NRRI Now

Autumn 2014

Natural Resources Research Institute

University of Minnesota Duluth

Driven to Discover℠

Steve Thomas is looking for value in homes that would otherwise be landfilled. He is founder of an organization that NRRI is helping to upgrade the recyclable resources, reducing waste and creating jobs

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~Growing Strong Industries

~Developing New Ideas

~Nurturing Natural Resources

FROM THE DIRECTOR: ROLF T. WEBERG

Rolf Weberg talks with Scientist Valerie Brady about a project she's leading to educate stormwater ditch maintenance crews about management practices that protect water quality.

> *"Perhaps most important, we will be engaging the public to define our mission and explain our role in advocating excellence in engineering, science and economic analysis for a sustainable Minnesota."*

It was a busy summer at the Institute. I have been on a steep learning curve, thanks to the patience and perseverance of my NRRI colleagues. They have taken me underground, into swamps, through taconite facilities, into laboratories to identify bugs and even taught me how to dig a better ditch! I have enjoyed many conversations with our customers and stakeholders to understand their needs and concerns. I am also pleased to have engaged UMD and UM-TC colleagues in defining new collaborative opportunities.

Our research teams have been busy in the field collecting data and specimens, mentoring our student workers and testing water treatment prototypes. At the Duluth and Coleraine Labs, major progress was made in the installation of our new Renewable Energy Center and in the development of basic data to support new material and process developments. One highlight was the two-day visit with Brian Herman, University of Minnesota Vice President of Research, during which the Institute had an opportunity to highlight its unique, applied research role within the University.

Two projects that extend our mission into new arenas are described in this issue. The collaboration with Better Futures Minnesota showcases a nice story that combines delivery of sustainable solutions via the harvesting of resources from old buildings with a social focus in providing job training and employment for ex-offenders. The effort to map complex ecological responses to environmental stresses is beginning to deliver tools to understand and address the impact of stresses such as development, climate change and/or invasive species.

Internally, we are completing a strategic plan to map our course as we engage in addressing the challenges of the rapidly evolving world we live in. We are working with our Advisory Board to ensure that it has broad stakeholder representation and to review our project portfolio to focus on key needs. Perhaps most important, we will be engaging the public to define our mission and explain our role in advocating excellence in engineering, science and economic analysis for a sustainable Minnesota. Stay tuned - we'll be coming your way!

NRRI MOVES UNIVERSITY FORWARD IN APPLIED, MULTI-DISCIPLINARY RESEARCH

Twin Cities campus leaders tour UMD, NRRI & the Iron Range

Brian Herman is a believer in serendipity – the phenomenon of unintentionally making desirable discoveries – and that cross-disciplinary, collaborative research encourages those serendipitous connections. As Vice President for Research for the entire University of Minnesota system, Herman is working to integrate that philosophy through a web of 19 collegiate units and five campuses.

But at NRRI, he found that cross-disciplinary collaborations are the norm. And with a 30-year track record, the institute has been able to prove that he's right. Serendipity – combined with diligence and open minds – works.

"I'm very excited to see the philosophy I've embraced as a cornerstone of our strategic plan is already resulting in real world successes," Herman told NRRI staff in August.

Joined by Jay Schrankler, executive director of the University's Office for Technology Commercialization, and Maura Donovan, newly appointed executive director of the Office of University Economic Development, Herman was fully exposed to NRRI's broad capabilities that span large industries, niche businesses and environmental research excellence. The visitors toured the Duluth facility, meeting our multi-disciplinary research staff – engineers and technicians along with macro to micro scientists – then toured the Minerals Lab in Coleraine, Minn., for a rich lesson in NRRI's mining and energy research.

"Among our many stakeholders, there's tremendous agreement that our environment, energy, and the water we all need to survive, are key research investments we need to make going forward," Herman said. "NRRI is working in areas at the heart of those themes. We're excited to see the competencies, abilities and successes you've already had that match well with where the University wants to move forward and be even more impactful."

