to illustrate the location of known outcrops and to plot new outcrops. In addition to normal field supplies, diamond bits were purchased for a portable coring machine. The coring machine will be used to collect hard to obtain and small-sized rock samples that will be submitted for geochemical analyses.

Relationship Between PGEs and Stratigraphy, Birch Lake Area, MN

Objective To understand the relationships between the PEG Unit, U3 Unit, and Platinum-Group Element (PGE) mineralization in the South Kawishiwi Intrusion (SKI).

Background Empirically, there is a spatial relationship between high PGE values in the U3 Unit and to a lesser extent, the overlying PEG Unit. However, very little detailed geochemistry and petrological sampling has been done outside of the Birch Lake PGE discovery area (BLA; an area where high PGE values have been delineated by drilling). The objective of this study will be to describe the petrological (minerals present, their composition, alteration, and relationships to each other) and geochemical aspects of the PEG and U3 Units and their relationship to PGE-Cr-Cu-Ni mineralization within, and outside of, the BLA. These petrological and geochemical characteristics can then be searched for in similar rock units well outside of the BLA to define other areas for further mineral exploration.

Previous Activity/Results Drill core logging continued. Additional samples for polished thin sections were collected. Polished thin sections began to arrive from Washington University. Petrography should begin in the next quarter.

Principal Investigator(s)
Steven Hauck

Collaborator(s)
Mark Severson

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$75,000

Start Date 10/1/99 **End Date** 6/30/01

Project No 5600205

Progress/Results
Drill core logging is complete. All of the sampling for the petrographic study is complete. The remaining samples will be sent to Washington University to have polished thin sections made. About 300 samples have been collected for petrography, and 15 samples have been collected for whole rock (approximately 66 elements) analyses. Upon review of the budget for the next fiscal year, additional geochemical samples may be collected.

INDUSTRIAL MINERALS 611

Evaluation of Geophysical Techniques to Reduce Clay Exploration

Objective This project will focus on determining the benefits of using geophysical techniques in conjunction with drilling to determine the extent and grades of clay materials on three Minnesota Valley Minerals (MVM) kaolin clay and ball clay properties.

Background As part of MVM's exploration and development program for 1998-1999, expansion drilling on two active mine properties is planned. In addition, exploration drilling on a recently mine permitted property is also planned. The use of geophysical techniques is being investigated as one possible way to lower costs of these programs. The geophysical program will be carried out by a consulting geophysicist hired by MVM in conjunction with the geological program.

Previous Activity/Results No activities were initiated. The company's tentative starting date for the drilling portion of the project was the middle of October 1999, but no firm date has been received from them.

Principal Investigator(s)
John Heine, Steven Hauck

Collaborator(s)
Scott Gooler (Minnesota Valley Minerals)

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$39,000

Start Date 7/1/98 **End Date** 12/31/00

Project No 5699304

Progress/Results
The project still has not started. The company is planning to drill in August. However, the cash match portion of this project has not yet been received, and work will not begin without the cash in hand.

Technical Reference for Minnesota's Industrial Mineral Mine Wastes

Objective This investigation will create a single technical reference, or catalog, of industrial mineral mine wastes, focusing on Minnesota's crushed stone and dimension stone industry, e.g., limestone, trap rock, granite, gneiss, and quartzite.

Background Wastes produced by Minnesota's crushed stone and dimension stone industries include fines, stripping materials, and marginal-grade stone in stockpiles or discard piles. These environmentally benign wastes are the end result of a tremendous expenditure of energy and capital, yet they go largely unexploited. However, in combination with other materials or processes, some might have potential for use in one or more applications, e.g., construction, wastewater treatment, soil amendment, etc.

Previous Activity/Results Larry Zanko attended the Fourth Annual Pavement Conference at the Earle Brown Center on the St. Paul Campus. The conference covered all aspects of paving, including aggregate and waste fines.

Principal Investigator(s)
Steven Hauck, John Heine, Julie Oreskovich, Lawrence Zanko

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$40,000

Start Date 11/16/99 **End Date** 6/30/01

Project No 5600301

Progress/Results
No work was done on this project during the quarter. Start-up of the project is scheduled for next quarter.

ENVIRONMENTAL REMEDIATION 731

Nitrogen Oxide (NOx) Emission Reduction During Pellet Induration by Fuel Addition to the Green Pellet

Objective To determine if solid fuel (coal or coke) addition to the green pellets will decrease NOx formation by 30 percent during fluxed pellet induration with little or no additional cost to the taconite facility.

Background The production of NOx during pellet induration is an environmental concern. The Minnesota Pollution Control Agency previously proposed a NOx control system, which would create process problems, increase production cost, and decrease NOx emissions by less than 20 percent. Previous work performed by CMRL in both the grate-kiln and straight-grate induration processes demonstrates that NOx production is directly related to flame temperature and energy consumption. NOx production is higher when natural gas is used as a fuel rather than wood or coal due to the high flame temperature of natural gas. NOx production is 30 to 50 percent higher when fluxed pellets are produced rather than acid pellets because of the increased fuel needed for limestone calcination. The addition of a small amount of coal or coke to the pellets will decrease the amount of natural-gas needed for limestone calcination leading to decreased NOx formation. The use of pebble-lime or lime-hydrate as the flux would require less coal or coke addition than a fluxed pellet made using limestone. An addition rate of 0.6 to 0.8 percent coal or coke would be needed to replace the pre-heat burners. Coal that contains about 10 percent ash and 1 percent sulfur would increase the silica in the final pellet by less than 0.04 percent and the sulfur by less than 0.006 percent.

Previous Activity/Results The Continuous Emission Monitoring (CEM) trailer was brought into working order and will be set up next to the building containing the pot-grate apparatus so that the gases leaving the pot-grate can be analyzed for SOx, NOx, oxygen, and carbon dioxide.

Principal Investigator(s)
Ronald Wiegel, Chuying Wu, John Engesser

Project Sponsor(s)	**Amount**
Permanent University Fund (PUF)	$60,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 5600401

Progress/Results
Vertical-tube furnace tests were conducted with pellets containing 0.6% coal and 1.0% coal. A series of four temperatures and four residence times was used to determine the oxidation rates of coal and magnetite. The calcination rate of the limestone was also determined. The muffle furnace test data indicate that calcination of limestone is 90 percent complete after 6 minutes at 1050°C. Most of the calcination occurs between 750°C and 1050°C. Very little calcination occurs below 750°C. Tube furnace tests demonstrate that 65% of the magnetite is oxidized after 6 minutes at both 950°C and 1050°C. Under the same conditions, 6 minutes at 950° and 1050°C, 65% and 90% of the coal is oxidized, respectively. Tube furnace tests are presently being conducted with fluxed pellets that contain no coal and flux pellets that contain 1% coal. CEM trailer instruments for CO, CO2, NOx, O2, and SOx were calibrated to ensure operational integrity.

Alternative Technology for Sediment Remediation

Objective To apply mineral processing technology as an alternative solution to the storage or treatment of dredged spoils.

Background A dredging operation is needed for maintaining harbor and navigational channels. Dredged material, because of the environmental concern, must be stored in a Confined Disposal Facility (CDF). The Erie Pier CDF in Duluth is nearing its capacity, and additional space is required for storage of dredged materials, either by construction of a new facility or by extending the life of the one currently in use. This project will apply mineral processing technology to separate the clean portion of the sediment for construction use, thereby creating more space for storage of the contaminated portion.

Previous Activity/Results The Coleraine Minerals Research Laboratory (CMRL) and the U. S. Army Corps of Engineers worked out a detailed proposal and contract for the phase of building and operating the plant. Details included the monitoring, sampling, and chemical analysis of plant products. This phase of the project began in April 2000.

Principal Investigator(s)
Chuying Wu

Project Sponsor(s)	**Amount**
United States Army Corps of Engineers	$266,720

Start Date 4/6/00 **End Date** 12/31/00

Project No 5600403

Progress/Results
The sediment treatment plant is in its final stage of building and testing at CMRL. The treatment plant has a capacity to process sediment at a rate of 50 to 150 tons per hour. Site preparation has been completed, and plant start-up is expected on July 10, 2000.

MACHINE SHOP 943

Retractable Duck Decoy Anchor

Objective To design and fabricate prototypes of a recoiling system.

Background The NRRI Machine Shop is assisting John Rashid of Duluth, Minnesota, in the design and prototyping of a recoiling duck decoy anchor. John, an avid duck hunter, has been searching for a solution to a problem that is troublesome to all duck and goose hunters---the tangling of decoys from the anchor strings when the decoys are set out at the start of the day. This problem surfaces again at the end of the day after the decoys are collected, the strings are wound around the decoys, and the decoys are placed in a bag for transporting. What John has envisioned is a recoiling system for the string on a duck decoy, similar to the recoiling of a tape measure. The product will have two functions: (1) to act as an the anchor for the decoy, and (2) to act as a device that will quickly wind and store the string for the decoy, thereby eliminating the potential for string entanglements. One other major improvement over the lead anchors currently being used is that the new device will be made of environmentally friendly materials such as stainless steel and plastic.

Previous Activity/Results This is a new project.

Principal Investigator(s)
Gene Betts, Steven Johnson

Project Sponsor(s)	**Amount**
John Rashid	$4,800 (in-kind)
Minnesota Technology, Inc. (MTI)	$7,000
John Rashid	$3,000

Start Date 6/22/00 **End Date** 9/15/00

Project No 1194022

Progress/Results
We have researched different types of cord used to attach the decoy to the recoil apparatus. Mr. Rashid decided on an optimum weight of 8 oz. with an option for 12 and 16 oz. models for deeper water. Several different types of recoiling devices have been purchased for examination. We are attempting to develop an optimum culmination of components to achieve the production cost guideline. We have examined several options for attaching the recoil device to the decoy itself and are considering the use of a swivel in order to keep the cord tangle free. A number of different spool styles have been fabricated for the purpose of wrapping the cord, but none seem to be advantageous. A progress meeting is tentatively scheduled for July 15 to approve the initial conceptual design.

Active Grants

Sponsor	Project	Budget FY1999-00
PEAT HORTICULTURAL		
MN Technology, Inc. (MTI)	Densified Peat Products: Phase I	79,300
MN Technology, Inc. (MTI)	Densified Peat Products: Phase II	48,500
MN Technology, Inc. (MTI)	Horticultural Peat Development Aitkin Agri-Peat Inc.	30,000
MN Technology, Inc. (MTI)	Horticultural Peat Development Berger Horticultural Products, Ltd.	34,000
WASTEWATER TREATMENT		
Iron Range Resources and Rehabilitation Board (IRRRB)	Alternative Sewage Treatment Demonstration Project	179,810
Legislative Commission on Minnesota Resources (LCMR)	Onsite Sewage Treatment Alternatives: Performance, Outreach and Demonstration	141,748
MN Technology, Inc. (MTI)	Commercialization of Containerized Peat Filters	37,500
MN Technology, Inc. (MTI)	Performance of Containerized Textile and Peat Biofilters as Alternative Wastewater Treatment Systems	70,700
St. Louis County Health Department	Development of a Model Code for Onsite Wastewater Treatment Systems	60,000
CHEMICAL DERIVATIVES		
Minnesota Power Inc.	Birch Bark Co-Products	164,934
MN Technology, Inc. (MTI)	The New Technology of Birch Bark Utilization	100,000
NaturTek LLC	Birch Bark Products Development 2000 Plan	280,000
Potlatch Corporation	Birch Bark Co-Products Project	134,946

Sponsor	Project	Budget FY1999-00
State Special	The New Technology of Birch Bark Utilization	70,000
FOREST PRODUCTS		
MN Technology, Inc. (MTI)	AgriSorb Plant Start-Up Assistance	16,000
MN Technology, Inc. (MTI)	Cryogenic Tempering Woodworking Machine Tooling	7,000
MN Technology, Inc. (MTI)	Development of New Products and Markets for Woodline Manufacturing	23,000
MN Technology, Inc. (MTI)	Development of a Rot Detection System for Trees	15,700
MN Technology, Inc. (MTI)	Development of RTA Cabinets and Furniture	20,000
MN Technology, Inc. (MTI)	Hot Foil Transfer to Timberline Furnishings	15,000
MN Technology, Inc. (MTI)	Laminated Truck Flooring for Industrial Hardwood Products	15,700
MN Technology, Inc. (MTI)	Northern Contours Order Entry and Production Control System	15,616
MN Technology, Inc. (MTI)	Paint Line and New Window Grille Development	15,700
MN Technology, Inc. (MTI)	Redevelopment of the R-50 Cabinet Door	6,500
MN Technology, Inc. (MTI)	SunRamp Solutions Product Development	36,000
MN Technology, Inc. (MTI)	Utilization of Tamarack as a Small Sawlog Resource	28,500
MN Technology, Inc. (MTI)	Value Added Agricultural Based Panel Products for Phenix BioComposites	12,000
Northern Contours, Inc.	Product Development and Process Improvement for Northern Contours	124,200
U.S. Department of Agriculture	Forest Products Innovation and Implementation	255,396

Sponsor	Project	Budget FY1999-00
U.S. Department of Agriculture	Forest Products Technology Advancement	218,116
U.S. Department of Agriculture	Forest Products Technology Implementation	218,153
USDA Forest Products Lab.	Advancing Technology to Manufacture Trusses From Hardwood Lumber	15,000
USDA Forest Products Lab.	Hardwood Lumber I-Joist Manufacturing	13,618
USDA Forest Products Lab.	NDE of Hardwood Log Quality	9,122
FORESTRY		
MN Technology, Inc. (MTI)	Enhancement and Assessment of Forest Productivity	29,784
AURI	Minnesota Hybrid Poplar Research Cooperative Program	391,000
FERROUS MINERALS		
MN Department of Natural Resources (DNR)	Chemistry and Physics of Taconite Agglomeration, Phase I, II	105,453
MN Department of Natural Resources (DNR)	Effect of Pellet Size Distribution on Bed Permeability and Gas Flow	36,805
MN Department of Natural Resources (DNR)	Geological Resources of Oxidized Taconite, Itasca County	25,000
MN Department of Natural Resources (DNR)	Investigation of Balling Circuit Using Computer Image Analysis System and Batch Balling Study Using Locked-Cycle Method	12,600 (Advance)
MN Department of Natural Resources (DNR)	Iron Ore Processing Improvements Through Process Modeling and Computer Simulation	238,333
MN Department of Natural Resources (DNR)	Minnesota Ilmenite Processing Using High Pressure Rolls	68,000
MN Department of Natural Resources (DNR)	Process Modeling of Pellet Induration Furnaces	119,542
MN Department of Natural Resources (DNR)	The Reduction of Fluoride Dissolution During Induration Off Gas Scrubbing	17,000

Sponsor	Project	Budget FY1999-00
MN Department of Natural Resources (DNR)	Weakening of Taconite in Small Scale Explosive Tests	58,400
MN Technology, Inc. (MTI)/USX Corporation	Bentonite Balling Characteristics Based on Cation Exchange Capacity	45,000
MN Technology, Inc. (MTI)/Minnesota Iron and Steel Company	Digital Mine Model and Statistical Evaluation	36,500
MN Technology, Inc. (MTI)/USX Corporation	Optimizing the Firing Cycle in a Straight Grate and Grate-Kiln System	50,000
Permanent University Fund (PUF)	Balling Circuit Study	65,000
Permanent University Fund (PUF)	Computational Fluid Dynamics (CFD) Special Problem Assistance	40,000
Permanent University Fund (PUF)	Davis Tube Based Taconite Mineral Liberation Measurement	65,000
Permanent University Fund (PUF)	Determination of Breakage Functions for Minnesota Taconites	75,000
Permanent University Fund (PUF)	Development of a Computational Fluid Dynamics (CFD) Model for the Pot Grate Tests	80,000
Permanent University Fund (PUF)	Development of a Generalized Production Scheduling (Mine Planning) Methodology for Open Pit Iron Mining Operations	90,000
Permanent University Fund (PUF)	Development of a Kiln Computational Fluid Dynamics (CFD) Model for Pellet Induration Processes	65,000
Permanent University Fund (PUF)	Development of a Mathematical Model of the High Pressure Rolls for Magnetic Taconite Comminution	50,000
Permanent University Fund (PUF)	Drum Magnetic Separator Model Development	60,000
Permanent University Fund (PUF)	Geological Resources of Oxidized Taconite Ore in the Vicinity of the Judd, Sally, Plummer, Holman-Cliffs, Homestead, Diamond, and Arcturus Properties: A Pilot Study	65,000
Permanent University Fund (PUF)	Mercury Removal From Combustion Gases Using Iron Oxide	85,000

