The Perfect Windstorm Study

What happens when millions of trees fall down in a forest wilderness?

CHRISTINE MLLOT

The wind had seized the tree and ha, and ha,
It held the shivering, the shaken limbs,
Then bathed its body in the leaping lake.

—Wallace Stevens, “The Hand as a Being”

Four years ago on the Fourth of July, a fierce wind and thunderstorm torpedoed through the boreal forest and lake-filled landscape along the Minnesota–Ontario border. When the winds died down, nearly 500,000 acres of US forest lay in disarray, an area greater than that blown down when Mount Saint Helens exploded. In Canada, the storm roughed up another 288,000 acres.

When blowdowns happen, loggers typically move in and salvage the downed trees. But this Independence Day storm hit a large piece of the Boundary Waters Canoe Area Wilderness, affecting more than a third of its million acres. Logging is prohibited in such congressionally designated wilderness, but research is not. In a field where researchers have been known to pull down trees in forests to approximate blowdowns and assess their impacts, the vast area of severely disturbed wilderness has given ecologists a rare chance to study how massive winds sculpt temperate–boreal forests.

“Ecologically it’s a gold mine,” says Chris Peterson, a forest ecologist at the University of Georgia who specializes in wind disturbance.

After three seasons of fieldwork, a picture is emerging of how the forest is recovering, adding to the relatively slim body of knowledge about large blowdowns specifically and catastrophic disturbance in general. As they dig through the woody debris, ecologists are finding that despite the area’s wilderness status, it has not gone untouched by human activity. Suppression of fire and a changing climate, in addition to or possibly related to the blowdown, are pushing the forest in new directions. The windstorm has simply sped up the forest’s passage down that path.

Derecho dynamics

The wind that seized the trees in the Boundary Waters emerged from an ordinary thunderstorm cell that had developed over the South Dakota–Wyoming border during the evening of 3 July 1999. What became extraordinary, says Warren Heilman, a meteorologist with the US Forest Service in East Lansing, Michigan, was how long the cell held together and then grew, over time and space.

By midnight, warm and humid air over the southern plains had energized the storm, sending
it on a northeastward track. It woke up residents and damaged buildings in Fargo on the holiday morning and prompted National Weather Service bulletins for northern Minnesota. By noon, as it reached the western edge of the Boundary Waters, the system kicked into overdrive: Cold downdrafts pulled the high-speed, high-altitude winds of the jet stream closer to the ground, creating on radar a signature "bow echo," or comma-shaped storm system bulging eastward. Screaming at speeds estimated to exceed 110 miles per hour, the winds uprooted trees, snapped the trunks of others, and hurled rain before the system hit Lake Superior's cold water, draining much of its energy. Weakened, the storm still continued on to New England.

Boundary Waters visitors said the storm passed quickly—the rain beat for as few as 15 minutes in any one spot and the winds quieted after about an hour. The heavily visited wilderness area, the largest in the eastern United States, loses two or three lives each summer to lightning or drowning. But none of the thousands of visitors that holiday died, though dozens were injured. The full impact of the storm only became clear days later, as Forest Service workers flew over the area and discovered a 30-mile-long megaphone-shaped swath of downed trees.

The power and extent of the Independence Day storm rank it as a derecho (der-AY-show), a recently borrowed Spanish term meaning straight, to describe a storm with straight-line (as opposed to rotational) winds. This explains why the downed or bent-over trees were largely pointing eastward, but several powerful downbursts associated with the storm splattered trees in other directions as well. Forest ecologist Lee Frels of the University of Minnesota estimates from satellite images that 12 downbursts occurred during the storm. The effect, he says, was "like pouring a cup of water while moving your arm from one end of a table to another."

After the storm, Forest Service and other scientists pulled together a research plan to assess the impacts of this once-in-a-millennium blowdown on everything from water chemistry to human recreation. But when wildfires broke out in Los Alamos and other western forests in 2000, the comprehensive Boundary Waters blowdown research never got funded, says Bill Mattson, Forest Service research coordinator for the Boundary Waters in Rhinelander, Wisconsin. Only a handful of researchers found funding and opportunity amid the trashed trees.

**Forest on the floor**

On a map, the Boundary Waters area looks almost as though it's more lake than land. The canoe, indigenous to the area, remains the conveyance of choice for visitors and researchers alike, especially after the storm. As is always the case in blowdowns, the disturbance was patchy.
Some areas lost hardly a tree, and "wind-firm" trees standing along lakeshores tended to survive. But in an estimated 90,000 acres, or almost 20 percent of the blowdown area, the forest canopy was completely destroyed. An occasional tree stands alone, good perching for eagles.

