

Trees Fit for the Future



By Gustave Axelson

Timber company owner Jack Rajala is doing things differently on his 35,000 acres of commercial forest land in Itasca County. On his paper birch stands, he's thinning out birches and managing for new canopy trees—oaks and white pines.

Shifting market conditions have nothing to do with Rajala's change in strategy. Rather, he's responding to the dim outlook for boreal trees in northern Minnesota. Climate change projections show that birches, firs, and spruces will suffer

The **boreal trees** in our north woods today might not survive in a warmer climate. Researchers are trying to figure out which species will be most likely to succeed in forests of the fast-approaching future.



Birch Rebound?

On his 35,000 acres of forest land in Itasca County, timber company owner Jack Rajala says, "We're putting white pines on the ground. And we're discriminating against birches that don't have strong crowns.

"And we're favoring oaks," says Rajala. "We're thinning out our forests to give the stronger trees room to grow."

Pines and oaks are good for his business, which focuses on saw timber for millwork and cabinetry. Rajala feels confident in his own ability to adapt to climate change. And unlike many ecologists, Rajala sees a future for birch too.

"We think we can facilitate birch. It may be an understory tree, not a canopy tree, but we can keep it in the woods," Rajala says. "Birch is too important to our business, for cabinetry and millwork and flooring, for us to give up on it."

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massive diebacks in the next century.

But that isn't an excuse for hand-wringing and despair, says Rajala.

"I've heard the gloom and doom, but let's move on with the business of managing forests," he says.

Likewise, ecologists in Minnesota are re-evaluating how they might foster future forests in a warmer north woods. Some think a new type of forest will be necessary. Others say we can hold on to our boreal forest. The discussions and

debates about courses of action are just beginning. But ecologists generally agree that some kind of action will be necessary to keep northern Minnesota a fully forested region, as climate change impacts will be so forceful and pervasive that "letting nature take its course" won't be an option.

"People will choose the look and composition of tomorrow's north woods," says Lee Frelich, University of Minnesota forest ecologist.

A Precarious Spot. The north woods is one of Minnesota's iconic landscapes. Ecologists call it the Laurentian mixed forest province, a 23-million-acre region dominated by conifer forests across northeastern Minnesota. The north woods support about 1,000 forestry and logging jobs, paying \$50 million in wages. Another 18,000 tourism jobs, paying \$240 million in wages, rely largely on the aesthetic pleasure of a trip "up north." The north woods is critical habitat for megafauna such as moose and lynx. And it is the only place in Minnesota suitable for 47 wildlife species at risk of losing habitat, including boreal owls, spruce grouse, and Canada warblers.

Minnesota's north woods sits in a precarious place. Here, in the middle of the continent, the southernmost extent of the mostly Canadian boreal forest meets the prairie from the west and the deciduous forest from the southeast. Since the last glacier retreated 12,000 years ago, these three biomes have been advancing and retreating across the state every few thousand years.

But never before have the biomes tried to move across a Minnesota landscape increasingly carved up by development. And never before have forests had to change so fast: Climate change projections show

that the suitable climatic range for black spruce could shift 300 miles northward, out of Minnesota and into upper Manitoba, in the next 100 years. That's what was previously 2,000 years of forest change in a single rapid-fire century.

The United Nations Intergovernmental Panel on Climate Change projects that temperatures in central North America could rise 4 to 11 degrees F by the late 21st century. Less certain are precipitation forecasts; the regional climate could be wetter or drier. The result is a range of drastically different possibilities for landscape changes, from moderate shifts in biomes to natural disasters.

The future of the north woods will depend on how much and how fast the region's climate changes. Efforts to reduce greenhouse gas emissions will lessen the impact and provide more time for northern forest ecosystems to adapt.

Warming Already. Over the past 30 years, northern Minnesota's average annual temperature has been 2 F higher than annual averages before 1980, according to the State Climatology Office of the Department of Natural Resources. That's enough warming to cause changes in Minnesota's northern forests in the here and now, say some ecologists. They point to the recent expansion in the boreal Boundary Waters of red maple, a temperate species that grows as far south as Louisiana. Red maples are sprouting and establishing themselves in the Sea Gull Lake area, where Frelich documented one red maple that grew four feet in one year (definitely peculiar for a boreal forest region, he says).

Along Minnesota's beloved North Shore, miles and miles of dead birch tree trunks stick out of green, brushy understory at odd

“We’ve changed the landscape, we’ve changed the fire [frequency], and now we’re changing the **climate**.”