Sponsor	Project	Budget FY1999-00
Permanent University Fund (PUF)	Oxidized Taconite	45,000
Permanent University Fund (PUF)	Pelletizing Taconite Concentrate With Lime/Dolomite Hydrate and Starch as a Bentonite Replacement	40,000
Permanent University Fund (PUF)	Preparation of a Proposal Related to Ore Blending and Concentrator Performance	10,000
U.S. Steel Corporation	Annual USX Research Budget – CY 2000	180,000
NON-FERROUS MINERALS		
Iron Range Resources and Rehabilitation Board (IRRRB)	Birch Lake Drill Hole Research Project	18,000
MN Department of Natural Resources (DNR)	Comparative Geology, Stratigraphy, and Lithogeochemistry of the Quartz Hill, Eagles Nest, and Five-Mile Lake VMS Occurrences, Western Vermilion District	95,000
MN Department of Natural Resources (DNR)	Relationship Between PGEs and Stratigraphy, Birch Lake Area, MN	75,000
MN Technology, Inc. (MTI)	Evaluation of a New PGE Exploration Method	44,000
MN Technology, Inc. (MTI)	Petrographic Characteristics of the Birch Lake PGE Ores	22,000
MN Technology, Inc. (MTI)/PolyMet Mining Corporation	Pre-Assay Sample Preparation and Geological Studies to Produce a Drill Indicated Ore Reserve for PolyMet Mining's Copper-Nickel NorthMet Deposit in St. Louis County, MN	86,000
MN Technology, Inc. (MTI)	Spruce Road Exploration Program	7,000
INDUSTRIAL MINERALS		
MN Department of Natural Resources (DNR)	Technical Reference for Minnesota's Industrial Mineral Mine Wastes	40,000
MN Technology, Inc. (MTI)	Evaluation of Geophysical Techniques to Reduce Clay Exploration	39,000

Sponsor	Project	Budget FY1999-00
ENVIRONMENTAL REMEDIATION		
Permanent University Fund (PUF)	Nitrogen Oxide (NOx) Emission Reduction During Pellet Induration by Fuel Addition to the Green Pellet	60,000
United States Army Corps of Engineers	Alternative Technology for Sediment Remediation	266,720
MACHINE SHOP		
MN Technology, Inc. (MTI)/John Rashid	Retractable Duck Decoy Anchor	14,800
Estimated amount		$5,527,696

Pending Grants

Sponsor	Project	Budget FY1999-00
PEAT HORTICULTURAL		
Legislative Commission on Minnesota Resources (LCMR)	Boreal Wetlands Management for Specialty Uses	373,453
WASTEWATER TREATMENT		
Iron Range Resources and Rehabilitation Board (IRRRB)	Alternative Sewage Treatment Demonstration Project Phase VI	31,550
CHEMICAL DERIVATIVES		
None		
FOREST PRODUCTS		
Iowa State University (USDA Prime)	Increased Utilization of Agricultural Fiber and Soybean-Based Adhesives to Manufacture Composites	235,254
Northern Initiatives	Red Maple Utilization	22,000
U.S. Department of Agriculture	Forest Products Innovation and Commercialization	226,682
FORESTRY		
Michigan Technological University (USDA Prime)	A Consortium to Evaluate Forest Biotechnology's Role in Northern Regions	649,905
U.S. Department of Agriculture Forest Service	Regional Field Test Assessment–Coop. Agreement	8,980
FORESTRY/FOREST PRODUCTS		
U.S. Department of Energy	Innovative Hybrid Poplar Systems for Integrated Production of Bioenergy, Value-Added Wood Products, and High-Value Proteins	839,983

Sponsor	Project	Budget FY1999-00
FERROUS MINERALS		
Akzo Nobel, Dreeland, Inc.	Pot Grate Tests	6,975
Center for Transportation Studies	Properties and Aggregate Potential of Coarse Taconite Tailings	126,000
MN Department of Natural Resources (DNR)	Chemistry and Physics of Taconite Agglomeration	65,196
MN Department of Natural Resources (DNR)	Investigation of Balling Circuit Using Computer Image Analysis System and Batch Balling Study Using Locked-Cycle Method	37,400 (Balance)
MN Department of Natural Resources (DNR)	Iron Ore Processing Improvements Through Process Modeling and Computer Simulation	111,691
Permanent University Fund	Effect of Demagnetization Between Drums on Magnetic Separators	30,000
Permanent University Fund	Geological Resources of Oxidized Taconite Ore in the Vicinity of the Canisteo, Hunner, King, Jennison, Buckeye, Jessie 1&2, and West Hill Mines: A Continuing Evaluation of Oxidized Taconite Resources in Itasca County	60,000
Permanent University Fund	Magnetic Field Application in Hydroseparators and Flotation Cells	83,000
Permanent University Fund	Magnetic Separator Model Development	30,000
Permanent University Fund	Mineral Liberation/Size Reduction Model for Taconite	32,000
U.S. Department of Energy	Iron Ore Processing Improvements Through Process Modeling and Computer Simulation	131,953
NON-FERROUS MINERALS		
Florida Institute of Phosphate Research	Grinding Media Wear Reduction in Phosphate Grinding Via Alloy Selection	71,640
Impala Platinum	Petrographic Characteristics of the Birch Lake PGE Ores	8,000 (MTI Match)

Sponsor	Project	Budget FY1999-00
Permanent University Fund	Copper±Nickel±Precious Metal Mineralization in the Giants Range Batholith Footwall of the Duluth Complex: Indigenous or Introduced Sulfides?	40,000
Permanent University Fund	Production of Value Added Products From Ilmenite Deposits in the Duluth Gabbro	75,000
INDUSTRIAL MINERALS		
Minnesota Valley Minerals, Inc.	Evaluation of Geophysical Techniques to Reduce Clay Exploration	10,000 (MTI Match)
Estimated amount		$3,306,662

PERSONNEL

Jacob Pessenda has accepted an engineering position at Cirrus Design Corporation in Duluth, Minnesota. Pessenda graduated from UMD in May 2000 and had been employed at the NRRI since April 2000.

FACILITIES

NRRI Greenhouse

The NRRI greenhouse continues to be used as the primary breeding site for the Minnesota Hybrid Poplar Research Cooperative's genetic improvement program. Approximately 160 crosses have been made in this facility this year, and seedlings are being raised for planting in nurseries this fall. This breeding program is one of the largest breeding programs of its type in North America.

REPORTS/PAPERS/PRESENTATIONS

Reports/Papers

A paper entitled "The Use of Drip in Minnesota" was accepted for presentation at the 9th Symposium on Individual and Community Sewage Systems sponsored by the American Society of Agricultural Engineers. The paper will be presented by Barb McCarthy at the meeting in Fort Worth, Texas, on March 11-14, 2001.

Brashaw, B. and V. Krause. 2000. Evaluation of CFC Flexrite™ Membrane Press Manufacturing Conditions (Confidential Report). NRRI Technical Report Number NRRI/TR-2000/14.

Brashaw, B. 2000. Colonial Craft Fastener Performance Testing (Confidential Final Report). NRRI Technical Report Number NRRI/TR-2000/15.

Brashaw, B. 2000. Colonial Craft Casement Fastener performance Testing (Confidential Final Report). NRRI Technical Report Number NRRI/TR-2000/16.

Brashaw, B. and B. Vatalaro. 2000. True North Fastener Performance Test Results (Confidential Final Report). NRRI Technical Report Number NRRI/TR-2000/18.

Edwardson, C. 2000. Laminated Flooring Testing Results For Oak, Hard Maple, and Maple From Rockland Industrial Products Rockland and West Lorne Plants. Technical Report Number NRRI/TR-2000/29.

Hopstock, David M., A re-examination of the performance of demagnetizing coils on finely ground natural magnetite, *in* International Journal of Mineral Processing, vol. 59, no. 1, (4/00), pp. 45-68. (Dr. Hopstock is a consultant to CMRL on Permanent University Trust Fund contract.)

Presentations

A presentation by Barb McCarthy regarding the NERCC alternative wastewater treatment systems and other systems in the area was made at the North Shore Annual Wastewater Conference on May 8, 2000, at Superior Shores in Two Harbors, Minnesota.

A tour of NERCC and Grand Lake was held on May 26, 2000, for Commissioner Karen Studders (MPCA) and various staff members from the MPCA, Cass County, St. Louis County, and the Iron Range Resources and Rehabilitation Board.

Brian Brashaw gave the presentation, "Heat Resistance of Thermoformed Components" to Northern Contours during their Annual National Sales Meeting in Fergus Falls, Minnesota.

Brian Brashaw gave the presentation, "Vacuum Forming Versus Membrane Pressing: Fact vs. Fiction" to Northern Contours during their Annual National Sales Meeting in Fergus Falls, Minnesota.

Bill Berguson gave a presentation to the Minnesota Forest Industries joint meeting on forest productivity. A summary of aspen productivity research, the Minnesota Hybrid Poplar Research Cooperative and recommendations for future forest productivity research was included in this presentation.

Neil Nelson gave the keynote address at the annual banquet of the UMD Sigma Xi Research Society, entitled "Science for Economic Development–Forestry and Forest Products Research at NRRI."

Chuying Wu gave a presentation on "Alternative Technology for Sediment Remediation" at the semi-annual Great Lakes Dredging Team meeting in Duluth in April. A similar presentation will be given to the Harbor Technical Advisory Committee (HTAC) in Superior, Wisconsin, in July.

Salih Ersayin presented a paper titled "Concentrator Modeling" at the May 2000 Iron Ore Cooperative Research meeting at IronWorld in Chisholm, Minnesota.

Ronald Wiegel presented "Size Reduction/Mineral Liberation for Magnetic Taconite Ores - A Work in Progress" and Iwao Iwasaki presented "Iron Ore Flotation: Past and Present" at the spring meeting of the Upper Peninsula (UP) Michigan Section of Society of Mining, Metallurgy and Exploration Engineers (SME) in May.

Steven Hauck, Andy Bite (Wallbridge Mining Company Ltd.), and Mark Severson presented a poster titled "Copper Mineralization in the Pyroxene Hornfelsed Archean Giants Range Batholith Footwall of the Keweenawan South Kawishiwi Intrusion, Duluth Complex, NE Minnesota - Archean or Keweenawan Mineralization?" at the 46th Annual Meeting of the Institute on Lake Superior Geology in Thunder Bay, Ontario.

PROGRAM NOTES

Proposals in Progress

The proposal, "Boreal Wetlands Management for Specialty Uses," was submitted by Kurt Johnson to the Legislative Commission on Minnesota Resources (LCMR). The proposed project will be a cooperative study with the UMD Bureau of Business and Economic Research (BBER) and the NRRI Peat Group. The proposal made the first cut and was defended at the LCMR public hearing on June 20. LCMR will make its final funding recommendations in mid-July.

NRRI was listed as a subcontractor on a proposal submitted by Northern Initiatives to the FastTrack Program, United States Department of Agriculture Wood Education and Resource Center. This proposal was titled Red Maple Laminated Veneer Lumber, and the NRRI funding request was in the amount of $22,000. This proposal was selected for funding to begin later this summer.

Ryan Rosandich, UMD Department of Industrial Engineering (principal investigator), and Brian Brashaw (co-investigator) submitted a proposal to the FastTrack Program, United States Department of Agriculture Wood Education and Resource Center. This proposal was titled Hardwood Lumber Defect Scanning, and the NRRI funding request was for $9,000. This proposal has been selected for funding this fall.

Neil Nelson (principal investigator) and Chris Edwardson (co-investigator) submitted a proposal titled "Forest Products Innovation and Commercialization" to the CSREES/USDA in the amount of $226,682.

Neil Nelson (principal investigator), Bill Berguson (co-investigator), and Arun Goyal (co-investigator) submitted a proposal titled "A Consortium to Evaluate Forest Biotechnology's Role in Northern Regions" to the Michigan Technological University (USDA Prime) in the amount of $649,905.

Neil Nelson (principal investigator), Bill Berguson (co-investigator), Chris Edwardson (co-investigator), and Arun Goyal (co-investigator) submitted a proposal titled "Innovative Hybrid Poplar Systems for Integrated Production of Bioenergy, Value-Added Wood Products, and High-Value Proteins" to the USDOE in the amount of $839,983.

Chris Edwardson (principal investigator) submitted a proposal titled "Utilization of Agricultural Fiber and Soybean-Based Adhesives to Manufacture Composites" to Iowa State University in the amount of $235,254.

Bill Berguson submitted a proposal titled "Regional Field Test Assessment-Coop Agreement" to the USDA Forest Service-North Central Research Station in the amount of $8,980.

The following proposals were submitted by the Economic Geology Group to the Permanent University Trust Fund (PUTF) Advisory Committee for minerals research:

"Melting of the Biwabik Iron-Formation by Duluth Complex Magmas and its Effects on the Distribution and Deposition of Platinum-Group Elements, Copper, Nickel, and Gold," by Steven Hauck and J. Grant, UMD Department of Geosciences. Amount: $141,000

"Sedimentation and Stratigraphy of the Biwabik Iron-Formation - A Potential Guide to Variations in Taconite Grades and to Later Mineralizing Events," by Mark Severson and Dr. Richard Ojakangas, UMD Department of Geosciences. Amount: $180,000

"Geological Resources of Oxidized Taconite Ore in the Vicinity of the Canisteo, Hunner, King, Jennison, Buckeye, Jessie 1&2, and West Hill Mines: A Continuing Evaluation of Oxidized Taconite Resources in Itasca County," by Steven Hauck. Amount: $130,000

"Detailed Mineralogy and Petrography of Oxidized Taconite Ores in the Lind-Greenway to Arcturus Mine Area, With Emphasis on Mineralogy, Grain Boundary Relationships, and Stratigraphic and Structural Controls That Affected Ore Grade and Mineral Textures," by Steven Hauck. Amount: $80,000.

"The Physical, Geological, Mineralogical, and Chemical Properties of Taconite Mining Byproducts as Related to Their Road Construction Aggregate Potential: A Baseline Study of Eastern Mesabi Range Taconite," by Larry Zanko and Harlan "Pete" Niles. Amount: $100,000.

"Copper-Nickel-Platinum-Group Element Mineralization in the Giants Range Batholith Footwall of the Duluth Complex: Igneous or Introduced Sulfides?" by Steven Hauck and Mark Severson. Amount: $66,000

"Regional Distribution, Mineralogy, and Geochemistry of the Cook Area Glacial Lake Clays and Their Applicability for Use as a Binder for the Taconite Industry," by Julie Oreskovich and Steven Hauck. Amount: $81,000

Notification was received on the funding of two of the above PUTF proposals: (1) "Geological Resources of Oxidized Taconite Ore in the Vicinity of the Canisteo, Hunner, King, Jennison, Buckeye,

Jessie 1&2, and West Hill Mines: A Continuing Evaluation of Oxidized Taconite Resources in Itasca County," awarded $60,000 for the first year; and (2) "Copper-Nickel-Platinum-Group Element Mineralization in the Giants Range Batholith Footwall of the Duluth Complex: Igneous or Introduced Sulfides?" awarded $40,000 for the first year.