"It looked like somebody had set off a very large bomb," says ecologist Alan Haney of the University of Wisconsin-Stevens Point. "I've never seen anything like it." A healthy forest typically harbors less than 10 tons of woody debris per acre on the forest floor; the windstorm left up to 100 tons per acre in the most severely affected areas, according to the Forest Service. That means researchers—mainly graduate students and helper crews—often have to scramble over or dive into the jagged woodpiles to set up and monitor research plots. "Undergraduates find it like a giant jungle gym," says Haney.

Roy Rich, who is writing his dissertation with Frelich and ecologist Peter Reich on the vegetation response to the blowdown, has worn out several pairs of boots tending his 780 research plots. It's often easiest, he says, to travel atop the debris, several feet above ground, using downed tree trunks as forest thruways. But the method is not without hazards: Crossing a ravine, he once slid off an aspen bole as the bark sloughed off, only to have a stray branch catch the sternum strap on his pack, leaving him dangling in midair—with a sharp, broken pine branch at his neck.

But amid the mosquitoes, blackflies, and loaded tree branches waiting to be sprung, the ecological questions to be plumbed are rich. "It's a once-in-a-lifetime opportunity to study such a big disturbance," says University of Minnesota graduate student Kamal Gandhi. Peterson and Frelich, for example, are interested in assessing whether the relationship between boreal vegetation response and disturbance severity is linear or whether it changes at a certain threshold, according to cusp catastrophe theory—a general mathematical equation that describes an S-shaped curve rather than a smooth linear relation.

The most obvious change to the forest so far, Rich, Frelich, and Peterson have noted, is the release of balsam fir, black spruce, and northern white cedar seedlings that had been shaded by the standing forest. These started to shoot up in 2000 and continued skyward during their second year, when there was also a surprising explosion of dogwoods. These shrubs are not common in the forest, says Frelich, and were probably carried in by birds, which consume the berries. Light-loving, easily dispersed fireweed surged in open areas in 2002, along with currant and blackberry. The
After mating, female bark beetles (Ips species) create tracklike galleries in which they lay their eggs. Upon hatching, larvae will feed on the phloem of this dead jack pine. Photograph: Kamal Gandhi.

ecologists have not seen much in the way of invasive nonnative plants, except around trailheads and campsites.

They have seen a shift, however, in the kinds of trees that will make up the post-blowdown forest. Not all tree species succumbed equally to the derecho, analysis of research plots is showing. For any species, older, bigger specimens were more likely to topple. Older trees were also more likely to have been pioneering species in forest succession, and those turned out to be most vulnerable. “The blowdown removed early successional species,” such as jack pine and aspen, says Frellich. “It looks like [the forest] jumped ahead by 50 years in terms of the succession.” Species that come in late in the forest’s succession, such as white cedar, had a better chance of surviving the storm, as did paper birch, which is common in older patches in the Boundary Waters.

The storm’s editing process also took out, by Frellich’s estimation, 13 percent of the old-growth red and white pine in the wilderness, a significant chunk of a now rare ecosystem that once grew from Maine to the northern prairie states. Before the storm, these 100-foot-tall, long-lived trees grew on 61,673 acres in the Boundary Waters, the largest remaining US refuge. “A big part of the attraction of the Boundary Waters was the magnificent red and white pine,” says Peterson.

But even before the storm, the trees were not thriving. Both species depend on fire to clear soil for regeneration, and the Boundary Waters hadn’t experienced significant fire since the early 1900s, so young red or white pines were diminished along with young jack pine, which depends on very hot fire that opens the resin-sealed scales and releases seeds from its cones. “The storm just accelerated the trend of diminished pine,” says Frelich. He predicts there will be virtually no pine in 50 years, a dramatic change from what the early voyageurs found: a forest of 60 to 70 percent jack pine and 20 percent red and white pine. “It’s too bad,” says Frelich, “because wilderness areas are supposed to retain the original, pre-settlement vegetation.”

In a few pockets of the Boundary Waters and the surrounding Superior National Forest, an experimental fire regime (see the box on the preceding page) may help rejuvenate some natural stands of the trees favored by 19th century loggers and today’s Boundary Waters visitors. But the pines still face another adversity: a changing climate. The Boundary Waters mark the southern edge of the boreal forest, and Frelich notes that it is “already responding to warming.” Temperate hardwood species, such as red maple and oak, have been moving into what has historically been conifer territory. Given the changing climate, the lack of fire, and the catastrophic windstorm, the forest of June 1999, much less of 1899, won’t be back any century soon.

**Faunal response**

With all the downed wood, foresters feared an outbreak of bark and wood-boring beetles, which feed on dead trees, build their populations, and then turn to feed on live standing trees. Some beetles have increased, but the lack of drought after the blowdown or other factors have kept them from exploding in number.

Kamal Gandhi has noted, however, that standing jack pines in some areas are being attacked by wood-boring sawyer beetles. Working with forest researchers Dan Gilmore of the University of Minnesota and Steve Seybold of the Forest Service in Davis, California, she has been monitoring six beetle taxa since summer 2000. Using beetle traps, she is comparing what turns up in blowdown, undisturbed, burned, and salvaged areas. Some of the plots are in the national forest surrounding the wilderness.