Schrankler has long been familiar with NRRI's innovative side, helping the institute usher along 23 patent filings and moving them to commercialization in the seven years he's been with the University. He proudly highlighted one of NRRI's most recent commercial successes – The Actives Factory which produces and markets patented birch bark extractives – in his office's Annual Report.

"With your direct links to industry, community and University partners, NRRI stands the closest to commercialization of about anyone in the University," he said. "You're on the precipice of actually getting the knowledge out of this organization and making use of it in the real world to make lasting impacts."

Because of the University's need to move at the speed of business, the Office for Technology Commercialization worked closely with NRRI to ramp up their staff and streamlined their processes. Today, University innovations can be licensed and paid for online with the swipe of a credit card. And they've worked closely with the legal department to develop non-patentable know-how into private sector business success stories.

Connecting the business community to the talents at the University is the specific purview of the Office of University Economic Development. Donovan is working across the campuses to swing wide the front door to provide critical linkages for industry throughout the state.

"But when the business community comes to the front door, it can be hard to navigate. The University is broad and deep; I understand that. We need to help with that and show them why they should come to the University at all," said Donovan. "We have a wealth of expertise and knowledge to offer. I want to share our stories to strengthen the University and industry connections."

UMD's Center for Economic Development, NRRI's entrepreneurial arm, does much the same thing for regional business support, responding to the needs of small businesses with multiple training programs and finance acumen.

Herman congratulated NRRI's staff on being "in the right place at the right time" with a unique research model for economic and environmental sustainability that will well serve the state of Minnesota, the University, the nation and the world.

"We, on the Twin Cities campus, recognize that the work you do – especially in forestry, the environment, water and mining – are critical to the success and wellbeing of our citizens," Herman said.

Deconstructing homes, reconstructing lives

NRRI helps organization find more value in old homes and create jobs

AT A TIME WHEN THE PRESIDENT OF THE UNITED STATES WAS CALLING UPON WORLD LEADERS TO "RAISE OUR COLLECTIVE AMBITION" AND "DO MORE" TO COMBAT THE THREAT OF CLIMATE CHANGE, A START-UP WITH AN OPTIMISTIC NAME WAS QUIETLY DIVERTING CO^2 EMISSIONS BY THE TONS.

Better Futures Minnesota has a fresh business model that still needs to overcome some hurdles. But if they succeed, they will most certainly live up to their namesake.

The non-profit organization is leading Minnesota into an era of building deconstruction – as opposed to demolition and landfill – while providing jobs and teaching skills to ex-offenders. As the hard-working and specially trained crew carefully separates the recyclable and salvageable components, they harvest reusable materials that can replace the manufacturing and shipping of new materials, saving greenhouse gas emissions and reducing materials headed to landfills by the tons.

"Eventually this will be the standard practice because the next generation is saying, this is stupid. We cannot take away a house and bury it. It's not a sustainable practice," said Steve Thomas, founder of Better Futures. "If we fail – and we don't intend to – it will be because we're in it too early."

It's not that building deconstruction is a new idea. It's quite common on the East and West coasts where the cost to landfill waste is much higher than in the Midwest. That's one of the hurdles Better Futures Minnesota faces. It also takes more workers to carefully pull apart a building and separate materials whereas a bulldozer and one operator is fast and efficient. Still, the societal and environmental

Rolf says . . .
"A nice story combining sustainable practices and social responsibility."

benefits tip the scale mightily toward deconstruction.

The idea to pursue deconstruction began in 2006, with Thomas trying to find better jobs for the formerly incarcerated. After seeing the waste that demolition creates, he used some grant money from the City of St. Paul and the Northeast Grant Foundation, to hire one of the country's top deconstruction trainers. The new crew got to work and in 2010 they deconstructed four homes with a 92 percent recycling rate.

Today, they're deconstructing about two buildings a month and working to build the markets for their services to private homeowners and government agencies. Simultaneously, they are ramping up their marketing of a growing inventory of goods pulled from old homes – beautiful cabinets, tightly grained old-growth wood flooring, antique fixtures – they just don't make them like that anymore.

