



NATURAL RESOURCES RESEARCH INSTITUTE

NRRI *Now*

Autumn 2006

Can this beautiful rock from the Canadian Yukon be the solution to replace dangerous lead?

Find out inside . . .



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From the director



Michael J. Lalich

The future is bright for NRRI's Coleraine Research Laboratory

These are exciting but challenging times for NRRI. If we take a look at overall budget activity from a "bird's-eye" view, the picture is one of relative calm with annual activity increasing gradually. In an institute as diverse as NRRI, however, there are pockets of intense activity. Leading the charge, in this regard, is NRRI's Coleraine Research Laboratory. NRRI researchers at Coleraine pride themselves, not only in laboratory scale research, but in their ability to develop technologies on the large pilot scale basis required as an intermediate step to commercial implementation. Trends and highlights of current program activity include:

- NRRI, to a large extent, has become the research provider for the entire taconite industry. At any given time, there are 10 to 20 projects focused on helping the existing taconite industry improve the efficiency of its mineral processing operations and quality of the taconite pellets produced.
- The Institute is actively engaged in development of byproduct applications from the industry's waste materials. The Institute has received a \$1.2 million federal grant, with additional matching money from other partners, to evaluate the use of waste rock and tailings from taconite operations for aggregate in highway construction.
- NRRI continues to focus on development of iron nodule technologies to serve the expanding mini-mill markets. NRRI's research interests are two-fold: to develop a new linear hearth furnace and to concurrently develop improved metallurgical processing compatible with Minnesota iron ores.

In addition to its traditional role of focusing on mineral processing for the taconite industry, the Coleraine Laboratory is uniquely suited to other applied research and development initiatives, for example:

- Mineral processing techniques are adaptable to environmental remediation. NRRI has been diligently working over a 10-year period on a program to research methods to economically remove mercury from gas streams, from coal-fired power plants. NRRI absorbents are showing mercury recoveries in excess of 90% and the Institute is gearing for a full scale trial at a Minnesota Power plant.
- NRRI has long been the leader in regional development of hybrid poplar clones for biomass with its consortium of industry and agency collaborators. Now, a pilot scale gasifier that will give Coleraine ongoing capability to study biomass fuels, is being purchased for installation at Coleraine. The first funded project, working with an industrial partner, will research conversion of biomass energy to hydrogen.
- Companies with non-ferrous mineral interests in Northeastern Minnesota will need laboratory assistance with hydrometallurgical processing, in addition to geological studies. With the addition of appropriate laboratory space and equipment, NRRI would have the capability to service the hydrometallurgical laboratory needs of these companies.
- NRRI has installed induction furnaces at Coleraine for high temperature molten metal processing. As interest in value added iron and steel increases, in conjunction with taconite iron ore operations, NRRI will be in a position to add scientific expertise and do research in this area.



Worth its weight



NRRI's High Temperature Reduction Furnace produces tungsten metal powder from tungsten oxide.

Economical tungsten can replace dangerous lead

Getting the lead out of the environment has been a goal of the Environmental Protection Agency for decades. Lead's weight and density made it so useful that it was readily used in many products—from paint and gasoline to shot gun shells and fishing sinkers. But we now know that exposure to lead can be toxic to humans and wildlife and its use is being outlawed in most products.

Various alternatives to lead replacement have been tried with limited success. Recently however, Minnesota-based Wild River Consulting has developed a way to make tungsten—a hard, heavy metal similar to lead—available as a lead replacement using composite technology. Tungsten is environmentally safe and it is more dense than lead, making it an ideal replacement material.

The key for Wild River was finding a way to make the composite from

tungsten ore, which brought them together with researchers at NRRI's Coleraine Laboratory. Together they developed a remarkable process for producing metallic tungsten powder from scheelite ore concentrate. This research, in part, has led to the announcement of a new manufacturing plant in Hoyt Lakes, Minn., that will produce tungsten composites, creating up to 80 new jobs for the proposed opening in late 2007.

Native Iron Ranger Kurt Heikkila, president of Wild River, said the company will be a joint venture with North American Tungsten Corp., a mining company which will provide an upgraded form of scheelite tungsten ore from their mining operations at the Cantung Mine in the Yukon.

