



# NATURAL RESOURCES RESEARCH INSTITUTE

# NRRI *Now*

Spring/Summer 2009

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Lab Director Pavel Krasutsky works with his team to extract bio-chemicals

~Growing Strong Industries

~Developing New Ideas

~Nurturing Natural Resources



*Michael J. Lalich*

## CLOSE TO HOME: FOREST-BASED BIO-FUELS

My colleagues and I continue to assess alternative energy opportunities, but sorting through candidate technologies is complex. We need technologies that contribute to more energy independence for the United States, and also consider environmental impact – including climate changing greenhouse gases (CO<sub>2</sub>, methane). Development and deployment of these technologies on a meaningful scale

will depend on governmental policies that will drive public/private partnerships and somehow level the economic playing field when compared to fossil fuels.

So.....what can NRRI do in the face of this rather daunting situation? In part, we can focus on regional program niches that will contribute to comprehensive alternative energy solutions.

Consider the forest products industry. With the loss of our area's three oriented strand board mills and other contractions in this sector, our attention should be on keeping our region's logging infrastructure viable. We have all read about efforts in our region to develop wood pellet companies which would rely on forest residues from logging operations and, perhaps, on under-utilized tree species. In this sense, they would provide valuable logging jobs and complement rather than compete with existing paper and forest products companies.

Assuming wood pellets can be economically competitive, there is another very important consideration. Pellets need to meet quality and uniformity standards, which is no small task. This need to focus on standards was driven home to me in recent months. This winter, I visited a wood products company on one of our ultra cold days. One of the employees was struggling to heat his home with wood pellets because of freezing in the stack venting system caused by high moisture in the pellets. Later that day I was at a meeting where an institutional wood-fired boiler user had a conversation with a wood residue supplier. Each had varying opinions on what should be accepted in terms of wood residue quality for pellets. In another instance, a homeowner explained to me that she routinely buys a bag of pellets and carefully watches how it seems to perform in her furnace. She will buy multiple bags of the pellets only if they perform adequately.

These are not conditions on which to build a successful industry. Consumers need to be able to depend on quality and reliability. Fortunately, we can overcome these obstacles and we need look no further than our taconite iron ore industry for guidance. Our region takes low grade ores, delivers them to plants for upgrading by pre-treatment to produce a quality product (taconite pellets). Similarly, logging residues can be treated to remove ash, moisture and to remove or control volatiles. The consumer would have a consistent quality product. In fact, the concept can be taken one step further to produce a "universal" fuel by using torrefaction to produce a bio-coal, or a coal substitute.

On the surface it may seem simple. However, if you consider some of these technological and resource management factors—in addition to related economic, government policy and resource management issues—the situation is complex. Nonetheless, I believe commercialization of woody biomass for energy is a viable opportunity. NRRI is working with collaborators to help make it happen.

# BUILDING BLOCKS FOR NEW PRODUCTS

**NRRI serves industry with  
CASEO chemical library**

**N**ew products drive the economy and chemicals often drive new products. But there can be an unhealthy side to synthetic chemicals, so scientists are increasingly turning to chemicals derived from nature.

NRRI's Chemical Extractives Laboratory holds many patents for separating valuable chemicals from plants and natural resource industry by-products. Now the lab is making it easy for bio-product businesses—agri-chemical, pharmaceutical, cosmeceutical, and nutraceutical—to have access to a large selection of chemicals. This will save industries time and money in the costly development of new products.

"There are hundreds and thousands of chemicals that could be interesting for biological research, screened against pathogenic diseases, applied to anti-viral, anti-bacterial products..." said program director Pavel Krasutsky. "Chemists in those industries can search our library to fill a need they may have."