Jimmy Wren has been crew chief for Better Futures for two years now. At first, he was skeptical that deconstruction made sense. "I thought, who's going to buy that stuff? But we made some samples of flooring and table tops, and they are beautiful. Why not save that wood? It does make sense," he said, adding that he and the crew take great pride in their work and the environmental mission.

Thomas figures that to make the business work, Better Futures needs to deconstruct 35 homes a year. If he can keep his work crew busy and sell the salvaged material he'll also meet the organization's goal to reduce landfill waste and cut greenhouse gas emissions.

"It's going to take a couple of years to pan out, and the best potential for revenue is what we're working on with NRRI – creating higher value furniture, alternative uses for the materials and partnering with other businesses. That's where we'll find success," he said.

NRRI PROJECTS

Better Futures accessed NRRI's expertise and assistance with $25,000 in funding from NRRI's Product Development Fund, supported through the Otto Bremer Foundation. In addition to these hands-on projects, NRRI helped the organization connect with potential collaborators and customers, engage with the state legislature and expand their efforts to northern Minnesota.

UPGRADING THE VALUE OF THE OLD WOOD AND FINDING MARKETS

NRRI wood experts assessed the quality of the old growth Douglas fir wood harvested from the deconstructed buildings, then brain-stormed some possibilities. They constructed table tops with a variety of finishes – leaving the weathered patina on some and refinishing for a new look on others – and the results were beautiful. Old oak, white pine and maple wood flooring was also tested as re-use flooring. It is labor intensive to carefully remove the wood in large pieces and remove the nails, but the potential is there.

"We made them table top sections and flooring samples that they can take to show customers," said NRRI Scientist Victor Krause. "Someone who wants to create unique tables or floors would really appreciate the aged lumber."

IMPROVING THE EFFICIENCY OF RECYCLING APPLIANCE COMPRESSOR MOTORS

NRRI also helped to figure out how to get the most money for the steel and copper found in the compressors of old appliances. Intact compressors are valued at about $300 per ton at the recycler, while pure copper fetches about $4,000 per ton, so it was important to find ways to get at it. NRRI developed a time efficient way to cut into the compressor and remove the copper. The challenge was finding a saw that could accommodate varying sizes of compressors and a fixture to hold them tightly.

After many time trials, NRRI developed a recycling process and helped Better Futures Minnesota identify equipment that will allow them to separate the valuable materials. Even better, the process creates jobs for the work crew.

UPGRADING THE VALUE OF OLD PORCELAIN

The first project NRRI got involved with was to find potential marketable uses for the old porcelain tubs, sinks and toilets pulled from the buildings. NRRI student workers wielded sledge hammers on the vitrified fixtures, then the material was run through a hammer mill, screened and tumbled. The result was a product that could easily pass as white landscape rock.

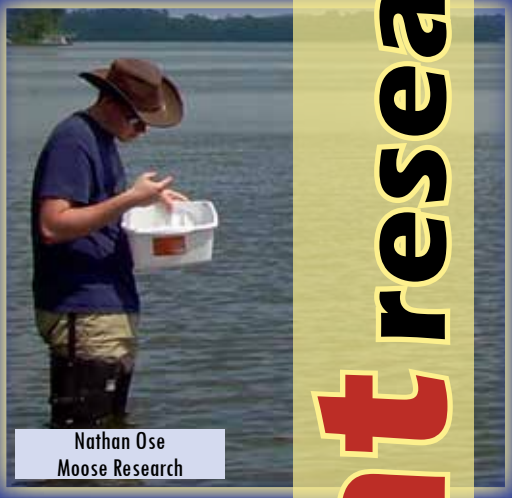
NRRI researchers also experimented with colorants and found that wood mulch dyes are absorbed easily into the porous porcelain. Inquiries to architects and landscape material brokers received positive responses and test marketing is planned for 2015.

nrri student researchers

Elizabeth Alexson
Water Quality Research

Conner Lundeen
Fisheries Research

Kendall Carden
Chemical Inventory



Nathan Ose
Moose Research

Ted Keyel
Bird Monitoring

Richie Vang
Product Development

NRRI takes great pride in the real-world, hands-on experiences it gives students. We're also grateful for their hard work and enthusiasm. We couldn't make the progress we do without them.