“Organizations like UMD's Natural Resources Research Institute were crucial in facilitating the development of various metal particle technologies that will be used in our manufacturing,” said Heikkila.

NRRI researchers Iwao Iwasaki, David Hendrickson and Donald Fosnacht came up with a way to transform the scheelite ore to



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metallic tungsten powder with a minimum number of processing steps. This made the process economical for success in this new venture.

“Our new tungsten process provided Wild River Consulting with a high purity form of metallic tungsten powder which Kurt needed to advance his unique tungsten product line,” explained Hendrickson, director of NRRI’s Coleraine laboratory.

Heikkila and his partners designed the Hoyt Lakes plant concept with the help of many agencies, including Minnesota Power, the East Range Joint Powers Board, Iron Range Resources, the Area Partnership for Economic Development and others. Heikkila’s “Gravity” lead-free sinkers can be purchased at Gander Mountain. This is a first application, but look for tungsten composites as a replacement for lead wheel weights on automobiles and in other automotive applications.

In support of this endeavor, North American Tungsten is expanding mining operations in the Yukon. In addition, 3M Corporation recently announced an agreement to market the tungsten composites to the automotive industry.



A process developed at NRRI makes metallic tungsten powder (pictured here) from scheelite ore concentrate. The tungsten can then be formed as lead replacement.

Did you know?



Tungsten was named from the Swedish words “tung sten” meaning “heavy stone.”

Tungsten is a gray-white metallic element. Tungsten from the Yukon mine is in the form of scheelite (the rock pictured on the cover). In other parts of the world, tungsten is in the form of wolframite. It is stable and is very resistant to acids and bases. It does, however, oxidize in air, especially at higher temperatures. It has the highest melting temperature of any metal (6,192° F), and the second highest of all elements (Carbon is highest).

Of the world’s tungsten reserves, over 90 percent are outside the United States. Of these resources nearly half are found in China. Canada and Russia also have large reserves. About one-third of the U.S. imports of tungsten are from China, Russia provides about 25 percent, and a variety of other nations provide the rest.

(From the Mineral Information Institute)

Biomass to

HEAT & POWER

Minnesota Homes

NRRI studies wood residues and brush as alternative fuel source

Is there a silver lining to the dark cloud of rising energy prices? Yes—focused attention on alternative sources. And one of the most promising of those alternatives is going to warm the homes of residents in the northern Minnesota towns of Virginia and Hibbing, producing renewable electricity for sale to the state’s largest utility this December. A group called the Laurentian Energy Authority is upgrading the towns’ coal-fired steam and electricity plants to heat homes with brush and other woody debris, converting biomass into renewable fuel to displace coal.

According to Terry Leoni, general manager of the Virginia Public Utility, this project is a natural fit for the needs of the two towns.

“In both Hibbing and Virginia we were looking at downsizing or eliminating our steam heat systems,” Leoni explained. “Our plants just weren’t producing to their full potential, yet about 3,600 homes and businesses are heated with them. But eliminating the plants would also have been very expensive, especially for the homeowners.”

The public utilities commission relied on NRRI forestry experts to analyze how much woody debris is

available within reasonable trucking distance to the combined heat and power plants. An additional \$1.2 million grant from the Department of Energy is now funding a more in-depth study on forest harvest residues, harvesting techniques, hybrid plantations and the potential biomass to be gleaned from harvesting brushland.

There are two benefits to harvesting brushlands—more biomass for fuel and improved habitat for sharptail grouse, a species of concern to the Department of Natural Resources. The DNR is currently spending its limited conservation dollars to clear sharptail grouse habitat, but the Laurentian project could save the state money if they cleared the brush for biomass fuel.

NRRI researchers are assessing brushland density and harvest opportunities near Virginia and Hibbing, and calculating the cost of harvesting. They’re also designing and testing modified harvesting equipment.