Technical Assistance

Kees van Beek, Federated Farmers of New Zealand, floral moss producer: NRRI Peat Group staff gave a tour of peat harvesting sites and *Sphagnum* moss regeneration studies.

Scott Laudenslager, MDNR, Red Lake Wildlife Management Area: NRRI Peat Group personnel toured their peatland restoration site south of Roosevelt, Minnesota, and offered advice on re-establishing *Sphagnum* moss and other peatland plants.

Matt Drzal, Michigan Peat Company: NRRI Peat Group staff provided information regarding horticultural peat pile design, and ways to avoid self-heating and spontaneous combustion.

Erv Berglund, MDNR: NRRI Peat Group staff assisted the MDNR in setting up a tour of peat harvesting and restoration sites for the Interagency Wetland Banking Committee. A number of potential sites were visited and an information package was assembled. The tour will be tentatively held in September.

Claude Samson and Jacques Gagnon, Premier Horticulture: NRRI Peat Group staff met with representatives of Premier Horticulture to discuss potential expansion of their Peatrex horticultural peat operation near Cromwell, Minnesota.

Diamond Brands, Cloquet, Minnesota: Several discussions were held regarding wood residue issues, veneer yield and wood watering issues.

Dow Chemical, Midland, Michigan: A review of membrane pressing technology and testing procedures was completed for a new Dow engineer who is working in their decorative laminate section.

Van Technologies, Inc., Duluth, Minnesota: Taber abrasion and KCMA finish testing was completed on steel and wood finishes to evaluate performance.

Timberline Furnishings, Grand Rapids, Minnesota: A review of their finishing operations was completed and modifications were suggested. Eighty percent of the suggested changes were implemented within two weeks.

Kleerdex Company, Mt. Laurel, New Jersey: Horizontal surface testing was completed on a set of Kydex laminates.

HB Fuller, Vadnais Heights, Minnesota: A balance beam scratch and mar tester was fabricated in the NRRI machine shop. This equipment will be used by their powder coatings group to evaluate surface properties. On-site training was provided.

Cirrus Design, Duluth, Minnesota: Ongoing quality control testing was completed as part of Cirrus' incoming raw materials program.

Ferche Millwork, Rice, Minnesota: Information on automated defect technology equipment was summarized and provided to Ferche. They are reviewing their rough mill operations and plan to purchase new processing equipment during the next 12 months.

Perceptron, Inc., Hatboro, Pennsylvania: NRRI has continued to participate with Perceptron as they commercialize ultrasound scanning technology for hardwood lumber. We introduced Perceptron's marketing manager to six leading hardwood components manufacturers resulting in four equipment demonstrations.

Northern Initiatives, Marquette, Michigan: Brian Brashaw has continued serving on a wood residue advisory panel in the Upper Peninsula of Michigan. The council is advising Northern Initiatives on problems due to wood residue issues.

Omnova, Auburn, Pennsylvania: Laminate pressing and testing was completed on several rigid thermofoil samples.

Dane Engineering, Brainerd, Minnesota: Several new clients were referred to Dane by NRRI staff. Dane is an equipment fabricator located in northern Minnesota that specializes in the forest products industry.

Exerquip, Inc., Duluth, Minnesota: Testing was completed on a new physical therapy aid that Exerquip is trying to bring to market.

Potlatch, Grand Rapids, Minnesota: Conducted a proprietary project for a new added-value product. The project involved strand manufacturing, panel fabrication, and product testing.

BASF, Wyandotte, Michigan: Conducted two proprietary panel manufacturing projects and additional routine testing of products supplied by manufacturers. The panel projects involved manufacturing and testing oriented strand board with proprietary isocyanate binder and manufacturing and testing ag-based particleboard.

OSB Chateaugay, Chateaugay, New York: Manufactured and tested OSB panel starting from aspen, maple, and pine logs shipped to NRRI from New York. Six combinations of species were evaluated, and we were able to demonstrate that a wide range of species mixture options is possible for meeting rated sheathing specifications.

International Paper Company, West Chicago, Illinois: Completed two proprietary projects for a building component concept. The work involved a laboratory study and a pilot plant run.

Blandin Paper Company at Grand Rapids, Minnesota: Technical assistance was provided in evaluating the accuracy of various sampling methods to determine moisture content in-situ in white spruce and balsam fir.

Senator Wellstone's St. Paul staff: Steve Hauck, Mark Severson, Larry Zanko, and Blair Benner provided the senator's staff with information on the history, mining, processing, and environmental concerns of copper-nickel exploration and proposed mining in Minnesota.

Cleveland-Cliffs personnel: Mark Severson, Steve Hauck, and Larry Zanko gave an overview of the copper-nickel exploration history, geology, and mineralization in the Duluth Complex to two different groups from Cleveland-Cliffs. Cleveland-Cliffs has an option on the closing LTV Steel plant in Hoyt Lakes, and they are evaluating the economic feasibility of converting the plant for copper-nickel ore processing.

Beaver Bay Joint Venture and Impala Platinum of South Africa: Steve Hauck and Mark Severson provided technical assistance to these partners on their Birch Lake area exploration program.

Grand Rapids resident: Larry Zanko provided technical assistance to an individual who found an interesting rock specimen. It was suggested that he speak to Pete Niles at Coleraine.

Dr. James Natlin of University of Miami: Information on the oxide-bearing ultramafic intrusions in the Duluth Complex was provided to Dr. Natlin, who has found about 1,500 meters of similar rocks during a deep sea drilling program on the southwest Indian Ridge.

OTHER

A workshop on control panels for the onsite wastewater industry was held at NRRI on May 2, 2000. Approximately 50 local contractors and area regulators attended the session. Three industry vendors participated in the workshop.

Barb McCarthy is participating in a New Technology Committee for onsite wastewater treatment systems recently organized by the Minnesota Pollution Control Agency.

John Heine attended a planning meeting for the year 2000 Minnesota Minerals Teachers Workshop that will be held in St. Cloud in early August 2000.

Larry Zanko attended a Laurentian Vision meeting in Hibbing. The Laurentian Vision consists of a group of iron mining company personnel, university personnel, and other interested individuals or groups who are looking at what the Mesabi Iron Range will look like 20 and 40 years into the future. This vision includes where iron ore mines will be mining, stockpiling, and disposing of tailings.

Steve Hauck and Mark Severson attended the 46th Annual Meeting of the Institute on Lake Superior Geology in Thunder Bay, Ontario, which included a field trip to the Lac des Iles Pd-Pt-Cu-Ni-Au mine north of Thunder Bay, and a field trip to examine outcrops of Gunflint Iron-Formation (equivalent to the Biwabik Iron-Formation in Minnesota).

Julie Oreskovich continued working on the Minnesota Geological Survey portion of a Legislative Commission on Minnesota Resources (LCMR) grant.

Julie Oreskovich attended a week-long seminar at UMD on the use of ArcView software for environmental projects.

Center for Water and the Environment

Progress Report for April -June, 2000
Table of Contents

CENTER ACTIVITIES

ENVIRONMENTAL CHEMICAL 553

Design of Novel and Environmentally Benign Photoactive Compounds

Objective The goal of this project is to carry out computer-assisted design of a novel set of photoactive chemicals which will have desirable photoactivity profile as well as acceptable levels of human and environmental toxicity. QSAR and computational tools developed at NRRI will be used for this purpose.

Background The purpose of this project is to design new photoactive chemicals which will have desirable photoactivity and low toxicity to the human and the environment. QSAR and computational chemistry methods will be used in this project.

Previous Activity/Results A number of photoactive chemicals have been designed and synthesized. Some of them have been tested for thier effectiveness as photoresists in collaboration with scientists in The Chromaline Corporation, Duluth, MN.

Principal Investigator(s)
Subhash Basak

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$53,686

Start Date 7/1/97 **End Date** 6/30/01

Project No 189-6156, -6188

Progress/Results
Attempts have been made to design photoactive chemicals with acceptable profile of properties. The possibility of applying for a patent on novel photoactive chemicals has been explored

ENVIRONMENTAL CHEMICAL 548

Prediction of Health and Environmental Hazards of Chemicals: A Hierarchical Approach Using QMSA and QSAR

Objective To develop novel methods of quantifying molecular similarity and use similarity techniques in selecting analogs of quadricyclane and fluorocarbon ethers for estimating toxicity and degradability of these chemicals. Limited experimental work will be carried out to test the validity of estimation methods.

Background The US Air Force has a large number of toxic waste sites which are contaminated by chemicals including quadricyclane and fluorocarbon ethers. Very limited or no experimental data necessary for hazard assessment is available for these chemicals. The NRRI group will be working on methods which help in the hazard estimation of chemicals in the presence of limited empirical data.

Previous Activity/Results High quality regression (HQR) methods have been developed and used in the prediction of properties. New dissimilarity methods based on structural descriptors and physicochemical properities have been used in the clustering of JP8 chemicals. The clustering method will help the US Air Force in selecting chemicals for testing in an effort to estimate the health and environmental hazard of JP8 jet fuel.

Principal Investigator(s)
Subhash Basak
William Herndon

Collaborator(s)
Keith Lodge, Gregory Grunwald

Project Sponsor(s)	**Amount**
United States Air Force	$518,514

Start Date 10/1/97 **End Date** 9/30/00

Project No 1613-189-6158

Progress/Results
The utility of hierarchical QSAR and clustering methodology as tools for predictive toxicology has been further explored. Five papers were presented on these topics at an international conference in New Delhi, India.

ECOSYSTEM STUDIES - LAND RESOURCES 572

Interactive GIS Database Development for Mining and Forest Land Management

Objective To develop a user-friendly, intuitive geographic information system (GIS) system for selecting, displaying, and manipulating information about leases, land holdings, and land uses associated with a mining operation.

Background LTV Steel Mining Company has land holdings and leases covering approximately 60,000 acres in St. Louis, Lake, and Cook counties. Employees in several different LTV divisions must have access to information about these lands in order to effectively manage them. LTV also must exchange information about its lands and management practices with several state and local government units, and with individual lease holders. In the past, this information was stored on paper maps, in notebooks, and in the memories of long-serving employees. New GIS methods are needed to store and access this complex information.

Previous Activity/Results Additional land holdings records, not previously available, were obtained from Cook and Lake Counties and converted into usable GIS format. Two meetings were held with LTV representatives to further refine and discuss additional options for the project. After re-processing the data to better meet LTV's needs, a CD containing all of the created GIS layers was prepared. This CD, along with written documentation was sent to LTV. A confirmation e-mail was received which contained an informal slide-show demonstration of how LTV is actually using the GIS system by selecting, displaying, and manipulating their mining operation information.

Principal Investigator(s)
Carol Johnston

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$26,037

Start Date 7/1/98 **End Date** 6/30/00

Project No 189-6169

Progress/Results
Carol Johnston worked with Public Relations staff to write about this project for NRRI Now.

EPIC ECOPHYS: Modeling Growth of Aspen and Hybrid Polar

Objective To model the physiological and physical processes occurring between plant roots and soils. Processes to be modeled include root architecture and growth in three-dimensional space, carbon allocation patterns, soil nutrient and water flows, and root-shoot interactions.

Background Understanding root-soil and root-shoot interactions is critical for developing predictive models of the plant response to climatic change or stress due to changing atmospheric composition. We plan to develop a root growth model for ECOPHYS, an established whole-tree growth process model, in order to simulate the effects of global change effects.

Previous Activity/Results Minirhizotron root images for the 1999 growing season have been collected and archived. Root image processing (capture and digitization) of 1998 data was recently completed and will be subjected to thorough analysis shortly. Programing work continues to improve parameter estimates of the root growth behavior of the ECOPHYS poplar model.

Principal Investigator(s)
George Host
Gary Theseira

Collaborator(s)
Jud Isebrands

Project Sponsor(s)	**Amount**
USDA Forest Service, North Central Forest Experiment Station (NCFES)	$88,764

Start Date 3/2/98 **End Date** 2/14/03

Project No 189-6162

Progress/Results
Analysis of the captured and digitized 1998 minirhizotron root image data continues. Efforts are currently focused on understanding the allometric relationship between root order and root diameter class as well as the size relationship between parent and child (branch) roots of each diameter class. In addition, the frequency distribution of root branching as a function of root size is being examined. Together, these data will contribute greatly to our understanding of root growth behavior in Populus and enable us to improve modeling of root growth in ECOPHYS.

Lake Superior Land Use Decision Support System

Objective This project will develop GIS decision support applications focused on the Lake Superior basin to address land use issues. It will be developed for local governments, regional planning agencies, individual resource management units, advocacy groups, educational and interpretive organizations, and individual citizens. The goal is to provide users with practical tools that can be applied to local land and resource decisions in a context of basin-wide objectives for long-term sustainability and stewardship. Another goal is to provide tools to interpretive and educational institutions to foster public awareness and support of GIS-based land use decision support.

Background Land use has evolved into one of the most important issues in ecosystem management. In the Lake Superior basin, this fact has struck a chord among government agencies, commercial interests, aboriginal groups, and advocacy groups. These groups are attempting to forge a consensus around issues fundamentally related to land use policy; the basin's future is directly dependent on the resolution of the issues. The impact of forestry and development results from the cumulative effects of a large number of small land use decisions, spread across time and space. When integrated across time and space, these land use decisions have major impacts on the basins resources. This project will develop databases and tools to help groups assess the consequences of land use plans.

Previous Activity/Results A data distribution system is being set up to allow users to download public domain GIS data sets for the Basin. We installed a new hard drive on the LSGIS server and reconfigured the original hard drive and computer to correct reported access problems. Two interactive touchscreen kiosks that display geographic information about the Basin are being tested in the CWE Computer Lab. The kiosks are running the Site Explorer program developed by Mike Koutnik, ESRI. The project co-sponsored a workshop on Stormwater Modeling for local and regional agency personnel. A hydrologic model, PC-SWMM, was applied to upper Miller Creek in Duluth, Minnesota, and is being tested. LSGIS staff met with planning personnel from the northern Wisconsin counties to discuss options for supporting local planning efforts with GIS and modeling data. We are currently defining the scope for a project that places geographic informa-tion and decision support tools on a CD-ROM for distribution to local planning agencies.

Principal Investigator(s)
George Host, Lucinda Johnson, Carl Richards

Collaborator(s)
Mark White, Gerry Sjerven

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$501,289

Start Date 8/6/97 **End Date** 9/30/00

Project No 189-6149

Progress/Results
During the first quarter of 2000, we created a map depicting the Important Habitat sites of the Lake Superior Basin. This map was submitted to a publisher and included in a report delivered to numerous State and Federal agencies. A copy of this map will be included on the website for download and viewing. Some of the data sets that are provided through the website were found to be too large for individuals using slower computers. Alternative data sets were made available to help those individuals. The Miller Creek Watershed pilot project has been completed and has been placed on the website. A form requesting basic information has been placed on the website to allow potential data users to tell us 1) what data they are downloading and 2)what they plan to use the data for. This will allow us to contact the users when there are further announcements in their areas of interest. A data set on shoreline classification was received and was imported and converted to a common coordinate system. This data set will be provided through the website soon. Work on updating metadata continues.

LTREB: Long Term Dynamics of Moose Foraging, Community Structure, and Ecosystem Properties

Objective To determine the spatial patterns of moose foraging and associated ecosystem properties through population cycles.