# C

CHEMISTRY

# A

ANALYSIS

# S

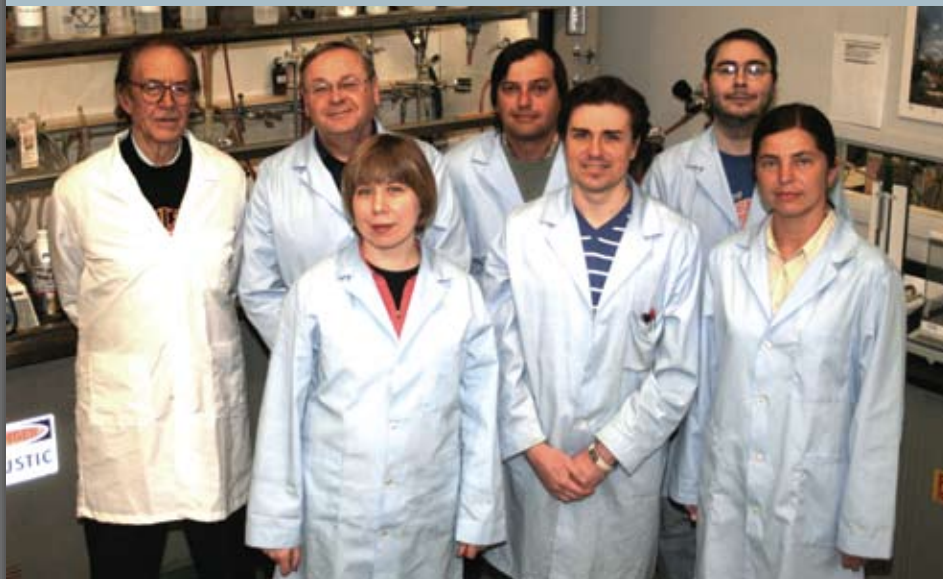
SYNTHESIS

# E

EXTRACTION

# O

OPTIMIZATION



The NRRI Chemical Extractives Team: (Back row, from left) Wolfgang Hechtl, Pavel Krasutsky, Oleksiy Kacharov, Jonathan Lee, (front row, from left) Oksana Kolomitsyna, Sergiy Yemets, and Liliya Kacharova.

NRRI is calling this new venture CASEO: Chemistry, Analysis, Synthesis, Extraction and Optimization, and it holds the promise of providing samples of thousands of high-value chemicals.

*“There are hundreds and thousands of chemicals that could be interesting for biological research, screened against pathogenic diseases, applied to anti-viral, anti-bacterial products... Chemists in those industries can search our library to fill a need they may have.”*

– Dr. Pavel Krasutsky

To effectively market CASEO’s potential, NRRI is seeking to partner with another provider of custom chemistry services, chemical building blocks and screening libraries in order to offer one of the largest and most diverse proprietary screening collections of small organic compounds in the world.

“A chemist can look at the chemical structures, analyze whether or not it will work for them and then request a supply—from 10 milligrams to 100 grams,” Krasutsky explained. “We have the capacity to produce up to 100 kilograms of chemicals for new drugs, hair care and cosmetic products, whatever need their industry has.”

NRRI’s Chemical Extractives Lab is especially well known for extracting betulin, betulinic acid, and its derivatives—long used in cosmetics—from birch bark. Betulinic acid was first identified

as having properties that fight carcinogenic melanoma. Especially remarkable are the biological and medical benefits of birch bark triterpenoids—a new class of anti-cancer and anti-HIV bioactives that attack the disease in a new way.

The patent portfolio from the Chemical Extractives Lab is the largest in the University of Minnesota system. To learn more about the services offered by the CASEO Service Center at NRRI visit [www.nrri.umn.edu](http://www.nrri.umn.edu) and click on the Chemical Extractives link.

### DID YOU KNOW



- ◆ Cosmeceuticals are a \$5.8 billion industry in the U.S.
- ◆ Pharmaceutical companies invested \$58.8 billion in research and development in 2007.
- ◆ Nutraceuticals are food, or parts of food, that provide medical or health benefits, including the prevention and treatment of disease.

# For the birds

New York has two. Pennsylvania is working on its second. Wisconsin just finished their first.

And finally, Minnesota—with its major continental flyway along the Mississippi—will join the other 47 states that have a comprehensive Breeding Bird Atlas. The six-year project gets underway this spring to assess how many breeding bird species there are, and where, across the entire state. It will also provide baseline data to monitor changes in their populations.

