NRRI is applying new technologies to streamlined processes for building homes in the Aurora Building Systems pilot plant in Aurora, Minnesota.
Cover Story

New building techniques bring new hope to Iron Range

Aurora Building Systems automates construction process

Home building is an old art form ripe for an infusion of new techniques. NRRI is helping to lead the way by bringing together professionals who, using a team approach, are building more than houses—they’re setting a foundation for economic development opportunities in the wood products industry in Northern Minnesota.

The new Aurora Building Systems pilot plant, in an old maintenance facility in Aurora, Minn., is based on a tried and true building technique—the kit house—updated with computer-driven technologies. Flat-packed, ready-to-build homes were a popular item in the Sears catalog from 1908 through the 1940s. Given today’s high construction costs and need for affordable housing, they can be popular again.

“Our goal is to build businesses that sell and produce knock-down, ready-to-assemble house systems,” explained NRRI wood products researcher Pat Donahue. “This way, pre-cut, wood-framed single and multi-family homes can be delivered to the job site and erected with a minimal level of skilled labor.”
The key to success is the shared vision by the Aurora Building Systems business team to use the pilot plant as a portal through which automated building system technologies can grow as an industry and as a focused economic development cluster using, as Donahue says, “Minnesota forests to build Minnesota homes.”

Aurora President Tink Birchem, also co-owner of Birchem Logging, knows how important it is to stay innovative in the wood industry. She and her business partner/husband Jerry, were inspired to re-think their logging business after a trip to Finland where innovation in the wood industry is pushed forward.

“We realized we needed to add value to our product,” Tink Birchem explained. “After meeting with Pat (Donahue) we saw how well this building concept would fit with our goal of diversifying what we do with wood.”

The potential for growth of spin-off industries related to Aurora Building Systems on the Iron Range is a welcome addition to the economics of the area. Seeing this, the Iron Range Resources and Rehabilitation Agency (IRRRA) backed the project some funding to remodel the maintenance garage into a pilot plant. Aurora will build two houses this fall, one in Hibbing and one in Tower-Soudan that will be sold through the respective cities.

Contractors have been enthusiastic about the kit house idea because it saves them time, which in turn, saves them money. The computer design software figures out how much lumber and materials are needed. The materials are delivered to the site, ready to be assembled. And there’s very little waste because all the lumber is cut to size right from the start.

An exciting part of Aurora’s innovation will come from design consultant Charlie Lazor. He is applying his successes in designing furniture kits that are beautiful, functional and affordable to the manufacturing of home kits.

“I’m very idealistic and care deeply about design and believe it’s as important as breathing fresh air,” said Lazor. “Aurora’s goal and my goal is to create a set of house products that are inspired, that make us say, ‘wow.’ There are many house products out there. My job is to differentiate the Aurora products from the rest of the field.”

The new opportunities being developed were not lost on Jerry Okerman of SOTA TEC Fund and now Aurora’s Chairman of the Board. He saw a niche growing for ways to combine computer technologies with the construction and building materials industry, which fits nicely with SOTA TEC’s goal to provide pre-venture capital funding for research at Minnesota institutions of higher education.

“I give a lot of credit to Pat Donahue for bringing together diverse parties to build this business together,” said Okerman. “We’re very excited about the possibilities.”
Wild rice is a sacred and spiritual element of the native Ojibway culture as well as a beautiful (and delicious) symbol of Minnesota’s northwoods wetlands. It’s also an interesting ecological puzzle for tribal resource managers and NRRI researchers as, together, we try to understand this native crop’s rhythmic boom-and-bust growing cycles.

The amount of wild rice in the lakes fluctuates on approximately four to five year cycles. Very productive years are almost always followed the next year by a crash in the population, followed by a slow recovery over the next three years to levels of the previous productive years. Then the cycle starts again.

