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The Bug That's Eating the Woods

A warming climate allowed pine beetles to ravage the West. Now they're spreading east across Canada.

By Hillary Rosner

One chilly morning in October 2013, Diana Six parked her white Subaru at the edge of a pine forest in southwestern Montana's Big Hole Valley. Beneath snow-tipped peaks, lodgepole pines in four different colors draped the hillside—a time line of carnage. The gray ones, now just trunks and branches, had died in 2009. Light red trees, still holding needles, had succumbed in 2011. Darker, auburn trees had perished in 2012. Even the seemingly healthy green trees, said Six, a ponytailed, bodybuilding, beer-brewing entomologist at the University of Montana, were not what they seemed. Roughly a quarter of them were already doomed.

Six zipped her jacket and ambled into the woods with an ax. She stopped at a mixed stand of emerald and burnt-orange lodgepoles. With the ax blade, she gently peeled a strip of bark from a green tree, exposing the pale wood beneath. There, wedged into narrow channels carved into the wood, were tiny black larvae the size of sesame seeds. They were dead, done in by an early hard frost—but it had come too late to save the lodgepole. Though the tree appeared to be thriving, its phloem, the fibrous layer under the bark that transports nutrients, was dry and brown.

Six moved to the next tree, another seemingly healthy one. Its phloem was greenish pink and pliant, clearly still hydrated. But it was laced with the same telltale channels. From their size and the lack of larvae, Six concluded that this tree had been invaded as recently as a week earlier. As she peeled back the bark with her ax, she accidentally squished a small black beetle.

Across western North America, in millions of acres of pine forest, the story is the same. Drive through parts of Colorado, and you'll encounter entire mountainsides painted with rust. From valley bottoms all the way to the tree line, nearly every single pine has been killed by an enemy smaller than a thumbtack: the mountain pine beetle. Tour British Columbia, and the scale of destruction is even more appalling. More than 44 million acres of pine trees there, an area the size of Missouri, have been attacked to varying degrees over the past 15 years.

Nature is always changing. But the mountain pine beetle is a troubling omen. It shows that global warming can push even native species to go rogue. At some point the epidemic will run its course, leaving a wake of ghost forests and altered ecosystems. "We need to see this as a harbinger of what's to come," Six says. "We're going to see one ecosystem after another begin to tip."

Unlike other organisms that have been ravaging the American landscape—Asian carp, kudzu—the mountain pine beetle isn't an immigrant. It's native to western pine forests, especially lodgepole and ponderosa forests, where it normally lives in relatively small numbers, killing a tree or two here and there. It's been normal too for the beetle's population to boom every now and then, and for it to kill large swaths of forest. But mainly in a single region—not across half a continent.

The scale of the current epidemic is unprecedented. Since the 1990s more than 60 million acres of forest, from northern New Mexico through British Columbia, have suffered die-offs. By the time the outbreak in British Columbia peters out, some 60 percent of the mature pines in the province may be dead. That's a billion cubic meters of wood.

The trees aren't the only casualties. A forest die-off disrupts everything, from food webs to local economies. In British Columbia timber-mill towns are cash-strapped; in Yellowstone National Park bears and birds have lost a rich source of nutrition. Falling trees have closed campgrounds, crushed cars, and sparked wildfires by toppling power lines. Formerly secluded forest homes now have views of the neighbors. With nothing to anchor it, soil washes away.

For its current good fortune, the mountain pine beetle can thank us. To start with, we've spent the past century eliminating forest fires—thereby turning the woods into beetle buffets. When the crisis began, British Columbia's forests were packed with three times as many mature pines as there would have been had they been allowed to burn naturally. Like mountain pine beetles, fire is native to western forests, and it's as important as rain to their health. It nourishes soil, spreads seeds, creates openings for sunlight, ensures habitat for all sorts of creatures.

According to Allan Carroll, an insect ecologist at the University of British Columbia who has been studying the beetles since he was an undergraduate in the late 1980s, only 17 percent of British Columbia's lodgepole pine forests were ripe for a beetle attack a century ago. By the mid-1990s that number had risen to more than 50 percent. Yet even that epic surge in vulnerable mature trees wouldn't by itself have killed whole mountainsides across ten states and two Canadian provinces. That vulnerability intensified the epidemic—but a change in climate was required to kick it off. The beetle has us to thank too for warming the whole planet with our carbon dioxide emissions.

