

# NRRI *Now*

Spring/Summer 2015

## Natural Resources Research Institute

UNIVERSITY OF MINNESOTA DULUTH  
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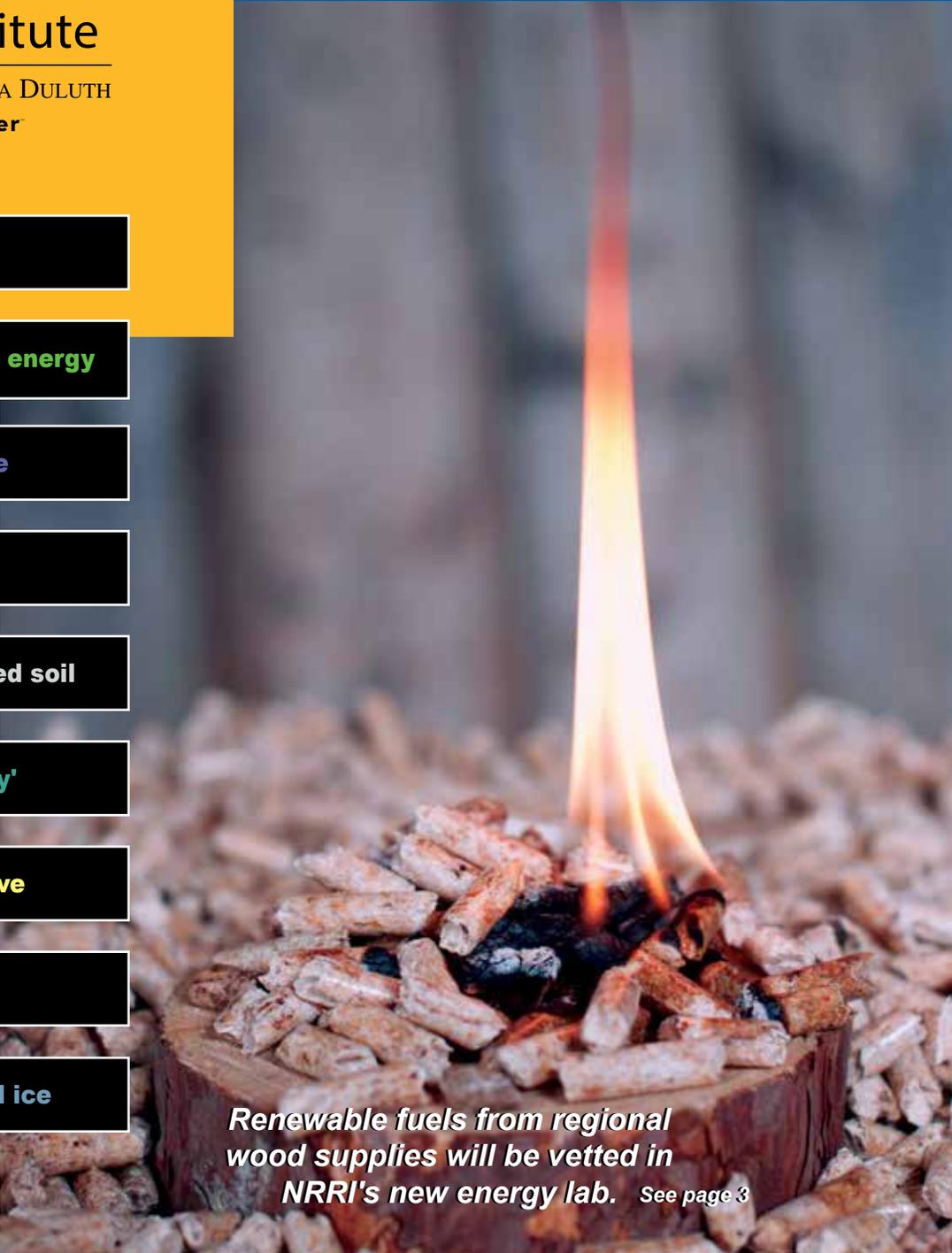
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*Renewable fuels from regional  
wood supplies will be vetted in  
NRRI's new energy lab. See page 3*

~ Growing Strong Industries

~ Developing New Ideas

~ Nurturing Natural Resources

# FROM THE DIRECTOR: ROLF T. WEBERG



“  
*Energy is a key component of the Minnesota economy – the state spends on the order of \$18 billion per year on our combined energy needs.*”

Welcome to Summer 2015. After a rather prolonged period of gray, it appears that color and warmth have arrived in the Northland.

NRRI researchers worked through our gray spring to continue their focus on delivering science-based solutions for responsible management of Minnesota’s environment, resources and economic development.

Although we were somewhat frustrated that the state legislature didn’t pass the University of Minnesota’s proposed Initiative for Mining Innovation, NRRI has continued to focus on developing technologies that will assist Minnesota’s mining industry compete in the evolving global market. With the unsettling announcements of mine closures and related employment challenges in Northern Minnesota, this work is even more important as we work to diversify and strengthen the economic base. NRRI will continue to pursue relevant programs that engage our stakeholder partners.