Why does this happen? One obvious possibility is that the boom/bust cycles are being driven by similar fluctuations in water levels. Indeed, raising of the water table kills wild rice plants. We’ve seen that increasing populations of beavers, and their dams, are flooding wild rice beds and causing declines in many areas. However, neither the water levels nor beaver populations fluctuate on the rice’s four to five year cycles. Moreover, even in the same lake, some wild rice beds might be increasing while others are declining in the very same year, and yet the water table is the same throughout the lake. Ducks and various insects feed on wild rice, but they also are probably not the cause of the cycles either because their populations do not fluctuate on cycles of this length.

Studies by scientists at Lakehead University in Thunder Bay have shown that the growth of wild rice appears to be limited by the supply of nutrients, particularly nitrogen, from sediments. And where does the nitrogen come from? It turns out that more than 90 percent of the nitrogen in sediments or soils is bound up in dead wild rice straw—and plant roots can’t take up these forms of nitrogen directly. It is only when the organic matter is well-decomposed that the microbes begin to release nitrogen back into the soil or sediment.

We have observed that wild rice straw decomposes relatively slowly. The decomposing microbes do not begin to release the nitrogen until at least the end of the following summer, or even two years later—well beyond the time when next year’s plants need to take it up in the spring and early summer. The nitrogen locked up in all that straw is not being released in synchrony with the timing of the nutrient uptake. Starved for nitrogen, many wild rice seedlings die and the population crashes to a low level that year. The following year, the large crop of straw is now well-decomposed and the nitrogen is released in large supply to the next generation of plants. The population begins to rebound.

Our research with the Fond du Lac Indian Reservation Natural Resources Program is now focusing on adding straw in varying stages of decay to wild rice plants to see if this will cause the fluctuations in growth that we’ve predicted with computer models and that we see in native wild rice beds.

What causes cycles in wild rice production is of interest, culturally and scientifically, to Ojibway band members as well as to the wider scientific community. For three hundred years, Ojibway tribes in Minnesota have harvested wild rice and have a strong interest in understanding the ecology of natural stands of wild rice. Through our cooperation with tribal biologists and students, we hope to assist in those efforts.

**DID YOU KNOW?**

- Wild rice, in the genus *Zizania*, is a different plant altogether than the tropical white or brown rice, which is in the genus *Oryza*.

- Identifying and protecting wild rice beds from logger’s dams was an integral part of the 1854 Treaty between Minnesota and the Ojibway.
Cool temps may hold down gypsy moth numbers

After last year’s busy summer of monitoring the life cycle of the gypsy moth in northern Minnesota woods, NRRI researchers have some good news to report. It seems the destructive non-native insect tree defoliator, the gypsy moth, finds Minnesota’s cooler late summer temperatures a bit uncomfortable.

“The moths tend to be abundant in warmer climates where they can complete their life cycle sooner,” said Mark White, NRRI lead researcher on the project. “Here in Northern Minnesota, because of cooler temperatures, they develop slower. The reproductive stage of their lifecycle likely would coincide with cooler early fall temperatures. This probably would limit their population growth. Cold winters may also slow gypsy moth population growth.”

The moth was accidentally introduced to North America with cargo from Europe some 134 years ago. They’ve done their damage to East Coast forests and have slowly but steadily hitch-hiked their way west. Moth populations have been detected in western Wisconsin. Isolated populations are currently being controlled in the Twin Cities metro area.

NRRI was enlisted to study gypsy moth behavior before they establish populations in Minnesota’s woods. To do this, the researchers set up pheromone traps in varying densities in three one-square-mile plots in the woods. Each week, over the course of three months last summer, they released 900 sterile male pupae. The study showed that temperature affects the moths’ ability to make their way to the female-scented traps. Research predictions indicate that male moth activity would peak in northeastern Minnesota in late August to mid-September. However, the sometimes cool temperatures in this area in the late summer to early fall could slow moth reproduction.

“What we could see here is what they’ve experienced in the UP (Upper Peninsula of Michigan),” said White. “They have gypsy moths, but the populations haven’t taken off and become destructive like they have on the East Coast. However, they could become established here and disperse to other warmer areas where they might become a problem.”

