



NATURAL RESOURCES RESEARCH INSTITUTE

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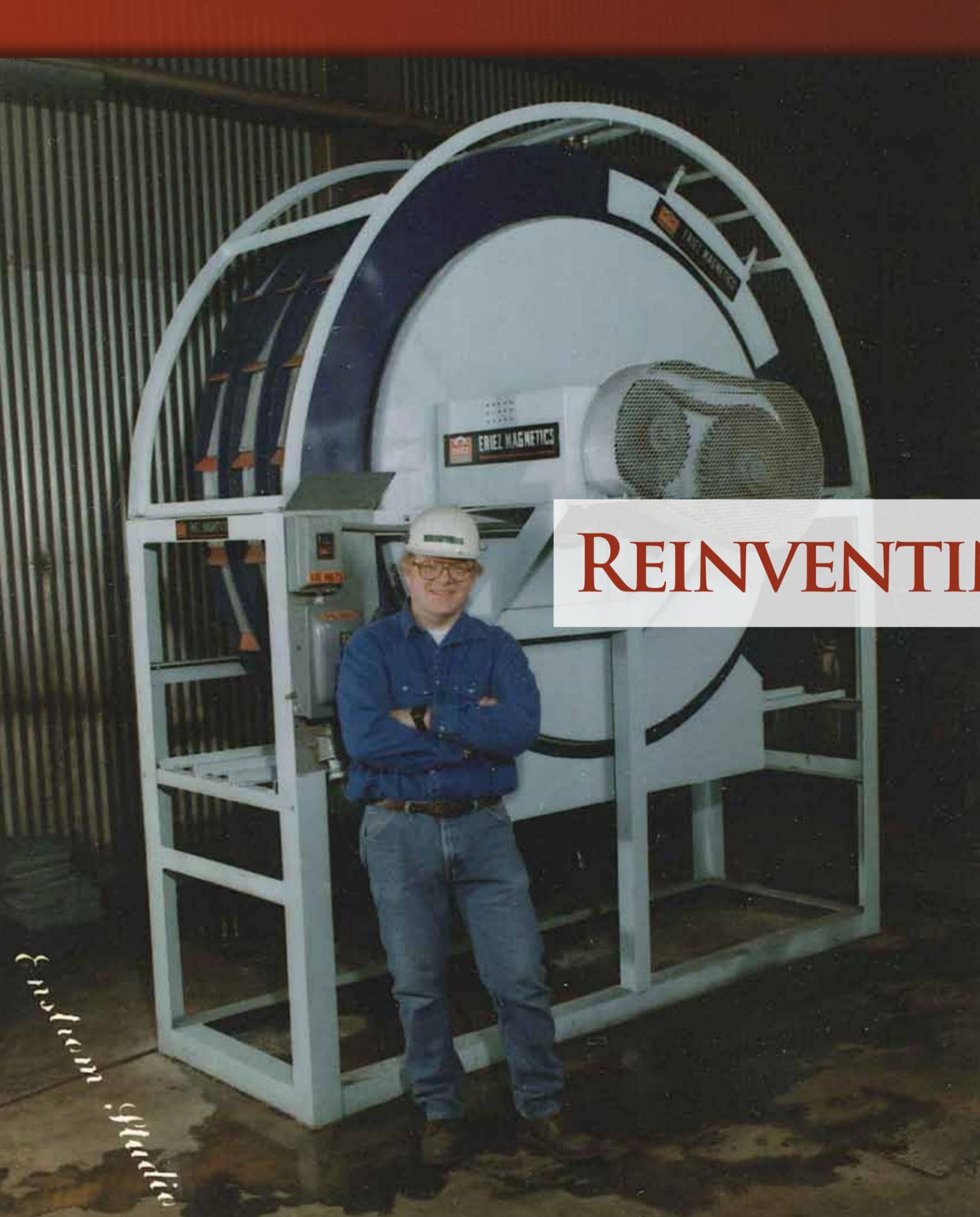


*It started with an idea . . . and grew
into a new Iron Range industry.*

~ Growing Strong Industries

~ Developing New Ideas

~ Nurturing Natural Resources



NRRI assists with early research that leads to new Iron Range business

Natural ore mining (the precursor to today's taconite mining) has long ended on Minnesota's Iron Range, but the tailings piles – waste rock leftover from the process – remains. Since it's already blasted, it makes sense to pull any remaining iron ore from it. All that's needed is an efficient way to extract it.