Energy is a key component of the Minnesota economy – the state spends on the order of \$18 billion per year on our combined energy needs. NRRI has been working on numerous projects in the energy sector and is now focusing its strategy on participating in Minnesota’s journey to develop renewable energy options.

Our primary focus will be on biomass-based fuel characterization and renewable energy storage. This publication highlights NRRI’s newly constructed Renewable Energy Lab located at our Coleraine facility. It will provide demonstration-scale

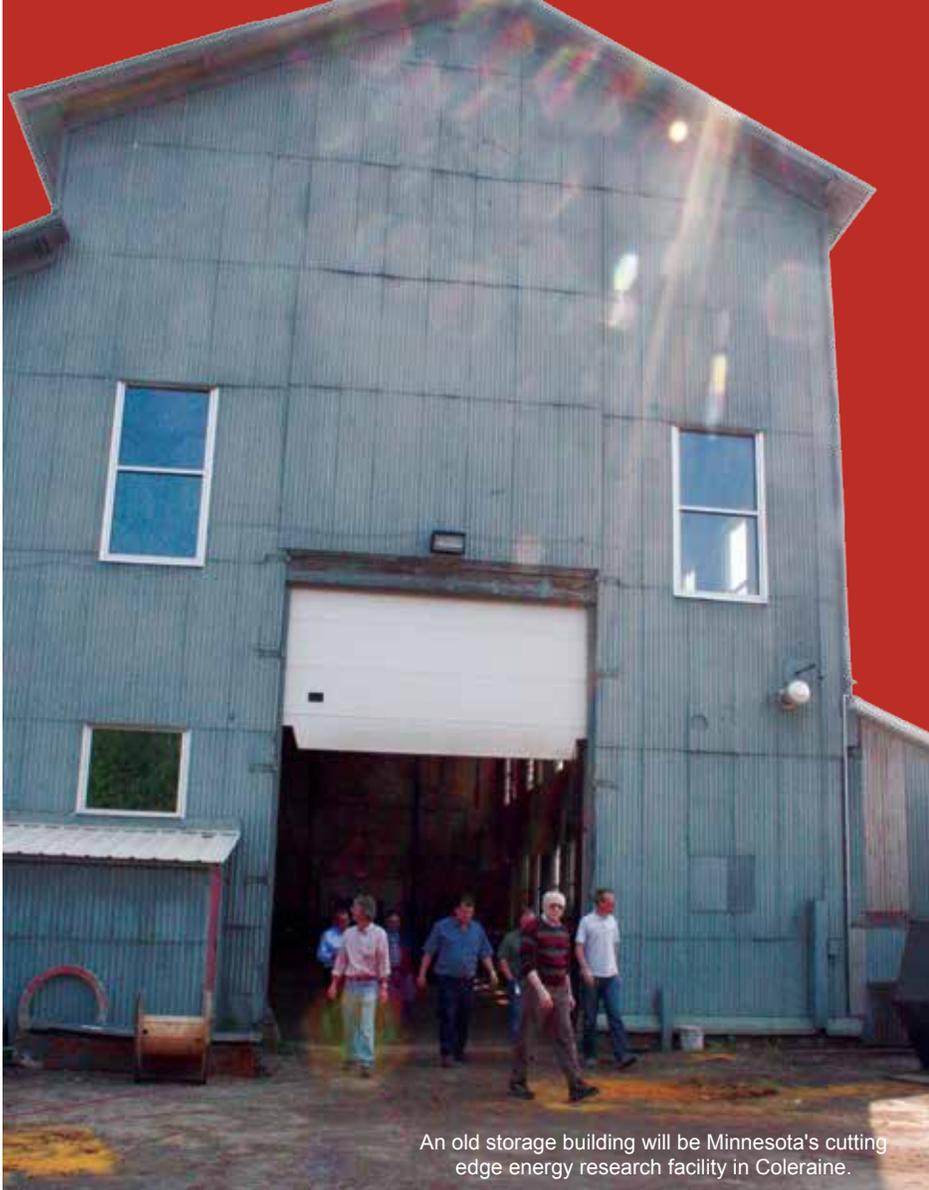
quantities of biomass-based fuels for experimentation in power generation facilities. This work will also engage the potential for development of higher-value chemical products from Minnesota’s biomass materials.

Ultimately this facility presents a number of exciting opportunities to fully characterize process options and the associated economic/environmental/community risks and benefits.

Finally, the arrival of summer brings with it the annual field season during which many of our staff and student assistants work long hours in the field to gather data concerning Minnesota’s precious land, air and water resources. This information is critical to informing Minnesota’s resource-based decisions. I will look forward to sharing these stories in the fall.

Until then enjoy your summer!

A handwritten signature in black ink, which appears to read "R. T. Weberg". The signature is stylized and fluid, with a long horizontal stroke at the end.



An old storage building will be Minnesota's cutting edge energy research facility in Coleraine.

# NRRI cultivates a renewable energy future

**New lab in Coleraine will fuel research**

Solar and wind energy readily come to mind when talk turns to alternative energy options. But the renewable options are much broader – and more complex.