Rising temperatures and drought have stressed trees, leaving them unable to fight an invasion. Warmer weather also has boosted the beetles' population and greatly expanded their range. They're flourishing farther north and at higher elevations, invading pine trees, such as jack pine and whitebark, that had rarely seen them until a few years ago. Because these trees aren't as good at defending themselves, a smaller band of beetles can overwhelm them. Three-quarters of the mature whitebark pines in Yellowstone National Park are now dead—a blow to grizzly bears, which eat the seeds in autumn, and to Clark's nutcrackers, which cache the seeds for winter.

In 2008 Carroll and other researchers produced a report for the Canadian government, concluding that the risk of the mountain pine beetle infesting jack pines in the boreal forest—which stretches right across Canada, covering a quarter of the country—was small but significant. But the beetle is already in jack pines. It has now colonized Alberta all the way east to Saskatchewan and north to the Yukon and Northwest Territories. Unlike lodgepoles, jack pines live as far east as Nova Scotia and down into the upper Midwest and New England.

"Will the beetle move across the continent?" asks Carroll. Colleagues call him Dr. Doom—if he's meeting with your local officials, it's a good sign your fo[illegible]'s are toast. He answers his own question: "Yes."

Atop Carroll's desk at the University of British Columbia in Vancouver, a motorcycle helmet and jacket sit at the ready for his semiweekly commute home to Vancouver Island—a trip that takes several hours and winds past thriving forests of Douglas firs. Carroll often takes back roads to spend more time amid robust trees. Under his desk is a white bucket containing a lodgepole pine log. Inside the log a female mountain pine beetle—Carroll calls her his office mate—has laid her eggs.

Carroll's office mate is a *Dendroctonus ponderosae,* one of about 6,000 species of bark beetles, including 500 that live in the U.S. and Canada. Most bark beetles lay eggs under the bark of trees that are already dead or dying. Only a few species burrow into healthy trees, and of those, most go in as a lone pair, posing no threat. Even the few species that do kill trees tend to target highly stressed ones. The mountain pine beetle is the bad bug of the bunch. Given the right conditions, it can ravage one healthy tree after another.

When a female mountain pine beetle like the one in the bucket lands on a tree, she first has to decide whether it's a decent place to raise a family. To do this, she'll chew into the bark and taste the chemicals. If the tree meets her standards, she'll continue burrowing, severing ducts that contain resin—the tree's first line of defense. Ideally for the tree, the resin will simply flush the beetle out.

But evolution is all about one-upmanship. And in a particularly elegant flourish, the beetle has evolved to ingest the resin—if she can survive swimming through the syrupy river—and convert it into a pheromone, a chemical that sends a message to other beetles. By releasing this pheromone into the air, the beetle signals that she's found a great place to congregate. Other beetles, male and female, gather. If there are enough of them, a mass assault ensues.

The tree doesn't give up easily. As soon as the burrowing beetles reach living cells, the cells commit suicide. As they die, they rupture, releasing a subst[illegible] that's supertoxic and beetle annihilating. If there aren't a lot of beetles, says Carroll, "generally the tree wins." But if the beetles invade with an army, not just a few scraggly mercenaries, they overwhelm the tree. Depending on the tree's condition, it can take many thousands or just a few hundred beetles to kill it.

The drought and warmer temperatures that have struck western forests in recent years have helped the beetles in two ways: by stressing the trees so much

that they succumb more readily and by giving the beetles more time to attack them. Beetles in Montana, says Six, used to fly from one tree to another mainly during two weeks in July. But now, as that infested tree in the Big Hole Valley shows, the flying season lasts into October. That means the beetles have additional time to reproduce—even as the extreme cold snaps of fall and spring, which helped keep populations in check, have become rare.

There's an eerie wisdom in a beetle mob. Sparsely distributed beetles besiege small trees; denser groups go for larger quarry. They seem to attack a large tree only when they know there are enough of them to take it. How does the first beetle know? Carroll and his graduate student Jordan Burke suspect it's the pheromone. A burrowing beetle releases it to call for help, but the amount that's in the air already tells her whether help is available and it's safe to lay her eggs. The beetle in Carroll's office is part of an experiment testing that hypothesis.

