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Global Warming's Unlikely Harbingers

by Michelle Nijhuis

The West is heating up — and bark beetles are moving in for the kill

Bark beetle. L. Manning, Canadian Forest Service and Natural Resources Canada

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STANLEY, Idaho — The lodgepole pines are dying. Inside the bark of the trees, tens of millions of beetles are tunneling, birthing, hatching, maturing. In early May, when Forest Service researcher Jesse Logan drives through the Stanley Valley to inspect the damage, more than half the lodgepole pines display dull red foliage — the signal flag of beetle victory. This summer, says Logan, the forested slopes will glow a brilliant rusty orange. In just a few more years, these broad bands of mature lodgepoles will be nothing but weathered snags, their supplies of water and nutrients choked off by a beetle no larger than a fingernail. Mountain pine beetles are one of the most industrious members of the genus *Dendroctonus* — loosely translated as "tree killers" — and every outbreak confirms the aptness of their grim scientific handle.

In lodgepole forests like this one, these tiny murderers anchor a familiar cycle. The ghostly, beetle-killed stands act as fuel for forest fires, and the fires kick-start a new generation of lodgepole pines. It could take these 150,000 acres of forest a century or so to fully regenerate, says Logan, but he's not too worried about their long-term future. During the past decade, lodgepole pines have started to bounce back in burned areas of Yellowstone National Park, and this forest is probably just as resilient.

From Galena Summit, at the top of the valley, Logan pauses to look back. Above are steep mountain slopes; far below is the winding cord of the Salmon River, edged with green meadows and the red, beetle-killed swaths of pines. When a passing motorcyclist stops to suss out the scenery, he soon discovers that Logan is a beetle expert. "Wow, I'm really glad I ran into you," he says with enthusiasm.

Massive beetle outbreaks, it seems, turn entomologists into minor celebrities.

The motorcyclist points down the valley, shaking his head, then peers at Logan through mirrored sunglasses. "I've lived here for 30 years, and I've never seen anything like this," he says. "I just keep thinking, 'Wasn't there something we could have done?' "

For Logan, this is an old question. He explains the cycle of devastation and regeneration, emphasizing that humans can't — and probably shouldn't — do much to stop this natural process. The frosty Stanley Valley was long thought to be too cold for a major outbreak, so these particular red trees are something of a scientific curiosity. Still, he says, they don't give us any real cause for panic. "These lodgepoles and the mountain pine beetle, they've got an understanding — even if we don't fully understand it ourselves," says Logan. "They've worked out a deal."

Logan then points upward, to the serrated peaks of the Sawtooth Mountains. The narrow ridgelines are fringed with squat, bushy shapes, tough trees designed for the harshest of winter conditions. "Those whitebark pines, now," he tells the motorcyclist. "I'm not so sure they've worked out a deal."

When Logan leaves the inquisitive motorcyclist, he crosses Galena Summit and zigzags into the next drainage. He's entering the Sun Valley area, the former home of Ernest Hemingway and the posh retreat of many a modern-day gazillionaire. Logan, however, isn't thinking about stargazing. Just a few hundred yards past the summit, he pulls over and grabs his binoculars, training them on the forest above. On the highest ridgeline is a solid line of whitebark pine, all flying the red flag of the mountain pine beetle.

Logan drops the binoculars and shakes his head. "Wow, that is amazing to me," he says, pausing to find the words. "There's a lot of mortality up there. That is … that is just astounding."

It's not easy to surprise Logan, at least when it comes to the mountain pine beetle. He's a research entomologist for the Forest Service's Rocky Mountain Research Station in Logan, Utah, which has been studying mountain pine beetles and other bark beetles for more than three decades. Logan has worked with the research station's Interior West Bark Beetle Project on and off through much of his career, which has included stints on the faculty of Colorado State University and Virginia Polytechnic Institute; he joined the bark beetle project full-time in 1992. His closest collaborator, entomologist Barbara Bentz, started working for the research station as a seasonal technician in the early 1980s and now, two graduate degrees later, leads the project.