NRRI is leading exciting developments in some of the lesser known renewable or alternative energy fuels, with the potential for significant impact. And yes, solar and wind technologies are part of the portfolio, even if the sun isn't shining or the wind isn't blowing. NRRI is looking at innovative energy storage options to balance supply and demand.

But what Minnesota might lack in sunshine or steady breezes, it makes up in biomass – wood, forest harvest residues and agricultural byproduct. How can we get the most BTUs out of those resources?

There's a lot of work ahead and NRRI is working with industry partners Minnesota Power, Xcel Energy, SynGas Technology LLC and the Coalition for Sustainable Rail to get it done.

An old storage building at NRRI's lab in Coleraine, Minn., is being transformed this summer into a state-of-the-art Renewable Energy Center. This \$2.5 million project will enhance the understanding of a variety of processes – characterizing their efficiency, industry applications and environmental impact – on commercially-relevant scales. Technologies are in place to convert woody biomass and agricultural byproducts into renewable, regional fuel products that can be used in combination with coal, diesel and propane. These biomass-based fuels have the potential to reduce sulfur, mercury and nitrogen oxide emissions.

This large-scale demonstration capability will make NRRI the upper Midwest's go-to research facility for developing alternative energy resources.

Here are the energy research programs underway:

Continued on page 4

## Converting biomass to fuels:

### Solid fuels

- *Torrefaction* – This roasting process converts biomass into a solid fuel with properties similar to coal in combustibility and BTU output. The torrefied biomass can be burned with conventional coal in power generation plants to reduce emissions. NRRI is installing an indirect-fired rotary kiln torrefaction and briquetting process that will produce 12 tons of biofuel a day, using wood chips and other biomass as feedstock. A steam-electric boiler/generator system will run in parallel to the kiln producing 100 kilowatts per day from a moving bed torrefaction system which will produce three tons of solid biofuels a day.
- *Hydrothermally modified birch bark for biofuel binder* – Once biomass has been torrefied, it must be consolidated for ease of transport and to use it as a partial replacement for coal. A binding material is needed to get the modified biomass to hold together as pellets or briquettes. NRRI is applying innovative chemistry to an age-old process to make birch bark tar, similar to that used by Native Americans to seal joints on birch bark canoes. This material can be developed for use as a moisture proof, high BTU, non-toxic and easy-to-use biofuel binder, especially for biomass feedstock that is hard to bind.
- *Hydrothermal Carbonization* – A “wet” torrefaction process that captures 100 percent of the carbon in the biomass to produce a biochar slurry material. This material will also be tested as a binder material.

### Liquid Fuels

- *Ethanol from hybrid poplar* – NRRI is working with a team in the Ukraine to conduct a trial planting of NRRI’s fast-growing hybrid poplars to help this country gain energy independence with biofuels.

- *Syngas (or synthesis gas) production with ilmenite catalysts* – A low cost process that efficiently converts biomass-based, low hydrogen syngas into hydrocarbon liquid fuels.

## Renewable Energy Resources:

### Energy Crops

- *Resource Assessment* – Minnesota currently harvests about half of its available, sustainable wood supply. There is also an estimated three million tons of roundwood (tops of trees not sawn) and harvest residues along with approximately seven million tons of agricultural biomass

available for renewable energy. NRRI is studying the balance of energy needs with increasing forest productivity.

- *Hybrid Poplar* – NRRI’s hybrid breeding program has produced genetically improved trees that can provide quick-growing energy crops on marginally productive lands. The Cottonwood/Black Poplar genus developed at NRRI grows to harvest size in eight years.
- *Forest Thinning and Productivity Research* – NRRI has an ongoing program to optimize yields of aspen and red pine resources by thinning low yield stands and understanding future opportunities.



NRRI Center Director Don Fosnacht and Director Rolf Weberg inspect progress at the new energy lab.



NRRI technicians Kevin Jamsa and Dick Bellefy continue building upgrades on the new lab.

## Solar

NRRI is evaluating three 10-kilowatt photovoltaic solar panel installations manufactured by three different companies to test their performance in a northeast Minnesota climate (including cloudy, rainy and snowy days), compare actual data to computer-model data and validate vendor claims. The panels are being tested on the rooftop of a seven-story building in downtown Duluth to understand the variabilities in panel placement and installation.

## Wind

NRRI is collaborating with other University units and with private industry to determine issues associated with large scale and smaller scale wind power technologies.

- NRRI helped identify a five-kilowatt gearless turbine for the UMD campus that is being used for power generation and student education projects. Students can monitor the performance of the new turbine under a variety wind conditions and atmospheric conditions.
- Two energy storage projects are underway. One is a collaborative effort to develop “Pumped Hydro” storage capabilities to capture excess wind and solar power using

abandoned mine pits on the Iron Range. The concept involves pumping water to a higher elevation when energy demand and cost is low, then releasing the water through turbines when the energy demand is high. This is a collaborative effort between the University of Minnesota’s NRRI, St. Anthony Falls Laboratory and Humphrey School of Business with industry partners Minnesota Power and Great River Energy. In a similar manner, “Compressed Air” energy storage is also being examined to use underground mines and mine shafts with a range of storage capacity from 8.75 to 100 megawatts.