In any case, the cycle feeds on itself. The bigger the tree, the more beetle babies a beetle mom produces. More beetles mean more mass attacks on bigger, healthier trees. Once there are enough beetles to blast large trees, large swaths of forest are essentially doomed.

In 2013 scientists at the University of British Columbia sequenced the mountain pine beetle's genome, making it only the second of more than 400,000 beetle species to bear that distinction. (The first was the red flour beetle, which infests stored grains.) But Joerg Bohlmann, the plant biochemist who oversaw the sequencing effort, doesn't think a biotechnical fix to the pine beetle epidemic is imminent.

"We have to be extremely careful we don't promise things that are not realistic," he says. Pesticides can save a few individual trees but not a forest; they're too expensive, and they'd kill all sorts of other organisms. Breeding beetle-resistant trees would take decades, even with modern genetics. And even then the beetles might rapidly adapt and break through the resistance.

For the moment most research, from the genome work to the beetle in Carroll's bucket, is aimed at simply improving our ability to predict insect outbreaks. "No one can give you a certain answer about where the bark beetle will be in five years," says Bohlmann. "That is the biggest issue." If you can get to a forest soon enough, when beetle populations are still relatively small, you may control the infestation. At least that's the theory that's being tested in Alberta, which has become the front line in the battle to stop the beetle's march across the continent.

In many parts of British Columbia and the western United States the infestation is slowing on its own—in some places because there aren't many trees left to kill. But in Alberta it began more recently. Alberta has about 15 million acres of pines, far fewer than British Columbia, but they're in vitally important areas, at the sources of mountain rivers that feed the prairies and cities below. If those forests are devastated, the unshaded snow will melt faster, and rivers will crest earlier—before the dry season, when people and ecosystems need the water most.

To save a forest, you have to cut a lot of trees; the only way to stall the beetles is to ensure that they have nowhere else to go. Alberta's long-term strategy is to log or burn most patches of forest that are dominated by mature pine trees and thus highly susceptible to the beetles. Its short-term strategy is to fight the beetle tree by tree. In the past decade it has spent more than $320 million (U.S.) on beetle management.

The aim, says Erica Samis, a senior forest manager at Alberta's Ministry of Environment and Sustainable Resource Development, is to limit the beetle's spread along the eastern front of the Rocky Mountains and east into the boreal forest. Foresters hand-fell any cluster of three or more trees that are green but actively infested—sometimes a whole stand—if there are enough vulnerable trees within three miles. They burn or chip the trees to kill the beetles. In the area around Grande Prairie, where the beetles had never been seen until winds carried them over the Rockies in 2006, foresters have cut down 200,000 trees just since 2012.

Carroll likens beetle management to paying down a large balance on a credit card. "What you have to do is hit more of the beetle than what is growing annually," he says. "You've got to get past the interest into the principal. But when the population gets so big that you can't even get partway through the interest, you're hosed."

So far Alberta has managed, year by year, to make a dent in the principal—at least in most areas. Parts of the province have been designated "holding zones," where the government is just trying to keep beetle numbers steady. Other parts have been deemed a lost cause: There are just too many beetles. If foresters can't remove at least 80 percent of infested trees, they figure, there's no point in doing anything. As Samis puts it, "You're peeing into the wind."

What lies ahead in the battle for North American forests? Alberta is burning its felled dead trees in huge piles set alight during the soggy weeks of early

spring. If you were to slice into one of those logs, you'd see a lovely blue stain seeping through the yellow wood. It's a telltale sign of a tree that was killed by mountain pine beetles, and it has generated a cottage industry in siding, cabinets, and furniture made with the blue-toned lumber. Throughout the western U.S. you'll find "beetle kill" pine adorning homes, stores, and restaurants. My house in Colorado has a ceiling built of beetle-kill planks.

In Missoula, Montana, Ryan Palma runs Sustainable Lumber Company, which sells high-end, handcrafted flooring, doors, and paneling made from blue-stained ponderosa pines, many 100 to 400 years old. He harvests only trees that have been dead at least two years, so that all the beetles are gone, and he dries the wood slowly in a large kiln that's fueled by scrap beetle kill. The stain "kicks the wood into a lower grade," says Palma, "so sawmills don't want it." But a luxury market is growing, mostly out of state. Musician Jack Johnson has a beetle-kill guitar; Al Gore owns a blue-stained ukulele.