Forest harvest residues—the brushy tops and limbs of trees left on the ground after a timber harvest—are also being studied by NRRI to determine the amount of wood lost

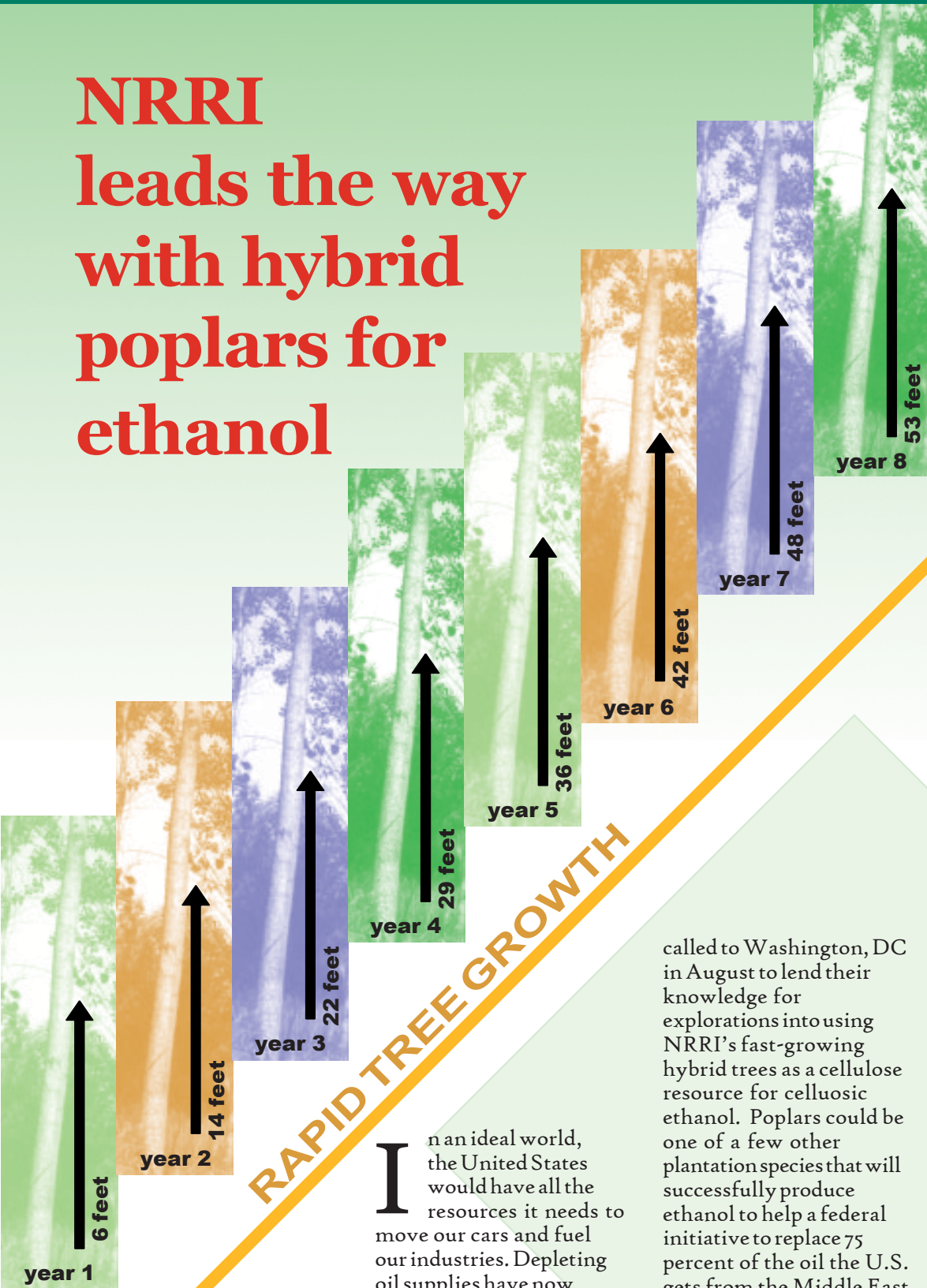
during winter vs. summer harvests. Analysis of new clones for hybrid poplars continues to be part of the project.

NRRI’s expertise in forestry research and environmental remediation is critical to this project says Jim Kochevar, general manager of the Hibbing Public Utility.