## Geothermal

NRRI collected temperature data from 106 water wells and mineral exploration drill holes. Fifty-seven temperature measurements were compiled into 31 new heat flow sites to show that Minnesota has a much greater potential for enhanced geothermal energy production than was previously thought. NRRI has defined broad geothermal targets that show west and central regions of the state have the most suitable conditions, although new data is showing increased potential in northern Minnesota also. The next goal is to define viable geothermal targets for the state.

## Cold Water Cooling

Use of deep sea water for air conditioning and other chilling applications is being done off the Kona Coast of Hawaii using sea water at depths of 5,000 to 6,000 feet. Lake Superior has water at similar temperatures at much shallower depths. NRRI is investigating the possibilities and implications of employing these energy saving technologies for Minnesota.



Rolf says . . .

“NRRI is actively engaging in addressing Minnesota’s energy challenges.”

## Consortium for Advanced Wood-to-Energy Solutions

NRRI is a key player in this collaboration of public and private sector institutions to advance sustainable, scalable, distributed wood-to-energy solutions. The group is committed to stimulating forest restoration and rural economic development through applied research. NRRI is involved in the Consortium’s focus on torrefaction by 1) demonstrating its use in electric power generation, 2) Optimizing the densification and 3) extending the current technology to use low value wood (with Georgia Southern University’s Advanced Materials Development Center).



# Room to grow

## Red pine thinning techniques maximizes yields

Minnesota's state tree is the mighty red pine, *Pinus resinosa*, or Norway pine. It's a plentiful tree whose trunk produces fine lumber and pulp for papermaking. Minnesota has about 630,000 acres of red pine which helps support the region's wood products industry. But a bit more than half of that wood is on public land and the rest is on privately owned land.

"That means we have to help the private land owners know how to manage their plantations so they can get a return on their investment," said Pete Aube, lumber manager for Potlatch Corporation in Bemidji. "And every sawmill, every pulp mill, needs access to wood to produce the forest products Minnesotans use every day."

Thinning of red pine is a standard plantation management practice that improves the productivity of the stand, but private landowners don't necessarily understand the economics of the practice. An unmanaged plantation runs the risk of growing trees that are too tall with small diameter. Spindly trees can be stressed by lack of room to grow and then they can't produce the board-feet that sawmills need.

And right now, Aube is seeing a lot of tall, spindly red pines. He and other forest industry professionals pulled together a team [see sidebar] to address the issue. Work done in the region by the U.S. Forest Service helped define the range of thinning treatments that might be used and NRRI research is providing guidance on the issue with a study of the practical realities of red pine thinning. Newer logging technologies and a variety of thinning methods are being studied to determine impacts on tree growth.

But stand management can range from intensive to less intensive, depending on the stand age and the objective of the land managers, according to NRRI Forestry Program Director Bill Berguson. Some landowners may choose to

thin stands intensively at younger ages and reduce management intensity over time.

"The emphasis of our research is to provide the best information to landowners to allow them to make informed decisions on management options particularly when stands are very young," Berguson said.

With the choices available, not all landowners will choose intensive management, according to Brian Palik, research ecologist at the USDA Forest Service. "It is very important that forest landowners understand the response to different types of thinning and when ecologically-focused management is a better choice," he said.

NRRI Research Plot Coordinator Dan Buchman helped loggers implement new thinning techniques and is using computers in the harvesting equipment to collect precise data on when a tree was felled, how long it took to process, cut and the size of the log. He learned that it doesn't take any less time for the machinery to harvest a small tree versus a larger diameter tree, but the value at the sawmill is in the larger trees. And maximizing value is important because loggers have a lot of money tied up in expensive machinery.

"We rolled together all the current data on the market value of trees of different sizes, stand growth and harvesting costs," said Berguson. "We found that if loggers spend their day trying to thin a stand with all small trees, they will lose money."

NRRI collaborated with the Minnesota Department of Natural Resources, the St. Louis County Land Department, Molpus Timberlands, Potlatch Woodlands and Minnesota Power to develop the research for landowners and loggers in implementing various thinning methods using cut-to-length logging equipment.

"Thinning the larger portion of trees in a stand doesn't have to happen repeatedly," Berguson explained, "When the stand is really small



diameter, that's when it's critical to make the economics work."

Aube sees this red pine thinning opportunity as a game-changing, win-win-win scenario.

"We've proved there's a better way to manage these plantations. Now the challenge is getting the word out to landowners," he said. "This red pine resource is growing and there's value for landowners, loggers, foresters and mills to change our approach to managing younger plantations."

The reason there's so much red pine in Northern Minnesota goes back to the 1960s when about a million acres of land were set aside for the Boundary Waters Canoe Area, unavailable for logging. To ease the loss to the logging industry, the federal government offered incentive funding to county, state and private landholders to plant the popular softwood. Red pine is especially well-suited for sawmills and the tops and branches go to pulp and paper mills.

"These are very productive trees," said Aube. "An investment was made back then and a return is expected. NRRI's applied research and collaborations to move this forward are just what we need."

### Red Pine Management Economics Task Force:

This group will update the guidelines for red pine plantation management and present findings at several symposiums in Minnesota throughout 2015.

