# NRRI Now

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Do you open your email inbox and just delete, delete, delete? Yeah, me too. We have a lot of information coming at us every day. But that's why I want to say thank you. It's because you didn't delete this email that we won the CASE V Silver Award this year. That's huge! Thank you opening and clicking and staying interested in our work.

And I'm excited to announce that when you click the links in this issue, you'll go to our brand new website! A complete overhaul and a new way to present our research. We'd love to hear what you think. **Visit our new website.**

NRRI was formed in the early 1980s by the state legislature to provide applied research for better understanding and management of our natural resources. And we'll continue to be here for you through the new year ahead.

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# NRRI refocuses biomass research to serve emerging markets

**June Breneman**

Dec 3, 2021

It's not easy to give up on a project. But NRRI and project partners knew when it was time to take research on solid biofuels in a new direction.

Research is rarely a straight-forward path to success. In fact, sometimes more is learned in the process of failing than succeeding. As inventor extraordinaire Thomas Edison famously said: “I haven’t failed. I’ve just found 10,000 ways it won’t work.”

## Case in Point

Fifteen years ago, natural gas prices were sky high and coal use was increasing. NRRI began research to develop a renewable solid fuel alternative that could replace fossil fuels in electric utility plants. The product could be made with waste biomass resources – like beetle-killed trees or railroad ties – to produce a clean-burning, direct replacement for coal.

NRRI pursued this research with an industry partner, Gradient Technologies, to scale up a novel, steam-based moving bed technology to make the bio-based solid fuel. The technology was tested with a small batch reactor at Gradient Technologies in Elk River, Minn., in 2014, then scaled-up four times larger at NRRI’s Biomass Conversion Lab in Coleraine, Minn.

The 35-foot-tall moving bed torrefaction system was funded with a renewable fuels grant from Xcel Energy. The reactor was designed to thermally treat up to three tons of biomass a day on a continuous basis as an industrial-scale demonstration. The fuel would burn in a unique boiler designed by the Coalition for Sustainable Rail to produce both steam and electricity.

But the process didn’t work as planned, the market drivers changed and NRRI researchers knew it was time to pivot to other opportunities, like biochar and other carbon products. The team is looking into new funding sources to further develop these opportunities.

“Sometimes we do projects with novel, one-of-a-kind equipment,” said Kevin Kangas, NRRI Coleraine site director. “We can’t just go to a reference manual on how to design a vertical steam torrefaction reactor. There isn’t one.”

## Scale-up and Market Drivers

While the process worked at the pilot-scale, problems started emerging in the scaled-up version. At the small scale, the wood chips were basically hand-fed into the process. But at the larger scale, material handling produced fines, a dusty material that gummed up some of the equipment. The wood chips also tended to stack up on each other, keeping the steam from circulating evenly, resulting in a non-uniform product.

“We thought this through and had contingency plans, but despite everybody’s best effort and thinking, sometimes there are challenges that are difficult to overcome without making significant changes to the system,” Kangas said. “So we, with our partners, decided to close the project and pivot our thinking to other options.”

Also, during the development, markets shifted for solid biofuels. The Coalition for Sustainable Rail is still interested in replacing fossil coal in historical locomotives, but passenger trains are moving toward electric or battery power. And there’s one solid biofuel start-up, Restoration Fuels, LLC, in John Day, Oregon, that NRRI assisted.  Restorations Fuels is focused on providing solid biofuels to electric utilities and potentially in locomotive boilers.

But there’s not enough market pull to justify overhauling NRRI’s reactor for solid biofuels, according to Eric Singsaas, NRRI Materials and Bioeconomy research group manager.

## Research Pivot

NRRI plans to continue developing the steam-based moving bed torrefaction technology to explore new markets for this process.  NRRI’s Materials and Bioeconomy research group will develop new renewable materials used for everything from water treatment to light-weight vehicles.

"Steam-based torrefaction gives treated biomass some unique surface properties that can be modified to make new materials for filtration media or as bio-based composite building materials,” said Singsaas.