“The knowledge base at NRRI is absolutely essential to confirm the availability, price and harvesting techniques for our \$80 million project,” Kochevar said.

Burning wood instead of coal is not necessarily less expensive, but it is better for the environment. Federal legislation is now making it cost effective for towns to use this cleaner energy source. Even better, conversion to wood-based biopower retains jobs at the plant and provides business to local loggers and truckers. The Hibbing/Virginia biomass fuel plants could become a model for other towns and large industries to follow, putting Minnesota at the forefront of development of biomass energy.

NRRI leads the way with hybrid poplars for ethanol



RAPID TREE GROWTH

In an ideal world, the United States would have all the resources it needs to move our cars and fuel our industries. Depleting oil supplies have now pushed the research that could make that ideal world a reality, and trees will likely play an important role.

NRRI's experts in hybrid poplar research were

called to Washington, DC in August to lend their knowledge for explorations into using NRRI's fast-growing hybrid trees as a cellulose resource for cellulosic ethanol. Poplars could be one of a few other plantation species that will successfully produce ethanol to help a federal initiative to replace 75 percent of the oil the U.S. gets from the Middle East by 2025.

In his 2006 State of the Union Address, President George W. Bush promised to fund research in "cutting-edge methods of producing ethanol, not

just from corn, but from wood chips and stalks, or switch grass." His 2007 budget increases funds for biomass research by 65 percent with the hope to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012.

NRRI is conducting a study with University of Minnesota researchers at a site in St. Peter, Minn., that shows promise to grow poplar trees 50 to 60 feet tall in just seven years.

"We have one of the most aggressive and diverse hybrid poplar programs in the country," said Forestry Program Director Bill Berguson. "We can definitely add to the potential of local resources for fuels. Essentially, we'll be able to distribute money to rural America that is now being exported to the Middle East. That's really exciting."

The U.S. Departments of Agriculture and Energy published a report in February 2005 that studied "whether the land resources

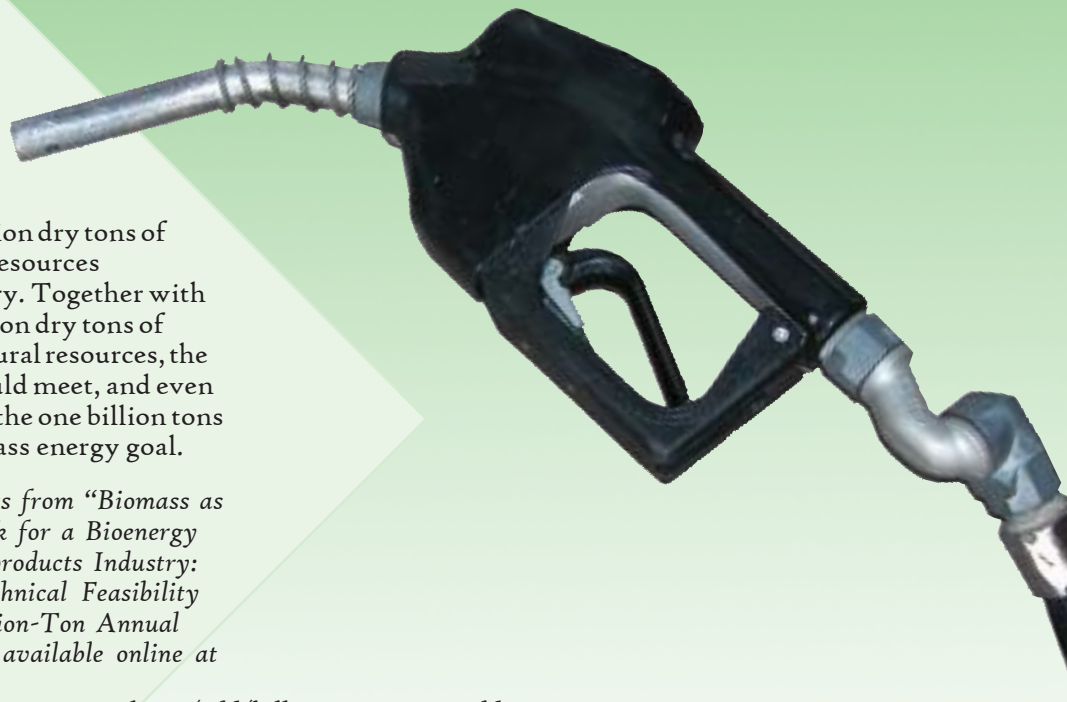
of the United States are capable of producing a sustainable supply of biomass sufficient to displace 30 percent or more of the country's present petroleum consumption.... It would require approximately one billion dry tons of biomass feedstock per year.”*