Here's a smattering of photos that reflects the range of activities our student crews engaged in this past summer. And lest one thinks it looks like they're having too much fun… it's all about the data!

Luke O'Neil
Moose Research

Carsten Knutson
Water Quality Research

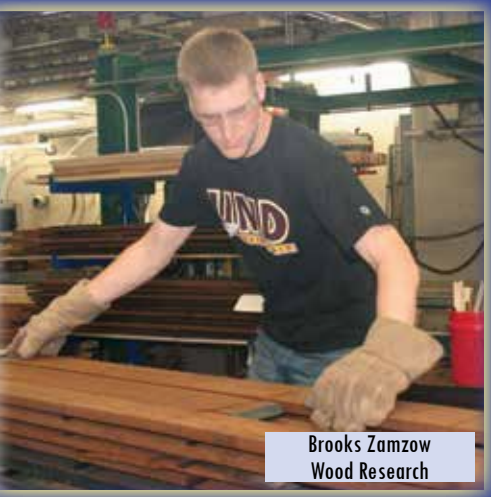
Wettie Nagbe
Product Development

Carissa Klonz
Biocoal Research

Alex King
Water Chemistry

Matt Young
Biofuels Research

Matt Detjen
Water Sampling



Brooks Zamzow
Wood Research

Rolf says . . .
"Engaging students with career-defining experiences is key to the NRRI mission."

Photo credit: Ron Moen

Student researcher helps moose

Young scientist investigates unique idiosyncrasies of moose and water

Since 2010, NRRI biologists have been collecting data on Minnesota's moose populations. Today, those piles of data are being parsed out as scientists piece together the puzzle of why moose are declining here. And for a young scientist stepping into research mode, the data is leading to new knowledge in a specific behavior that seems to make moose tick – why do they spend time in the water?

Cord Reno is an undergraduate student in UMD's biology program who received a coveted Undergraduate Research Opportunities Program financial award this year. The UROP gives curious and capable students a chance to design their own research project with a faculty advisor in their area of interest. The funding will also help cover his travel to a national conference to present the research.

For Reno, the interest in biology and wildlife came after he started perusing course offerings.

"I came to UMD looking to be an engineer," he said. "But when I looked at the courses in biology, anatomy and animal diversity, that was a lot more interesting to me. And then I met [NRRI Scientist and Biology Professor] Ron Moen as a freshman and did field research for him that summer."

Of course, helping to understand the complexities of the moose situation in Minnesota and spending time in the woods was also appealing to the avid outdoorsman. Once he declared a major in biology, Reno also added a minor in Geographic Information Systems.

Reno's research focuses on the question of why moose spend time in the water. Is it only to stay cool? Is it to harvest the sodium in aquatic vegetation? A study done on Isle Royale moose in the 1980s found that in the early summer, moose spend a lot of time in the water eating plants to meet their sodium needs. Terrestrial plants don't have as much sodium as aquatic plants. Reno wanted to test that theory using modern GIS technologies and overlaying that with air temperature data to see if moose are simply trying to stay cool.

Tracking data gathered from moose wearing radiotelemetry collars over the years provides Reno with scads of moose location and temperature information.

"There are so many factors going into the disappearance of moose, but one might be that if their main food source starts to disappear in certain areas, it could be a factor in trying to figure out this problem," said Reno.

In his initial findings, Reno was surprised when the collar data showed that moose spend relatively small amounts of time in the water. He will continue to investigate what drives them there.

"It's a really cool field," he added. "I like working with animals and the research on what's causing them to move or change. It's very collaborative, especially around the moose research."

Young forests are for the birds

Large harvest plots attract variety of bird species 20 years later

It wasn't what she was looking for, but noting the presence of the golden-winged warbler was a special treat for Alexis Grinde this spring. Research has shown that this tiny feathered friend is experiencing one of the steepest population declines of any bird species in the past 45 years.

With a yellow cap and eyes masked like Batman, the golden-wing has been designated a "species of greatest conservation need" by the Minnesota Department of Natural Resources. Elsewhere it's been put on "threatened" or "endangered" lists.