Alan Fritz of Grand Rapids had an idea, and with some assistance from NRRI, a business partner, and a

With only 20-30 percent weight recovery, however, "it wasn't the greatest in the world," Fritz admitted.

But that early research eventually led to a new Minnesota Iron Range business, Magnetation, Inc., with business partner Larry Lehtinen as chairman. Lehtinen became interested in the idea of recovering ore from natural ore tailings. In the end,

REINVENTING THE (FERROUS) WHEEL

bit of serendipity, it has grown beyond the initial idea to a new Iron Range industry.

As a mine superintendent at the now-defunct J & L mine, Fritz witnessed poor attempts at reclaiming ore from their two tailings plants. Then he heard that MIT (Massachusetts Institute of Technology) found a way to recover iron oxides from previously mined taconite. But when he saw the MIT equipment, he wasn't impressed.

"So I started fooling around in my garage with different tailings from around the Iron Range. And I found out, yes, I could do this with rather high intensity magnets," Fritz said.

This led to an invention he called the Ferrous Wheel which proved to be successful at extracting good iron ore from waste tailings piles. NRRI Technician Jerry Lien helped to machine the parts and they built a pilot-scale model from scratch at NRRI's Coleraine Minerals Lab.

Basically, the Ferrous Wheel used the magnets and a screen matrix to separate the good ore from the worthless rock.

"Al made some models of the process and we just made it bigger," said Lien of the invention.

however, the Ferrous Wheel proved to be difficult to operate and maintain.

"The Ferrous Wheel got us started, but we needed to reinvent," said Lehtinen. "We learned things from it, but now we have a new process, the Rev3 Separator, with very high uptime and a very efficient process."

Lehtinen's engineers took out their pencils and reconfigured the process so that the materials flow with the natural pull of gravity on a turntable style, instead of upright like the Ferrous Wheel, among other innovative changes.

In early 2011 Cargill signed an agreement to jointly develop the technology with Magnetation and market the iron concentrate internationally. Cargill's investment enabled Magnetation to boost production from 150,000 to 450,000 tons per year on two Rev3 Separators.

"NRRI offered support and Jerry Lien did a lot of work with me on the Ferrous Wheel," said Fritz of starting the project.

"Now we're growing rapidly and our technology continues to improve, but it all started with Al's early work on the original Ferrous Wheel," said Lehtinen. "If it wasn't for his persistence we wouldn't be where we are today."

Cover: The new Rev3 Separator at Magnetation, Inc.

Left: Jerry Lien with the prototype Ferrous Wheel in 1999

Nurturing Success

Duluth businesses thrive with NRRI research



2000 – UMD’s Center for Economic Development introduces the entrepreneurs to NRRI and a long-term relationship ensues. **NRRI** conducts time studies to compare cutting ramp parts by hand vs. using CNC cutting technology. True Ride invests in CNC machines.

1997 – Greg Benson, Dave Benson and Tony Ciardelli launch TrueRide, in Hamel, Minn., to design and build custom municipal skate parks. They opened with a 1,200 sq. ft. shop and soon expanded to 2,400 sq. ft.

1999 – The men move their business to Duluth, to a 6,000 sq. ft. facility on Bergquist Road. They expand each year to 25,000 sq. ft. before moving again.



2001 – **NRRI** conducts performance testing of True Ride skate park products and cooperates on product development testing of a new cutting board product manufactured from Richlite, the waste pieces of skating surface.

2003 – **NRRI** conducts the first of several lean manufacturing training and continuous improvement projects. The first project team, “Streamliners,” improves logistics on the True Ride manufacturing floor by 30% and reduce floor space requirements by 50%.



2003 – Epicurean Cutting Surfaces is launched using Richlite. The material is Forest Stewardship Council certified paper and also recycled paper. **NRRI** conducts ultraviolet light and freeze/thaw testing on the product.