Gandhi is still sorting the hundreds of thousands of beetles she has collected so far, but she has found a few other surprises, including the first recorded presence in Minnesota of an exotic ground beetle from Europe. The beetle was introduced on the eastern and western coasts in the late 1800s and has been invading the continent. At least four other ground beetle species not previously recorded in Minnesota have turned up in her collections as well.

The insect response, in turn, is affecting the mix of bird species living in the blowdown. In a study of forest structure, Haney and his coworkers have been monitoring birds and bird song in 60 permanent study plots in the Boundary Waters since 1976. Six of those plots were in the path of the storm. “It gave us a unique opportunity, serendipitously, to look at before and after effects,” he says.

The first year after the storm very little changed. “Bird populations were remarkably similar to what they were before.” Even if the canopy was gone, “they still hung in there,” says Haney. But in 2001 and 2002, he says, “there were radical changes in many species.” Most of the 65 monitored songbird species decreased in numbers. The bay-breasted warbler, a species of concern, totally disappeared. The blackburnian warbler to continued to decline. Some species did better: Magnolia warblers, white-throated sparrows, chickadees, and woodpeckers were “much more abundant” than before the storm.

This shift in bird species relates to a change in food and habitat, Haney says, as the downed canopy has created a dense
shrub layer. Gone are most of the treetop insects that many warblers feed on, but now abundant are larvae feeding on downed wood, good eating for woodpeckers and the like.

There has been one “big surprise,” says Haney: The shy yellow-bellied flycatcher, rarely seen during the 25-year study, showed up the first year after the storm and has since been present on every site. He attributes this to the blowdown’s glut of nesting real estate, in the form of upturned tree roots.

Haney and other researchers have informally observed effects on the ecosystem’s top predator and its prey, the gray wolf and moose. Northern Minnesota, including the Boundary Waters, was the last US bastion for wolves in the 20th century, after they were wiped out of every other state except Alaska. From this refuge, wolves have multiplied and re-established territories in the upper Great Lakes region. It’s not uncommon for campers in the Boundary Waters to hear wolves howling; lucky visitors may spot one crossing a road.

The summer after the storm, Rich found the splayed remains of a moose that had been pinned by a falling tree and then scavenged. Another moose was observed that winter trapped amid the debris and cornered by wolves. But Haney points out the new green browse in opened areas, and how easily the long-legged moose move through the debris.

“I don’t know who has the advantage, wolf or moose,” he says.

Although that question isn’t formally under study, since 1967 wildlife ecologists David Mech and Mike Nelson of the US Geological Survey have been studying 50 to 70 wolves that range over 800 square miles in northern Minnesota. Two to four wolf packs have territories that poke into the blowdown area, but they haven’t experienced any changes outside of the usual fluctuations in pack size since the storm, according to radio telemetry data. “As big as the blowdown is,” says Nelson, “in the overall scheme of things it’s a relative speck on the map for wolves and moose.”

**Storm of the future century?**

Though there is little doubt that the Boundary Waters forest is already experiencing the effects of a changing climate, opinion differs as to whether the windstorm itself was related to climate change—whether such storms are becoming more frequent. Globally, the third assessment of the Intergovernmental Panel on Climate Change, issued in 2001, predicts more extreme weather events such as hurricanes, but on a regional level, “trends in severe weather events are notoriously difficult to detect.” The record for tornados, derechos, and other severe windstorms just isn’t long enough, adds Heilman.

Several notable windstorms have taken a toll on US forests in recent years. A spectacular 1977 windstorm—coincidentally also hitting around noon on July 4—affected 850,000 acres in northern Wisconsin; two 1995 events felled trees on 100,000 acres in Minnesota and a similar-sized area in the Adirondacks. A recent analysis estimates one large derecho hits each year in North America, and most forests have been affected by them.

The conditions that give rise to these storms, says Peterson, may very well be more common, since warmer air temperatures create more convection and more precipitation. “In my mind it wouldn’t be surprising if there are more of these storms. I think we need to keep...open to the possibility.” Foresters would do well, he adds, to understand this force of nature and how best to manage the blowdowns.

However destructive the storms appear to be, Peterson and other ecologists don’t see them as bleak events. “Natural disturbances are part and parcel of being a forest.” Boundary Waters visitors haven’t been put off by the blowdown either (though they are avoiding areas with campfire restrictions). Early this season, they found tracts of blowdown neatly camouflaged by a tableau of pale lime-green new growth, pinstriped with stark white birch. They heard the warble of songbirds and the drumming of grouse and woodpeckers above a background of gnawing beetles. Blowdown for one species is windfall for another.

---

Wisconsin-based science writer Christine Mlot (e-mail: cmlot@nasw.org) visited the Boundary Waters on a CASE Media Fellowship for Environmental Journalists.