Together, Logan and Bentz helped shift their agency's attitude toward bark beetle management. For much of the last century, the Forest Service treated beetle outbreaks like plagues, clobbering them with heavy (and mostly ineffective) doses of pesticides. In those days, Forest Service scientists concentrated largely on slowing beetle damage to timber. But Logan and Bentz recognized that bark beetle outbreaks were part of a natural process. They convinced their bosses and rewrote the mission of their research project, moving it away from beetle police work and toward longer-term ecological studies. "Our major focus was on natural disturbance — and how we can live with it," says Logan.

Project researchers have long collected detailed data on the life history of bark beetles, particularly the widespread mountain pine beetles. In recent years, Bentz, Logan, entomologist Jim Vandygriff, and a crew of other researchers have monitored sensitive weather stations and temperature data collectors at various study sites, postholing through snowbanks in the early spring and fighting off

swarms of mosquitoes in the summer. They peel off samples of tree bark throughout each year, noting how the beetles' development responds to variations in climate. These data, they hope, will help them understand the intricate ecological machinery that runs a beetle outbreak.

Early on, they found that temperature had a powerful influence on the mountain pine beetle, so powerful that Logan wondered about the effect of global warming on beetle outbreaks. Not many shared his concern: Ten years ago, he raised the issue during a presentation at a scientific meeting in Hawaii. "The response was, 'That's an interesting idea, but it would be better if you'd do something that actually mattered,' " he remembers.

But Logan persisted with his questions. Building on the work of other beetle researchers, Logan, Utah State University mathematician Jim Powell, and Canadian entomologist Jacques Régnière used the station's field data to create a complex computer model of beetle behavior. The model showed that, most of the time, mountain pine beetles just couldn't get it together at very high elevations. The cold temperatures made it impossible for them to complete their life cycle in one year, forcing them to confront a second winter at a vulnerable point in their development. The adult beetles also couldn't synchronize their emergence and flight from their birthplaces. With so few beetles attacking new trees at any one time, healthy trees could defend themselves by drowning the tiny beetles in resin. Under these conditions, beetles could only kill diseased and otherwise weakened trees.

Two dying lodgepole pines stand among still-healthy trees. Jeffrey J. Witosky, USDA Forest Service

Logan and his collaborators then plugged some new numbers into their model. The United Nations-sponsored Intergovernmental Panel on Climate Change (IPCC), widely considered the world authority on climate change science, predicted in 1990 that global mean temperatures would rise 2.5 degrees Celsius (4.5 degrees Fahrenheit) by 2030, assuming humans took no major action to reduce carbon dioxide levels in the atmosphere. Curious about the effect of this change on mountain pine beetle outbreaks, the researchers gradually stepped up temperatures in their model. When temperatures hit two degrees Celsius higher than the average conditions at one of their whitebark pine study sites, prospects for the beetles improved dramatically. Beetles raced through a one-year life cycle at higher elevations. They also synchronized their emergence, allowing them to join forces and overwhelm tree defenses. High-mountain mass attack — and mass tree death — suddenly became possible.

These results were reassuringly theoretical until about five years ago, when Logan and Bentz started hearing about a new round of beetle attacks. This time, it seemed, the mountain pine beetles weren't as interested in the lodgepole forests. They were outbreaking in the whitebark pines.

Whitebark pines form the roofbeam of our mountain landscapes. These thick-trunked trees, found at high elevations throughout the Northern Rockies, support a wide web of animal dependents (HCN, 12/4/00: Last chance for the whitebark

pine). Known as "stone pines," the trees store heavy, fatty seeds inside stubbornly closed cones. The Clark's nutcracker, a cousin to crows and jays, harvests the cones each year; it eats some seeds and hides the rest, recovering the caches in late winter in order to feed its young. The seeds it leaves in the ground become the next crop of whitebark pines. In his book *Made for Each Other*, biologist Ronald Lanner sums up this elegant relationship: "Working in concert, the Clark's nutcracker and the whitebark pine build ecosystems."

Red squirrels also collect whitebark pine cones, stockpiling their booty throughout the forest. In the fall and early spring, when other food is hard to find, grizzly bears plow up these hidden high-fat meals. When whitebark pine seeds are scarce, grizzlies head for lower elevations, where they often run into humans. Biologist David Mattson, who has studied Yellowstone grizzlies and their ecosystem since 1979, documented a severalfold increase in grizzly-human interactions during years of low whitebark cone production. Because of these encounters, he says, humans kill nearly twice as many grizzlies during poor cone years.