Should these alternative fuel sources be utilized at their full capacity, NRRI's knowledge in fast-growing hybrid poplars could be instrumental in meeting

368 million dry tons of forest resources necessary. Together with 933 million dry tons of agricultural resources, the U.S. could meet, and even exceed, the one billion tons of biomass energy goal.

**Excerpts from “Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply” available online at*

feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf



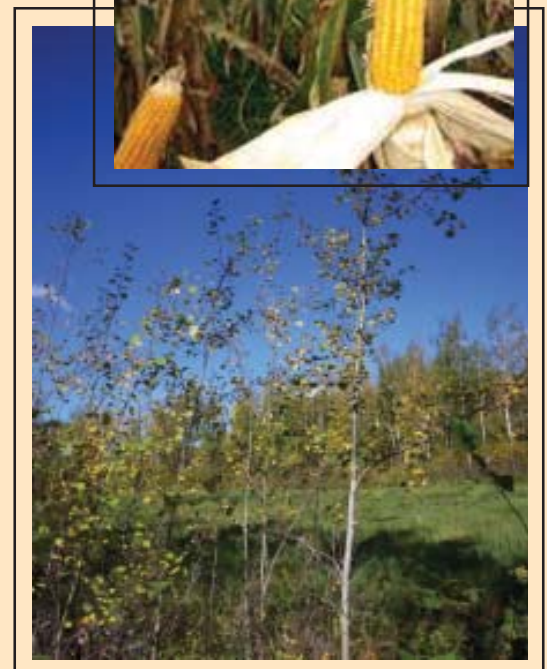
Corn vs. Cellulosic Ethanol:

Wall Street Journal reporters John J. Fialka and Scott Kilman wrote in June, 2006 about the exploding interest in cellulosic ethanol: “Generally, ethanol is the same thing as grain alcohol, a beverage that has been fermented and distilled from the sugars in kernels of corn, wheat, rye and barley for centuries. To make cellulosic ethanol, scientists are going after the sugar that is locked away in the stalk and leaves of the plants in the form of cellulose, the basic building block of plants.”

We're already familiar with ethanol as a way to stretch our fossil fuel consumption. Corn-based ethanol is regularly mixed with the petroleum-based fuels at the gas pumps, which also makes the fuel burn more cleanly. Cellulosic ethanol can be used in the same way, using plants such as hybrid poplar trees and switch grass which grow well on marginal croplands.

The “technology” under intensive development is enzymes—produced by tiny microorganisms—that can extract and digest the sugars from cellulose fibers as efficiently as they now can from corn. Continued strides in genetic research to develop these cellulose-processing enzymes are making them cost effective to use on a commercial scale.

Even better, the by-product of the cellulosic ethanol process is lignin that hardens and strengthens cell walls of plants. The lignin can be burned to fuel the ethanol-making process. This means fossil fuels are not needed to run the cellulosic ethanol facility, as they are in starch (or corn)-based ethanol facilities.



Vital Signs of the National Parks

NRRI expertise broadens knowledge base around Great Lakes

Change is happening all around us. In our environmental world some changes are good, some are bad. The key is to know exactly what is changing, and why.

That's the impetus that set into motion the National Park Service's Inventory and Monitoring Program, which in turn sent them to NRRI. The experience NRRI scientists gained during the Great Lakes Environmental Indicators project has made them experts in coordinating large-scale research.