NRRI is working cooperatively on this project with the USDA APHIS program, USDA Forest Service, the Minnesota Department of Agriculture and the Minnesota Department of Natural Resources.
Minnesota’s back roads are peppered with some 4,000 bridges made with timber for vehicles, snowmobile trails or for other recreational uses. Sure, they can take a beating, but like anything made of wood, water is their worst enemy. And when timber support beams start to rot from the inside, it’s often hard to tell how damaged they are.

“There are literally thousands of timber bridges out there in need of a better inspection method,” explained USDA Forest Service Project Leader Bob Ross. “The current method is a visual assessment, but that often will miss what’s going on inside the timber.”

The Forest Service asked for help from NRRI because of the institute’s reputation for bridging the gap between basic research and the private sector and NRRI researchers’ knowledge of wood inspections. NRRI’s role was to search the international market for the latest technologies in wood rot sensing and try them out to see how well they worked. Forest Products researcher Brian Brashaw scouted the market for a variety of tools and is now cooperating with Michigan Technological University and the Forest Products Laboratory in Madison, Wisc., to put the tools to work on Minnesota’s rural bridges.

“Ultimately, we want a better understanding of the structural integrity of these bridges,” explained Brashaw. “The more we know about the bridge, the better we can take care of it, and the longer it will last. That’s being fiscally responsible.”

Using old timbers collected from decaying bridges around the region, NRRI Researcher Bob Vatalaro tested the options—seven pieces of equipment that used varied techniques of measuring moisture content and ultrasound wave movement. Then they developed useful working relationships between the equipment readings and the level of decay.

Working with the Northland Advanced Transportation Systems Research Laboratory—comprised of experts from UMD, Minnesota Department of Transportation (MnDOT), and U of M’s Center for Transportation Systems—Brashaw organized what they learned into training courses about the new options for MnDOT field inspectors. So far, they’ve provided a short course for each of the eight MnDOT districts and trained more than 250 inspectors and engineers in advanced inspection techniques.

But that’s just the beginning. Next summer Brashaw and his forest products team will go out in the field with the inspectors and the new equipment, with complete instruction manuals on all the options. Their goal is to learn how to build testing equipment right into the bridges. NRRI’s engineers will help build pilot scale bridges with the new technologies at Michigan Tech and with the USDA Forest Service.

Working with the bridges meshes well with NRRI’s nondestructive evaluation technology program. The forest products group’s goal is to gain a better understanding of the full range of wood materials, including trees, lumber, veneer, products and structures.

“We see this as an ongoing research program, not just a single project,” said Brashaw. “This is an important part of the USDA’s mission to improve rural transportation by using wood to help build rural economies.”
NaturTek, LLC, a company spun out of NRRI’s chemical derivatives lab and housed at the institute, announced a name change to NaturNorth Technologies effective September 1.

“We’ve come a long way from the NaturTek concept to where we are now with NaturNorth—achieving production quantities and finding exciting new applications for these extraordinary natural compounds,” said NaturNorth President David Peterson.

NaturNorth Technologies is a partnership formed with the University of Minnesota Duluth, ALLETE and Potlatch Corporation. The new name reflects the unique nature of the product—chemical compounds derived from birch bark for a wide variety of cosmetic, agricultural and industrial applications. The bark used is a waste by-product, so there’s no new cutting of birch trees.

“The successful start-up of NaturNorth Technologies is due to the commitment of working together by each of the three entities,” said University of Minnesota Duluth Chancellor Kathryn Martin. “Each partner brings their own area of knowledge and expertise to the table.”

New rapid prototype technologies attract best and brightest

Projections of population trends for rural Minnesota show a continued migration of young, well-educated workers seeking employment in large metropolitan areas. The reason? That’s where big companies, using the latest technologies, are most often found.

But Northern Minnesota’s economy needs those young, forward-thinking minds and NRRI just proved it can play a small role in keeping them here.

Britt Buerskin, a 1999 Hermantown High School graduate and Bemidji State college student, was seeking a home for her newly acquired skills in model design technology. Her college peers had to go as far away as Texas to find a job, but she was adamant about wanting to stay in Minnesota.