2004 – **NRRI** conducts extensive performance testing to the skate ramp materials, simulating exposure to weather extremes found around the world. This establishes a baseline for evaluating new materials in the future.



2004 – Distribution of Epicurean boards in Duluth and Minneapolis begins. The company sells a few hundred the first year. (By 2011 they’re selling well over a million annually.)

2005 – The men form Hawks Boots, LLC to purchase a building to house True Ride and the new and rapidly expanding businesses. The site was a contaminated brownfield that the company restored, and redesigned with the help of renowned architect David Salmela.

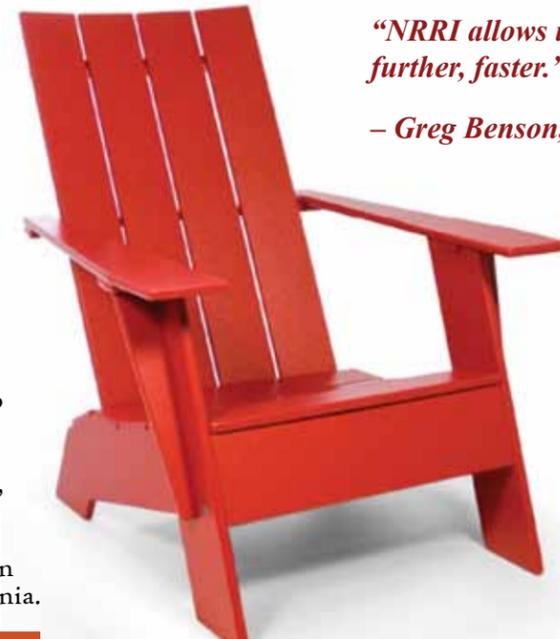


2005 – In an effort to use their material to its fullest, parts for Adirondack styled chairs are nested into the CNC router files with skate park components. The tough skate park material is structural, durable, free, and maintenance free, making ideal outdoor furniture.

2006 – Loll’s Adirondack collection is launched online on Thanksgiving Day. The modern design and durable, recycled material was an immediate hit. The company sold a few hundred chairs the first year. (By 2011, they sell more than 10,000 products annually.)

2007 – After building over 450 custom designed skate parks all over the country, TrueRide is sold to skate park competitor Spohn Ranch in California.

2007 – **NRRI** is an ongoing cooperator, helping to implement new production processes for Loll and Epicurean to meet increasing orders. Performance testing continues to help Loll select high performance materials and Epicurean to assess accelerated aging of their cutting board products.



“NRRI allows us to do more and progress further, faster.”

– Greg Benson, President/CEO, Loll



2009 – Epicurean boards are sold in over 5,000 retail stores throughout the U.S. and Canada and in over 50 countries throughout Europe, Asia, Australia, and North America.

2010 – The Hawks Boots building is bursting at the seams. Both Epicurean and Loll have had double digit growth right through the current recession. The search for a separate facility for Loll Designs begins.

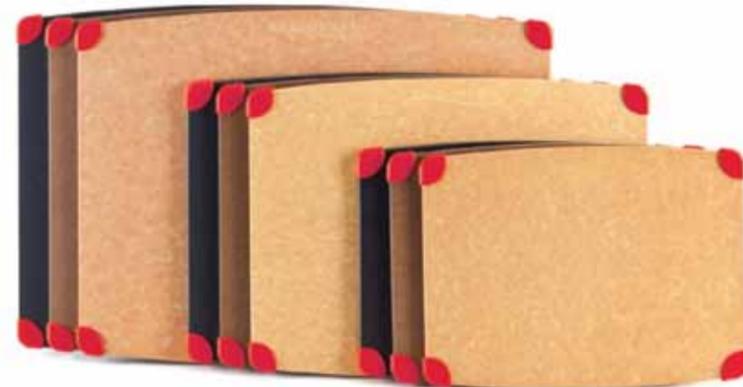
2010 – A third business, Intectural, is formed to focus on distribution of innovative architectural materials which have a commitment to conservation and sustainability.