NRRI is leading the scientific data-gathering and analysis portion of the project. And it's familiar work for NRRI ornithologist and scientist Jerry Niemi. For many years, Niemi provided leadership for the institute's long-term bird monitoring program in the Chippewa, Superior and Chequamegon national forests.

"This atlas project is consistent with the methodology we've used on the national forests," said Niemi. "We're taking our scientific approach and going statewide."

Over the next five years, NRRI's newly hired and highly trained birding team will listen and watch for breeding birds in every township in Minnesota—some 2,300—for three 10-minute counts. This

summer is the trial run to figure out how long the process actually takes.

By 2016, Minnesota will have scientifically observed and documented data on the estimated 225 to 250 bird species that breed here each spring, along with maps, charts and graphs.

A second part of this extensive study will incorporate the findings of almost 1,000 volunteer birders across the state. Minnesota Audubon is seeking bird enthusiasts across the state and will coordinate the data collected from them. Because of the inconsistencies in volunteer skill levels, time, and numbers, Niemi said NRRI will use a limited amount of the volunteer information in their study.

"No state that I know of has used the scientific point count approach that we use, but the ones I've talked with said they wished they had," Niemi said.

NRRI's funding will also allow Niemi to send observers to areas that are very remote, like the Boundary Waters Canoe Area Wilderness and the Red Lake Peatland.

Baseline data on breeding bird populations is critical for measuring the health of bird populations, ecosystems, and understanding how people affect the landscape. NRRI's project is funded by the Legislative-Citizens Commission on Minnesota Resources.





# Count begins for Minnesota Bird Atlas

## HOW POINT COUNTS ARE DONE

As the sun rises during bird breeding season (June 1 to July 10), observers trained and tested to identify the songs of over 80 different bird species go into the woods and listen. Listen carefully. They make notations on a clipboard to indicate bird species they hear inside and outside a 100 meter radius.

Observers also record the minute they heard the bird and information about its behavior—singing, calling, carrying nesting material, or whether it's a sight observation.

# NRRI research leads to new use for taconite rock

## Iron Range aggregate heads for Chicago via tug/ barge



Since 2001, NRRI has been intensely studying taconite aggregate—a hard, durable rock material found in superabundance on Minnesota’s Iron Range. Over the years, the research has shown that, if properly integrated into highway mix designs, by-products of the mining industry could decrease the life-cycle cost of highway and railway construction, as well as reduce the need for new stone and gravel quarries throughout the United States.



The most recent four-year study, “Research, Development and Marketing of Minnesota’s Iron Range Aggregate materials for Midwest and National Transportation Applications,” demonstrates the use of taconite materials in real highway construction applications, while focusing on the economics, markets and environmentally-wise use of this resource. The end result should be expanded production and use of taconite-based materials (taconite concentrate, coarse taconite tailings, taconite blast rock, coarse crushed taconite rock and ore) for highway, railway, airport, and waterway infrastructure projects.



This research program is funded by the U.S. Department of Commerce (Economic Development Administration), with matching funds from Iron Range Resources, the Blandin Foundation, Minnesota Power, Minnesota Technology, Inc., and the University of Minnesota Permanent Trust Fund.

The aggregate project has been comprehensive, covering historical, current and potential applications for the various materials produced during iron ore mining and processing. It also investigates the logistical and economic aspects of moving taconite by-products to market and various opportunities for the material, comparing the quality to materials currently used.

Areas of research covered in this overall project include:

- The geology of taconite aggregate
- Formulation of taconite rock use in highway mix designs
- The development and licensing of highway repair compounds
- Using microwave technology for pothole repair and deicing
- The use of coarse tailings as friction materials
- The development of slurry seals and stone matrix asphalt products using mining by-products
- Demonstration programs using various aggregate products
- The logistics of using products from our taconite operations
- The overall possible applications that can be developed using the various materials
- The potential for new commercial development using these aggregate opportunities