Mountain pine beetles are not unknown in the whitebark pine zone — in fact, there were several intense outbreaks during the previous century. In the past, however, the beetles have behaved more or less politely, outbreaking occasionally in healthy stands but sticking mostly to trees weakened by drought, disease, or other stresses. When Logan and his colleagues got news of the fresh outbreaks, they feared the beginning of a very different phenomenon.

The beetle researchers set up a new study site on Snowbank Mountain in southeastern Idaho, where healthy whitebark pine had started dying from bark beetle attacks. They started watching beetles march through whitebark pine on Galena Summit in the Sawtooth Mountains. Last year, even their highest-elevation study site got hammered: The whitebark pine on 10,000-foot-high Railroad Ridge, an area that Logan and his coworkers have monitored for more than a decade, was hit hard by the mountain pine beetle. Sure enough, as temperatures warmed, beetles at these sites shifted from a two-year to a one-year life cycle — just as the model predicted.

Reliable data on the extent of previous mountain pine beetle outbreaks are difficult to come by, but current outbreaks in the whitebark pine zone "seem to be broader" than outbreaks in past decades, says Ward McCaughey, who studies whitebark pine communities as a research forester for the Forest Service. "In the 1980s, it hit very intensively in isolated areas," he says. "Now, we're seeing outbreaks across the spectrum."

Diana Six, a University of Montana entomologist who studies whitebark pine in Idaho, Montana, and Yellowstone National Park, says beetles at all of her 12 study sites have adopted a one-year life cycle. What's more, she says, outbreaks now move even faster at high elevations than in the beetles' more familiar lodgepole pine territory. In the past, beetle outbreaks in whitebark were often helped along by spillover from the lodgepole zone, but that assistance is no longer necessary. "Instead of moving up from lodgepole pine, mountain pine beetles are starting in whitebark pine, and building up huge populations," she says. "They're producing four to seven times more brood in whitebark than they do in lodgepole."

While lodgepole forests only need a few human generations to recover from similar outbreaks, whitebark pines aren't designed for quick action. The trees mature slowly, and can live for centuries. For Logan, long acquainted with whitebark pines through decades of research and backcountry ski trips, these newest outbreaks have a tragic aspect.

"When I see outbreaks intensify in the lodgepole pine, it's an interesting ecological event," says Logan. "When I see a 700-year-old whitebark pine go down, I have a completely different reaction. It breaks my heart."

Overall temperatures in the Rockies — and around the world — are rising dramatically. The Intergovernmental Panel on Climate Change reports that global mean surface temperature increased by 0.6 degrees Celsius (about 1 degree Fahrenheit) over the 20th century. In the Western Hemisphere, the warming was greater than in any other century for the last 1,000 years, and the 1990s were the warmest decade of the entire millennium. The IPCC, which issued its most recent assessment report in 2001, now predicts that global mean temperatures will rise anywhere from 1.5 to 5.8 degrees Celsius (2.5 to 10.4 degrees Fahrenheit) between 1990 and 2100 — a rate of warming very likely without precedent in the last 10,000 years. If Logan's model is correct, even a few uninterrupted years of these widespread, unusually high temperatures will unleash the bark beetle as never before.


Forest Service researcher Jesse Logan. Photo courtesy Jesse Logan

Of course, Logan and his colleagues can't say whether the warmer temperatures we've been experiencing result from our affection for fossil fuels. That's not their job. But other respected researchers say the connection is difficult to deny. The IPCC stated in its 2001 assessment that the concentration of carbon dioxide in the atmosphere increased by about 30 percent in the past 250 years, and that the current rate of increase is unprecedented in the last 20,000 years. "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities," the panel said. The National Academy of Sciences also states that "temperatures are, in fact, rising," and adds that the observed warming over the past several decades is "likely mostly due to human activities." For scientists, who tend to be a cautious crowd, these are blistering words.

Combine Logan's model with the conclusions of the IPCC and other authorities, and the story is stark. We're performing a gigantic experiment on the planet, and today's unusual beetle outbreaks are part of the result.