2011 – Loll production moves to an old Michelina’s facility formerly owned by Duluth businessman Jenno Palluci, now owned by Weston Wier.

2011 – Epicurean, Loll and Intectural continue to build on their 11-year relationship with **NRRI** to support their sustainable growth by helping them create and implement efficient manufacturing practices and develop high performance products.



EPICUREAN®



“NRRI’s lean training really helped us with manufacturing efficiency as a first thought, not an afterthought.”

– Tony Ciardelli, President/CEO, Epicurean

Long days, hard work: Field season 2011

Not only is field season a great learning experience for college students interested in biology, ecology and the natural world, it just flat out tests their stamina. Two of NRRRI's projects required a full summer of waders in the water.

Eight field workers sampling for fish and bugs, and another two collecting vegetation data, got their training in the St. Louis River Estuary in June. From there the crews set out to put their new skills to the test. Starting in Green Bay, Wisc., the crew worked their way along the Great Lakes coast back to Duluth, then north to Thunder Bay, Ontario.

In spite of putting in long days, the crew enjoyed their summer job - catching fish and observing wildlife while getting paid for it.

"They put in long days," said Valerie Brady, field coordinator and NRRRI scientist for the Coastal Wetland Monitoring project. "They would start at 7 a.m. and work until sunset, then still had to process the water samples back at their motel. We swapped out crews every week so we didn't wear them out."

The crews collected data about the fish and aquatic bug communities, along with surveying the wetland vegetation for Brady's project and for a second project, phase two of the Great Lakes Environmental Indicators project led by Lucinda Johnson, director of NRRRI's Center for Water and the Environment. They also noted wetland bottom types and collected samples to test for water quality.

"Basically they were out there carefully and thoroughly observing and gathering data on the coastal zones to help us understand how we can safeguard these ecosystems that are so important to Great Lakes fish and birds," said Brady.





Geologist Jim Miller (left) with workshop participants.

NRRI geologists educate educators on earth resources

"It's one thing to read about it in a book, but getting out and touching, seeing, getting your hands in the soil... it puts it all in perspective."

—Teacher Laurie Severson

From the shower nozzle in your bathroom and the spoon in your cereal bowl (including the clay bowl itself) to transportation and televisions – everything we use is either grown or mined. Whether we notice it or not, we rely heavily on our earth resources.

And we rely on teachers to help students understand the role of mining in our society.

UMD–NRRI Geologist Jim Miller has been helping to educate the educators through the Minnesota Minerals Education Workshops since its inception in 1997. This summer, he and other local geologists focused on helping teachers understand the wide variety of mining careers, as well as updating them on what's new in Minnesota's ancient geological formations.

"Our goal is to educate teachers about the geology and mineral resources in their school districts," said Miller. "We emphasize the importance of educating

students about the critical role that minerals play in their everyday lives. As earth science educators, our job is to teach the next generation to become responsible stewards of the earth's non-renewable mineral resources."

The group of about 76 K-12 educators started the workshop in familiar territory – in the classroom – with a choice of short courses on things like "The Roadside Geology of Minnesota" and "Mineland Reclamation." Then they got up close to the huge drilling machinery of the industry, went to a mining museum and looked at rocks, rocks and more rocks.

Middle School teacher Laurie Severson has been teaching earth science in Duluth for 25 years. She goes to the mineral workshop to get questions answered by experts, refresh her knowledge and get out in the field to collect new rock samples.

"It's like when kids go on field trips. It's one thing to

read about it in a book, but getting out and touching, seeing, getting your hands in the soil... it puts it all in perspective," said Severson. "Kids who have a rock collection or an agate, they're interested in knowing how it got there. And in Duluth, there's so much geology to see in your own backyard."

The Minnesota Minerals Education Workshops are sponsored by the Minnesota Center for Mineral Resource Education, a non-profit organization staffed by volunteers from academia, state government, and the mining industry. The Precambrian Research Center, a joint program of NRRI and UMD's Department of Geology, has volunteered to be the principal organizing agency for the 2011-2013 teacher workshops. Volunteers and donations from industry and private individuals keep registration costs low for participants. Visit www.mmew.org for more information.