—Peter Reich, University of Minnesota forest ecologist



North Shore Dieback?

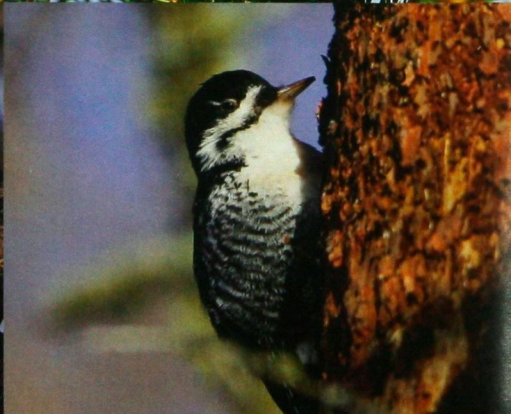
Birches along the North Shore sprouted in the wake of fires in the early 1900s. Now those birches are dying. Under natural forest succession, the birch forest would have succeeded into white pines, but deer have eaten the pine saplings. Now the understory is crowded with bluejoint grass and alder and hazel brush that stifle new tree growth. Whether or not this birch dieback is caused by climate change, it may offer a preview of what climate change might do to the northern forest—dead forest that degrades into brushland.

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angles like a jumble of white poles. There are multiple causes of death, including a string of droughts stretching back to the 1980s and an earthworm invasion. Frelich adds higher soil temperatures to that list and says these dead birches are among the first cli-

mate change casualties in northern Minnesota, though other ecologists aren't willing to make that connection yet. Regardless of the cause, the birch dieback offers a vision of what might happen in a warmer climate—a dead forest degrading into brushland.

Boreal Habitat at Risk: Minnesota's boreal forest is the prime nesting grounds for about 25 wood warbler species. According to the DNR's comprehensive wildlife conservation strategy, the Laurentian mixed forest province offers the only suitable habitat in Minnesota for 47 wildlife species at risk of losing habitat. Some of the species at risk include [clockwise from upper left] boreal chickadee, boreal owl, Cape May warbler, black-backed woodpecker, American black duck, and spruce grouse.



DNR Forestry ecologist John Almendinger points to the recent increase in forest pest infestations as a clear barometer of climate change. Milder winters over the past decade have allowed greater winter survival for eastern larch beetles. These native bugs burrow into tamaracks and lay eggs, which hatch into larvae that feed on the inner bark and cut off the tree's circulation. More larch beetles surviving into spring means higher-than-normal summer populations and increased infestations, which have killed about 65,000 acres of tamarack trees since the late 1990s.

Likely Losers. Last year Frelich and fellow University of Minnesota forest ecologist Peter Reich published a paper in *Natural Areas Journal* that lists tree species likely to disappear as major components of Minnesota's northern forests with a warmer climate. It's a list of the classic trees that put the "north" in north woods: balsam fir, black spruce, white spruce, jack pine, and red pine.

Climate-change secondary effects would impact even more tree species. Paper birch and aspen would die off from increased drought. White cedar and white pine regeneration would be extinguished by hungry deer herds that expand thanks to milder winters. The line-up of tree killers, including more violent windstorms and the arrival of new forest pests such as mountain pine beetles, would impact almost every tree species found in the north woods today.

And Frelich and Reich don't expect a smooth transition from one healthy forest type to another. The rate of warming air and soil temperatures will outpace the intergenerational movement of tree species (i.e., how far a tree's seed can travel via birds or wind and grow into a new tree). Over the next 100

years, Minnesota's portion of the boreal forest will dwindle. Hardwoods won't be able to move en masse from the south fast enough to fill in all the places where boreal species decline. Meanwhile dead forests could degrade into brushlands, where the predominant trees would be the species that specialize in moving fast and filling a void—possibly invasive species such as nonnative buckthorn.

Resistance—Keep It Boreal. Last year in the scientific journal *Biological Conservation*, University of Minnesota ecologist Susan Galatowitsch identified three adaptation strategies—resistance, resilience, and facilitation—that could maintain biological diversity in Minnesota. The strategies aim to lessen unavoidable impacts of climate change, such as changes in forest habitats caused by warming that's already underway.

Resistance means holding on to the current boreal tree species in northern Minnesota. But it doesn't mean doing nothing. In fact, it could require intensive forest management actions. For example, foresters could conduct prescribed burns that mimic historic fire patterns. Such burns would increase numbers of fire-dependent species—such as paper birch, black spruce, and jack pine—and allow them to spread over more areas with a wider variety of growing conditions. In the process, these species would become more diverse genetically, thus possibly improving their prospects for persisting in a changed climate.