Background In previous grant awards from NSF on this long-term project, we have determined that the spatial patterns of ecosystem properties, such as soil fertility and the distribution of tree species, were accentuated during the latest moose population cycle on Isle Royale. There is, therefore, a connection (albeit poorly understood) between animal population cycles and the spatial patterns of ecosystem properties across the landscape. In this project, we will monitor moose browsing intensity and associated ecosystem properties on three greis of 1000 points apiece in different sectors of Isle Royale to determine the dynamics of spatial patterns of ecosystem properties during moose population cycles.

Previous Activity/Results Based on our results over the previous five years, we submitted a renewal proposal to NSF requesting further funding for an additional five years. The proposal was approved and the project begins this quarter.

Principal Investigator(s)
John Pastor, Yosef Cohen, Bradley Dewey, Ronald Moen

Project Sponsor(s)	**Amount**
National Science Foundation (NSF)	$119,999

Start Date 9/1/93 **End Date** 6/30/00

Project No 1638-189-6167

Progress/Results
Geostatistical analyses of spatial patterns of soil nitrogen, conifer abundance, browse availability, and browse consumption by moose show that these are arranged in patches across the landscape of about 100-300m in diamter and that these patches repeat themselves every 300-500 meters. A reaction-diffusion model is proposed to account for these higher order patterns. This is the first demonstration in the scientific literature that herbivores determine the spatial patterns not only of their food supply but also of the ecosystem properties that support them. A paper on these results and discussing the implications for foresters and wildlife managers has been published in Ecological Applications 8: 411-424 (1998).

ECOSYSTEM STUDIES - LAND RESOURCES 373

Moose Foraging Strategy, Energetics, and Ecosystem Processes in Boreal Landscapes

Objective To use GPS collars to track moose movements and identify habitats used by moose.

Background Our previous modeling of moose foraging shows that different decisions a moose makes about what and when to eat cause different distributions of plants within its home range. To test this, we are beginning a pilot study testing new global positioning system collars to continuously and accurately track moose in Voyageurs National Park.

Previous Activity/Results The moose were recaptured; collars were upgraded, fit with new batteries, and deployed on six moose fro the current year in Voyageurs National Park. We have obtained over 50,000 GPS locations from these collars. About half of these locations have been differentially corrected and imported into GIS database for analysis.

Principal Investigator(s)
John Pastor, David Mladenoff, Yosef Cohen

Project Sponsor(s)	**Amount**
National Science Foundation (NSF)	$765,000

Start Date 3/15/95 **End Date** 8/31/00

Project No 1638-189-6098

Progress/Results
The moose were again recaptured. Collars were upgraded, fit with new batteries, and deployed on six moose for the current year in Voyageurs National Park. We have obtained over 60,000 GPS locations from these collars. We also began measuring moose browse consumption on a network of permanent plots in Voyageurs National Park.

Minnesota's Forest Bird Diversity Initiative

Objective Develop procedures to monitor forest songbird populations in relation to forest changes due to harvesting. Develop geographic information system (GIS) tools that can use field data, relate regional forest changes to bird population levels, and provide useful techniques to forest managers for integrating forest birds with timber harvesting and management.

Background We will use GIS and remote sensing to create a land cover/vegetation map of forested regions of the state. Data collected in the field on national forests and historical data collected across the state will be analyzed to relate bird populations to changes in forest types and their extent over the landscape. We will develop protocols for monitoring birds and techniques for predicting large scale change in forests and bird populations to be used by forest managers.

Previous Activity/Results During the last quarter of 1999 we made public our project's World-Wide Web (WWW) (http://www.nrri.umn.edu/mnbirds). We have continued to refine and expand information related to managing forests for birds available to all interested persons. Before completing the annual analysis of our population monitoring data, we decided to change techniques to account for new advancements in this field. This change was justified since we now have at least 8 years of data for our northern study sites and in light of recently published studies. Implementation of a new method was completed and data for 79 species were analyzed using a non-linear, locally-weighted regression procedure. We detected significant population trends for 63 species (16 species had no significant trends). Of these trends, 79 total tests (e.g., species by region combinations) indicated that a species had a significant change in abundance over the monitoring period, but that the population in the last year of the survey (1999) was not higher or lower than the population at the beginning of the survey period. A total of 19 species showed significant increases in abundance and 20 species had significant decreases. These results have been compiled into an annual population monitoring report. We continued development of a stand alone program that assimilates the output from LANDIS and produces data suitable for linking to our habitat models.

Principal Investigator(s)
Gerald Niemi, David Mladenoff, Lee Pfannmuller, Malcolm Jones, JoAnn Hanowski, Peter Wolter, James Sales, Nicholas Danz

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$350,000

Start Date 7/1/91 **End Date** 6/30/01
Project No 189-6192

Progress/Results
We continued to refine habitat models for making predictions based on the output of LANDIS. Our models now incorporate a priori probabilities that a species will be observed in a 10ha forest stand. The probabilities, derived from our population monitoring surveys, are specific to particular cover types. We completed development of a program that applies these refined models to the output of LANDIS. Preliminary predictions have been made; we are assessing the accuracy of this process. We have implemented a new ecological index that gives a way of quantifying the specificity of any species we monitor to any of 16 habitat types. In the past, we had a choice of using either abundance or the incidence (i.e., proportion of sites occupied) of a species in a particular habitat type. This index combines both pieces of information, providing a novel view of habitat use. This index will be extremely useful in drafting specific forest management recommendations. We continue to update and expand the amount of information available on our World-Wide Web (WWW) site (http://www.nrri.umn.edu/mnbirds). A new data query is installed, and we have several more under development. The information regarding our trend analyses has been updated to reflect the results presented in our most recent population monitoring report.

ECOSYSTEM STUDIES - LAND RESOURCES 378

Direct and Indirect Effects of Climate Change on Boreal Peatlands: A Mesocosm Approach

Objective To construct 54 mesocosms (1.8 m2 area, 0.6 m deep) with intact soil structure and plant communities from two wetland types, fens and bogs, and determine the effects of climate change on ecosystem and community processes. Background Significant changes in global climate

Background Significant changes in global climate are predicted to occur in the near future due to increases in atmospheric concentrations of greenhouse gases. The largest temperature increases are predicted to occur at higher latitudes where large portions of the landscape are covered by peatlands that contain up to one third of the world soil carbon pool. These climate changes will likely have significant impacts on peatland structure and function, including the potential for increased production of greenhouse gases in a positive feedback effect.

Previous Activity/Results Funding has been renewed. We are currently processing 1997 field data.

Principal Investigator(s)
John Pastor
Scott Bridgham

Collaborator(s)
Karen Updegraff, Cal Harth, Peter Weishampel, Carmen Chapin

Project Sponsor(s)	**Amount**
University of Notre Dame	$334,589

Start Date 8/1/97 **End Date** 7/31/00

Project No 1907-189-6148

Progress/Results
In bogs, warmer temperatures and drier conditions cause a shift from Sphagnum moss to shrub domination of productivity and an increased allocation of productivity to roots. Warmer temperatures and drier conditions also cause an increased allocation of productivity to roots in fens, but there are no clear changes in species composition. A greater proportion of incoming heat is transferred to the peat beneath the fen graminoid community than beneath the bog Sphagnum-shrub community. Consequently, the soil warmerd more in the fens than in the bogs. The net result of these different effects is that the bogs accumulated carbon while the fens lost carbon, the gain or loss being proportional to the heat applied and to the increasing dryness. Thus, whether or not northern peatlands are a source or sink for atmospheric CO2 depends on the relative proportions of bogs and fens in the landscape, which currently is poorly known.

Lake Superior Decision Support Systems: North Shore Analyses

Objective This project will develop GIS decision support applications focused on the Lake Superior basin to address land use issues. It will be developed for local governments, regional planning agencies, individual resource management units, advocacy groups, educational/interpretive organizations, and individual citizens. The goals are 1) to provide users with practical tools that can be applied to local land and resource decisions in a context of basin-wide objectives for long-term sustainability and stewardship; 2) to provide tools to interpretive and educational institutions to foster public awareness and support of GIS-based land use decision support.

Background Land use has evolved into one of the most important issues in ecosystem management. In the basin, this fact has struck a chord among government agencies, commercial interests, aboriginal groups, advocacy groups. Collectively these groups are attempting to forge a consensus around issues fundamentally related to land use policy; the basin's future is directly dependent on the resolution of these issues. The real impact of forestry and development results from the cumulative effects of a large number of small land use decisions, spread across time and space. When integrated across time and space, these land use decisions have major impacts on the basins resources. This project will develop databases and tools to help groups assess the consequences of land use plans.

Previous Activity/Results We are also setting up a data distribution system which will allow users to download public domain GIS data sets for the Lake Superior Basin. To alleviate performance problems on the web site, we installed a new hard drive on the LSGIS server and reconfigured the original hard drive and computer. This corrected a number of access problems that had been reported. Two interactive touchscreen kiosks that display geographic information about the Lake Superior Basin were developed and are being tested in the CWE Computer Lab. The kiosks are currently running the Site Explorer program developed by Mike Koutnik of ESRI. The LSGIS project cosponsored a workshop on Stormwater Modeling to a number of local and regional agency personnel. A hydrologic model known as PC-SWMM was applied to the upper Miller Creek watershed in Duluth, and is currently being tested. Lastly, LSGIS staff met with planning personnel from the northern Wisconsin counties to discuss options for supporting local planning efforts with Geographic Information System and modeling data. We are currently defining the scope for a project that places geographic information and decision support tools on a CD-ROM for distribution to local planning agencies.

Principal Investigator(s)
George Host, Carl Richards, Lucinda Johnson

Collaborator(s)
Mark White, Gerry Sjerven

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$501,289

Start Date 8/6/97 **End Date** 9/30/00

Project No 189-6177

Progress/Results
A final key GIS product was the development and implementation of a system to download GIS coverages. This involved translating the data into downloadable file formats, and organizing the data by state, county or province. Each dataset is provided as an ArcInfo export file and an ArcView shapefile (when applicable). We have successfully applied the EPA PC-SWMM Stormwater Runoff model to the Miller Creek watershed. The model closely predicts measured hydrographs, accounting for the increased retention of stormwater in the headwater wetlands and increased runoff from the mall complex. The modeling of runoff parameters will allow planners and others to determine the likely effects of proposed changes in the basin and evaluate options for reducing pollution loads to Miller Creek. We have also begun development of a CD-ROM to deliver spatial data and planning resources to local units of government, such as township or local municipalities. The CD will use Arc Explorer to allow interactive manipulation of data, and will also contains examples of draft ordinances, landscape plans, and graphics of alternative planning scenarios. The NRRI group continues to work with Mike Koutnik to deliver information and assist in development of the touchscreen kiosks for deployment in visitor's centers around the basin.

Hierarchical, Parallel Algorithms for Simulating Plant Response to Environmental Stress

Objective To use high-performance computing techniques to adapt the ECOPHYS plant growth model for use in a parallel computing environment.

Background Global atmospheric carbon dioxide may double in the next 100 years and tropospheric ozone is increasing by 1-2% per year. The effects of these greenhouse gasses on tree growth are complex, involving tissue damage, changes in growth habit, and alterations in plant chemistry. Large-scale changes in plant productivity affect local economies and regional environmental quality. Because global change involves so many interacting factors, it is difficult to project effects of global change on forests of northern Minnesota. To resolve this problem, a team of plant biologists, mathematicians, and computer scientists will be using a high-performance computing approach to simulate tree responses to environmental stress. We will create a forest of "virtual trees", and use a network of powerful computers working simultaneously to simulate how trees capture sunlight, convert sunlight to sugars, and use sugars around the trees to grow leaves and roots. In addition, we will make our virtual forest sensitive to global warming effects, particularly to increase carbon dioxide and ozone.

Previous Activity/Results A number of numerical experiments were conducted with the parallel version of ECOPHYS. In terms of processing speed, the increase gained from parallel computing tends to be offset by network overhead when more than five computers are included in the simulation. Analyses of the model results have lead to some suggestions for improving light interception calculations. These numerical experiments were conducted by graduate student Gang Wu in the Department of Mathematics and Statistics, who successfully defended his dual Master's degrees during this quarter. Four undergraduate interns were hired for the summer to work on various projects, including development of virtual reality modeling tools, statistical analysis of real and simulated root data, interface development, and visualization of aboveground parts of the tree. Dr. Marion Martin from Essex University in the UK was hired as a project scientist to add ozone sensitivity to our root model and to link the ECOPHYS model with EPIC.

Principal Investigator(s)
Mark Coleman, Kathryn Lenz, George Host, Harlan Stech

Collaborator(s)
Gary Theseira, Wanlun Zhao, Laura Karnowski, Gang Wu, Don Zang, Chandra Balasubramanian

Project Sponsor(s)	**Amount**
National Science Foundation (NSF)	$380,073

Start Date 10/1/97 **End Date** 9/30/00

Project No 189-6151

Progress/Results
We have adapted a process-based model for predicting effects of acute ozone exposure on wheat photosynthesis to the ECOPHYS model. This ozone algorithm allows us to simulate the effects of chronic ozone exposure on the photosynthetic capacity and growth of ozone-sensitive aspen clone 259. We have derived an analytical solution to our photosynthesis model, which was formerly calculated using an interative formula. This new routine is far more computationally efficient and less sensitive to error than the previous solution; this work was presented by Wanlun Zhao at the annual Sigma Xi poster session in February.

Mapping native plant communities of the Northern Superior Uplands

Objective Mapping of the native plant communities for the Northern Superior Uplands section of the Minnesota Ecological Classification System. The range of land area for each growth stage within each NPC can then be calculated based on analysis by Frelich (1999).

Background

Previous Activity/Results

Principal Investigator(s)
George Host
Mark White

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$20,000

Start Date 6/5/00 **End Date** 6/30/00

Project No 1663-189-6195

Progress/Results
This is a new project.

ECOSYSTEM STUDIES - LAND RESOURCES 576

Widlife Species: Response to Forest Harvesting

Objective To assess the approximate buffers or amounts of various types of riparian zones that are needed by bird species, determine the response of bird species to various forest management practices that may occur within riparian zones, and to complete a geographic assessment of the implications of alternative management strategies on forest acreage and forest birds within these systems.

Background Riparian forests provide critical habitat for a variety of forest birds. However, response of birds or other wildlife species to forest harvest in and adjacent to riparian areas is not understood. We believe that two major questions need to be addressed: 1) how does forest wildlife respond to degrees of selective cutting, buffer widths, and other alternative forest management of riparian systems, and 2) how will implementation of alternative management strategies impact riparian systems and other forests on a landscape scale. A before-and-after impact study will be conducted in coordination with scientists that will assess affects of forest harvest in two study regions in northern Minnesota.

Previous Activity/Results Our work on the Louisiana Waterthrush, a species of special concern in Minnesota and a riparian dependent species revealed the following results. First, our GIS analysis demonstrated that Louisiana Waterthrush breeding success is positively associated with two riparian attributes in southeastern Minnesota: Lowland Hardwoods and algific talus slope. Any activities that disturb these communities (e.g. timber harvest, livestock use, uncontrolled recreation) may impact waterthrush productivity. Banks, under story, and stream flow are especially important features to protect. We also found that Louisiana Waterthrush reproductive success was lower at sites managed for trout production than unmanaged sites. Habitat improvement for trout homogenizes the geomorphology of the stream and decreases the amount and presence of some habitats and invertebrates. Habitat management strategies extend beyond the stream and into the riparian zone, potentially affecting a variety of plant and animal species associated with riparian ecosystems in southeastern Minnesota.