### NRRI RESEARCHERS INVOLVED IN THE STUDY:

- Don Fosnacht - Co-Principal Investigator
- Larry Zanko - Co-Principal Investigator
- Steve Hauck, Deputy Director, Economic Geology Group
- Mark Severson, Geologist, Economic Geology Group
- Tamara Diedrich, Group Leader, Particle and Materials Characterization
- Dick Kiesel, Program Director, Coleraine Minerals Research Lab
- Blair Benner, Program Director, Coleraine Minerals Research Lab
- John Heine, Scientist, Economic Geology Group
- Marsha Patelke, Scientist, By-Product Use and Remediation Group
- Julie Oreskovich, Scientist, Economic Geology Group
- Devon Brecke, Sr. Lab Technician
- Robert Peterson, Student Assistant

### INDUSTRY/ORGANIZATION COOPERATORS

- Supply:**  
Iron Range taconite mines
- Private Sector:**  
Laurentian Aggregate of Duluth  
Superior Coating Specialists of Proctor
- Mix Design Development:**  
University of Minnesota Dept. of Civil Engineering
- Logistics Study:**  
University of Wisconsin-Superior  
Prime Focus, LLC  
Tinklenberg Group
- Microwave Applications:**  
David M. Hopstock & Associates, LLC
- Other Cooperators:**  
Minnesota Department of Transportation (Mn/DOT)  
Other Midwest and Great Lakes state

## ***NRRI processes copper-nickel ore from Teck's Mesaba Deposit***

**M**ining has long been an economic backbone for Minnesota, fluctuating through the decades with the value of ore. Today, there's a new mining horizon waiting to be tapped—rich copper, nickel, palladium, platinum, cobalt and gold possibilities from the Duluth Complex along the northeastern corner of the state.

NRRI—a committed research partner for Minnesota's taconite industries—is now posing itself to carry on the same kind of bench-to-pilot scale research for copper-nickel processing by bolstering its hydrometallurgical laboratory capabilities.

NRRI's non-ferrous expertise is already in demand. Teck Cominco, a \$6.9 billion diversified mining company, asked: Could the Coleraine crew process 1,500 tons of copper-nickel ore from its Mesaba Deposit in just 12 weeks? Using a rod mill, ball mill, flotation cells and disk filter equipment from pilot scale taconite processing—and hiring 16 additional technicians to work around the clock—the Coleraine lab answered “yes.”

Fifteen hundred tons of mined rock were crushed, classified and concentrated to produce a 20 percent copper flotation concentrate which was sent to Teck Cominco's hydrometallurgical lab in Vancouver, Canada.

“We're here. Their deposit is here. It saves them a lot in efficiencies to have the copper separated from the tailings here instead of shipping it all north,” said Dave Hendrickson, Coleraine Lab director. “And we got the copper recovery they needed.”

As NRRI develops its new hydrometallurgy lab capabilities, Hendrickson envisions boosting the efficiencies of non-ferrous mining in much the same way NRRI has improved the taconite pellet processes over the decades.

“Copper-nickel processing is well researched, but you can always make the process better,” said Hendrickson.

Duluth Metals and Franconia Minerals are also talking to Hendrickson about future non-ferrous minerals research projects. And if PolyMet's Environmental Impact Statement (EIS) is approved, their NorthMet mining venture in northeastern Minnesota will begin.

Minnesota has one of the largest copper-nickel deposits in North America, along with other minerals needed by industrialized countries. The diversity of minerals in this area makes it even more economically feasible to mine because the value of each metal product is high.

“It's long been known that Minnesota has rich non-ferrous deposits,” said Hendrickson. “One of NRRI's earliest goals has been to define the economically viable minerals in Minnesota, so that exploration companies would be motivated to refine their technologies to extract them. We're at that point in history now.”



Blair Benner directs the Mineral Processing and Hydrometallurgy program at NRRI's Minerals Research Laboratory in Coleraine, Minn., and coordinated the Teck Cominco copper-nickel processing project.



# Down the Drain

## Low water levels in the Great Lakes spur NRRI report



Soo Locks at Sault St. Marie

**R**ecord low water levels in the Upper Great Lakes are tough on recreation, property values, habitat diversity, and commercial navigation.

Precipitation and evaporation drive the lake levels and the past 10 years have been particularly hard on Lakes Michigan and Huron which recently were 15 inches below average. Lake Superior was nine inches below average in January 2009 according to NOAA.