"Fires deal our forests a new hand of cards, and the trees play all their aces," Frelich says.

Other resistance actions include planting seeds instead of saplings for silviculture, because field-grown seedlings undergo natural selection earlier than nursery-grown seed-

lings, and hence may be better able to survive environmental stresses. Reducing the northern deer population through intensive hunting zones would aid regeneration of trees. Likewise, an all-out effort to remove invasive plant species just as they sprout would help maintain the existing forest.

In her paper, Galatowitsch quotes another ecologist who said “resisting climate change is akin to paddling upstream.” But she notes that resistance forest management might at least preserve native trees for a few decades, perhaps buying foresters some time to develop and implement other adaptation strategies.

The DNR’s Almendinger thinks resistance forest management will do more than

just buy time for boreal trees. He says there’s proof that a boreal forest can survive in a warmer climate. Almendinger studied pollen records dating back 4,000 to 8,000 years, during the mid-Holocene when average temperatures were higher than they are today. He found evidence of boreal trees such as balsam firs and black spruce in Minnesota’s Arrowhead region.

“The temperature was 2 to 5 degrees hotter, with maybe three-quarters of current precipitation, but we know from the pollen records that there were still boreal trees in [present-day] Lake and Cook counties,” says Almendinger. “Our gene pools have lots of plants that may be naturally resistant.”

Old-Growth Blueprint?

Among the corn and soybean fields of Kandiyohi County, there inconceivably grows several hundred acres of old-growth forest. Bill and Ute Reid own much of it and have counted 105 bird species here. Three species of elms (American, red, and rock) and basswoods with leaves as large as teacup saucers create a shaded understory crowded with hip-high forest-floor plants.

On peninsulas that jut out into Little Kandiyohi and Swan lakes, grassy savanna grows punctuated with bur oaks.

University of Minnesota forest ecologist Lee Frelich says this is the lone remnant of the forest that dominated Minnesota at the middle of the current Holocene epoch. That was the last time Earth’s climate was as warm as it is predicted to be by

the middle of the 21st century. Frelich says this forest will likely escape every tree-killing malady that could come with a warmer, more volatile climate. And he suggests that ecologists start studying this remnant forest today. “It should be used as a reference, an ecological blueprint, and possibly as a seed source for future forests farther north,” he says.



“We must prepare for an unpredictable future by applying greater **diversity** of silvicultural approaches.”

—Dave Epperly, DNR Forestry director

Resilience Through Diversity. A resilience strategy seeks to boost a forest's immune system through diversity—mixed tree and plant species, and mixed stands of young, mature, and old trees. Resilience silvicultural practices include planting various native tree species and partial timber harvesting that leaves behind patches of older trees. In the

north woods, resilience would foster a gradual change to more hardwoods but keep the forest healthy in the face of volatile weather and invasive species, two threats likely to increase with climate change.