Principal Investigator(s)
Gerald Niemi, JoAnn Hanowski

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$84,000

Start Date 1/14/97 **End Date** 12/31/00
Project No 189-6176

Progress/Results
We used a landsat classified image in a geographic information system platform to quantify landscape characteristics resulting from applying 2 buffer widths, 28.5 m or 57 m on riparian areas in a 100 X 100 km area of northern Minnesota. 585,144 ha were classified as forest. 113,993 ha of the forest area was adjacent to and within 27.5 m of non-forested wetlands, lakes, intermittent or perennial streams. 214,298 ha of forest was within 57 m of the water bodies, representing 36.6% of the total forest area. Over 80% of the total amount of riparian forest was adjacent to non-forested wetlands. Riparian areas along perennial streams and lakes represented ~ 9% of the total riparian area; less than 2% was adjacent to intermittent streams. Imposing a 28.5 m buffer on water bodies increased edge amount on the landscape and slightly increased the amount of interior forest area. Water bodies buffered with a 57 m forest strip had a slight increase in forest edge; this buffer width resulted in the largest amount of interior forest. Riparian areas that now provide habitat for riparian dependent bird species should be maintained on the landscape by using wider buffers, extended rotation, or uneven-aged forest management practices. Because riparian buffer strips increase the amount of edge which may have negative effects on breeding bird reproduction, application of buffers to all water bodies is not appropriate in this landscape.

Continued Studies of Boreal Owl Ecology in Northeastern Minnesota

Objective To review and revise existing monitoring program for boreal owl in northeastern Minnesota. Use radio telemetry to obtain information on foraging and roosting habitats of breeding male boreal owls withing two areas of the Superior National Forest. Locate and characterize nest sites at local and landscape scales. Complete a habitat/landscape assessment of change in breeding habitat of the boreal owl over the near and long term withing the primary breeding range of the species. If time permits, compile, analyze, and summarize existing unpublished data on boreal owls within the Superior National Forest.

Background The boreal owl has been a species of concern in the northern forest region of the state for many years. The status of its population in northern Minnesota is unclear. The species nests in the state, primarily in the extreme northeastern region, but its population fluctuates widely. In addition, there are limited data available on its specific nest site requirements, its foraging activity (especially during late winter) and the breeding season when food is likely most important, and the nature of its dependence on immigration from larger populations in Canada.

Previous Activity/Results A limited monitoring program has been on-going for many years in the extreme northeastern portion of Minnesota since the late 1980s. In addition, some data have been gathered on foraging and nest site use of the boreal owl by William Lane in a master's thesis completed in the mid-1990s at the University of Minnesota. An attempt was made last spring to identify nesting boreal owls, but nesting activity during the spring of 1999 was extremely limited and no paired birds were located for more detailed telemetry studies.

Principal Investigator(s)
Gerald Niemi

Project Sponsor(s)	**Amount**
USDA Forest Service, Superior National Forest (SNF)	$20,000
Minnesota Department of Natural Resources (DNR)	$20,000

Start Date 7/1/99 **End Date** 12/31/02

Project No 189-6179,6184

Progress/Results
A graduate student, Lisa Belmonte, was hired in May 1999 to begin working on a master's thesis on the species. Data are being compiled on existing locations where the species has been observed with a special focus on the identification of nest sites. Nest sites will be examined with respect to various scales of habitat (e.g., microhabitat, patch size and shape, and landscape context). A monitoring program for owls is being considered and plans are being made for field activities next spring.

ECOSYSTEM STUDIES - LAND RESOURCES 650

Predicting Water and Forest Resources Health and Sustainability

Objective Create working tool that predicts outcomes of forest management activities on health and sustainability of Minnesota's forest and water resources.

Background Our objective is to compile existing or create new indicators of biodiversity, soil productivity and water quality and to incorporate these metrics into a decision support model that will predict forest and aquatic ecosystem health and sustainability under a variety of management scenarios. Using existing databases on forest birds, amphibians, aquatic insects and ecosystem conditions, we propose to integrate tools such as geographic information systems (GIS), satellite image analysis, multivariate statistical methods, and simulation models to create this management tool. Project investigators are currently documenting changes in terrestrial and aquatic species resulting from forest and agricultural management practices in several regions of Minnesota, therefore large data sets on birds and aquatic insects are on-hand. Other databases will be acquired and used in indicator development. Relevant GIS data layers also have been developed or acquired for Minnesota, including forest cover classification, elevation, hydrography, soils, surficial geology and wetland classification. Together the environmental and organismal data will be used to test existing indicators and develop new indicators where necessary.

Previous Activity/Results Indicator species for the bird group have been selected for the northern study areas. Species were chosen based on their ability to indicate a change in a forest cover type. We first compiled data from over 1200 point counts that have been conducted in this region over the past nine years. Species relative abundance patterns and distributions were then computed by forest cover type for the two northern study areas. We chose species that had high proportions of their populations in a particular cover type. For example, Pine Warbler was chosen as an indicator of mature white and red pine cover types because over 65% of the individuals that were observed in the region were in these cover types. Approximately 30 species were selected as indicator species for the Chippewa Plains and Northshore Highlands study areas. Preliminary decision support models have been developed for the bird group.

Principal Investigator(s)
George Host, Carl Richards, Lucinda Johnson, JoAnn Hanowski

Collaborator(s)
Terry Brown

Project Sponsor(s)	**Amount**
Legislative Commission for MN Resources (LCMR)	$300,000

Start Date 7/1/99 **End Date** 6/30/00

Project No 189-6180

Progress/Results
In addition to study site selection, the other major task completed was defining "sustainability" and how it will be quantified for use in our models. We decided to use the concept of natural range of variation in native plant communities as the basis for defining sustainability. In this sense, we infer that forest and water resources will be sustainable if we manage within the range of variation that they occurred on the landscape throughout time. Two steps are required to obtain this information. The first step, calculation of the range of natural variation for native plant communities has been completed by Lee Frelich. The next step is to map locations and extent of native communities so that we are able to calculate the amount of area and location of the various native communities. This has been completed for the Chippewa Plains study area by Dave Shadis and John Almendinger. The North Shore study area is currently being mapped by personnel at NRRI with funding from the Minnesota Forest Resources Council and their assistance coordinated by Dave Miller. We will be able to use this definition of sustainability for the two northern study areas where the map and range of variability has been completed. We are still working on a sustainability definition for the southern study area.

Distribution of Canada Lynx in the Upper Midwestern United States

Objective Develop and test a sampling framework that is logistically feasible and optimizes the detection of lynx in the upper Midwestern United States.

Background The Canada lynx is being proposed as a threatened species (under the Endangered Species Act) throughout its entire range in the northern tier of the lower 48 United States. The Canada lynx is present in northern Minnesota and was trapped in the state into the mid 1980's. However, the actual status of its population in the state is unclear. For example, it is unknown whether there is a sustained, breeding population in the state or if individuals found in the state are primarily immigrating from breeding populations in Canada. Moreover, there is little scientific information about Canada lynx populations or their habitat requirements in the Great Lake state regions. The first step of our activity is to develop a sampling protocol that will be useful to describe the current distribution of the species in northern Minnesota, northern Wisconsin, and northern Michigan. The protocol includes a statistical sampling framework across a relatively large region, material to attract Canada lynx, and verification of Canada lynx via DNA analyses.

Previous Activity/Results A national protocol to detect Canada lynx in the Rocky Mountain region of the United States has been developed. This protocol will be tested in northern Minnesota, Wisconsin, and Michigan during the fall of 1999 and winter of 1999/2000.

Principal Investigator(s)
Gerald Niemi

Collaborator(s)
Bill Route, JoAnn Hanowski, Tim Jones, Peter Wolter

Project Sponsor(s)	**Amount**
USDA Forest Service, Superior National Forest (SNF)	$30,000

Start Date 9/3/99 **End Date** 9/30/04

Project No 189-6186

Progress/Results
More than 350 stations have been established in the Ottawa National Forest, Nicolet National Forest, and Superior National Forest during the fall of 1999. The stations will be checked twice at two week intervals for hair samples. Any hair samples will be sent to the USDA Forest Service in Montana for verification of Canada lynx and DNA analysis will be used if necessary. Results of the surveys will not be known for several months, depending on the ability and speed that the labs in Montana can process the various samples they receive.

ECOSYSTEM STUDIES - LAND RESOURCES 939

Mapping and modeling forest change in boreal landscape

Objective Use Landsat TM data from 1984-2003 to classify species cover and follow successional changes in forests undergoing either natural or managed disturbances. Markov modeling will be used to determine current trends and predict future status of the natural and managed region of boreal forest on the Minnesota/Ontario border.

Background

Previous Activity/Results

Principal Investigator(s)
John Pastor
Peter Wolter

Project Sponsor(s)	**Amount**
National Aeronautics and Space Administration, NASA	$79,780

Start Date 5/1/00 **End Date** 4/30/01

Project No 1618-189-6196

Progress/Results
This is a new project.

Testing the efficiency of buffers for protecting seasonal ponds and forest songbirds

Objective Understand the habitat value of seasonal forest ponds to migratory songbirds and what impact forest management has on habitat use. Assess the use of seasonal ponds by breeding birds prior to harvest of the surrounding forest.

Background

Previous Activity/Results

Principal Investigator(s)

Collaborator(s)
Gerald Niemi

Project Sponsor(s) **Amount**
None / New Amount Added $9,000

Start Date 5/26/00 **End Date** 12/31/00

Project No 1637-189-6199

Progress/Results
This is a new project.

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 some North American species are declining in abundance, in particular, neotropical migrants or species that breed in North America and winter in Central/South America. With increased awareness of the status of these birds, several organizations have developed strategies to monitor abundance of these species. We have established monitoring programs in 3 Great Lake's national forests: Chippewa (1993), Superior (1991), Chequamegon (1992). Long-term monitoring will give information on species abundance patterns over time; data will be used to identify species that are significantly increasing or decreasing in abundance.

Previous Activity/Results Over five years of study in southeastern Minnesota, 13,396 individuals of 99 species have been detected at our sampling points. Fifty of these species, mostly migrants and/or non-forest birds, were represented by 20 or fewer individuals. The majority of the species tested (26 of 35) showed no statistically significant trend in abundance between 1995 and 1999. The American Crow and American Robin increased significantly and the Blue-winged Warbler, Song Sparrow, and Brown-headed Cowbird decreased significantly. We compared trends of species we tested to those obtained from USGS Breeding Bird Survey data, within the same physiographic region. The American Crow and American Robin both had a non-significant annual change of less than 1% annually. BBS data indicate a significant annual increase (+17%) for the Blue-winged Warbler, a non-significant annual decrease (-5%) for the Song Sparrow, and a non-significant decrease (-8%)for the Brown-headed Cowbird. The difference in results between our study and BBS data may be due to the fact that BBS routes are along roads and are not habitat-specific. It is also important to note that we have only five years of data from the Southeast, and trends from this area should be viewed with caution.

Principal Investigator(s): Gerald Niemi, JoAnn Hanowski

Collaborator(s): Jim Lind

Project Sponsor(s)	**Amount**
USDA Forest Service, Chequamegon/Nicolet National Forests	$98,000

Start Date 5/1/99 **End Date** 4/30/01

Project No 189-6187

Progress/Results

Six observers sampled a total of 1,644 sites in five study areas between June 1 and July 7, 2000. Preliminary data summaries show that a total of 32,649 individuals were detected this year, which is up from 1999's total of 24,197 individuals. Species specific analyses of population trends will be completed in the fall. In the Chippewa National Forest (NF), 7,799 individuals of 105 species were detected at 393 sites. In the Superior NF, 9,315 individuals of 95 species were detected at 496 sites. A total of 7,747 individuals of 108 species were detected at 377 sites in the Chequamegon NF. In the St. Croix study area, 3,647 individuals of 83 species were detected at 168 sites. In the Southeastern Minnesota study area, 4,141 individuals of 81 species were detected at 210 sites.

Dispersion and ecological interactions of clonal and sexual fish in a successional landscape

Objective Examine the influence of natural disturbances associated with beaver pond succession on spatial variation in abundance of a widely dispersed clonal fish lineage, along with the subsequent influence the clonal lineage has on competitive interactions in different successional environments.

Background

Previous Activity/Results Initial meetings were held with the North Dakota team and objectives were outlined for the present and future.

Principal Investigator(s)
Paul Meysembourg
Carol Johnston

Collaborator(s)
Isaac J Schlosser, University of North Dakota

Project Sponsor(s)	**Amount**
None / New Amount Added	$50,000

Start Date 2/4/00 **End Date** 12/31/02

Project No 1653-189-6194

Progress/Results
New field maps were prepared for the North Dakota researchers. These included digital ortho quads with watershed boundaries, pond outlines and stream traces delineated.

ECOSYSTEM STUDIES - WATER RESOURCES **850**

Effects of Forest Fragmentation on Community Structure and Metapopulation Dynamics of Amphibians

Objective Quantify the effects of forest fragmentation on amphibian community structure and population dynamics of vernal pool ecosystems; develop models to predict results of landscape changes.

Background Recent evidence of declines and an increased rate of malformations in amphibian populations has prompted much interest and research into the potential anthropogenic stressors associated with these occurrences. Results of some of this research indicate that habitat fragmentation may have a significant effect on the metapopulation (groups of individual populations in a region) dynamics of amphibian communities, which could result in declines and regional extinctions of populations. Forest fragmentation results in changes to forest landscapes and habitats that may have both direct and indirect effects on local and regional amphibian communities (e.g., direct habitat loss, disruption of dispersal corridors, altered habitat structure, and microclimate changes). We hypothesize that forest fragmentation can be directly related to changes in landscape structure and local habitats (e.g., vernal pools) that have a quantifiable effect on the integrity of amphibian communities.

Previous Activity/Results Sites selection was completed in April, consisting of 38 sites in 6 clusters. Two clusters each, one located in unfragmented woodland habitat and one in a more fragmented area. were selected in 3 areas: Cloquet, Grand Rapids and Duluth, MN. Collection of pertinent GIS data for the study region was initiated.

Principal Investigator(s)
Lucinda Johnson
Catherine Johnson

Project Sponsor(s)	**Amount**
U.S. Environmental Protection Agency (EPA)	$769,623

Start Date 12/1/99 **End Date** 11/30/02

Project No 189-6191

Progress/Results
The first 2 sets of calling surveys were completed at all sites. Water quality data and invertebrate samples were collected in association with each of these surveys, and a UV assessment was completed for each site during the second survey. Amphibians collected via minnow traps or activity traps were examined for malformations, and wood frogs and salamanders were marked as part of our mark-recapture effort. Silt fence was installed around the eight Cloquet wetlands and associated pitfall traps have been checked daily for amphibians. Wood frogs and salamanders collected in these traps have been uniquely marked prior to release to allow individual identification during subsequent recaptures. Aerial photos have been acquired for all sites, and vegetative analyses of wetland sites and surrounding habitat is ongoing.

Evaluation of Combined Pond and Indoor Culture System for Important Minnesota Baitfish

Objective Our research is evaluating the feasibility of spawning and rearing hornyhead chubs in small aquaculture facilities that would provide a cost effective alternative source of fish for the Minnesota bait industry.

Background The baitfish industry in Minnesota is worth several millions of dollars annually. One of the most valuable and desired species in Minnesota's baitfish market are hornyhead chubs (sometimes known as redtail chubs). Unfortunately, this fish is currently only available from wild harvest and these stocks are dwindling.

Previous Activity/Results Hornyhead fry were harvested from streams and brought directly into our recirculation system at NRRI in the fall of 1997. Fry were harvested from streams and placed in a pond for six weeks the summer of 1998. In October of 1998, these fry were brought to our facility at NRRI. They had grown in length while in the pond, but were quite thin. After being in the NRRI tanks for several weeks, the fish put on weight and are now healthy. The size of this group of fish is four months ahead of last years fish at the same point in time. We feel that this is primarily due to their having spent time in the pond prior to being brought indoors.