“If I couldn’t find a job in my field, I would have gone back to college to become a high school math teacher,” said Buerskin. “I really wanted to stay here.”

Lucky for her, the Northern Lights Technology Center opened at NRRI this spring, offering the latest in model and prototype technology. Buerskin’s interest in CAD design and three-dimensional renderings was honed through Bemidji State’s design technology degree program and her skills are well used in NRRI’s rapid prototyping center.

“This lab is really great. I like the variety, working on all the different machines and with different materials,” she said. “I really enjoy what I do and I’m very glad to be here in Duluth doing it.”
Most folks notice the change right about at Hinckley on drives from the Twin Cities to Duluth—the coolness hits and the landscape starts to change. Oaks and maples give way to spruce and jack pines; the deciduous forest gives way to the boreal. It’s the coolness “up north” that dictates the landscape around us and some think that coolness will eventually give way to the warm temperatures found further south.

While scientists are still debating if global warming is occurring and, in particular, whether or not contributing greenhouse gases are manmade, most scientists believe evidence that shows a trend toward global climate change. Some models predict that over the next 50 to 100 years, increased CO2 and ozone gases that trap the earth’s heat will raise Minnesota temperatures by 6-10 degrees Fahrenheit in the winter and 7-16 degrees in the summer. Extremes in precipitation are also expected, with more heavy storms and longer periods of drought.

These trends were published in a report, “Confronting Climate Change in the Great Lakes Region,” released last spring. Regional experts, including NRRI aquatic ecologist Lucinda Johnson, compiled the research for the Union of Concerned Scientists and the Ecological Society of America.

NRRI has three research projects underway that focus on how these predicted changes, if realized, would affect wetlands and amphibians, aspen forests, and prairie grasslands.

Frogs face many stressors in drier wetlands

Given the drier conditions predicted in climate change models, scientists anticipate that seasonal wetlands will dry up sooner and permanent wetland water levels will decrease because of evaporation. What affect will that have on the frogs that live there?

“Amphibians are an important species in wetlands ecosystems,” explains NRRI aquatic ecologist Lucinda Johnson. “They’re the top predator and they eat a lot of mosquitoes and other insects. They also eat a lot of the algae and plant material that grows abundantly in wetlands, and they are a critical part of the food chain.”

Frogs also make excellent research subjects. They’re sensitive to other stressors the researchers are studying for this project: ultra-violet radiation and agricultural herbicides.

This year, the first of the three-year project, the research team is collecting and comparing frogs from local wetlands surrounded by either crops or grasslands. To predict the effect of climate change on the wetland water levels, the researchers are assuming that ponds that are now semi-permanent will dry up sooner, acting more like seasonal ponds. The team is studying amphibian life in seasonal ponds and comparing it to the amphibian life in semi-permanent ponds.

In the wetlands surrounded by crops, the researchers want to understand how amphibians are affected by Atrazine, a weed-killing herbicide used extensively on corn crops. To do this, NRRI researcher Pat Schoff is exposing tadpoles to one of two levels of Atrazine or a control pond of clean water. The first level of Atrazine is the amount commonly found in wetlands near crops, the higher level is occasionally found in nearby ponds or streams when there’s runoff from heavy rains.
A tribute to Minnesota’s air quality can be found in our trees. Air pollution has all but killed off ozone sensitive aspen on the East Coast, yet here in Minnesota we still have a diversity of aspen types. The abundance of aspen forests in Minnesota, the genetic variability of the tree species, and its importance to forestry economics makes aspen a worthy focus for climate change research.

We know how too much ozone affects people: it scars lung tissue, makes eyes sting and throats itch. At the same time, scientists are finding that increased amounts of carbon dioxide (CO2) are trapping the earth’s heat causing predictable and documented rising temperatures. A study underway by NRRI scientists is taking a hard look at how ozone and CO2 interact with each other, and how they will affect Minnesota’s prolific aspen forests if these trends continue.