NRRI is also exploring this technology as a pre-treatment for synthesis gas (syngas) and green hydrogen production. These products could provide renewable alternative fuels.

"We’d like to produce a cleaner syngas, which can be converted into alternative jet and diesel fuels, or as a source of renewable hydrogen for future heavy industry," added Singsaas.

Kangas acknowledged that closing out a project before it succeeds is a difficult decision to make. But he is confident that Xcel, NRRI and the entire team made a good business decision.

“It just makes sense,” he said. “We don’t have the same drivers as when the project started 15 years ago. But we gained a more viable series of research options toward other products and other markets.”

# Meet the Researcher: Mei Cai

June Breneman

Dec 3, 2021

***Developing new technologies to clean up polluted water keeps environmental engineer busy***

**Photo right:** Mei Cai collects stormwater samples to monitor the performance of waste material along a newly constructed road. The filtration media is a mixture of salvaged peat and compost.

Sometimes it really does take a village. In Mei Cai's case, it's community – colleagues, city leaders, water treatment facility workers and college students.

Many hands helped Cai, with project co-leader Shashi Rao, complete a three-and-a-half-month pilot trial of a sulfate reduction technology that meets Minnesota's strict sulfate level discharge regulations. The team effort included NRRI geologists, engineers, technicians and University wastewater expertise.

"Our project pulled together many experts across NRRI and the University. The local communities also gave us large support in our field pilot trials," said Cai. "And the project could not be done without the undergraduate and graduate students who helped operate the system and performed repeated tests."

## Waste Not

Cai is an environmental engineer, statistician and Geographical Information Systems analyst. She joined the NRRI team in 2012 after starting her career as a post-doctoral researcher at the University of Tennessee – Knoxville, working on long-term acid rain effects on water and soil in the Great Smoky Mountains. Now she is leading one of three sulfate reduction projects at NRRI to help Minnesota meet this challenge.

What's exciting for Cai is using waste and other cost-effective materials and technologies to solve water quality issues. The current go-to technology for removing sulfate from water systems is reverse osmosis, which is very expensive and unattainable for small municipalities or businesses. Meanwhile, Minnesota requires sulfate levels to be no more than 10 parts per million for water discharged into wild rice waters to protect this sensitive plant.

"We verified during our pilot trials that this technology reduces sulfate from 60 to 120 parts per million to below ten," said Cai. "There have been very few studies evaluating sulfate reduction technologies in such low concentrations, such as below 200 parts per million, so this is really new."

The chemical precipitation system was scaled up from lab experiments to a pilot-scale that was deployed in a large trailer and tested at two municipal water treatment facilities this past summer. Next spring it will be deployed again at a mining pit lake to treat sulfate in combination with a microbial treatment system, one of the other sulfate solutions NRRI is developing.

### Runoff Clean Up

Waste materials were also used in a project Cai worked on to filter contaminants in stormwater runoff from roads and parking areas. Vehicle traffic, atmospheric deposition and winter road maintenance contribute pollutants that can leach into groundwater systems. Left-over and salvaged peat, taconite tailings and street sweepings were evaluated for chemical properties and effectiveness for stormwater filtering. Lab tests and field trials led to recommendations for implementation to the Minnesota Department of Transportation.

### Central Support

The large sulfate project has many moving parts – literally, it's on a mobile trailer – and is kept on track by Matt Mlinar, Portfolio Management Office manager.

"All his work helped us move the project along on track and under budget while achieving successful results," said Cai.

Many orders for equipment, supplies and chemicals were expertly handled by Tammy Thomasson-Ehrhart, principal office specialist.

"Tammy helped us place the orders immediately, find the right suppliers, contact them to fit our timing needs and give us order updates," Cai said. "It was invaluable to have the help of these two professionals."

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# Southern flying squirrels are climate migrants

June Breneman

Dec 7, 2021

Climate change is changing the species that inhabit Northern forests. NRRI scientists are starting a study to document the expanded range of the Southern flying squirrel.