Principal Investigator(s)
Jeff Gunderson
Carl Richards
Paul Tucker

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$89,536

Start Date 7/1/97 **End Date** 6/30/00

Project No 189-6157, -6189

Progress/Results
There were successful hornyhead spawns and subsequent hatches of fry in three different (industrial cooperators) outdoor facilities and in an indoor laboratory setting during May and June of 1999. Zooplankton, fish, and water chemistry samples were taken from the systems during the course of the summer. Fish grew well in the outdoor facilities and some of the population reached market size by the end of the summer. All three cooperators are planning to have larger systems on line for the spring of 2000.

ECOSYSTEM STUDIES - WATER RESOURCES 571

Evaluating Riparian Area Dynamics, Management Alternatives and Impacts of Harvest Practices

Objective We are assessing the degree to which stand-level riparian forest management prescriptions are effective in meeting ecological, downstream, timber, economic, and cultural resource objectives. We use a randomized complete block design to test the effects of two harvesting methods (tree-length vs. cut-to-length) and several paired overstory conditions (clearcut vs. green-tree retention, clumped vs. dispersed residual) with a focus on i) in-stream biotic and abiotic conditions, ii) terrestrial conditions including regeneration and iii) harvest effectiveness. Our central objective is to develop and communicate quantitative relationships between riparian condition, riparian management action and in-stream as well as adjacent terrestrial ecosystem properties. We will achieve that through harvesting forest landscapes with commonly applied and non-traditional practices, involving different of riparian conditions (e.g., basal area remaining), then assessing terrestrial and aquatic responses.

Background Information pertinent to Minnesota conditions is needed to identify ways to make forest management prescriptions profitable in riparian areas while also protecting riparian functions and values.

Previous Activity/Results We found no significant differences in amounts of coarse woody debris or number of debris accumulations due to harvest activities. Coarse particulate organic matter (CPOM) in erosional habitats (riffles) increased in cut-to-length plots compared to the non-harvested control. In addition, full-tree system reaches also differed from cut-to-length reaches, suggesting a potential effect due to harvest method. CPOM in depositional habitats was not affected by harvest treatments. We did see significant effects due to harvest in the amounts of CPOM in the riffles downstream of harvest areas. We also found a potential difference in the amount of CPOM between the two harvest systems. Results of the CPOM and CWD studies suggest that further study over longer time frames will be required to verify effects of harvest activities on the supply of organic matter in streams.

Principal Investigator(s)
Carl Richards, Lucinda Johnson

Collaborator(s)
Jim Perry, Ray Newman, Brian Palik

Project Sponsor(s)	**Amount**
Minnesota Department of Natural Resources (DNR)	$14,331

Start Date 4/16/99 **End Date** 12/31/00

Project No 189-6183

Progress/Results
Data collection for the 1999 field season involved an assessment of the standing stocks of coarse woody debris and coarse particulate organic matter in the stream. Field data collection has been completed and organic matter samples are being processed. Data entry is ongoing.

Evaluating Potential Re-introduction Sites for Coaster Brook Trout Within the Lake Superior Basin

Objective Our objective is to identify watershed and landscape-scale attributes that can be used to predict watersheds mot suitable for reintroduction of coaster brook trout (Salvelinus fontinalis) in the Lake Superior basin. This task will be accomplished by completing the following set of sub-objectives; 1) Identify attributes associated with preferred reach-scale habitats of coaster brook trout. 2) Utilize GIS-based landscape data to identify linkages between geological and land use/land cover features and the physical habitat factors. Identify watersheds within the Lake Superior basin most suitable for reintroduction using widely available GIS databases.

Background One of the primary factors regulating the composition and function of stream ecosystems is the structure and dynamics of physical habitats. Physical habitat and the factors that regulate it vary with space and time. By examining the factors that regulate habitat structure at a range of spatial scales, we can better understand the factors controlling stream fish populations.

Previous Activity/Results We completed sampling in 15 streams on the Canadian shore of Lake Superior. Sites were stratified across four geologic types (bedrock, ground morraine, lacustrine clay/silt, and lacustrine sand). Stream data were collected at three spatial scales to discriminate between factors affecting the distribution of coaster brook trout. Spatial data are currently being assembled from our Canadian collaborators. Statistical analysis and spatial analysis of GIS data will take place over the winter.

Principal Investigator(s)
Lucinda Johnson
Carl Richards

Collaborator(s)
Seth Moore

Project Sponsor(s)	**Amount**
University of Minnesota Sea Grant	$96,350

Start Date 6/1/98 **End Date** 6/1/00

Project No 189-1020

Progress/Results
Fish sampling was completed three times in Canadian streams to assess the standing stocks of young of year fish, and to estimate growth rates. Eight streams on the south shore of Lake Superior (in Minnesota and Wisconsin) were surveyed to assess potential locations for reintroduction of the coaster brook trout. Data entry and analysis is ongoing.

Development of an Inexpensive Data Logging Ultraviolet - B (UVB) Dosimeter

Objective Develop an inexpensive, data logging, ultraviolet (UV) light sensor and dosimeter for field studies or for personal dosimetry (i.e. sunburn monitoring)

Background Recent evidence of stratospheric ozone depletion has resulted in increasing global UV levels in the UVB (280-320 nm) region. Increases in erythema (sunburn), skin cancers, and eye disorders have been shown to increase with increasing UVB levels, as well as suppression of normal immune function and increased rates of viral infections. The role of UVB is currently being investigated in population declines seen in frog and salamander species. Other studies have shown adverse effects on plant growth, photosynthesis and respiration as a result of enhanced UVB irradiation. One impediment to a better understanding of the effects of UV on plants and animals and on human health is the lack of suitable instrumentation for adequately characterizing true field exposures. The high variability of UV doses requires a relatively high number of sensors that can be deployed for extended periods. An individual's dose depends upon their behavior and location at a given time. A personal UV monitoring device must be affordable, easily transported and simple to operate and interpret. The technical plan for the project consists of the following objectives: 1) test and determine the optical limits and specifications of prototype electronic UVB dosimeters; 2) compare response of prototype electronic instruments as well as other dosimeters; 3) evaluate the utility of prototype electronic dosimeters for environmental research; and 4) evaluate the utility of proposed sensor as a personal dosimeter (i.e. sunburn warning system).

Previous Activity/Results A portable broad brand radiometer capable of measuring spectral regions (UVB, UVA, and visible) was purchased from Advanced Photonics International, Inc. This instrument is identical to the instrument selected by the USEPA-Duluth to be used by the National Park Service to measure UV radiation in several national parks as part of a long-term amphibian monitoring project. For our purposes, this radiometer will provide an independent dose of measurement in both aquatic and terrestrial environments, for comparison to the proposed UVB and the existing NRRI/EPA polysulphone UVB dosimeters. To facilitate this, software has been written to provide datalogging capabilities necessary for the planned field comparisons.

Principal Investigator(s)
Anatoly Skirda, Greg Peterson, Richard Axler

Collaborator(s)
Apprise Technolgies, Inc., S. Diamond (USEPA- Duluth)

Project Sponsor(s)	**Amount**
Minnesota Technology, Inc. (MTI)	$52,611

Start Date 7/1/99 **End Date** 6/30/00

Project No 189-6185

Progress/Results
Data from the polysulphone dosimeters used in summer and fall 1999 has been processed and a manuscript for journal submission is in preparation. The new portable broad brand radiometer for measuring UVB, UVA, and visible light was evaluated in March 2000 in St. Cloud area wetlands that thawed unusually early this year. The instrument was used simultaneously with our exising underwater spectroradiometer in the springtime to provide a direct comparison for establishing appropriate specifications for the electronic dosimeter. Evaluation of various potential UV sensors and software has continued in collaboration with Apprise Technologies, Inc.

Lake Access: Making Water Quality Real and Relevant for Minnesotans

Objective Water On the Web investigators have joined with Hennepin Parks and the Minnehaha Creek Watershed District to i) integrate the real-time RUSS sensor data with the historical and current monitoring data, ii) combine these data with appropriate watershed-based land use and cultural data, and iii) place these data into a web, kiosk, and programmatic framework that provides not only public access to data, but also the educational materials required for data interpretation, and iv) develop and implement mechanisms for incorporating public input into the decision-making process. .

Background Communities are becoming increasingly involved in land management decisions that affect their quality of life. Access to information for making informed decisions has been a limiting factor, both in terms of availability and understanding. A new, innovative water quality monitoring technology holds promise for delivering real-time information to the public. The Remote Underwater Sampling System (RUSS), a mobile underwater sensor package tethered to a platform containing an on-board computer, solar panels and telemetry equipment, transmits data on a suite of water quality variables to a land based computer in real time. Concurrent with development of sensor technology has been an NSF-funded education initiative to provide college and high school students with skills needed to resolve today's environmental problems. Known as Water on the Web, the project provides an Internet interface to the RUSS units, building curricula of water chemistry, biology, aquatic ecology, data visualization, and other aspects of science around RUSS units deployed in Minnesota lakes.

Previous Activity/Results Two RUSS units were deployed in the study region - one in Lake Independence and two in Lake Minnetonka. The Lake Minnetonka units provide a contrast between a heavily impacted bay and a relatively clean site in nearby West Upper Lake. The RUSS units are transmitting data to a base computer at NRRI; data is then transferred to a web site. We have begun development of several tools to make the data more interpretable to the general public. We have also drafted a brochure to provide information to the adjacent homeowners and the general public, and have begun to plan a survey to identify water quality issues within the Hennepin Parks district.

Principal Investigator(s)
Cindy Hagley, Richard Axler, Bruce Munson, George Host

Collaborator(s)
Elaine Ruzycki, Lindsay Anderson, Norm Will, Gerry Sjerven

Project Sponsor(s)	**Amount**
Suburban Hennepin Regional Park District	$278,664

Start Date 1/1/99 **End Date** 12/31/00

Project No 189-9005

Progress/Results
Over the winter, three RUSS units were deployed in ice houses located on Lake Independence and in Halsted Bay and West Upper Lake in Lake Minnetonka. Data were collected daily throughout the winter and were removed prior to ice out. The RUSS units transmitted data to the EMPACT base station at NRRI, and can be viewed on the Lake Access web site at http://www.nrri.umn.edu/empact We conducted a survey of homeowners in the region to understand how they perceive their lakes, the important issues, and how they prefer to receive information. Results from the survey are being used to redesign the Lake Access web site. We also founded a focus group of naturalists and other educators in the Hennepin Parks region to discuss issues and information delivery. This group will work with the project over the next 6 months. The Lake Access project was selected by EPA to demonstrate the environmental monitoring and data flow process for a handbook they are developing for other EMPACT projects.

Mine Pit Lake and Sediment Survey

Objective To assess the status and recovery of mine pit lakes near Chisholm, Minnesota, that were used for intensive salmonid aquaculture from 1989-1995.

Background The Minnesota Pollution Control Agency (MPCA) requested assistance from NRRI to conduct a water quality survey of the Sherman and Twin City-South pit lakes used by Minnesota Aquafarms, Inc. and of the Fraser pit lake that is the source of raw water for Chisholm's drinking water. The study involves collecting a set of physical, chemical, and biological parameters that are comparable to data previously collected by NRRI and in large part published in peer-reviewed literature from 1992-1998 and in NRRI technical reports in 1992 and 1995. The data will be valuable to State resource and regulatory agencies (MDNR [Department of Natural Resources], MPCA, MDH [MN Department of Health]) and local agencies (e.g., Chisholm Public Works Department which manages the city's drinking water supply) by providing a longer-term estimation of the rate of "recovery," or return to pre-aquaculture conditions, of two lakes affected by aquaculture waste loads in the early to mid-1990's. The new data would be extremely important to any future management of these lakes, in addition to allowing for an assessment of potential changes attributable to high waste loading from the fish farming operations. The Fraser pit lake is the primary source of potable water for Chisholm, and to our knowledge has not been monitored since ~1993-94. Besides the obvious public health reasons, knowledge of the nutrient budgets of the lakes is also essential to their management for recreational purposes such as for sport fisheries by the MDNR.

Previous Activity/Results Limnological surveys were conducted in May, June, July, and October to characterize water quality under the ice at the end of winter, during spring mixing.and during late-summer stratifcation. The lakes will be resampled in November during fall mixing. Water chemistry analyses and biological identifications are in progress. An interim data report was submitted in December 1999.

Principal Investigator(s)
Richard Axler, Jerald Henneck
Collaborator(s)
Lindsay Anderson, Elaine Ruzycki and Paul Drevnick

Project Sponsor(s)	**Amount**
Minnesota Pollution Control Agency (MPCA)	$20,000

Start Date 4/30/99 **End Date** 6/30/00
Project No 189-6178

Progress/Results
Final lake surveys were conducted in fall 1999 during lake overturn. All water chemistry and sediment analyses and zooplankton enumerations have now been completed. Draft water quality data figures were sent to the MPCA in March 2000. A Final Report including all of the 1999 data, as well as data from NRRI surveys since termination of aquaculture (1996-1998) and prior published data (1988-1995) is in preparation.

Control of Productivity and Plant Species Segregation by Nitrogen Fluxes to Wetland Beaver Meadows

Objective To study hydrologic controls on plant growth in beaver meadows at Voyageurs National Park

Background Moist grass meadows are a key stage through which beaver ponds pass during changes in water level, which may govern the dynamics of the landscape. Our previous fertilization experiments in beaver meadows showed that plant productivity is nitrogen limited, and that nitrogen mineralization rates cannot account for all the N taken up by plants. We hypothesize that this N is being supplied by ground and surface water inputs. We also hypothesize that the spatial distribution of water and nitrogen supply within a beaver meadow influences the vertical allocation of plant biomass and nitrogen to capture light, and that this determines the segregation of plant species in these meadows. To test these relationships, we will couple a spatially explicit model of hydrology and nutrient budgets within beaver ponds and meadows to a model of plant growth, canopy allocation, and the vertical light gradient under different nutrient and water regimes.

Previous Activity/Results Groundwater measurements and samples were taken throughout the quarter. Vegetation cover was measured in August. A paper on "Monitoring and analyzing lateral flow of surface and ground water into a beaver meadow" was presented at the 1999 ESA conference in Spokane, Washington.

Principal Investigator(s)
John Pastor
Carol Johnston
Howard Mooers

Project Sponsor(s)	**Amount**
National Science Foundation (NSF)	$20,000

Start Date 3/1/97 **End Date** 2/28/01

Project No 189-6137 6140

Progress/Results
Water samples collected this summer were analyzed for nitrogen. Work progresses on the plant response portion of the beaver meadow modeling. A paper was accepted for publication by Ecological Modelling (see Publications), and a first draft was completed of a paper entitled "Monitoring and Modeling Lateral Flow of Surface and Vadose Zone Water into a Beaver Meadow." Undergraduate Dan Allison is continuing to work on a paper about the results of his evapotranspiration measurements in the beaver meadows.

Lake and Stream Water Analysis

Objective To analyze lake and stream samples for the Minnesota Pollution Control Agency in order to assess the acid sensitivities of, and environmental inputs to, northern water bodies. Quarterly surveys began in 1988.

Background Northern lakes and streams may be subject to declines in pH and alkalinity brought about by acid rain and spring snowmelt. NRRI's Central Analytical Laboratory is assisting the MPCA by analyzing water samples taken from lakes in Pine, Carlton, Itasca, St. Louis, Lake, and Cook Counties; and from four North Shore streams. Lake water data will be used by the MPCA to expand a database of acid-sensitive lakes. Data on stream water chemistry has been used to select two study streams displaying acid sensitivity. These sites have been monitored intensively during the project. Data from these sites and from analysis of snow will be used to assess long-term water chemistry trends and to determine the importance of spring snowmelt as a potential contributing factor to acidic conditions.