NRRI's Indicators project sought, and found, the most practical and reliable bioindicators of the health of the U.S. Great Lakes basin. Similarly, the Park Service is looking for "Vital Signs" (a.k.a. indicators) of ecosystem change in their nine parks within the Great Lakes Network. (See map)

Monitoring the environment of the parks isn't new, but the process hadn't previously been as extensive nor as broadly coordinated. Water quality samples, for example, taken over the past few decades were assessed using slightly different methods or different variables at each of the parks.

"A good example is an

'recording location' and the researcher wrote 'canoe!'" explained George Host, NRRI statistician and forest ecologist. "The historical data were found to be somewhat disorganized. We worked with park staff and other university and agency collaborators to set up detailed procedures so new information is gathered in an organized way in the future, making the data much more useful."

Once the historical data was organized in a database it could be built upon across all of the parks. Then, NRRI scientists developed recommendations as to how each park should continue monitoring their lakes—how and where to collect samples, how to process samples in the field and laboratory using methods and quality assurance procedures approved by the Environmental Protection Agency and U.S. Geological Survey.

According to NRRI water quality specialist Rich Axler, working collaboratively with National Park Service Ecologist Joan Elias, the intent is to generate state-of-the-art data that will "allow park lakes to be compared with each other, and also with lake data generated by Minnesota, Wisconsin and Michigan,

and the National EPA assessment program."

The new procedures allow the Network to ask specific monitoring questions, such as, "Are similar ecological trends occurring across the park and across the network parks?" And, "Has water quality deteriorated, improved or stayed the same?" Questions that were difficult to get conclusive answers for.

The Park Service's Vital Signs indicators also needed specific protocols that would detail how sampling should be done. NRRI's role was to coordinate the efforts of five different collaborating agencies which took on separate protocol tasks. (See "Reading the Parks' Vital Signs")

"The National Park Service has undertaken a huge task with this project," said Bill Route, project coordinator. "We would be unable to do this without partners like NRRI. The analysis of bird monitoring data has been especially informative. NRRI's scientists made recommendations that parks are starting to adopt and that will make future monitoring data more useful, consistent and reliable."

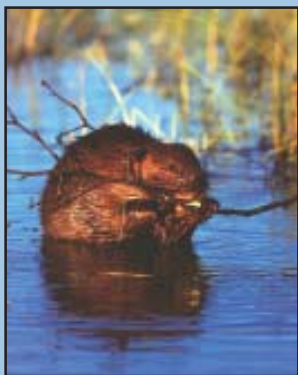
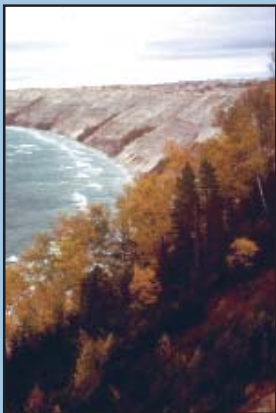


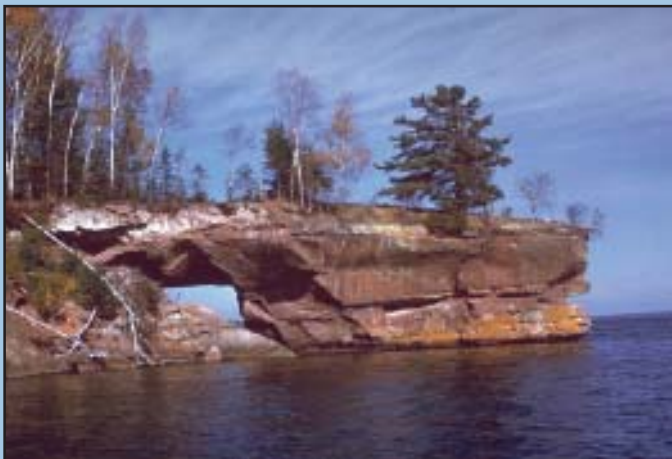
Photo Credit:
David Westphalen/Painet Inc.

READING THE PARKS' VITAL SIGNS

The program's first four sets of Vital Signs (with the agency that conducted the research) being implemented are:

- 1.) Lake water quality (NRRI)
- 2.) Large river water quality (St. Croix Watershed Research Station)
- 3.) Land use and land cover changes (University of Minnesota Twin Cities)
- 4.) Shifts in composition and abundance of plants (University of Wisconsin Madison)
- 5.) Responses of amphibians to environmental quality (Amphibian Research and Monitoring Initiative at USGS)

Bird communities, air quality, weather and climate, and contaminants will be monitored as the program progresses.