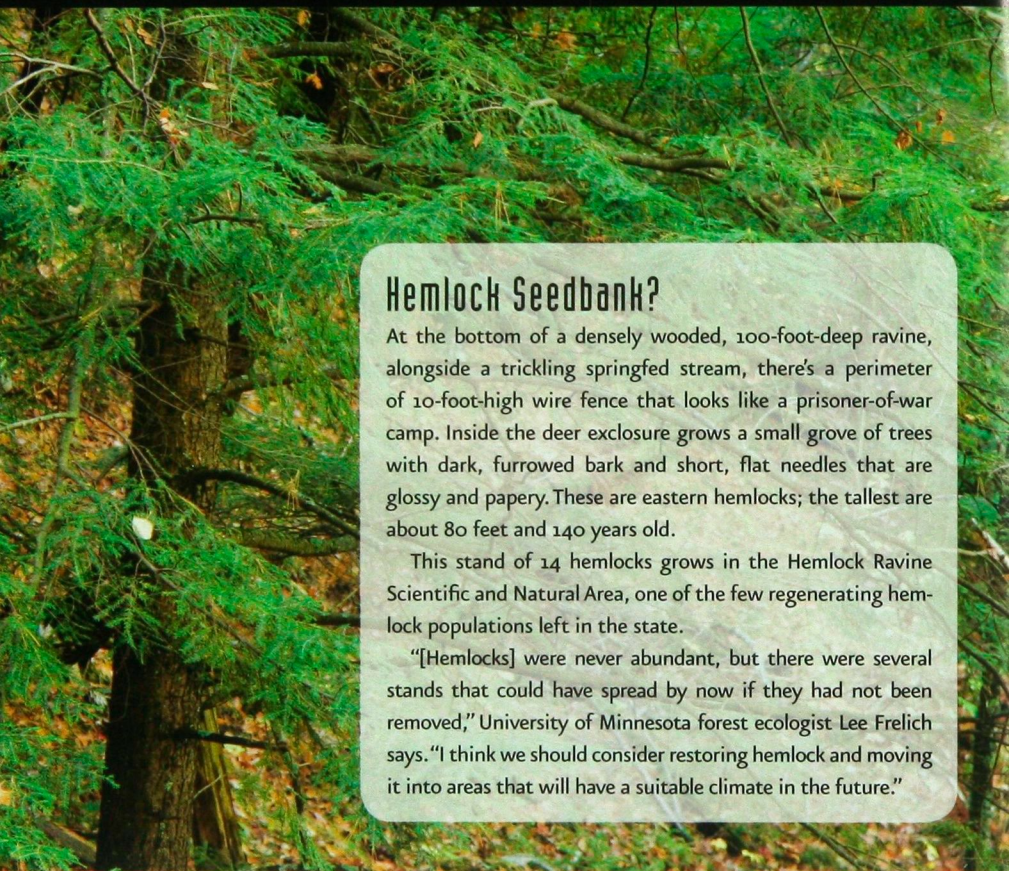
The Nature Conservancy, a private non-profit conservation group, is forecasting what resilient forests of the future might look

BUR OAK SAVANNA AND BASSWOOD BY GARY ALAN NELSON



“Our forests will need as many different avenues of **adaptation** as possible.”

—Lee Frelich, University of Minnesota forest ecologist



Hemlock Seedbank?

At the bottom of a densely wooded, 100-foot-deep ravine, alongside a trickling springfed stream, there's a perimeter of 10-foot-high wire fence that looks like a prisoner-of-war camp. Inside the deer enclosure grows a small grove of trees with dark, furrowed bark and short, flat needles that are glossy and papery. These are eastern hemlocks; the tallest are about 80 feet and 140 years old.

This stand of 14 hemlocks grows in the Hemlock Ravine Scientific and Natural Area, one of the few regenerating hemlock populations left in the state.

“[Hemlocks] were never abundant, but there were several stands that could have spread by now if they had not been removed,” University of Minnesota forest ecologist Lee Frelich says. “I think we should consider restoring hemlock and moving it into areas that will have a suitable climate in the future.”

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like. TNC Minnesota forest ecologist Mark White built computer models to show how forest management could alter outcomes for northern forests in a warmer climate. Under a resilience strategy, White's models showed maples, white pines, and oaks might in-

crease, while jack pines and spruces could be retained. Without resilience actions, northern forests might be reduced to maples and aspens with lots of areas of grass and brush that no longer support forest.

Meredith Cornett, TNC director of

conservation science in Minnesota, says TNC is using resilience management on its three preserves in northeastern Minnesota: "We're expecting fir, spruce, and birch may be gone in the next 100 years. We'll see fading northern forest components and increased hardwoods. But we want that hardwood forest to be the best hardwood forest it can be.

"I've been inspired to see [TNC] turn away from doom-and-gloom predictions toward what we can do to help the natural areas we've protected adapt to climate change. We must ensure the gains we have made will persist in an uncertain future."

On the Manitou Forest Collaborative project, TNC is working with the U.S. Forest Service and the DNR to create greater diversity in forest structure and species, with emphasis on trees such as maples and yellow birch. TNC is also working with both agencies on tree harvesting and planting techniques that promote white pines.

Facilitation of Future Forests. Facilitation means moving tree species to entirely new ranges where they don't grow today. It's based on the notion that rapid climate change will make it impossible for natural tree migratory processes, such as seed dispersal, to occur. The idea has caused controversy.

In North Carolina, a group of scientists planted *Torreya taxifolia*, a federally endangered yew, in private forest reserves. Wild *Torreya* currently only grows in a single dwindling population near the Georgia-Florida border. The group argued *Torreya* grew in the southern Appalachian Mountains during the Pleistocene and could grow there again. Critics called the planting "very dangerous tinkering."