Previous Activity/Results The MPCA has now expanded the original study to include a variety of lakes from which sediment cores have been obtained, or are scheduled to be cored, in 1997 or 1998. NRRI is analyzing these samples for a suite of "conventional" chemicals. Additional samples collected in the fall of 1997 have been analyzed and the data submitted to the air quality and water divisions of MPCA.

Principal Investigator(s)
Richard Axler, John Ameel, Patrick Brezonick, Gary Glass, George Rapp
Collaborator(s)
John Ameel, Anastasia Bamford, Elaine Ruzycki, Jerry Henneck, Paul Drevnick, Lindsay Anderson

Project Sponsor(s)	**Amount**
Minnesota Pollution Control Agency (MPCA)	$20,000
Minnesota Pollution Control Agency (MPCA)	$5,000

Start Date 5/18/00 **End Date** 6/30/00
Project No 1663-189-6175, 1663-189-6198

Progress/Results
A contract for continued collaboration is in preparation. Analyses have continued sporadically as samples arrive from MPCA.

Development of a Fluorescence Based Sensor for Determination of Optical Brighteners

Objective Sensor development for tracing domestic wastewater effluent in ground water.

Background Inadequate wastewater treatment and poor disposal practices impact coastal surface waters via eutrophication and threaten human health via direct contact, contamination of drinking water and ingestion of contaminated aquatic organisms. This project is developing a sensor to detect the fluorescing optical brighteners (whiteners) in laundry detergents as a tracer for wastewater plumes. Market share for the product was conservatively estimated at $476,000-952,000 annually. The NRRI Sensor Research Group has developed several sensor platforms for determination of analytes in aquatic systems. A theoretical model for determining optical brighteners using multi-wavelength detection methods will be developed and evaluated using a newly developed blue light emitting diode (LED) in combination with a green and red LED light sources. Until late 1996, high intensity blue LEDs suffered from low spectral output and short life spans. A new LED produced in Japan was evaluated for spectral output and life span. Preliminary investigation of this type of LED light source indicated high output energy at the desired 400-580 nm range for optical brighteners and a low power demand with long life expectancy. This LED breakthrough should allow a blue LED to be used in combination with a green LED to produce a completely solid state light source for this application.

Previous Activity/Results A final prototype for field testing was developed. Several critical milestones in the development of such a prototype were achieved including: an optical filter-based variant for second derivative sensing was developed, assembled and successfully tested; an electronic step-motor was identified and tested with satisfactory results; an evaluation platform for multi-wavelength sensor with a minispectrophotometer and a PDA (photodiode array) for brightness detection was developed. Currently the following units for the prototype are being developed: (1) the electronic boards for the filter-based sensor and for the minispectrophotometer and (2) a specially designed photosensor for multiple channel amplification.

Principal Investigator(s)
Richard Axler

Project Sponsor(s) **Amount**
Minnesota Technology, Inc. (MTI) $66,765

Start Date 7/1/97 **End Date** 6/30/00

Project No 189-6155

Progress/Results
Subsequent time measurements indicate this mode of operation to be stable, with an estimated lifetime of several thousand hours of operation. This finding is significant for the development of the optical brightener probe because there are indications that excitation in the UV region could be used for spectral separation of the brightener components, in particular for those fluorescent whitening agents found in groundwater. This light source should have several advantages, including power demand and spectral purity, over other UV light sources in this range. A literature and patent search has not, to date, revealed this observation by other researchers of a blue to ultraviolet conversion under this mode of operation. Because this type of light source may have significant applications outside of the optical brightener sensor applications, with applications in ultra high efficiency fluorescent lighting as well as diagnostic devices, Apprise has submitted (in partnership with the University of Minnesota) a provisional patent on this mode of operation based on the MTI findings.

ECOSYSTEM STUDIES - WATER RESOURCES **500**

Water on the Web - Monitoring Minnesota's Lakes on the Internet

Objective 1) Develop integrated, multi-disciplinary science and math curriculum modules that capitalize on the Internet and remote sensing technology in order to bring the study of the environment into the classroom; 2) disseminate the advanced technology curriculum modules; 3) provide internships with natural resource agencies and the private businesses to students experienced with the curriculum; 4) evaluate Water on the Webs success.

Background The purpose of Water on the Web is to contribute to a more scientifically and technologically competent work force through an educational program for high school and college students and teachers. We will develop curriculum modules that teach basic science concepts illustrated through the use of real-time remote sensing technology, Geographic Information Systems, and the Internet. Multi-disciplinary teams of academic, science, and technology specialists will cooperatively develop this curriculum. Through this project students will conduct interactive inquiries of widespread environmental systems using newly-developed, real-time, remote sampling technology linked with classrooms through cellular communication and Internet networks and participate in industry-sponsored internships.

Previous Activity/Results Discussions with Hennepin County Parks and the Minnehaha Creek Watershed District led to collaboration on a RUSS deployment in Lake Independence and a joint proposal submission to US EPA for adult and public education (EMPACT) that was subsequently funded. The WOW Website displays various aspects of the project, a primer, the RUSS data and curriculum modules (http://wow.nrri.umn.edu). The site has been demo'ed extensively and is in constant revision. A variety of data visualization tools are being tested. Presentations were made at NSF's annual PI meeting in Washington, DC in November, at EPA in October and December, at national limnology/aquatic sciences meetings in November 98 and February 99, at the annual Great Lakes Extension meeting in March 99, and at a national teacher education meeting in January 99. Mechanisms for obtaining critical review of the site and its curricula have been initiated at several levels.

Principal Investigator(s)
George Host, Richard Axler, Bruce Munson, Cindy Hagley, Chris Owen

Collaborator(s)
Elaine Ruzycki, Norm Will, A. Tokhtuev, Lindsay Anderson, John Jereczek, Glenn Merrick (LSC)

Project Sponsor(s)	**Amount**
National Science Foundation (NSF)	$658,000

Start Date 7/1/97 **End Date** 6/30/00
Project No 189-9004, -9004

Progress/Results
Two St Louis River sites are now possible as we have finalized collaborations with both the Burlington Northern Railroad (site attached to the bridge) and with the USGS and MPCA and Army COE to attach a unit to the Duluth inlet at the Lift bridge. Data should be on-line in April 2000. Numerous presentations were given at local, regional and national meetings in 1999 and early 2000 and the team was awarded a 1999 Technology Enhanced Learning Award form the University of Minnesota. Mechanisms for obtaining critical review of the site and its curricula have been initiated at several levels. The existing curriculum is being tested at the high school and community college level.The Website http://wow.nrri.umn.edu was revised extensively in the Fall and reviewed at the annual meeting of the WOW National Panel and curriculum writers in Duluth and the annual NSF PIs meeting in Washington, DC, both in late October 1999.

Environmental Factors That Influence Amphibian Community Structure and Health

Objective We will assess the relationship between amphibian community structure and measures of wetland ecosystem integrity in wetlands throughout southern Minnesota, Wisconsin and northern Illinois. We will use data collected in the field as well as from remote imagery such as satellite imagery and aerial photography. We will then intensively study the health (including the number and type of malformations) and community structure of amphibians. These data will then be related to independent measures of wetland ecosystem integrity.

Background The recent discovery of large numbers of malformed frogs across Minnesota and the upper Midwest has increased the public interest in this relatively unstudied group of organisms, which have long believed to be sensitive indicators of environmental conditions.

Previous Activity/Results Spatial data for Minnesota, Wisconsin and Illinois have been summarized at several scales; spatial analyses (e.g., Fragstats) have been completed for the 64 sites included in the Level I assessment. Photo-interpretation of the 36 Minneota sites included in the more "intensive", Level II assessment is ongoing. Field data collection, data entry and quality control has been completed for the 1998 and 1999 field seasons, including calling surveys and other biotic surveys, physical and chemical site assessments, and anuran malformation assessments. The University of Illinois has finished its initial examination of frogs collected during 1998 and 1999; further internal examinations of these specimens are being conducted at the EPA Lab in Duluth. In addition, the National Wildlife Health Center in Madison, WI is examining snails and frogs collected in 1999 to assess parasite burden. The results of our study to date were presented at several meetings in 1999, including the N.A. Benthological Society meeting in Duluth (May 25-28); the International Association for Landscape Ecology Meeting in Snowmass, CO (July 29-August 3); the "Predicting Species Occurrences: Issues of Scale and Accuracy" symposium in Snowbird, UT (Oct. 18-22), and an invited seminar at the University of Rhode Island in November. A manuscript "Predicting the occurrence of amphibians: an assessment of multiple-scale models" was peer-reviewed and accepted for publication in the Proceedings of the Snowbird symposium.

Principal Investigator(s)
Catherine Johnson, Carl Richards, Pat Schoff, Lucinda Johnson

Project Sponsor(s)	**Amount**
University of Illinois	$363,150

Start Date 10/1/97 **End Date** 9/30/00
Project No 189-6161

Progress/Results
Frog calling surveys were conducted in April-May and June of this year and the final, 3rd survey is ongoing. Water quality data collection for the 36 sites included in the intensive analyses has been completed and photo-interpretation of these sites is currently undergoing quality control. Sediment samples from these sites have been sent to a Soils laboratory in South Dakota for analyses. Data entry for vegetation and macroinvertebrate samples collected in 1999 has been completed. The anuran malformation survey for 2000 is nearing completion. Specimens collected as part of this survey will be sent to the University of Illinois and the National Wildlife Health Center (NWHC) for health assessments and analysis of parasites. The NWHC also will assess snails collected at these sites for parasite burden. After their analyses are completed, specimens will be forwarded to the EPA lab in Duluth for further analyses. The results of our study to date will be presented at the Wetlands Symposium in Quebec in August.

ECOSYSTEM STUDIES - WATER RESOURCES 491

Development and Evaluation of Multi-Scale Mechanistic Indicators of Regional Landscapes

Objective To develop, evaluate, and integrate ecological indicators, we will employ a multi-tiered sampling and modeling strategy, integrating data collected at regional scales via satellite imagery, local scales via low-altitude photography, and field sampling. These data will be used to identify indicators at each scale that reflect critical ecosystem process related to the health and sustainability of those ecosystems. We will develop and test indicators representing these fundamental driving variables and processes at multiple spatial scales, and integrate them into a system for identifying positive or negative trends in the health of ecosystems in regions heavily dominated by agriculture and mixed land uses. These data will be used to identify indicators at each scale that reflect critical ecosystem process or state variables related to the integrity and sustainability of those ecosystems.

Background Sampling approaches are needed to assess the health of regional ecosystems such as large river basins and their associated watersheds. Due to their large size and numerous individual tributary streams, conventual methods that require sampling each stream are prohibitively costly and ineffective. This research will develop new cost-effective methods of assessing large areas using satellite data and strategic stream sampling of fish, water quality, and other organisms. Methods for combining these very different types of data for the purposes of predicting water quality and other stream characteristics will be developed.

Previous Activity/Results Michigan sample sites were visited in April to assess current conditions. Sites in Minnesota were chosen on the basis of their dominant land use and geologic characteristics. Field sampling in both study sites is ongoing and will continue until late October. In addition, GIS and Remote Sensing specialists continue to assemble spatial databases for both regions. Work is ongoing on satellite image classification of land use in the Minnesota study area.

Principal Investigator(s)
Lucinda Johnson, George Host, Carl Richards

Project Sponsor(s)	**Amount**
U.S. Environmental Protection Agency (EPA)	$925,000

Start Date 10/1/97 **End Date** 9/30/00

Project No 1628-189-6153

Progress/Results
All instream sampling has proceeded as anticipated with the exception of algal bioassays at half of the Michigan sites. Exceptionally low flows precluded sampling at these sites. Algal bioassays were conducted at all other sites on two three-week occasions in Michigan and Minnesota. Macroinvertebrates were collected at all Minnesota sites in late summer and coarse woody debris was collected at representative sites in Minnesota and Michigan to compare to full surveys that will be conducted next year. In addition, water samples for nutrient and other water quality parameters were collected at the initiation and termination of each algal bioassay experiment. We have completed the satellite image classification for Minnesota and Michigan.

Active Grants

Sponsor	*ID #*	*CUFS #*	*Project*	*Budget for fiscal year 1999-00*
Environmental Protection Agency	491	189-6153	Development and evaluation of multi-scale mechanist indicators	308,333
US Air Force	548	189-6158	Prediction of health and environmental hazards of chemicals: a hierarchical approach using QMSA and QSAR	171,772
Environmental Protection Agency	492	189-6161	Environmental factors that influence amphibian structure and health as indicators of ecosystem integrity	165,321
Minnesota Department of Natural Resources, EPA Prime	494	189-6149	Lake Superior land use decision support system	159,467
MN Legislative Commission on Minnesota Resources	650	189-6180	Predicting water and forest resources health and sustainability	150,000
Environmental Protection Agency	850	189-6191	Effects of forest fragmentation on community structure and metapopulation dynamics of amphibians	149,649
Suburban Hennepin Regional Park District, EPA Prime	557	189-9005	Lake access: making water quality data real and relevant for Minnesotans	139,332
Notre Dame (NSF prime)	378	189-6148	Direct and indirect effects of climate change on boreal peatlands: a mesocosm approach	117,803
National Science Foundation	421	189-6137	Control of productivity and plant species segregation by nitrogen fluxed to wetland beaver meadows	100,000
		189-6140	REU supplement	8,889
Environmental Protection Agency	558	189-6165	*In Situ* characteristics of ultraviolet and visible light in *Rana pipiens* (Leopard Frog) habitats	75,000
National Science Foundation	370	189-6167	LTREB: long-term dynamics of moose foraging, community structure, and ecosystem properties	60,000
Minnesota Technology, Inc	553	189-6188	Design of novel and environmentally benign photoactive compounds	53,686
Minnesota Technology, Inc	560	189-6185	Development of an inexpensive data logging Ultraviolet B (UB V)	52,611
Forest Resources Research Council	576	189-6176	Wildlife species: Response to forest harvesting	49,171

CENTER ACTIVITIES

Active Grants

National Science Foundation	462	189-6151	Hierarchical parallel algorithms for simulating plant response to environmental stress	47,509
National Science Foundation	500	189-9004 189-9003	Water on the Web: monitoring Minnesota's lakes on the Internet	47,863 44,425
USDA Chequamegon, Nicolet National Forests	420	189-6187	Bird monitoring in the Great Lakes national forests	49,000
Minnesota Technology, Inc.	579	189-6189	Development of an economic model and improvement in improvement in the culture of the horneyhead chub	42,052
US Department of Agriculture, North Central Forest Experiment Station	466	189-6162	EPIC-ECOPHYS: modeling growth of aspen and hybrid poplar	37,861
Mississippi State University, USDA, CREES	570	189-6163	Forest product technology advancement	27,760
Minnesota Sea Grant	565	189-1020	Evaluating potential reintroduction sites for coaster brook trout within the Lake Superior basin *research asst monies not counted in this amt*	27,417
Minnesota Board of Water and Soil Resources (Legislative Commission on Minnesoto Resources prime)	585	189-6193	Miller Creek Management	25,000
Northeastern/North Central Forest Experiment Stations	419	189-6125	Interacting effects of CO_2 and O_3 on aspen forest ecosystems	25,000
Minnesota Technology, Inc.	400	189-6154	Alternative on-site treatment systems, Phase III: assessment of recirculation systems	24,373
Minnesota Sea Grant	561	189-1025	Pathogen and nutrient removal by constructed wetlands for treatment of single home and small community wastewater flows	23,567
USDA Forest Services Superior National Forest	740	189-6186	Distribution of Canada lynx in the upper Midwestern USA	23,077
Minnesota Technology, Inc	579	189-6157 189-6189	Evaluation of combined pond and indoor culture system for important Minnesota baitfish	22,768

Active Grants

*National Council for Air and Stream Improvement	578	189-6197	Minnesota integrated riparian study	5,000
Minnesota Pollution Control Agency	441	189-6178	Mine Pit Lake and Sediment Survey	19,200
National Science Foundation	373	189-6098	Moose foraging strategy, energetics, and ecosystem processes in boreal landscapes	17,778
		189-6141	REU supplement	4,967
USDA Forest Services Superior National Forest	648	189-6184	Boreal owl: its habitat and prey in the Superior National Forest	15,714
National Science Foundation	946	189-6200	A GPS-linked model helicopter system for stream imaging	15,463
Minnesota Technology, Inc.	553	189-6156	Computer-assisted design of environmentally benign photoactive chemicals	15,000
Minnesota Department of Natural Resources	648	189-6179	Continued studies of Boreal owl in NE Minnesota	13,333
National Aeronautics and Space Administration	939	189-6196	Mapping and modeling forest change in boreal landscapes	13,297
Minnesota Technology, Inc.	572	186-6169	Interactive GIS database development for mining and forest land management	13,018
Minnesota Technology, Inc	501	189-6155	Development of a fluorescence based sensor for determination of optical brighteners	12,671
Apprise Technologies, Inc (NSF-SBIR Prime)	568	189-6182	Development of low-cost optical probe to detect red-tide blooms	11,677
Minnesota Forest Resources Council	571	189-6183	Evaluating area dynamics, management alternatives and impacts of harvest practices	8,389
*National Science Foundation	949	189-9006	Intergovernmental personnel act program assignment	7,827
University of North Dakota (NSF prime)	940	189-6194	Dispersion and ecological interactions of clonal and sexual fish in successional landscapes	7,143
*Minnesota Pollution Control Agency	371	189-6198	Lake water chemistry analysis	5,000
Minnesota Department of Natural Resources	465	189-6177	Lake Superior decision support system: North Shore analyses	3,000

CENTER ACTIVITIES

Active Grants

*USDA North Central Research Station	945	189-6199	Testing the efficiency of buffers for protecting seasonal ponds and forest songbirds	1,286
			Estimated Total	$2,433,469

* Indicates project is new this quarter.