"But there are a lot of golden-winged warblers in here now," said Grinde from a study site in UPM Blandin Paper Mill's experimental "large plot," about 20 miles outside of Grand Rapids, Minn. The site was harvested 20 years ago and is now considered an early successional forest. "Before the harvest, only a few were detected," she added.

Grinde is a NRRI graduate research assistant and doctoral candidate in UMD's Integrated Biological Sciences program. Blandin is funding a part of her research to find out what birds are breeding and living in the large, young forest. As a conservation biologist, one might think she'd be at odds with working for a forest products company. Instead, Grinde knows that forest management done right is good for wildlife.

"Large scale forest fires used to happen regularly in nature, but now logging is the major disturbance," said Grinde. "I think it's important to maintain a diversity of forest structures – young, old and in between. If forest companies can do that in a sustainable way and communicate with scientists about harvest practices to benefit wildlife and ecological balances... that's exciting."

Grinde and NRRI Research Fellow Annie Bracey have been noting the wide variety of species using the large plot this summer – many ovenbirds and red-eyed vireos – whose abundance is surprising because they are species that usually inhabit older forests. Also interesting are the large populations of chestnut-sided warblers and veery joining the golden-wings. And that's why the research is important, even though flittering birds can be difficult to count.

Binoculars, especially in the thickness of the forest, are limited in what they see. Point counts – listening and noting bird calls – gives more information about who is in the forest, and that work continues. But Grinde's project goes even further by using mist nets – very finely stringed nets placed strategically in narrow, cleared rows – to gently capture the birds. This allows researchers to identify, weigh, age and place bands on the birds' legs before releasing. It helps them know if the birds are likely to be breeding age and ensures that they're not documenting the same birds over and over.

Gerald Niemi, NRRI's bird research program leader, was working with UPM Blandin and conducting bird surveys on their property in the mid-1990's when it was decided that this large plot should be cut. Now, 20 years later, the site presents a unique opportunity to follow-up on how the breeding bird community has changed over this period as the forest re-grows.

ABOUT THE GOLDEN-WINGED WARBLER

Food: caterpillars, moths and other insects, and spiders

Nests: The female builds the nest, usually on the ground, at the base of a plant.

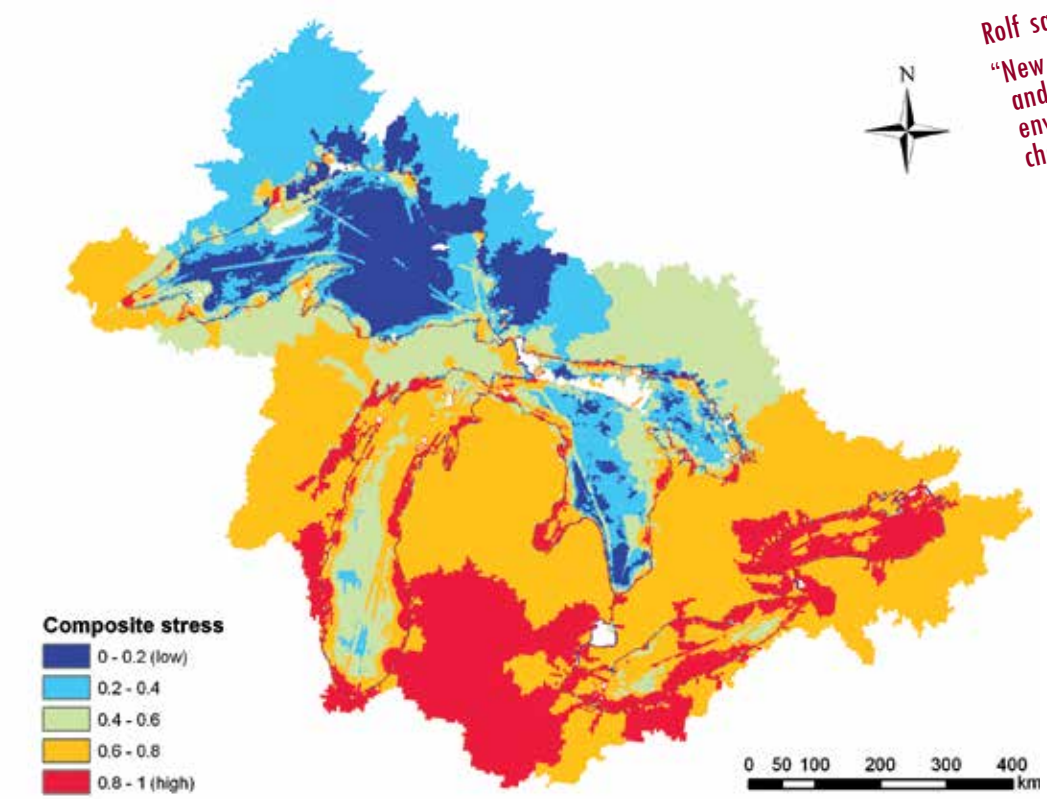
Do Not Disturb: Females are very sensitive to disturbance and may abandon nests, even after laying eggs.