“Aspen is a major tree species in the Great Lakes states, both ecologically and economically,” said lead researcher George Host. “Knowing how it responds to climate change stressors is critical to this region.”

The research is taking place at the Harshaw Experimental Forest near Rhinelander, Wisc., in Free-Air Carbon Dioxide Enrichment (F.A.C.E.) rings. The rings are 12 open-air circles of small Aspen forests, about 33 yards across, that are dosed with varying levels of CO2 and ozone gases. Using data from the ringed forests, and working with the University of Minnesota Duluth Math Department, the researchers are simulating tree growth on a computer, modeling the effect of the greenhouse gases on tree productivity.

“One of the things we’re learning is that ozone reduces tree productivity by quite a bit,” said Host. “CO2 tends to increase tree productivity, but we don’t know yet how the two interact with each other.”

The third element of the study looks at the effect of increases in ultra-violet (UV) radiation on amphibians. Higher UV levels have been shown to increase frog mortality rates and may also be part of the incidences of frog malformation. The researchers use a meter that separates UV-B and UV-A wavelengths as well as photosynthetically active radiation (PAR). The meter is located at varying depths in the wetlands and records light levels every 15 minutes.

In the second and third years of the study, the smaller scale research will be applied to 100 or more wetlands in South Dakota’s “prairie pothole” region.

“The expanded study allows us to extrapolate our intensive information and apply it over a much larger region,” Johnson explained. “The EPA wants to know how these trends translate over a much larger landscape.”

Using each of these stressors as an input, the researchers hope to have a model that can be applied to future studies.

“Once we’ve identified stressor A, stressor B and stressor C, we can apply this model that tells us, what are the effects of adding A plus B, or A plus B plus C,” Schoff explained. “We’re adding layers and layers of stressors to the environment and we want to know at what point do we tip the balance toward a population crash.”

The three-year study is funded by the Environmental Protection Agency STAR (Science to Achieve Results) research program.

Aspen forests face changes from increased greenhouse gases

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The highly detailed computer model simulates every leaf on the tree—right down to how much sun and shade it gets and how much sugar each leaf produces. It allows the researchers to do things they can’t do experimentally at the open-air F.A.C.E. sites, for instance, simulate the affect of temperature changes.

“Plants have an optimum temperature and if we get on either side of that, too hot or too cold, their productivity goes down,” said Host. “Going out on a limb… I’d say that anything that affects the productivity of aspen trees is going to have a significant impact on the economy.”

The modeling work for the aspen F.A.C.E. experiment is funded by the Northern Global Change Program, administered by the U.S. Forest Service.
Rainfall extremes will affect grassland productivity

NRRI researcher Philip Fay is conducting research on the effect of anticipated rainfall extremes on grasslands.

Heavy storms and more intense droughts are among the predicted changes in climate over the next century in response to ever-increasing greenhouse gas concentrations.

Given these anticipated rainfall extremes, scientists are taking a hard look at how the “packaging” of rainfall will potentially affect grasslands. Most grasslands are water-limited, which makes them sensitive to changes in how much and how frequently it rains during the growing season.

“Up to about half of Minnesota is grassland, primarily in the south and west,” explained NRRI researcher Philip Fay. “We might expect that the patterns of grassland productivity and species composition currently found further south will, over time, migrate north and east as the northern climate becomes warmer and drier.”

Fay is conducting studies at the Konza Prairie Biological Station in Kansas, where he works with Kansas State University researchers on how grasslands respond to variations in rainfall patterns. So far, Fay and colleagues have found that making rainfall patterns more extreme—keeping the amount of rain over the growing season the same, but in a few, large downpours—reduced plant productivity by about 10 percent, but increased the number of species in the experimental plots.

This extreme rainfall pattern led to lower and more variable soil moisture in the top 12 inches of soil, where the majority of grass roots grow. Organisms important to the ecosystem processes, like decomposition, live in this soil layer. Plants also showed signs of water stress during the drought periods.