The experience NRRI scientists gained during the Great Lakes Environmental Indicators project has made them experts in coordinating large-scale research.



CURRENT NRRI PROJECTS WITH THE NATIONAL PARK SERVICE

- Exploratory analysis of long-term water quality trends for lakes in the Great Lakes Network.
- Effects of beaver on Voyageur National Park landscape pattern: An update of previous research done at NRRI.
- Restoration of white pine forests at Grand Portage National Monument.
- Surface water quality survey and assessments of Apostle Islands National Seashore and recommendations for long-term monitoring.
- Assessment of impact of exotic earthworms in beech-maple and aspen-fir boreal forests at Pictured Rocks National Lakeshore and Voyageurs National Park.
- Analysis of bird population trends in the Great Lakes Network of National Parks.
- Exploration of amphibian sampling methods across Great Lakes Network Parks
- Study of Canada lynx in Voyageurs National Park (To begin in December, 2006)



NRRI paves the way for safer roads

Continued research proves Mesabi Hard Rock™ as marketable aggregate

Now that NRRI studies have shown the enormous potential of taconite waste rock, the work ahead lies in conducting research that expands its use as an aggregate material in pavements, roadbeds and road repair projects, in and out of Minnesota. The rock's natural angularity and hardness make it perfect for a durable road surface that provides excellent traction. And the fact that it's already mined, with much of it waiting in large piles at Minnesota's taconite plants could mean less need for new aggregate mines elsewhere.

NRRI received a grant of \$1.25 million from the U.S. Economic Development Administration, with matching funds from the U of M Permanent University Trust Fund, Iron Range Resources, Minnesota Power, the Blandin Foundation and Minnesota Technology. These partners are enthusiastic about the potential for this waste rock—marketed under the name Mesabi Hard Rock™—to improve the economy of Iron Range industries, while also meeting the growing need for quality aggregate and providing safer roads.



Fine taconite aggregate is applied over a tacky, adhesive base on a bridge deck in Frisco, Colorado. This pilot project tests Mesabi Hard Rock applications to reduce vehicle skidding on bridges.

“We feel that Mesabi Hard Rock™ can be an important source of durable aggregate for many markets, especially where access to—and the availability of—quality aggregate resources is getting more problematic,” said Larry Zanko, NRRI researcher and aggregate project co-leader.

The three-year project will delve deeper into the transportation logistics and economics of moving the aggregate, as well as marketing the product in the Upper Midwest. Mesabi Hard Rock™ will be tested by the U of M Department of Civil Engineering and the Minnesota Department of Transportation so its performance can be compared to other aggregates. For example, it can be mixed with limestone to improve the strength of pavements made with what is typically available locally. Pothole patching compounds and the use of microwave technology to de-ice taconite-paved roads will also be thoroughly tested.

Did you know?

Every year, Minnesota uses about 55 million tons of sand and gravel and crushed rock, or aggregate, for construction projects, including roads.

Nearly one ton of *fine* Mesabi Hard Rock™ is generated for every ton of finished taconite pellets produced, adding up to millions of tons a year. Tens of millions of tons of *coarse* Mesabi Hard Rock™ are also generated every year.

Taconite waste rock has long been used on roads near the taconite mines on the Iron Range. Mine roads made of coarse taconite rock withstand regular use by 250-ton trucks.

Information about demo projects, meetings, mix designs and more can be found at www.nrri.umn.edu/egg/TACAGG. All reports can also be downloaded from this site.



Living 'lagom'

Sabbatical in Sweden is cultural collaboration

DOES THIS SOUND FAMILIAR?

Picture a fine university town a few hours north of a bustling metropolitan area that sits on a large inland sea with an international harbor. It's a town that still has pine-forested areas that it protects for the enjoyment of its 100,000 or so residents, visitors and wildlife. Timber, mining and tourism flourish, and while commercial fishing is declining, the diligent still make a living at it. In the late summer, folks pick blueberries and during the long, snowy winters they frequently ski. Tribes of native people also continue to carve out their existence among the Europeans who populated the area after them...