This isn't a Hollywood disaster movie — no tidal waves or giant ice sheets here — but news from the world of beetle behavior is, in its own way, just as worrisome as anything you might see this summer in The Day After Tomorrow. In British Columbia, says Canadian Forest Service ecologist Allan Carroll, "We have the largest outbreak ever recorded currently on the go." The most recent forest survey, conducted in 2003, found that more than 10 million acres of lodgepole pines — an area the size of Switzerland — had been killed the previous year. The outbreak's reach has been almost doubling every year since 1998.

Carroll has studied 40 years of forest health surveys by the Canadian Forest Service, and he's found that the mountain pine beetle is spilling over the northern margin of its historical range. "In the past, the beetle has collapsed when it's run out of food," says Carroll. "Now, we're seeing new areas opening up in front of it." This expansion could have innumerable impacts on northern ecosystems; woodland caribou in northern British Columbia, for instance, depend on lichen that grow beneath lodgepole pine stands. There's never been an infestation recorded in these stands, but now the mountain pine beetle is headed in their direction. As these lodgepole pines go, so may go the lichen and the caribou.

Though Canadian outbreaks haven't ventured into the whitebark pine zone, the beetles have a new food source in their path. Carroll says the beetles are now between 60 and 120 miles from the nearest stand of jack pine, a species not previously acquainted with mountain pine beetles. Experimental evidence suggests that the beetles will thrive in jack pine, an important timber species that extends through much of Canada. The Great Plains have long been considered an

insurmountable barrier to the mountain pine beetle, but once the beetle hits this new host, nothing would stop it from plowing eastward into stands of eastern white pine and cruising south all the way to the loblolly pine forests of the Southeastern United States. This would add up to a supersized sweep of outbreaks, beginning in the U.S. Southwest, stretching across the southern half of Canada, and curving down the Eastern Seaboard of the United States into southern Texas. "The shortest route from Logan, Utah, to Nacogdoches, Texas," says Logan, "might be through Ontario, Canada."

These pines define landscapes — and, in some cases, economies. Imagine a swath of standing dead snags stretching from British Columbia to New England to the Deep South. Imagine hundreds of busted logging and mill towns, unable to process all the timber before it began to rot. Imagine the cloud of carbon dioxide these decaying — or burning — trees would ultimately release into the atmosphere. Regeneration of the forests would take at least a century, and it might not happen at all; if temperatures stayed high, the beetles could just keep coming.

The mountain pine beetle has a huge extended family, and its relatives are also responding to the warming climate. More than a decade ago, on the outskirts of Homer, Alaska, ecologist Edward Berg watched spruce beetles take down the thick spruce stands around his house. "We saw the beetles building up, and these incredible summer beetle flights like something out of an Alfred Hitchcock movie," he says. The kill eventually spread to 4 million acres, covering the Kenai Peninsula and overflowing into other parts of south-central Alaska; on color-coded maps of spruce beetle outbreaks, the peninsula sticks out of the state's southern coast like a bloodied thumb. It wasn't long before a logging rush got under way.

"Suddenly, the landowners were thinking 'Good God, all the trees are dying, they're all going to fall down and create a mess,' " says Berg. "But Realtors loved it. They described all the beetle-killed properties as having 'emerging views.' "

Berg, for his part, abandoned his newly exposed acreage and moved into town. As a researcher for the Kenai National Wildlife Refuge, he also looked into the reasons for the spectacular beetle kill. When beetles open up space in a spruce forest, the surviving trees react with a growth spurt, and the spurts show up as wide rings inside tree trunks. So Berg looked for prolonged "growth pulses" in the tree-ring record. This evidence, combined with historical observations, showed that the Kenai Peninsula had experienced a beetle outbreak of some size about once every half-century for the last 250 years. Though rainfall and stand density probably affected beetle behavior, says Berg, the historical outbreaks are most closely linked with higher temperatures.

"The gun has to be loaded, and something has to pull the trigger," he says. "The loading is having a lot of mature trees. The run of warm summers is the trigger."