**Bill Berguson**, NRRI Forestry Program Director  
**Pete Aube**, Potlatch Lumber Mill Manager  
**Alan Ek**, Univ of Minn, College of Natural Resources  
**Jim Gubbels**, U.S. Forest Service  
**Eli Sagar**, Potlatch Lumber Mill Manager  
**Rick Kleborn**, DNR, State Silviculturist  
**Dan Prazak**, DNR Hibbing Area Forest Supervisor  
**Aaron VandeLinde**, DNR School Trust Land Administ  
**Mark Weber**, St. Louis County Land Commissioner

# 'Fluke' of nature

## NRRI researches lifecycle of Giant Liver Fluke and deer/moose impact

It's not easy being a parasite. Specifically, it's not easy being a Giant Liver Fluke, a flatworm whose life is dependent upon the deer host excreting its eggs near a snail that the flatworm larvae can infect which will attach to an aquatic plant that a deer will happen to eat, completing the fluke's lifecycle. And even then only four to ten percent of the flukes actually make it to the liver.

But it's also not easy being a scientist studying the impacts of this difficult parasitic life. NRRI graduate student researcher Trevor Vannatta has a hard time getting people excited about the snails that are one part of the fluke's life cycle.

"People care about moose. People care about deer. But they don't care as much about the snails and I think they're the champions in this liver fluke mystery," he said.

Moose are in steep decline in northeastern Minnesota and there are a lot of possible causes. One possibility is that Giant Liver Fluke (*Fascioloides magna*) are also using moose as hosts, weakening their livers and making them susceptible to other stressors. But moose are a dead end road for the liver fluke – their life cycle is stopped once they get to the liver. In deer, however, the parasitic worms live their full cycle by producing eggs and infecting snails. Vannatta is working to understand the extent of fluke infections in a specific population of deer so he can zero in on what plants the snails are associated with that the deer are also eating. It's where the deer and moose interact that flukes can impact moose populations.

"Right now, we don't have a great idea of what snail it is and there are about 16 snail species that are potential hosts," he explained. "We also don't know which plants are associated with the snails."

Slowing his progress even more, the previous research on these infected snails – and there's not a lot – is just plain confusing. Different taxonomists have given different names to the same snail species; as many as eight names. "So I have to sort through all this and decide which taxonomic reference to follow," said Vannatta. "It turned into a mess pretty quickly."

Luckily, he's getting enthusiastic assistance in acquiring deer livers from hunters within the city limits of Duluth. He's received 48 livers in one season and is hoping for even more in the next season to give him a bigger sample size. So far, the fluke is present in about 35 percent of Duluth deer. Knowing that Giant Liver Fluke are able to complete their lifecycle within the City of Duluth gives Vannatta a microcosm to work within as he searches for the culprit snails and plants hosting the parasite.

Vannatta is also hoping to add more research about the age of the deer and if it has an influence on fluke infections. So far, the only research he could find on deer age and flukes came from South Carolina, which might not hold true for northern deer. Finding answers to these basic biological questions will expand the understanding of the deer-moose-fluke relationship.

"In the end, these knowledge gaps can be viewed as obstacles or opportunities," said Vannatta. "I prefer the latter."



Rolf says . . .  
"Being an eco-detective is  
hard work – no fluke!"

Trevor Vannatta dissects  
a deer liver in search of  
Giant Liver Fluke.



# Restored MINELAND SITE GROWS WITH RECYCLED SOILS

Hibbing Taconite demonstrates beneficial use of harbor channel sediment

For less than \$100, a person can get a yard of top soil delivered to their home. That's not bad for a home project. But what if you need 30,000 yards or more to restore a large industrial site that's been cleared of top soil? Suddenly that per yard rate is exorbitant. Plus, who has that kind of soil inventory to sell?



So when Cliffs Natural Resources needed to get things growing again in a two-acre pit at Hibbing Taconite, they turned to NRRI to help source a cost effective top soil. NRRI Senior Research Fellow Larry Zanko went to the Duluth-Superior Port Authority for dredge material excavated out of the shipping channels and stored at Erie Pier. It's basically a combination of sand, silt, and clay from the St. Louis and Nemadji River watersheds that washes into the harbor and needs to be regularly removed so the ships can get through the channels.

"It's a big deal if we can find a beneficial use for something needed by industry that's a byproduct of maintaining the channels for commerce," said Zanko. "Erie Pier is reaching its capacity to hold any more sediment so finding ways to recycle it is important."

But first it was thoroughly tested. The U.S. Army Corps of Engineers tested the material for potential contaminants – heavy metals and other organic pollutants – and the results showed that the material meets the soil standards set by the Minnesota Pollution Control Agency.

Taking this pilot scale project a step further, Hibbing Taconite wanted to try the sediment in three

different test applications: six inches of top soil, 12 inches of top soil and then an application of top soil disked into what is currently on site. But rather than seeding and planting immediately, the project team recommended that the material lie fallow for a year on site. This allowed for monitoring of random plants that sprouted and potential invasive species, along with planning for the best selection of native plants and weed control options.