Building a better tool NRRI's prototype lab improves chemical testing

Steve Kossett was ready for a challenge. So when UMD Civil Engineering Professor Nate Johnson came to NRRI's rapid prototype center with an idea to improve his research Kossett said, "Let's give it a try."

Johnson uses voltammetric microelectrodes to measure the chemicals in river bottom sediments. To get accurate water concentration measurements between sediment particles with the least disturbance possible, the electrodes need to be tapered long and thin with an outer tip diameter no bigger than one millimeter.

"And one millimeter is fairly large, actually," said Johnson. "But the smaller it is, the more fragile."

Add to that tiny girth that the tapers are typically made of pulled glass. Rigid, but brittle indeed.

So Johnson's idea was to make a custom taper at NRRI's rapid prototyping center out of a less brittle material. Kossett, prototype center director, suggested an epoxy-based material using the laser precision of the stereolithography machine.

Even so, building the thin three-inch long taper with a tiny hole at the end was a challenge and tested the limits of the machine.

"But it worked better than I anticipated," said Kossett.

Johnson and Kossett worked on a half dozen different taper designs and chose a final design that has been working well in the lab.

"We took some samples in the St. Louis River estuary to measure chemicals, dissolved oxygen, iron and sulfide," said Johnson. "And we've had great success measuring vertical profiles that show depths at which different chemicals occur."

The custom designed taper and more durable voltammetric electrodes will help the scientists understand how hazardous chemicals move through the environment.

NRRI's Northern Lights Technology Center has four different technologies for rapid prototyping – stereolithography, selective laser sintering, fused deposition modeling and two 3D printers. Each machine has different capabilities and can use different materials to build limitless items. For more information visit www.nrri.umn.edu/nltc or email Steve Kossett at skossett@nrri.umn.edu.



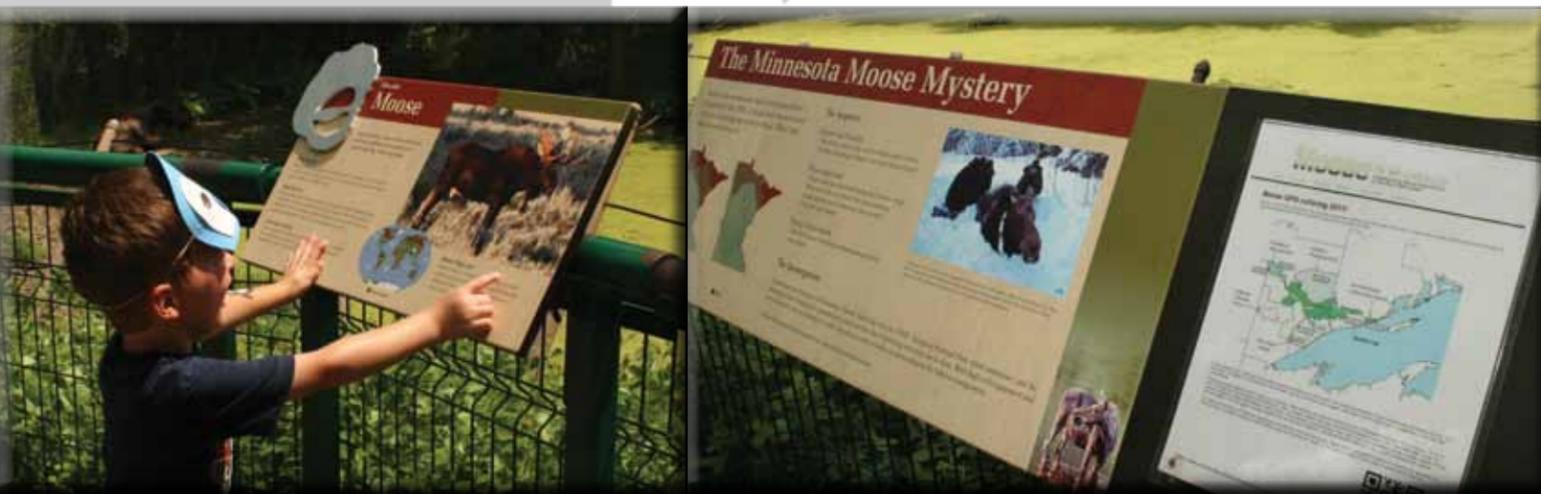
Above: Tapered electrodes sit in deionized water between use. Insert: A microelectrode tip is lowered into sediments collected from the St. Louis River estuary testing it for toxic chemicals.