The latest warm spell is the longest yet. Summers in Alaska warmed up the late 1980s, and Berg says temperatures have been "on overdrive" ever since. The long, hot summers allowed the beetles to complete their life cycle in one year instead of two, and, Berg says, "the beetles just grew exponentially." While cooler temperatures knocked back past outbreaks after a year or two, there was nothing to stop the most recent infestation. Nothing, that is, except the near-total exhaustion of the food supply.

Matt Jedra, a graduate student at Northern Arizona University, examines a bark beetle. AP Wide World

"Essentially, they ate themselves out of house and home," says Berg. Summer temperatures remain above the historical mean, he says; if there were still trees to be attacked in his neighborhood, the spruce beetles would still be hard at work.

Unlike residents of the Lower 48, Alaskans already see plenty of anecdotal evidence of global warming. "It's a fact of life here," says Berg. "We can see the treeline going up, the glaciers retreating, and the roads buckling because the permafrost is melting." The idea that rising global temperatures also amp up beetle outbreaks doesn't surprise him — or his neighbors. "I always considered it kind of an obvious thing," he says. "I had one neighbor who told me that they just needed someone like me with a Ph.D. to come along and make it official."

In the Southwestern United States, beetle damage is also reaching Hollywood proportions, but it's not as clear that global warming is the culprit. Mike Wagner, an entomologist at Northern Arizona University in Flagstaff, estimates that bark beetles killed 20 million ponderosa pines and 50 million piñon pines in New Mexico and Arizona in 2002 and 2003. "We're seeing entire watersheds — blocks in excess of several thousand acres — where 80 to 90 percent of the trees have been killed," says Wagner. In the Southwest, the mountain pine beetle gets help from related species such as the Mexican pine beetle, the roundheaded pine beetle, and several types of ips beetle.

The extent of the recent beetle attack is "unprecedented," says Wagner, but he warns there's no solid evidence that the region's warming temperatures are behind the outbreaks. The pine forests of the Southwest are weak from years of drought; the area has been drier than normal for eight of the past 10 years, and tree-ring scientists say 2002 was the driest single year in northern Arizona in the last 1,400 years. (Drought is one possible outcome of increasing carbon dioxide levels, but tree-ring scientists say there's also a long tradition of severe, long-lasting droughts in the Southwest; so far, the current drought appears to be part of this tradition.) Wagner says the ponderosa pine forests have also changed dramatically over the past century, with stand densities tripled or quadrupled by fire suppression and an unusually wet period in the 1970s and '80s. "These changes are more than sufficient to explain the outbreaks," he says. "We don't need to invoke the concept of global change." Wagner calls Allan Carroll's work in British Columbia "convincing," but he says it's impossible to use results from such distant forests to explain the beetle attacks in the Southwest.

The region is full of unanswered questions. Craig Allen, an ecologist with the U.S. Geological Survey who's worked in northern New Mexico for most of his career, documented what he calls a "massive forest dieback" in the Jemez Mountains over the past two years. Piñon populations increased dramatically during the wet decades of the 1970s and '80s, and the drought that began in the '90s began to "squeeze the excess out of the system," he says. In 2002, however, the piñons started dying wholesale, killed either by the direct effects of drought or by an associated invasion of piñon ips, another relative of the mountain pine beetle. By March 2003, most of the piñon pines in Allen's study area — even the seedlings — were dead. Piñon populations are crashing throughout the region; in many areas of southern Colorado, the one-two punch of drought and beetles has killed 90 percent of mature piñon stands.

Though the current drought in the Southwest hasn't yet lasted as long as a previous severe drought in the 1950s, Allen says its effects on the Jemez Mountains piñon pine forests already outstrip those observed in that earlier dry spell. "The magnitude of mortality is pretty astounding right now," he says. "Arguably, this drought is more stressful because it's warmer." Unlike the mountain

pine beetle, which hits some high-value timber species and has been studied for decades, no one has paid much attention to the piñon ips. "It does make sense that (the ips outbreaks) are temperature-driven," says Northern Arizona University entomologist Neil Cobb, "but there are a lot of holes in the knowledge."

So has this beetle been helped along by thicker piñon forests? The drought? The warming climate? Or all three? It's nearly impossible to untangle these factors, but Allen and other researchers hypothesize that, here as well, warming temperatures play a major role.