Pending Grants

1. Moen, Ron. Integrating energy protein and mineral metabolism in ruminants: Sodium and potassium. National Science Foundation. $154,370.
2. Kingston, John, R. Axler, and C. Hagley. Sustainable development of NE Minnesota lakes resources– White Iron Lake. Northeast Region Sustainable Development Partnership Grants. $53,514.
3. Basak, S. C. Assessment of health and environmental hazards of chemicals: a hierarchical computational approach. Agency for Toxic Substances and Disease Registry. $264,541.
4. Host, G.E., G. Theseira; H. Stech, K. Lenz, R. Regal (UMD, Mathematics and Statistics. Biocomplexity: Multi-scale mechanistic modeling to predict individual tree and forest ecosystem response to interacting environmental stresses. National Science Foundation. $2,862,274.
5. Richards, C. Multi-scale effects of UV radiation in arctic streams: A molecular, community, and landscape-level evaluation. University of North Carolina, Greensboro (National Science Foundation prime). $149,999.
6. Basak, S.C. and B.Gute. Computer-aided design of polyamines as anticancer agents. SLIL Biomedical, Inc. (Department of Health and Human Services prime). $58,879.
7. Onsite Sewage Treatment Alternatives - Application, Implementation and Management Legislative Commission for Minnesota Resources. Submitted for $ 960,911 (+ $692,500 match). J. Anderson (UM-St Paul), B. McCarthy, R. Axler, D. Gustafson (UM-SP), R. Hicks (UMD-Biology), J. Crosby (St. Louis County); Pete Weidman (WLSSD); [Coordinated with Minnesota Pollution Control Agency. 7/01-6/03.
8. Kingston, J.K. Microbial observatory for Lake Superior: Community structure and physiological ecology in the microbial loop. Michigan Technological University (National Science Foundation prime). $100,000.
9. Niemi, G.J. and P.T. Wolter. Development of environmental indicators for the US Great Lakes Basin using remote sensing technology. US Environmental Protection Agency. $600,000.
10. Niemi, G.J., R. Axler, J. Hanowski, G. Host, L. Johnson, C. Johnston, J. Kingston, CWE/NRRI; R. Regal, Dept. of Mathematics and Statistics; C. Richards, Minnesota Sea Grant; D. Swackhamer, Dept of Environmental and Occupational Health, UMN; R. Howe, University of Wisconsin-Green Bay; B. Bedford, C. Smith, Cornell University; J. Ciborowski, University of Windsor, Canada; J. Johansen, G. Sgro, John Carroll University, Ohio; D. Mladenoff, J. Zedler, U. of Wisconsin-Madison (UW-M); E. Stoermer, U. of Michigan; *US EPA Office of Research and Development Cooperators*: S. Bradbury, G. Ankley, J. Brazner, P. Cook, N. Detenbeck, S. Diamond, J. Kelly, R. Kreis, M. Moffett, Mid-Continent Ecology Division-Duluth (MED), MN and Grosse Ile, Michigan. Development of Environmental Indicators of Condition, Integrity, and Sustainability in the Great Lakes Basin. US Environmental Protection Agency. $600,00.
11. Kingston , J.K., C. Johnston and Cynthia Hagley. 7/2001-6/2003. Maintaining Water Quality in Northeastern Minnesota Lakes. Legislative Commission for Minnesota Resources. $379,691.
12. Host, G.E.; C.Hagley, B.Munson, and B. Liukkonen (Minnesota Sea Grant), John Barten (Suburban Hennepin Regional Park District), Glenda Spiotta (Minnehaha Creek Watershed

District), Joy Teirney (Plymouth, MN) Lee Gunderson (Bassett Creek Water Management Commission), and Christopher Owen (Apprise Technologies, Inc.). Managing urban runoff using real-time, community-based monitoring to improve lake water quality. USEPA-EMPACT Program. $400,000.

13. Basak, S.C. and D. Hawkins (UM-TC). Integration of biodescriptors and chemodescriptors for predictive toxicology: A mathematical/computational approach. Air Force Office of Scientific Research. $716,468.
14. Host, G.E. and M.A. White. Mapping native plant communities of the Northern Superior Upland. Minnesota Department of Natural Resources. $20,000.
15. Schuldt, J.A., L.B. Johnson, G.E. Host, C. Richards. Protocols for selecting classification systems and reference conditions: A comparison of methods using Great Lakes coastal ecosystems. US Environmental Protection Agency. $1,499.497.
16. Richards, C. and L. B Johnson. Alaska streams: Classification, reference conditions, and a landscape assessment framework. Idaho State University, Pocatello (US Environmental Protection Agency prime). $187,967.
17. Basak, S.C. Assessment of health and environmental hazards of chemicals: A hierarchical computational approach. Agency for Toxic Substances and Disease Registry. $149,448.
18. Basak, S.C. and D. Hawkins (Computer prediction of chemical toxicity to human cells. National Institute of Health. $2,205,187.
19. Johnson, L.B., G.S. Peterson, R. Axler. Behavioral responses of larval amphibians to solar UV-b radiation: Is UV-B a valid hypothesis for malformations of frogs in the Great Lakes region? Minnesota Sea Grant. $71,426.
20. Schuldt, J.A. and L.B. Johnson. Critical elements of brook trout habitat in Lake Superior. Minnesota Sea Grant. $99,158.
21. Basak, S.C. and G.J. Niemi. Assessment of endocrine disrupting potential of chemicals using proteomics-based integrated QSARs. US Environmental Protection Agency. $149,838.
22. Schuldt, J.A. Pilot demonstration of ballast water treatment using hollow fiber membrane filtration. Chesner Engineering (National Sea Grant prime). $68,201.
23. Richards, C. A geomorphic trophic hypotheses for arctic lake productivity. University of North Carolina, Greensboro (National Science Foundation prime). $195,094.
24. Pastor, J. Modeling ecosystem dynamics in peatlands under changing climate and nutrient regimes. University of Notre Dame (National Science Foundation prime). $642,087.
25. Cohen , Y. (UM-TC), R. Moen, J. Pastor. Herbivores and nutrient cycling in ecosystems. National Science Foundation. $8891,407
26. Munson, B. (UMD, Education), R. Axler, C. Hagley (Minnesota Sea Grant), G.E. Host. Water-on-the-Web: Using real-time lake data for teaching core and environmental science. National Science Foundation. $499,998.

Natural Resources Geographic Information System Laboratory

Projects using the GIS Laboratory (FY 00):

•170-6048	Key Connections in Arctic Aquatic Landscapes (NSF) - Richards
•175-6023	UMD Geomorphology - Mooers
•186-2115	Native plant communities (DNR) - White
•186-2201	Water on the Web (NSF) - Host
•189-1020	Evaluating potential reintroduction sites for coaster brook trout within the Lake Superior basin (Sea Grant) - Richards/Johnson
•189-2753	Silent Sports Map (Voyageurs Region National Park Assoc.) - Johnston
•189-2756	Winton Dam FERC relicensing (Minnesota Power) - Johnston
•189-2758	Natural Resources Inventory (City of Duluth) - Johnston

•189-6098	Moose foraging strategy, energetics, and ecosystem processes in boreal landscapes (NSF) - Pastor
•189-6135	Great Lakes assessment: data visualization and decision support (USFS) - Host
•189-6137	Control of productivity and plant species segregation by nitrogen fluxes to wetland beaver meadows (NSF) - Johnston/Pastor/Mooers
•189-6148	Direct and indirect effects of climate change on boreal peatlands: a mesocosm approach (NSF) - Pastor
•189-6149	Lake Superior land use decision support system (DNR, EPA) - Host/Johnson/Richards
•189-6153	Development and evaluation of multi-scale mechanistic indicators of regional landscapes (EPA) - Richards/Johnson/Host
•189-6159	Minnesota's forest bird diversity initiative, Phase IV (LCMR) _ Niemi/Hanowski
•189-6161	Environmental factors that influence amphibian structure and health as indicators of ecosystem integrity (EPA) - Johnson/Richards/Schoff
•189-6169	Interactive GIS database development for mining and forest land management (MTI) - Johnston
•189-6170	Minnesota integrated riparian study (NCASI) - Hanowski
•189_6179	Continued studies of boreal owl ecology in northeastern Minnesota (USFS, DNR) - Niemi
•189-6180	Predicting water and forest resources health and sustainability (LCMR) - Hanowski/Johnson/Host
•189-6186	Distribution of Canada lynx in the upper Midwestern United States (USFS) - Niemi
•189-6191	Effects of forest fragmentation on community structure and metapopulation dynamics of amphibians (EPA) - Johnson
•401-6011	Landscape and site_level modeling of white pine blister rust incidence (USFS) - Host

Central Analytical Laboratory

Community Outreach

JoAnn Hanowski served as an instructor for the Minnesota Logger Education Program. April 2000.

JoAnn Hanowski was an invited speaker at Itasca Community College for a May Migratory Bird Month program, and at the Esko School for Career Days. May 2000.

Scientific Meetings

JoAnn Hanowski attended the National Council for Air and Stream Improvement regional meeting, held in Green Bay , WI. April 2000.

Teaching

Publications

Currently submitted, in press, or published during the quarter
Cumulative published totals from 1985 to present
Publications— 411, Technical Reports— 79

Axler, R.P., J. Henneck, J. Pundsack, R. Hicks, B. McCarthy, D. Nordman, S. Monson Geerts, J. Crosby, P. Weidman. Cold climate performance of constructed wetlands for removing pathogens and nutrients from domestic wastewater in Northern Minnesota. In: Proceedings of the Third National Workshop on Constructed Wetlands/BMPs for Nutrient Reduction and Coastal Water Protection, June 10-11, 1999, New Orleans, LA. In press.

Axler, R.P., J. Henneck, D. Nordman, B. McCarthy, S. Monson Geerts. Operation and Maintenance Experiences with Constructed Wetlands in Minnesota. In: Proceedings for the National On-Site Wastewater Recycling Association 8th Annual Conference, November 3-6, 1999 Jekyll Island, Georgia. Submitted.

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ADMINISTRATION

Sue Hendrickson and Brian Gute (Center for Water and the Environment) participated as test sites for UMD Library's one month trial of a Chemical Abstracts citation database. Their input on usefulness, etc. was given to the librarians at UMD who will make a decision whether or not to purchase the database.

FACILITIES AND EQUIPMENT

No new equipment or software was acquired during this quarter. Barb Hauck began moving several years of journal back-issues to storage. She also did a shelf-reading and book moving project to free up space on the library's shelves.

LIBRARY SERVICES

Research

Online literature searches provided this quarter for the following:

- company searches
- patent searches
- deer antlers
- peatlands, peat
- mineral processing models
- company financial information
- taconite processing
- citation verifications
- frogs
- grouse
- Instructions for authors (journals)
- DNA sequences
- forest soil
- peatland restoration
- forest growth models
- gold
- constructed wetlands
- limnology
- phytochemicals
- dissertations
- climate change
- short rotation forestry
- dimensional stability (lumber)
- research grants, funding
- Birch
- peat ions
- coarse woody debris
- specific gravity (wood)
- herbivores
- taconite
- phototaxis (amphibians)
- amphibians, anurans, frogs
- bioactive peptides
- structure-activity of peptides
- zebra mussels
- Ozone and poplar
- ruffe
- wastewater systems
- beavers
- moose
- global climate change
- lignin
- birds
- constructed wetlands
- sphagnum
- tannins
- poplar and climate change
- flavanoids
- bioremediation
- QSAR
- Medicinal plants

Interlibrary Loans

The following is a summary for the period of April 1, 2000 – June 30, 2000.

Materials Borrowed

Source	No. of Documents
Minnesota Region (Minitex)	356
UMD Libraries	109
US Libraries (OCLC)	023
Other US Libraries (Direct)	005
Total	493

Use of Borrowed Materials by NRRI Centers

Center	No.. Of Documents
CARTD	131
CWE	361
CED	000
Central	001

Material Loaned to Other Libraries

Borrowing Organizations	No. of Documents
Minnesota Region (Minitex)	008
US Libraries (OCLC)	017
US Libraries (Direct)	009

ACQUISITIONS

The library catalogued 65 new items this quarter.

PUBLIC RELATIONS ACTIVITIES

SECOND QUARTER 2000

During the second quarter of 2000, commercial equivalent coverage of NRRI amounted to $40,791.57 with 48 stories placed in print, radio, TV and the Internet site of Discovery.com. Our year-to-date total now equals $156,840.96 of equivalent commercial coverage.

Of 40 print stories, 26 stories were run in the Duluth media, 3 from the Twin Cities area, and 11 throughout Minnesota on topics from birds, copper-nickel, altered trees, peat, aquaculture, LTV closure, and a mathematical chemists conference sponsored by NRRI.

Two radio stories covered the mathematical chemist conference during the quarter. And five local TV stories covered NRRI geographic information systems lab inventory, mathematical chemists conference and LTV closure. NRRI researcher Ron Moen's work on the Irish elk was covered again through the Internet site of Discovery.com with national implications.

Public relations staff have initiated a series of articles featuring NRRI facilities in the ENTER publication sponsored by CED and the Duluth News Tribune.

NRRI's web pages are continually being updated to include important news releases and stories of local interest.

VISIBILITY

NRRI hosted 91 people on tours through the Institute during the second quarter of 2000.

NRRI director Mike Lalich hosted a talk at the Duluth's Kitchi Gami Club to 75 people on NRRI projects and products.