The International Joint Commission is addressing this by asking the Army Corps of Engineers and Environment Canada to examine six core areas of concern related to low water levels in the Upper Great Lakes. The information will be used to further discussions on lake levels regulated by the Soo Locks at Sault St. Marie. Currently, flow from Lake Superior into Michigan-Huron is 75,200 cubic feet per second.

NRRI was asked to use knowledge gained during the Great Lakes Environmental Indicators project and other published information to prepare a report titled “Ecosystem Responses to Regulation-based Water Level Changes in the Upper Great Lakes.”

“This is going to be a big issue over the coming years,” said NRRI scientist Jerry Niemi who is co-lead investigator on the project. “The water levels have been going down for a number of years and with the projections from climate change models, the water levels may decrease even more.” Jan Cibrowski from the University of Windsor, Ontario, is the other co-lead investigator.

The 40-plus page report has already been well received by regulatory agencies that need to understand the responses of a variety of bio-indicators—endangered/threatened species, birds, amphibians, fish, water quality, and invasive species—to water level changes. Water level fluctuations also affect nitrogen and metal cycling, and the microbiology in the ecosystems.

“This report brings together the science of what’s known about water level changes, with respect to these important indicators, that should be measured and examined,” said Niemi.

A copy of the complete white paper can be downloaded from NRRI’s Web site at [www.nrri.umn.edu/cwe](http://www.nrri.umn.edu/cwe).

# Restful reservoir

## Do changing water levels affect nesting waterfowl?

**H**ydropower is nothing new—think watermills for grinding grain. Today, hydroelectric power is an important energy source—it’s clean, renewable and, compared to fossil fuels emits very low levels of greenhouse gases (Environmental Literacy Council).

Minnesota Power manages hydroelectric facilities on five reservoirs in southern St. Louis County which are important in other ways, too. They’re home to over 30 species of waterfowl. And when you live in a reservoir, timing is everything.

To make energy on demand, the water flow is carefully controlled, which makes it a different habitat than a natural lake. There’s a gradual draw-down of water throughout the winter—as much as 10 feet in some lakes—with refill beginning in late March, and usually complete before June 1. But some waterfowl (geese, ducks, loons and grebes) build their nests soon after ice out, which can be anywhere from mid-April to mid-May.

Could nests flood if used for incubation before the reservoirs refill?

As part of their relicensing agreement, the Federal Energy Regulatory Commission requires Minnesota Power to find out if the spring reservoir water levels negatively affect the waterfowl’s nesting and incubation. NRRI



Ron Moen

biologist Ron Moen and his research team were enlisted to study waterfowl and waterfowl nests to answer this question.

For one year, the researchers documented the location, nests and brood production of waterfowl living in the five reservoirs. “We went out every day we could as soon as the ice was out, which wasn’t until mid-May this year,” said Moen.

They also went to natural lakes to document the ducks and geese living there as experimental control sites. As on the reservoirs, the researchers kayaked or boated around, looking for birds with broods.

“We found the best ‘control’ lakes we could to use as comparisons,” said Moen, “but they were much smaller than the reservoirs. There just weren’t any truly comparable lakes in the area.”



Andy Wendlandt and Paul Dolan-Linne

Also important, the researchers analyzed historical data because, as Minnesotans know, any one year can be an anomaly. Ice-out dates, changes in water levels due to precipitation, and length of incubation were studied back to 1997. As it turned out, 2008 had a late winter which can potentially change when the birds nest.

With all the variables accounted for, Moen found that changes in reservoir water levels “are likely to have little effect on duck and goose production,” he states in his report. Research continues, however, with GIS aerial imaging to evaluate the shoreland conditions in reservoirs to determine the amount of potential nesting habitat for the waterfowl.

“We will contrast reservoirs with control lakes again to see if there are other factors that could affect duck reproduction,” said Moen.

# Coming Clean

Don Fosnacht knows that Minnesota has the resources to lead in clean energy technologies. But more than that, he knows that NRRI is uniquely positioned to provide research and development to help move them forward.