It's long been said that the only constant is change -- and change has come to our Minnesota moose. The northwest moose population declined from over 4,000 to about 100 in the 1990s, and the northeast population has declined from over 7,000 to less than 5,000 over the past five years.

NRRI Scientist Ron Moen has been studying the decline in moose populations in northeastern Minnesota for the past three years. Now he is sharing what he's learning with Minnesota Zoo visitors. As part of a grant from the Environment and Natural Resources Trust Fund, The Minnesota Zoo developed new interpretive materials with Moen to help people learn about moose in Minnesota, and to provide information on how climate change can affect moose.

Mixing with moose

Zoo-goers get fresh information about Minnesota's "super deer"



"The Minnesota Zoo gets 1.3 million visitors a year and is the state's largest environmental education resource," said Steve Boyd-Smith, interpretive planning lead at the zoo. "We've had moose here on the Northern Trail for a long time, but it was time to update the content and the look. Ron provided us with new information that we can easily update as we continue to learn more."

To give visitors a sense of how big these creatures are the zoo commissioned a local artist to build two life-sized metal moose. And

Boyd-Smith plans to check in often at the Moose in Minnesota website (www.nrri.umn.edu/moose) that is regularly updated with new research by Moen and his team.

"Moose are the biggest of the northern species that live in Minnesota," explained Moen. "People care about moose, and one part of this project is learning how we can manage habitat to keep moose in Minnesota."

The zoo project and the use of GPS collars to track moose in Minnesota

are funded by the Energy and Natural Resources Trust Fund which is administered by the Legislative-Citizens Commission on Minnesota Resources. The zoo/public education portion is part of a much larger project that includes Voyageurs National Park, the Grand Portage Indian Reservation and other tribal bodies, as well as Quetico Provincial Park in Ontario.

Visit the Moose in Minnesota website for more information and a complete list of project cooperators.

A BETTER CORN BIOFUEL

PILOT PRODUCTION OF ETHANOL EXTRACTIVES BEGINS

The idea behind corn ethanol is to reduce U.S. reliance on oil imports and build a biofuel infrastructure, but production of ethanol itself is energy intensive. It takes one unit of fossil fuels to produce 1.3 energy units from the resulting ethanol.

Still, at least into the foreseeable future, ethanol is here to stay. So NRRI chemist Pavel Krasutsky, a master of extraction, took a long hard look at the by-product of the corn ethanol process: the Distillers Dried Grains and Solubles (DDGS). What he discovered is that this low-protein mash, often used for cattle and swine feed, holds more value than was realized.

NRRI funded the initial research, followed by \$250,000 from the Initiative for Renewable Energy and the Environment at the University of Minnesota, which recently kicked in another \$60,000. This was added to \$100,000 from the Minnesota Corn Growers Association and another \$40,000 from NRRI. This funding will allow Krasutsky and his team to move his promising research from the lab to the pilot scale.

Using his patented process on the DDGS, Krasutsky extracted oil and carbohydrates to make biodiesel fuel, zein (a protein used in a wide variety of products), and glycerol and carbohydrates to make additional ethanol. The extraction process also enhances the protein level of the DDGS making it a more desirable feed product.