"Our job was to facilitate getting the material to HibTac in the quantities they needed," said Zanko. "So we worked with the Corps and the Port Authority to do that." Zanko secured about 3,700 cubic yards which was trucked to the site in 2013.

Transportation offers the biggest challenge to the project. Zanko worked with trucking companies to find back-haul opportunities. He connected with another mining company that needed to truck taconite aggregate from the Iron Range to Duluth for shipment. "As long as the trucker has material going both ways, we'll get the best rate," said Zanko. But even with the cost of hauling, the per-yard rate is likely a significant savings over anything else available.

"Our goal is to do things that maximize the use of our resources in both directions," Zanko added. "We also want to demonstrate that this material has great potential for site reclamation."

NRRI forestry specialist Tom Levar coordinated the planting effort on the site to add a variety of native species that were selected for their compatibility with Erie Pier sediment and provide diverse habitat for wildlife and pollinators. With help from NRRI scientists Craig Maly and Sara Post, the sites are now greening up with a variety of plants, including bur oak, American hazel, white birch and two berry species, adding to the naturally emerging vegetation. The plants were treated with deer browse deterrent before winter set in and have responded well.

"The state requires that native plants are to be used on mineland reclamation sites," explained Levar. "And the ones we planted are known to be suitable for a drier, upland site like this one. We'll continue to monitor the site as funding is made available."

# Focused on the 'little guy'

## UMD's Center for Economic Development is the small business go-to

During the economic woes of the 1980s when NRRI was established, major northern Minnesota industries – taconite mining and wood products – were a primary focus for research attention. But it was also apparent that entrepreneurs and small businesses needed assistance of a very different kind.

“Things like marketing help, guidance in writing a business plan and help with financing, along with product development and process improvements,” explained Mike Lalich who served as NRRI’s director for 30 years. “That’s why we established the NRRI Business Group.”

Then, as now, small businesses deliver big economic impact, accounting for 60 – 80 percent of all U.S. jobs. NRRI continues to do product research and development for small businesses, but early on they realized that the UMD Center for Economic Development, Northeast Minnesota’s Small Business Development Center, could also provide even more entrepreneurial assistance. The NRRI Business Group was formed as a joint program of NRRI and the Center for Economic Development.

The NRRI Business Group joined forces with UMD’s Labovitz School of Business and Economics to incorporate the University and the federally-funded Small Business Development Center. The SBDCs were established as Congress’s response to the recession of the early 1980s in the Small Business Administration. At the state level, many other programs were being implemented to help grow the economy.

“The Center for Economic Development was created to bring all the programs for small businesses together,” said Elaine Hansen, the Center’s director. “And we’re complementary to NRRI’s mission to develop new products, enhance products and find new ways of doing things. We are the commercialization link.”

Today, the Center for Economic Development is located in downtown Duluth to be easily accessible to entrepreneurs and business owners. The staff provides a variety of services including business consulting at no-cost to the client, and low-cost training services that help small businesses grow and succeed. At its heart is one-on-one assistance by consultants with business expertise.

Business Consultant Curt Walczak is one of them. His expertise includes technology, social media marketing, and helping businesses use it to their advantage. He’s also versed in accounting, Quickbooks, and management.

“One of the great things is that our services are at no charge to the entrepreneur because of the grant funding we receive through the Minnesota SBDC,” he said. “We’re not pushing a product. We offer an objective perspective, information and guidelines.”

One of the Center’s new initiatives is called “Economic Gardening.” It’s a program that identifies business-specific information – market trends, improved visibility and information for decision-making – to help the business grow. The Center also started the Student-to-Business Initiative that offers a win-win of experiential learning for UMD students while providing assistance to businesses throughout the region. University



Rolf says . . .

“Entrepreneurial support is key to nurturing a more diverse economy!”



Consultant Curt Walczak

students studying accounting or marketing learn in the classroom and apply the knowledge to a business client during the course of the semester. It is hands-on, applied learning that goes beyond the typical case study project to actually helping a small business.

Over the years the Center for Economic Development has offered a variety of programs, services and resources like the Northeast Innovation Center and the Minnesota Technology program. It works with a variety of economic development organizations and pieces together resources for small business success.

“If we’re working together, we can accomplish so much more than if everyone works independently,” said Hansen.

And the Center has plenty of small business success stories to prove she’s right.

Old World Meats, a small, family-run meat market in Duluth, used the Student-to-Business Initiative to develop a marketing plan and social media advertising. Following up on that success, the Center helped the business get a Small Business Assistance loan and bank financing to expand his customer base to other businesses. “The Center for Economic Development has been able to help me think big and reach out, not only on a local level, but a global one,” said owner Paul Wrazidlo.

Another great example is entrepreneur Connie Pearson whose soil testing business, Precision Testing, Inc. The small business grew ten-fold with encouragement from the Center to become a certified Disadvantaged Business Enterprise and Pearson was given the confidence to go after big contracts. “Taking that leap was the best thing for my company. I’m sending proposals out every day,” she said.

Walczak calls it Grassroots Economics, working with one client at a time. “If a business increases its sales or hires someone, we have made a positive impact on the economy of this region,” he added.