Flying squirrels are a big-eyed, nocturnal, caped crusader of the treetops. They're a native species in Minnesota and their white belly might be spotted gliding overhead at a late-night summer bonfire or descending into a backyard bird feeder for an evening snack.

But the warming climate is allowing the Southern flying squirrel to expand northward, pushing its larger northern cousin further north.

And that surprised NRRI Wildlife Biologist Michael Joyce.

Surveying small mammals in northern Minnesota forests in 2020, he and his team didn't capture the expected Northern flying squirrel. They only captured the Southern flying squirrel, even though historical data points to the study area being Northern flying squirrel territory.

"We had seen flying squirrels on our cameras set up to monitor our fisher den boxes, but it isn't always possible to tell which species it is because they're so similar," said Joyce. "After the survey we took a harder look at the images and they are probably all Southerns, which are slightly smaller than Northerns."

*Photo right: Two Northern flying squirrels.*
*Photo credit: Ryan Pennesi*

But what's really surprising is how fast the Southern species' ranges is expanding – up to about 12 miles a year, according to studies done in Ontario.

"And that's really fast for such a small animal," said Joyce.

So while he could find studies in Michigan, Wisconsin and Ontario documenting flying squirrel range shifts due to climate change, there's no data on exactly where each species currently lives in Minnesota.

Joyce is hoping to change that.

NRRI provided the seed money he needed to outline this new research. The NRRI Funding Review Board approved $7,500 for a pilot study on flying squirrels in Northern Minnesota. Now complete, Joyce and his team are now ready to design a significant research program and seek funding with regional agency partners.

NRRI's internal funding gave the wildlife team time to get comfortable with new equipment, understand the parameters of the research and think strategically about what research questions need to be answered. Having a proof-of-concept data before seeking full funding is critical for successfully attracting grant support.

"We set up acoustic detectors because the Northerns and the Southerns have different calls," said Joyce. "One of my colleagues says the Southerns' call is slower, like a bit of a drawl."

Specifically, Joyce wants to know where each species lives in Minnesota and how quickly their range is expanding. Could their different eating habits impact the forest ecosystem? Are the Southerns hybridizing with the Northern species?

"It's important to document changes to the ecosystem due to climate change because it may affect the system in ways we don't yet know," said Joyce. "Not every change is going to have a strong consequence, but it's important to understand potentially cascading impacts for forest and wildlife health. We can't address a change if we don't know, and can't document, it's happening."

### 5 Fun Facts about Flying Squirrels

1. Flying squirrels do not fly, but glide from one perch to another made possible by a skin membrane which extends from the front to the hind feet.
2. The squirrels can glide as far as 150 feet, though most glides are between 20 and 30 feet.
3. Flying squirrels eat a variety of fruits and nuts, insects, small birds, and meat scraps. Some people have lights at bird feeders so they can watch the flying squirrel's antics at night.
4. Living in tree hollows or leaf nests, flying squirrels are the only nocturnal squirrels in Minnesota.
5. Flying squirrels do not hibernate, but slow their body activity in winter and sometimes nest in groups to stay warm.

**Source:** Minnesota DNR

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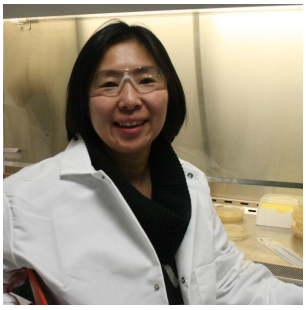
## Around the U:

# Environmental engineer innovates for Minnesota



Chan Lan Chun considers herself an environmentalist first and foremost. As an environmental engineer, she solves problems that affect the natural environment, but she has found that her innovations can also aid corporations.

"People see industry and environmentalism as fighting each other," says Chun, "but we can help each other too."

Read the Tech Comm article: Dr. Chan Lan Chun: Environmental Engineer