Duluth, Minnesota? Nope. Umeå (pronounced *oo-me-awe*) in Sweden. It's a town that NRRI scientist/UMD biology professor John Pastor calls Duluth's twin. He returned this summer from a year-long sabbatical at the Swedish University of Agricultural Sciences in Umeå with a long list of accomplishments and a head full of thoughts about science, teaching, culture and balance.

Among the scientific books and papers he wrote, the lectures and courses he gave and the research proposals he submitted, Pastor says what he's most proud of is his collaboration with his Swedish colleagues and the ability of both groups to learn from each other.

"I've learned the Swedish word 'lagom,' Pastor said. "It's a concept that implies an elegant solution to some problem, and it's something Swedes embrace in fashion, cooking, politics, literature, as well as art and science. Elegance, simplicity and balance are all part of it. It's almost untranslatable."

As a forest and soil scientist, Pastor admires the "lagom" at work in

balancing the needs of many in their small country—especially as it relates to land use. He finds their policy of respectful use of all land, private or public, (called "Every Man's Right") very refreshing.

"Balance is so much more prevalent in Sweden," said Pastor. "They don't solve their land issues in courts the way we do. I've never seen a

Pastor has been nurturing his relationship with Sweden for the past 10 years studying, alongside his Swedish colleagues, how moose populations and their food supply affect one another. This summer, he and Professor Kjell Danell co-authored a book on the conservation of mammals such as moose, as well as reindeer, bison and other large herbivores. As a team, they also



"No Trespassing" sign. I think it would be considered rude."

His Swedish colleagues in Umeå, on the other hand, gleaned their share from Pastor during his stay, especially his background in Mathematical Ecology. During one of Pastor's classes at the Swedish University of Agricultural Sciences, students learned how to analyze mathematical models that can help future forest and wildlife managers understand ecosystem stability, sustainability and the consequences of harvesting different species. NRRI is also testing Swedish soils in its Duluth laboratory for nitrogen and other measures of soil fertility.

published papers on moose impacts in the forests and the side effects that will help forest managers maintain lands for both moose and trees. Students of both Pastor at UMD and Professor Danell in Sweden have spent time in each other's laboratories doing research for their theses projects.

"I have been able to learn so much while on this sabbatical that I hope to share with students in the classes I will teach this year at UMD and with my colleagues at NRRI," Pastor said.

Pastor's sabbatical was funded by NRRI and The Kempe Foundation in Örnsköldsvik, Sweden.

20th ANNIVERSARY

Celebrating NRRI's small business link



NRRI congratulates the UMD Center for Economic Development on their 20th anniversary! The Center for Economic Development was formed in 1986 and rapidly grew to accommodate a broad entrepreneurial client base. NRRI recognized early on the importance of healthy entrepreneurial and small businesses to the regional economy and partners with the center through the NRRI Business Group.

Each year, the Center for Economic Development counsels about 10 percent of the region's small businesses and conducts over 300 workshops. NRRI's Business Group specializes in the commercialization of natural resources and development of new markets for existing natural resource-based products.

The mission of the Center for Economic Development is to assist entrepreneurs and help businesses grow and succeed. Their vision is to strengthen the viability of the region as a recognized leader in small business and entrepreneurial development.

Check us out: www.nrri.umn.edu

The Natural Resources Research Institute was established by the Minnesota Legislature in 1983 to foster economic development of Minnesota's natural resources in an environmentally sound manner to promote private sector employment.

Michael Lalich, director

Center for Water & the Environment

Gerald Niemi, director

Center for Applied Research & Technology Development

Donald Fosnacht, director

Center for Economic Development

Elaine Hansen, director

NRRI Now

Nora Kubazewski, managing editor

June Kallestad, editor/writer

Trish Sodahl, graphic design

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Natural Resources Research Institute

University of Minnesota, Duluth

5013 Miller Trunk Highway

Duluth Minnesota 55811-1442

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