Size: Slightly smaller than a black-capped Chickadee

Behavior: They forage among brushy and shrubby areas, carefully inspecting leaves for prey. Males are extremely bold and vocal during breeding season, becoming secretive during nesting and raising young. Males are mostly monogamous.

MAPPING ENVIRONMENTAL STRESS

Comprehensive data is gathered from land to deep water



Rolf says . . .
"New tools are critical to understand and describe the complex environmental relationships in our changing world."

Composite stress on this map is the compilation of 34 stressor variables such as land & water development, agriculture, and rural poplulation densities collected by NRRI for the watersheds of the Great Lakes' deep waters. The map will provide a more comprehensive understanding of these complex ecosystems.

Stress. Humans know a thing or two about it, but we're not the only organisms that do.

On the land, ecosystems get stressed by things like over-development, chemicals and agriculture. In water, organisms are stressed by invasive species, pollutants and heavy shipping, for example. And just like with humans, too much stress on the environment makes for a weakened system.

Just how do those stressors – from the watersheds to the deep water in the Great Lakes region – come together to impact the environment? Getting to that answer is very complicated. The Great Lakes hold six quadrillion gallons of fresh water, and have more than 10,000 miles of coastline. The ecosystems within are very complex. But NRRI is working to simplify some answers.

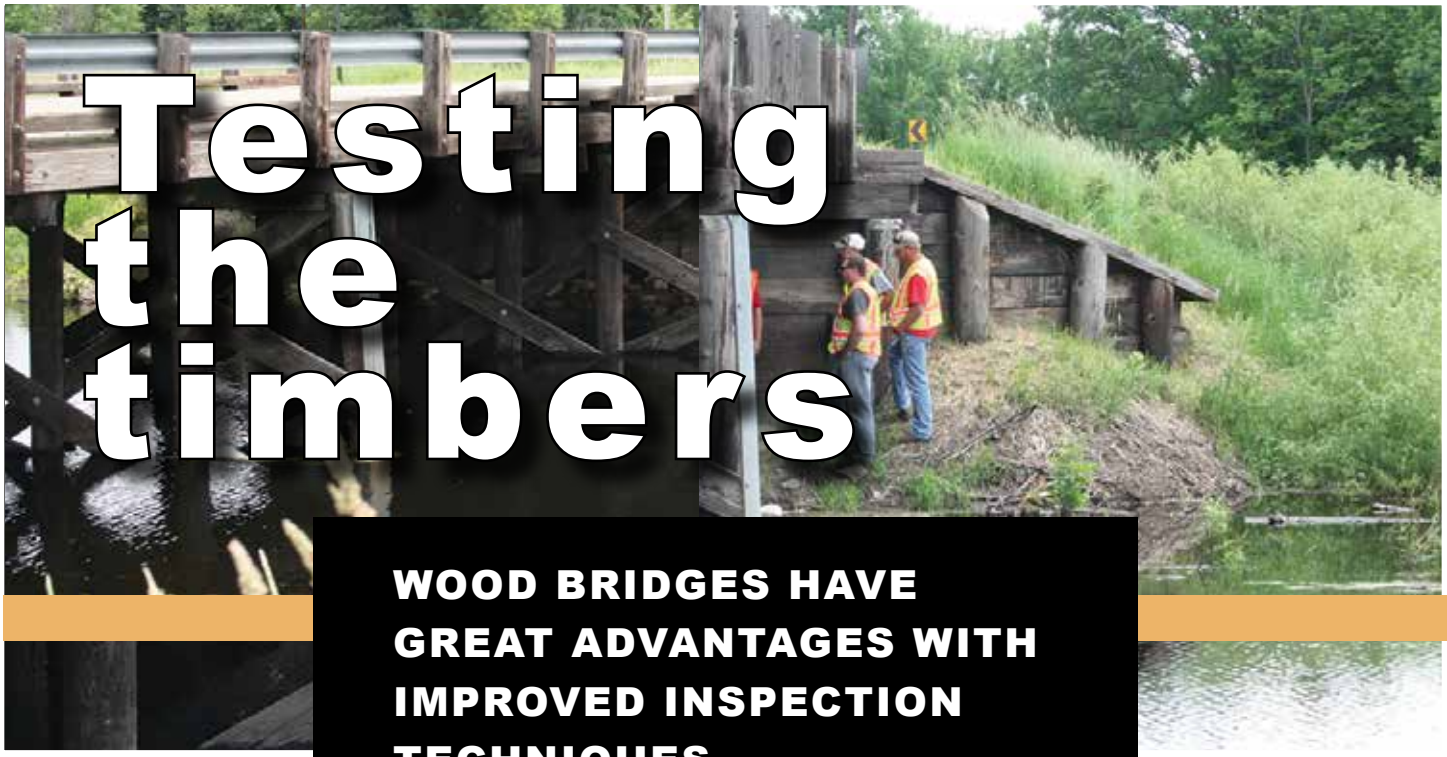
> *"Fisheries, phytoplankton, zooplankton… we're seeing dramatic changes in those species."*
>
> Lucinda Johnson

The University of Michigan has collected stress data on the deep waters of the Great Lakes for an Environmental Assessment and Mapping project, to which NRRI is adding watershed stress data collected for the Great Lakes Environmental Indicators project. The goal is to have a comprehensive map that shows a stress gradient – from minimal stress to severe – on both the land and in the water. That map will help answer questions like: What's causing the stress? What can resource managers do to fix, or at least, explain what's happening?