In a talk this spring at a state energy meeting between industrial, academic, and governmental representatives, Fosnacht painted a hopeful and exciting picture of current and future research possibilities at NRRI. As director of the institute's Center for Applied Research and Technology Development and member of the Governor's



Pilot-scale iron nugget furnace with oxyfuel coal burners



Advanced calorimeter

***NRRI's energy research is focused on solutions***

Collaborative on Clean Energy Technology, Fosnacht is making sure the research is practical, solution-oriented, commercially-driven, collaborative, and environmentally wise.

"We can make our coal ultra clean, store carbon dioxide, capture renewable energies, convert waste to good uses, design for optimal energy efficiencies..." Fosnacht said. "With good foundational research, these areas—and much more—are waiting to be tapped."

NRRI has a well-established forestry group whose research on biomass production is growing exponentially. The world-class hybrid poplar genetic improvement program, thinnings from pine and aspen forests, and analyses of

forest harvest residues are research areas that could feed production of woody bioenergy. Further research at NRRI is also focusing on the pretreatment of biomass to make torrefied wood pellets (biocoal) that can be used in coal-fired plants.

Key to NRRI's programs is its continuously expanding research infrastructure, Fosnacht further explained. Some of the equipment capabilities include:

- A working downdraft gasifier, with oxygen addition capability



House<sup>3</sup> ready-to-assemble concept

- Two pelleting mills and two briquetting machines
- Pilot-scale material processing equipment
- A portable and fixed gas analyzer
- Chemical extraction equipment to treat alcohol plant residues
- A gravimetric furnace to characterize biomass properties

"We are proposing to actively work with the U.S. Department of Energy to produce a biocoal equivalent from woody biomass using advanced torrefaction technologies,"

said Fosnacht. "We'll be able to prove out the use of prepared biomass in pulverized coal grinding and injection systems at existing power plants."

NRRI's efforts don't stop there. The Wood Products group is busy designing the next generation of wall panels. These structural, insulated panels and oriented strandboards are made of energy-efficient inorganic binders that can replace energy-intensive Portland cement and petroleum-based resins. The same team is also working on a high-efficiency, rapidly deployable housing concept that



25 kW biomass gasifier

is structurally durable and movable with integrated energy, electrical and plumbing systems.

Making the corn ethanol process more efficient, developing energy absorbing cements and glasses for solar panels, and mapping Minnesota's geothermal potential are other areas of active research.

"We believe that the state must be very active in technology development and implementation to be successful energy providers in the future," said Fosnacht. "We welcome all inquiries of commercial, industrial and academic collaborations to move Minnesota forward."

## Check us out: [www.nrrri.umn.edu](http://www.nrrri.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**

Lucinda Johnson, interim director

**Center for Applied Research & Technology Development**

Donald Fosnacht, director

**Center for Economic Development**

Elaine Hansen, director

*NRRRI Now*

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Trish Sodahl, graphic design

*NRRRI Now is published to provide information about our programs and projects. For details call (218) 720-4294.*

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## **World-wide connections**

### **Computerized chemistry speaks many languages**



Participants at the 4th Indo-U.S. Lecture Series on Discrete Mathematical Chemistry, held in January, 2009 in Hyderabad, India.

**N**RRI scientists Subhash Basak and Jerry Niemi (fourth and fifth from the left in photo) joined 23 lecturers from India, Canada, and Singapore at the Fourth Indo-U.S. Lecture Series on Discrete Mathematical Chemistry in Hyderabad, India in January.

The lecture series was initiated by Basak to stimulate creativity and interdisciplinary research in young scholars and scientists. The series attracted 82 graduate students and post-doctoral fellows. It was sponsored by the Indo-U.S. Science and Technology Forum; the Government of India's University Grants Commission, Council of Scientific, Industrial Research, and Department of Biotechnology; and the Andhra Pradesh State Council of Higher Education in Hyderabad, India.

Basak also initiated the Indo-U.S. Workshop on Mathematical Chemistry in 1998 which regularly brings together scientists in this field from around the world for applications to drug discovery, environmental protection, genomics and proteomics.