Hang around with ecologists for a little while, and you notice their fear of sweeping proclamations. There's always more to study and consider before they reach a simple conclusion. It's not hard to see why: The systems they study are so complex, so variable in space and time, that what they see on one hillside may be quite different from what they see in the next watershed. The drought-addled forests of the Southwest, for instance, are different from the somewhat moister forests of the Northern Rockies or the still-wetter stands of Southern Alaska. The types of trees, the species of beetles, and the forests' relationship with fire vary tremendously throughout the Western half of the continent. And though oddly enormous beetle outbreaks seem to be pervading the region, there are exceptions. In the mountains of Colorado, says University of Colorado ecologist Tom Veblen, "We don't see any evidence that spruce beetle outbreaks are outside the range of outbreaks over the last few hundred years." Temperatures at high elevations in the state, says Veblen, also don't show the same clear warming trend as other areas in the West.

So the outbreaks are a typical scientific puzzle: The closer you look, the blurrier the picture seems to get. But even many ecologists admit that a couple of general statements are in order here. The number of red — and dead — trees in the region is breaking records. So are thermometer readings. "We're seeing changes in (mountain pine beetle) activity from Canada to Mexico," says Logan, "and the common thing is warming temperatures."

This news complicates an already fearsome set of management dilemmas. Land managers have only recently accepted beetle kills as a natural process, rather than a crisis requiring large-scale logging or armies of seasonal workers armed with backpack sprayers. But just as they've learned to work on nature's terms, we've drastically changed the terms. Understanding this new reality, let alone reacting to it, means another venture into the unknown.

It's not as if managers have a lot of spare time for exploration. The current sweep of beetle outbreaks is increasing public fear of wildfires, leading to new pressure to pull trees out of Western forests. "There's a lot of public expectation that we're going to cut and remove every red tree," says Jim Rinehart, who, as forester for the Sawtooth National Forest in Idaho, is overseeing some 2,500 acres of thinning projects near towns and developed areas in the Stanley Valley. Clear-cuts and widespread logging, he says, aren't part of his forest's response to the outbreak: "We're just trying to live with it."

The Bush administration-backed Healthy Forests Restoration Act, passed by Congress and signed into law last year, strengthened the political push for logging in beetle-killed stands. Some ecologists, however, are calling for a more subtle approach. "We need to recognize that lodgepole pine forests are very different from ponderosa pine forests, that ponderosa pine-type thinning prescriptions are not appropriate in piñon pine," says Colorado State University fire ecologist Bill Romme. The new legislation, he says, "treats all forest types alike."

Mountain pine beetle galleries. Ladd Livingston, Idaho Department of Lands

Romme and other scientists sent a letter to Interior Secretary Gale Norton last December, arguing that beetle outbreaks in the piñon pine forests of the Southwest may reduce, not increase, the danger of large, intense fires in the tree canopy. When piñon needles drop to the ground, Romme explained, the tops of the trees are less likely to burn. "We urge managers to resist pressures to launch ambitious salvage or tree-removal operations in the mistaken assumption that the dead trees constitute a serious fire hazard," he wrote. It's the ecologist's constant reminder: Every forest is a little different from its neighbor; every year is a little different from the last. Everything is a lot more complicated than we think.

Especially when global warming is involved, says John Gatchell of the Montana Wilderness Association. "It sometimes makes sense to cut trees, but treating the symptoms won't cure the problem," he says. "In terms of bark beetles, we're dealing with such a big landscape-scale change — we're altering the climate — that we can't very well expect to log our way out of the problem."

The whitebark pine — the sentinel of the high mountains, the supporter of ecosystems — confronts an especially fierce predicament. It's dealing with multiple serious threats: The suppression of forest fires has interrupted the regular handoff between sun-loving whitebark pines and shade-loving spruce-fir communities, allowing spruce and fir to dominate. White pine blister rust, a fatal disease, has spread throughout the range of the whitebark pine and related tree species since it was introduced to North America from Europe around 1900. The Forest Service, in cooperation with university researchers, has begun a painstaking effort to find and breed rust-resistant trees; that work, however, is now jeopardized by the mountain pine beetle. "Our main worry is that trees resistant to blister rust are not resistant to mountain pine beetles," says Diana Tomback, a professor at the University of Denver and a longtime whitebark pine researcher. "Here you have the cornerstone of a restoration program, and they can be killed by mountain pine beetles in a year." Rust-resistant trees can be protected from beetles with insecticides, or with pheromone traps that draw beetles away from the trees. But these labor-intensive measures are impractical on a broad scale.