"Fisheries, phytoplankton, zooplankton… we're seeing dramatic changes in those species," said Lucinda Johnson, NRRI Center Director and leader of the project. "How much of those trends can be related to invasive species or too much phosphorous or something else?"

NRRI Statistician Meijun Cai is charged with management of the project. Using Geographical Information Systems, Cai had to find a way to merge the 34 water-related variables (like, ice-out dates and fishing pressure) with 207 land-based variables (like, nutrient inputs and land use). Simplifying the watershed variables and adding the water variables results in a comprehensive – and extensive – data picture.

This joint mapping project will be completed in June, 2015 and made available to land and water resource managers. The project was funded by the University of Michigan Water Center.



Testing the timbers

WOOD BRIDGES HAVE GREAT ADVANTAGES WITH IMPROVED INSPECTION TECHNIQUES

Brian Brashaw recalls being under a wooden bridge years ago and seeing the cross beam squish down about four inches when a big gravel truck passed over it. You couldn't tell from the outside, but the inside of that important bridge beam was rotted. Therein – literally – lies the problem.

Wood is a traditional material for building bridges with a lot of benefits – it's renewable, sequesters carbon and can be rapidly installed using local manufacturers. Timber bridges are especially prevalent in rural areas and Minnesota has more than 2,000 with wooden support structures and/or decking material. But water, insects, cracking and minimal maintenance can wreak havoc on bridge structures – and that havoc is not always apparent.

"The biggest areas of decay are because water is not getting off the bridge deck very well," Brashaw, NRRI Wood Program director noted. "Railings connections are an area of concern and snow plows also cause a lot of damage."