Brian Garhofer, Pavel Krasutsky, Pam Sarvela at Crown Iron

"The pilot scale work on the extraction process has exceeded expectations. Now we're working on the biodiesel production." — Project Manager Brian Garhofer

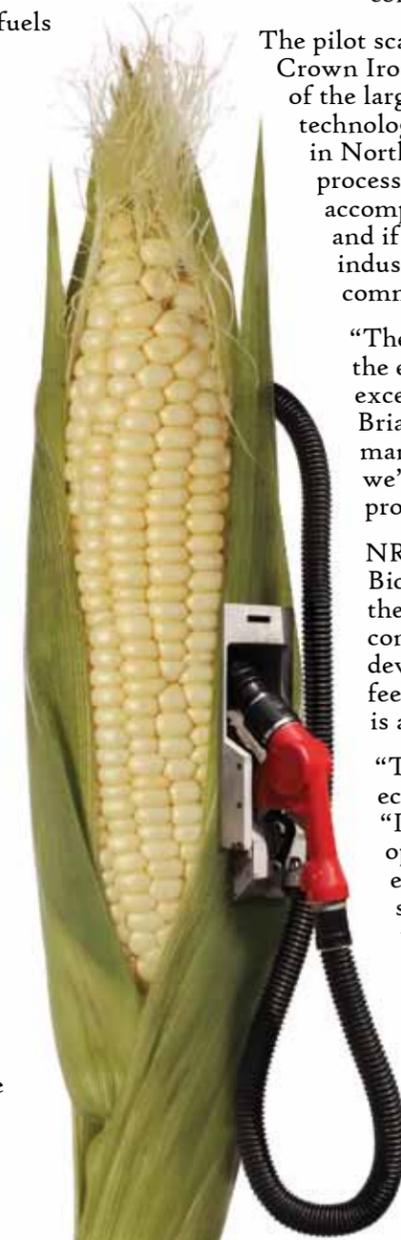
"The ethanol co-product, the DDGS, is a very cheap product," Krasutsky explained. "From this cheap feed we are producing 20 percent more biofuel and at the same time increasing the feed value, increasing the protein concentration by 15 percent."

The pilot scale work is taking place at Crown Iron Works in Minneapolis, one of the largest suppliers of extraction technology and refining equipment in North America. There the process will prove out what can be accomplished at the plant scale, and if successful, will attract industry partners leading to commercialization.

"The pilot scale work on the extraction process has exceeded expectations," said Brian Garhofer, a contracted manager for the project. "Now we're working on the biodiesel production."

NRRI is working with Glycos Biotechnologies, Inc., using their patented process to convert glycerin to ethanol. The development of animal specific feed with the high protein grain is also underway.

"This has really good economics," said Garhofer. "It could keep ethanol plants operating on a profitable level, even in hard times. We have some leading industry players very interested in this."



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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.

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Taking the internship by the horns

Student from England sets sights on NRRRI



Jamie Rogers, a third year student at the University of Birmingham in England, had no idea how to apply his interest in environmental science to the real world. But he knew that NRRRI does this very well. So he decided to hop the pond and spend some time with the Center for Water and the Environment as an intern.

And he didn't let the fact that NRRRI had no funds for this placement stop him.

Rogers learned of NRRRI's applied environmental research through one of his professors. He had also travelled through Duluth on a summer trip to the

U.S. years before and thought it was lovely. So Rogers sacrificed and saved to fund and organize his own six month internship at NRRRI.

"I found it particularly interesting that NRRRI had so many research projects into the practical application of ecology and its relationship with human activities," said Rogers. "To make informed decisions about future careers, I felt I should know what it's like to actually work in environmental research and protection."

His moxie paid off. Center Director Lucinda Johnson welcomed Rogers into the fold and put him to work in three areas: Great Lakes Worm Watch, amphibian research, and Geographic Information Systems (GIS) lab work.

And what was Rogers' biggest surprise? Learning that European earthworms are an invasive species in Minnesota's hardwood forests.

"I found that to be surreal," he said. "But seeing what they do at Great Lakes Worm Watch helped me develop a greater understanding of the importance of environmental education."

Rogers is now in his final year at the University of Birmingham with a dissertation still to accomplish ("Privatization of the Public Forest Estate: A multiple stakeholder perspective") and an impressive list of new skills on his resume.

"The internship was one of the most valuable things I have ever done," Rogers added. "It helped me grow academically and professionally, but I also developed socially. People in England are very reserved, but everyone I met in Duluth was very nice and open."

And now he can brag about enduring -10 degrees F with wind chill.