## Riverfront retrospective

# Duluth's Western Waterfront Trail got its start in the late 1970s

Duluth is akin to Lake Superior – the great lake and the city are synonymous. But Duluth Mayor Don Ness thinks it's time to highlight the natural beauty hidden in the backwaters of Lake Superior – the St. Louis River Estuary.

"There's no question that if not for Lake Superior, Duluth would be defined as a river city," Ness has said. "Duluth should be defined by both the world's greatest lake and the world's largest fresh water estuary."

It's not exactly a new idea, but past industrial residue and pollution in the estuary have hampered progress. Now, with a few hundred million dollars in federal, state and private funds for restoration, there's a real opportunity for revitalization. It's time to dust off an old plan.

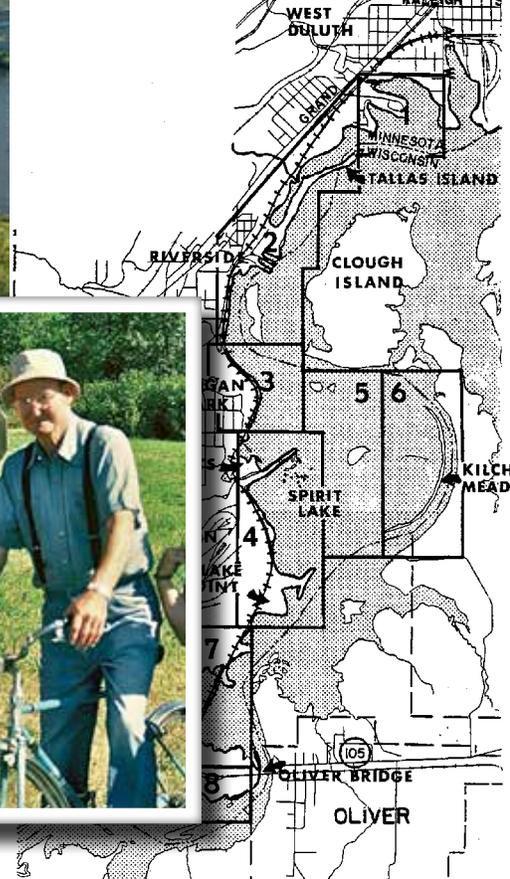
Turning Duluth's western riverside into a natural attraction was supported and documented in 1978 by Gerald Niemi and his colleagues in a report commissioned by the City of Duluth. Today, Niemi is wrapping up a long career at NRRI having served 20 years as director of NRRI's Center for Water and the Environment, professor in biology, and as senior research associate for the past seven years. Back in the 70s, though, Niemi was a young biologist, happy to be paid anything to do flora and fauna assessments.

"We put a lot of time into gathering extra data, and I was pretty cheap at the time so the money went a long way," Niemi said with a laugh. "It was a fascinating area."

He was hired by Duluth's then-city planner Jerry Kimball who wanted to know more about the potential of the area. Burlington Northern Railroad had been persuaded to give the City four miles of rail line along the St. Louis River shoreline. Could it host a tourist train? Might this polluted industrial area actually attract recreational use?

The final report, "Flora and Fauna of the Western Waterfront Trail," showed that even before the much needed sanitation system came online and U.S. Steel's footprint was still intact, the area had interesting biodiversity in plants and wildlife. Niemi collaborated on the study with then-colleague Tom Davis, and UMD Professors Hollie Collins, Pershing Hofslund, Paul Monson, and John Kotar.

"What's so impressive is how very prescient they were," said Jim Filby Williams, City of Duluth director of Public Administration. "To have envisioned that in the 1970s... that Spirit



Lake would have peace, quiet and natural beauty. Today we are following the roadmap they set out remarkably close."

What Niemi did was investigate the physical and biological qualities that make the area unique – like several unusual and legally protected plants in the orchid and lily families. He reported that "the abundance and diversity of plant species... are rivaled by few areas in the Duluth vicinity." They also identified 178 bird species, noting that Spirit Lake is an important spring migration stop for bald eagles. Fourteen species of mammals and nine species of reptiles were found, although the abundance of reptiles and amphibians was lower than expected.

"It was exciting," said Niemi. "We put the yellow-headed blackbird on the cover of the report because its colony at Mud Lake was virtually unknown at the time. I think we were all just surprised at how beautiful the area was."

The 125 page report included recommendations for a nature center, parking and access for tourists at scenic vistas, canoe routes and island campsites. "The study really opened some eyes," said Kimball. "People didn't know that the area is like being in the Boundary Waters Canoe Area."

The Lake Superior and Mississippi Railroad excursion train was established on the donated rail line exposing about 10,000 riders a year to the area. But the rest of the trail plan stalled and the city's focus shifted to other things.

"What we didn't have is funding, but they do today and that's great," said Kimball. "I really hope they keep this report on everyone's desk who is working on it."

Filby Williams said yes, they are. The Western Waterfront Trail will be renewed and extended the summer of 2015. The cleanup of the U.S. Steel site should be done by 2018 and the trail can then be pushed further west to a popular boat landing.