The Minnesota Department of Transportation needed better wood bridge inspection techniques. To meet this need, Brashaw teamed up with the U.S. Forest Service, Iowa State University and HDR Engineering. This summer they launched a field manual called "Advanced Timber Bridge Inspection" and took it on the road around Minnesota with new technologies to train state and county inspectors. About 100 participants came to the workshops, including Scott Theisen, a "fracture critical" bridge inspector for the state of Minnesota.

"This will give us more tools to do better, more in-depth inspections," said Theisen. "With the availability of new tools and the training, we'll be able to quantify deterioration much better than we have in the past."

One thing won't change – inspectors will still start with a visual inspection and their trusty hammer, tapping the wood to hear the hollow sound of rot. But a notation after the "sounding" technique will only read "good" or "bad" and will miss the decay present in thick beams and posts. The new technologies include stress wave timers and resistance microdrills that can identify more exactly the percentage of deterioration without damaging the wood further.

One commercial stress wave timer comes from Hungary. It measures the speed of acoustic stress waves initiated by striking the timber or by application of ultrasonic pulses. The stress waves travel faster in sound, high quality wood and slower in deteriorated wood.

"Just tap it in, get three time readings and away you go," Brashaw told the workshop group. "It's fast and effective."

The resistance microdrill was developed in the late 1980s for arborists and tree care professionals to evaluate the condition of urban

[Top left] Brian Brashaw (center) provides information to bridge inspectors on site. [Top right] NRRI technician Matt Young (right) holds a stress wave timer on a bridge support for. [Bottom photos] State and county bridge inspectors listen in the field and during classroom instruction to learn about new technologies for wood bridge inspection.

trees. What makes it effective for timber bridge inspection is the super-thin, flat-tipped drill bit – just 1/8 inch at its largest – so that damage to the timber is minimal. The bit travels through the timber at a defined rate that signals the exact location and extent of the damaged area. Of course, decayed wood and internal voids have little to no resistance to the drill bit.

Theisen said he's grateful for the new techniques and plans to put them to use as soon as he gets the new tools.

"The data will make it better for the folks doing structural analysis and load ratings," he added. "We've never had a bridge failure on any bridge we've inspected, which I'm happy to say."

Brashaw noted that there are examples of well-designed and maintained timber bridges in Minnesota that are upwards of 70 years old. "Timber bridges have a future in Minnesota, and this project helps engineers and inspectors understand them better," he added.

This project is funded by the Minnesota Local Road Research Board and the Iowa Highway Research Board.

Rolf says . . .

"The capability to easily assess the integrity of our wooden bridges helps maintain our rural infrastructure safety and reliability."

Causes of timber bridge decay:

- Poor drainage from bridge deck
- Freeze/thaw of ice
- Debris floating down river
- Vehicle or plow impacts

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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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Lucinda Johnson, director

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Center for Economic Development
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MINNESOTA RESOURCES ON THE ROAD TO ALASKA

NRRI Scientist Larry Zanko supervises the installation of Minnesota taconite as a surface coating on Alaska's Glenn Highway in September.

Anyone who drives a vehicle – especially in wet or winter conditions – appreciates roads and bridges that grip the tires. For that, an especially hard friction aggregate is applied to the road surface called calcined bauxite. It is typically sourced from China or India.

But there's a Minnesota option that is being tested on some of the toughest road conditions in the United States – Alaska highways (and yes, they still use studded tires there). Waste taconite rock, known as tailings, an industrial by-product from Minnesota's Iron Range, could be a potential bauxite alternative.

NRRI Economic Geologist Larry Zanko has been researching, testing and promoting the use of hard taconite rock as a road aggregate since 2006 with a grant from the U.S. Economic Development Administration. He made some industry connections and did some demonstration projects with the Minnesota Department of Transportation.

"Actually, it goes back as far as 2001 when we started characterizing the properties of taconite tailings to see what sort of applications we could find for it," said Zanko. "We laid the groundwork with a lot of technical data first."

The Alaska Glenn Highway is a major route out of Anchorage. This demonstration project is a great opportunity to see how the material wears over a period of a few years in challenging conditions. NRRI is working closely with a private sector partner and the Alaska Department of Transportation to monitor the results.