For the whitebark pine, fire suppression, blister rust and mountain pine beetles may turn out to be the least of its problems. Beetles aren't the only organisms responding to warming temperatures, of course; their short generation time just allows them to react more quickly to changing conditions. Under most climate-change scenarios, forest types are predicted to shift uphill, implying that the forest that regenerates after a modern-day beetle kill may look very different from the one that came before it. In a 1991 study of whitebark pine communities in Yellowstone National Park, ecologist Romme found that the lower limit of the

whitebark pine zone would move up about 1,500 feet if the concentration of carbon dioxide in the atmosphere were to double. That scenario may sound far-fetched, but the IPCC now says that, given various economic and social situations, the atmospheric carbon dioxide concentration in the year 2100 could be anywhere from 1.5 to 2.6 times greater than it was in the year 2000. Romme says that whitebark, usually found just below treeline, would then be “crowded into smaller and smaller portions of the landscape” on mountaintops. Where there’s nowhere to go but up, the effects of a warming planet will be speedy and cruel.

Scientists and managers who think about climate change often talk about managing for “resilience,” about helping natural processes withstand major climate shifts and other stresses. In extreme cases, like that of the whitebark pine, resilience may be a good idea come much too late. Even in less dire situations, managing for resilient forests, grasslands or tundra requires a specialized — and very rare — sort of knowledge. “For my forest, I think I know what makes it stable and resilient,” says Nate Stephenson, a researcher at Sequoia-Kings Canyon National Park in California. “But I’ve been there 25 years.”

Westerners are notorious for frontier nostalgia, but we no longer have to look to the past — or, for that matter, to Hollywood blockbusters — for thrills. We’re on the edge of a very real, and very daunting, modern frontier. During a recent conference of climate scientists on the shores of Lake Tahoe, Swiss scientist Harald Bugmann commented on the now-visible effects of rising temperatures on Western mountains. “I am sorry for where you are,” he said in German-accented English. Then, he pointed out one bright spot: Beetle outbreaks and other unsettling phenomena may finally grab the public’s attention.

In the West, Bugmann explained with a small smile, we don’t have to wait to witness the consequences of global warming. Today, he said, is the day after tomorrow.

Michelle Nijhuis is contributing editor to High Country News.

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Whitebark Pine Ecosystem Foundation www.whitebarkfound.org

Intergovernmental Panel on Climate Change www.ipcc.ch.

SIDEBAR - July 19, 2004

Life cycle of a bark beetle

by Staff

Life cycle of a bark beetle

	Two-year cycle	One-year cycle
Summer	Female beetles lay eggs in "galleries" dug into inner bark of tree.	Female beetles lay eggs in "galleries" dug into inner bark of tree.
Fall	Some beetles are in freeze-tolerant large larvae stage; others are in smaller, more cold-sensitive larval stages.	Beetles are in freeze-tolerant large larval stage.
Winter		Larvae mature into pupae.
Spring	Beetles develop into pupae, or early adult stage.	Adult beetles emerge from bark of trees, fly to new trees and tunnel into inner bark to lay eggs in galleries.
Summer		Cycle begins anew.
Fall		
Winter	Beetles overwinter in pupae stage, which is not as freeze-tolerant as the large larval stage.	
Spring	Surviving beetles develop into full adults.	
	Cycle begins anew.	

Mountain pine beetle, from left, eggs in galleries; larvae; pupa; adult beetle. Feeding larvae "girdle" the tree, cutting off its supply of nutrients; attacking adult beetles also introduce a fungus that interrupts water flow within the tree. USDA FOREST SERVICE PHOTOS BY DAVE POWELL, DAVID MCCOMB, JEFFREY J. WITCOSKY

Life cycle of a bark beetle. USDA Forest Services by Dave Powell, David McComb, Jeffrey J. Witosky