The implications of this have yet to be studied, but it’s possible that weakened grassland productivity could make it easier for invasive species to become established, or the nutrient content of the grasslands could change for prairie grazing animals, like buffalo or cattle.

“Because there is uncertainty in climate model projections of future rainfall patterns, we wanted to find out what kind of rainfall patterns would be likely to have the greatest impact on grasslands,” said Fay.

A new project funded by the National Science Foundation will monitor the effects of 16 different rainfall scenarios in synthetic grasslands composed of native grasses and wildflowers.

“Changes in climate are extremely important and we’re just beginning to grasp its far-reaching impact on ecosystems,” said Fay. “A region’s climate pattern determines the kinds of vegetation it will support, and how productive the vegetation will be. This is also important for agriculture, where a farmer’s success depends on not just how much rain falls, but when it falls.”
Wetlands are a coveted commodity, valued as an ecosystem that works hard to maintain a balanced environment. More valuable still are *Sphagnum* moss-dominated bogs (Type 7) and wooded wetlands (Type 8) because the climate and moisture conditions to “grow” them are unique.

NRRI’s Fens Research Facility near Zim, Minn., has those unique conditions and will soon hold a wealth of this ecosystem as a Wetlands Bank. The facility hosts two types of wetlands: fens, a soggy peatland that receives water from precipitation and groundwater, and bogs that receive water only from precipitation. Because of their value, federal laws require that there be “no net loss” of wetlands in the United States. That means when a wetland is filled or disturbed, another wetland must be made within the same watershed or county to replace it.

When the Minnesota Department of Transportation builds its new four-lane highway from Virginia to Cook next year, then later extends it from Cook to International Falls, they will need to replace about 150 acres of wetlands. The Board of Soil and Water Resources (BSWR) is responsible for mitigation of wetlands at the local level when county and township roads are improved for traffic safety.

Fortunately for all involved, NRRI’s 525-acre facility has 325 acres of former peat bog that was extensively drained in the 1950s to grow crops and in the 1970s for peat fuel experiments. NRRI also has the deep knowledge base of researcher Kurt Johnson who tested the “Canadian Approach” of peat bog restoration on areas that were mined by peat companies in Minnesota.

Reestablishing these drained acres as valuable Type 7 and 8 wetlands puts NRRI at the forefront of peatland restoration research, moves economic development forward with new and safer roads, while also returning the dried out acreage to its former, soggy glory.

Draining these wetlands in the 1950s and 1970s was probably as much work as it will be now to restore them. First, the land has to be cleared and the drainage ditches closed. Next, the land is leveled. The leveling process is critical to growing *Sphagnum* moss, an essential ingredient in the vegetative mix of peat.

Then, three inches of live vegetation is collected from a nearby bog, chopped up and spread on the restoration area. It takes about one acre of native bog to reseed 10 acres of restored bog. And enough is left at the native site to allow it to regrow. The final step is the application of straw mulch to reduce erosion and hold in moisture.

“Then we have to be patient and let Mother Nature do her work,” said NRRI Project Leader Tom Malterer. Peat is considered a slowly renewable resource and growth is measured in inches per one hundred years. “All we can do is provide the right hydrology and vegetation to, essentially, turn back the clock to an earlier successional stage and let the bog grow in its own time.”
NRRI Staff

Sharing our skills:

Basak heads distinguished society of mathematical chemists

Subhash Basak, NRRI senior research associate and adjunct professor in UMD's Department of Chemistry and Department of Biochemistry and Molecular Biology, has been elected President of the International Society for Mathematical Chemistry for a four-year term.

Mathematical chemistry is becoming increasingly valuable in computer-assisted drug designs and computer modeling of toxic chemicals. Evaluating chemicals with computers helps scientists prioritize them based on their predicted toxicity, saving millions of dollars in drug development.

The Society is a body international scientists promoting applications of mathematics to all branches of chemical research. This research is of interest to regulatory agencies like United States Environmental Protection Agency, U.S. Food and Drug Administration in computer (in silico) evaluation of chemicals for human and environmental health protection.

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