"Every time we talk about the vision for the St. Louis River corridor, we make reference to those seminal studies, for good reason," said Filby Williams. "They provided a foundation for all the good thinking that has followed."



Rolf says . . .  
"Multi-angle approaches pay off!"

## Every species counts

### NRRI frog research leads to understanding of predator biodiversity

**W**hat is the inherent value of biodiversity? Do we really need such a wide variety of organisms in every nook and cranny of our planet?

Yes, because the natural world evolved with a stabilizing balance that keeps ecosystems from being thrown off course. Healthy ecosystems, with all organisms doing their part, can resist change and are resilient when challenged.

NRRI Center Director Lucinda Johnson points to a specific example in findings released in February at the Proceedings of the National Academy of Sciences. Research begun at NRRI led to the discovery that biodiversity of small predators – dragonflies and other aquatic bugs that eat parasites – can reduce infections in frogs. This is important because amphibians are experiencing alarming extinctions worldwide, while at the same time holding an important position in the food chain as a consumer and a food source.

"We started our amphibian research back in 2001 because there was a big panic about what was causing frog malformations," explained Johnson. "Part of the analysis that our collaborators were involved in was looking at parasites as a possible cause of those malformations."

NRRI scientists were studying malformation prevalence, frog

species distribution and the role of invertebrates ("bugs") in the wetland food chain. A web of connections eventually led scientist Jason Rohr to NRRI's amphibian data and caught his interest. Rohr is now associate professor of integrative biology at the University of South Florida. Using NRRI's data and collaborating with Val Beasley, now at Penn State University, Rohr led research published in *Nature* in 2008 showing that the cause of malformations is complicated. It's not just the atrazine (an agricultural herbicide) as was hypothesized, but atrazine and phosphorous (a chemical often used in fertilizers). That chemical combination related to higher numbers of parasites while also compromising amphibian immune systems, leading to frog limb malformations.

"So often, lab studies are simple cause-and-effect exercises, but that study tells us there may not be a direct effect of atrazine and the malformations," said Johnson. "The pathways are complicated and the lesson is that you can't just look at one piece of information; sometimes it takes two or three different approaches to arrive at an answer."

Rohr then took the amphibian research one step further to understand the effect of dwindling environmental biodiversity and worldwide spikes in infectious diseases. Instead of focusing on the

diversity of parasite hosts – those unfortunate critters who carry the parasites – Rohr looked at the importance of the diversity of species that prey on parasite hosts.

The study showed that it takes a variety of species of dragonfly larvae to reduce the infections in frogs caused by parasitic flatworms, called trematodes. Wetland surveys, microcosms (small experimental wetlands) studies and mathematical disease modelling were employed, revealing fewer flatworms in frogs where there were more species of flatworm predators. The field study also showed that the diversity of these predators was a better predictor of flatworm infections than nutrients, frog immunity or the diversity and abundance of parasite hosts, according to an article by Penn State University. NRRI Toxicologist Patrick Schoff and Biologist Cathy Johnson (now with the U.S. Forest Service) were lead researchers on NRRI's original amphibian research in 2001.

"The way we function at NRRI is to connect the dots between these types of studies," said Johnson. "We do studies that are really deliberate. All of the state's big environmental challenges have to be tackled with multiple lines of evidence. Ultimately, our goal is to help ecosystems be healthier by being more resistant and resilient."

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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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## Ready for the worst

### NRRRI 3D printed ice makes wing tests easier

Here in Minnesota – like other northern climes – ice is a reality for about half of the year. Ice on airplane wings gets especially intense scrutiny because it can reshape the surface of the lift-producing parts of the plane – the wings and the tail.

De-icing systems on aircraft work very well, but what if the de-icing system fails? The Federal Aviation Administration requires all aircraft to complete rigorous testing to ensure that it will perform safely in worst case scenarios. Cirrus Aircraft of Duluth, manufacturer of all-composite personal aircraft, got assistance from NRRRI to meet that requirement with specially fabricated ice simulations made in the rapid prototyping lab.

“We’ve been using 3D printing technologies more and more for concept development,” said Garrett Homan, Cirrus Systems Engineering Team Lead. “It’s pretty cost effective in terms of reducing fabrication times, especially for things you want to touch and feel. For some parts, we’ll use 3D printing to iterate and refine the design before we invest in the tooling.”

The company’s increased experience with 3D printing made it an attractive option for fabricating the simulated ice shapes for flight testing.

NRRRI Prototype Lab Director Steve Kossett received the ice shape files from Cirrus and got the Fused Deposition Modeling (FDM) prototype machine running like never before. Making ice shapes to cover complete wing and tail systems was a large job that kept the machine going 24/7 for a few weeks. To keep the computer file size small, the ice designs did not include all the bumps and ridges that form on real ice in flight. To simulate that, Homan coated the parts with an adhesive and covered them with cracked corn.



“The rough surface of ice on wings affects the aerodynamics, so we apply roughness to the fake ice, too,” he explained.

Before 3D printing became readily available, ice shapes like these were made with foam and hotwire or machined out of wood or plastic, but Homan said that process was very labor intensive and not as detailed.

“This is a great example of what 3D printing can do in a real life, functional test for certification,” Kossett added.