In Minnesota Frelich says forest managers should consider assisted migration of eastern hemlock trees from an isolated remnant stand near Duluth to areas along the North Shore. He says hemlocks could replace boreal conifers lost in a warmer climate.

Frelich also proposes other interventions such as a restoration strategy of planting white pines inside the Boundary Waters Canoe Area Wilderness. White pines are present in the wilderness, but they have suffered a 40 percent decline in the region. They would do well in the BW-CAW where deer density is low, and they could thrive in a warmer climate. But the U.S. Forest Service currently doesn't allow interventions such as planting pines inside the wilderness.

Reich, Frelich's fellow University of Minnesota forest ecologist, is uneasy about facilitation, but he says some traditional rules for wildland management might need to evolve. "It takes a lot of hubris to think we can manipulate nature. We've done it before . . . and we've failed," he says. "But we've changed the landscape, we've changed the fire [frequency], and now we're changing the climate.

"If you're looking at emerald ash borer wiping out an ash forest, and you've got no other trees to fill in that space, well, in Ohio and Michigan, buckthorn has moved in to fill that void. I'm 100 percent in favor of planting new species, picked carefully, in that case."

Almendinger remains steadfastly opposed. "Facilitation is my nightmare, that we'll think we're smart enough to figure out how to move things," he says. Instead, Almendinger says tree species could still move naturally along traditional forest migration routes. Again consulting the pa-

leoecological records, he says that forests historically advanced and retreated along the Itasca and St. Croix moraines, elevated ridges that run from northeastern Minnesota west to the prairie and southeast to Wisconsin's hardwood forests. Those moraines still have lots of continuous forest, he says, citing public lands such as the Chippewa National Forest, Foothills State Forest, and Itasca State Park.

"It's not just continuous forest that is needed for species migration, it's also the continuity and variety of microclimates that allow trees to move," he says. "And that's what these moraines provide with their elevation."

All of the Above. Ecologists are still at the dawn of thinking about how to manage forests in the face of climate change. Resistance, resilience, and facilitation are strategies under construction, and ecologists are experimenting with all three.

On its northern Minnesota preserves, TNC is augmenting resilience forest management with resistance actions such as seeding spruce, and in the future TNC may consider facilitating red oaks and basswoods. Frelich says other forest managers should be open to such an "all of the above" strategy.

"Our forests will need as many different avenues of adaptation as possible," he says.

The DNR is beginning to formulate strategies for forests stressed by climate change. In its *Strategic Conservation Agenda*, the agency states a commitment to "enhancing ecosystem resilience to climate change" and to "create wildlife corridors, improve habitat connectivity, and expand habitat buffers to facilitate plant and animal migration as climate changes."


DNR Forestry is already adopting resil-

ience silvicultural changes, such as partial harvesting timber sales that retain significant and biologically diverse components of canopy trees and forest floor vegetation.

"Forest management, by its nature, is a long-term endeavor. And climate change adaptation is one of the forest manager's most important issues," says Dave Epperly, DNR Forestry director. "We must prepare for an unpredictable future by applying greater diversity of silvicultural approaches to keep our forests healthy and to enhance their capacity to adapt."

Any adaptation strategy will rely on intensive on-the-ground monitoring of changes in ecosystems. The DNR's network of 148 scientific and natural areas, 40,000 acres of protected old-growth forest sites, and remote portions of 66 state parks provide opportunities to monitor climate change impacts on natural lands minus human impacts. The Minnesota County Biological Survey is a DNR inventory of animals and native plant communities statewide. Program supervisor Carmen Converse says MCBS could include monitoring and assessment of the influence of climate change on Minnesota's native landscapes and species.

The challenge for the DNR, and all Minnesotans, is preservation of the north woods as a special place, a reservoir of biological diversity, the wildest forest east of the Mississippi.

"It is widely recognized that people have become a geological force in changing whole ecosystems," says Keith Wendt, a DNR manager in the policy, research, and planning section that coordinates the agency's climate change planning. "We must take responsibility for that and realize that our choices in the next decade will determine the forest of the future." 

“The more we can **reduce** the amount of **warming**, the easier adaptation will be.”

—Lee Frelich, University of Minnesota forest ecologist

Forests for the Future

A new DNR program managed as a public-private partnership will broker conservation easements that prevent development on more than 330,000 acres of forest statewide by 2010. Since each acre of Minnesota forest holds an average of 99 metric tons of carbon, protecting forests from development keeps stored carbon from being released into the atmosphere.