The blue hue is caused by a fungus, one of two that the mountain pine beetle carts around in a "fungal suitcase" in its exoskeleton. (The beetles also carry yeasts, and for years Six used one variety to home brew a beer she called Six-Legged Ale.) When beetles bore into a tree, the fungi slip out of the suitcases and grow alongside the larvae, providing them with nitrogen-rich food. "The beetles can't survive on the wood," says Six. "It's pretty much junk food. The fungi act like nutritional supplements, and that's what allows the beetles to do what they do."

One of the two fungi thrives in cool temperatures; the other likes things warm. Their populations in the beetles shift with temperature. Six's lab created models to see what might happen to the fungi as the planet warms. "If we warm things up a degree," she says, "what appears to be a very symbiotic, fine-tuned system begins to fall apart." Over the course of a century the cool-loving fungus disappears.

That's a small source of hope. The cool-loving fungus is the superior source of nitrogen; it enables the beetles to produce one-third more offspring, which can make all the difference to a forest. Six says the cool fungus is already vanishing in warmer parts of Montana; in some low-elevation ponderosa forests, less than one percent of the beetles now carry it. Global warming has been letting the beetle thrive—but as it continues, it could cut the epidemic short.

Or maybe not. The genome work has shown that mountain pine beetles are as genetically variable as humans are. That genetic variability is a source of adaptability; so is beetle behavior. For whatever reason, beetles at the northern end of the Rocky Mountains in Canada seem better able to deal with co temperatures than beetles in the United States. No one really knows yet how the species—or the forests themselves—will respond to a warmer future.

In the Jemez Mountains of northern New Mexico, a few miles west of Bandelier National Monument, Craig Allen stands on an outcrop of flat, craggy rocks and stares into Cochiti Canyon. The slanting autumn sun carves shadows on the slopes. It's a spectacular vista, except for one thing: Virtually every tree in sight is dead.

A forest ecologist with the U.S. Geological Survey, Allen has been based at Bandelier and taking in this view for nearly 30 years, and his heartbreak is palpable. Mountain pine beetles weren't a factor here—Bandelier is at the southern end of their range—but other species of bark beetle have killed many trees. So has a trio of huge wildfires, the last in 2011. In all, about two-thirds of the trees in Bandelier have died since 1996. Some forests vanished completely, killed by one fire and consumed by the next, leaving open meadows where thick stands of trees recently stood.

What happened in the Jemez Mountains, Allen says, is an extreme example of an emerging global phenomenon—what Diana Six calls tipping ecosystems. In New Mexico, beetles and fires tipped a system that was already stressed by drought. And all over the world, as in New Mexico, according to studies done by Allen and other researchers, drought-stressed forests are being tipped toward death by a global amplifier: rising temperatures.

We tend to equate drought with a dearth of rainfall. But warmer air can also reduce a tree's water supply, by pulling even more moisture out of leaves and soil. The Jemez Mountains got hit by both: a severe lack of rain compounded by soaring temperatures. Allen calls this kind of historically unprecedented combination of drought and heat a global-change-type drought. It has caused forest die-offs in other parts of the world too, from southwest Australia to inner Asia and from the Amazon to the Mediterranean. The warmer future forecast by climate models suggests the American Southwest in particular is in for more of the same: Allen, Park Williams of Columbia University, and their colleagues project that by 2050 the stress on southwestern forests will routi be worse than in the worst droughts of the past millennium.

For all the destruction wrought by pine beetles, they may be simply messengers. Around Bandelier these days the dead trees are falling pretty much every day. Cautionary road signs show one falling on a person. In much of the area, Allen says, the trees won't regrow; grasses and shrubs are replacing them. Driving back down into Los Alamos, he tries to conjure some optimism. Elk love the new open meadows, he points out.

"People always say things like, A thousand acres were lost," he says. "But they weren't actually lost. The land is still there, full of new life again. I personally lost friends in the fires—individual ancient trees I knew and loved. But these systems are in the process of adjusting. Nature goes on."

That's no doubt a healthy attitude, but it's not an easy one to sustain. In Montana, Six too has seen massive changes to landscapes she loves. At the turnoff to a forest road not far from Butte a sign says, "Keep Montana green." Six laughs mordantly. "Tell that to the beetles," she says.

Hillary Rosner teaches journalism at Syracuse University; this is her first feature for the magazine. Photographer Peter Essick's first appeared in 1986.