A seedling grows next to the stump of a tree harvested after a 2014 wildfire near Georgetown, California. Climate-driven wildfires are complicating the use of forests as "offsets" for carbon emissions.
PHOTOGRAPH BY MAX WHITTAKER, BLOOMBERG, GETTY IMAGES

ENVIRONMENT

Polluters are using forests as ‘carbon offsets.’ Climate change has other plans.

Billions of dollars hinge on forests soaking up CO2 for decades to come. What happens when drought and fire kill the trees?

BY **CRAIG WELCH**

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On July 6, 2021, lightning ignited a fire in the Fremont-Winema National Forest of southern Oregon, in an area packed with dead trees from a mountain pine-beetle outbreak. Fueled by drought, the Bootleg fire exploded, at one point consuming 1,000 acres per hour. Flames pushed out of the national forest, racing through white fir, ponderosa, and lodgepole pine owned by timber company Green Diamond.

Hundreds of miles north, in a Seattle suburb, Elizabeth Willmott was tracking events closely. As the carbon program director for technology giant Microsoft, she had a special interest in Green Diamond's Klamath East forests: They were storing some of her company's carbon.

Microsoft has committed to one of the country's most ambitious corporate carbon-cutting programs, aiming to reach net-zero emissions by 2030, not just for its own buildings and factories but also for its supply chains. But since curbing emissions outright will take years, Microsoft announced it was investing in a slate of projects that would pull 1.43 million tons of carbon dioxide from the sky. That included 265,000 tons of CO2 that Microsoft had paid Green Diamond to remove by increasing the growth of trees—many of which had just gone up in smoke in the Bootleg fire, returning their carbon to the atmosphere.

As companies face increasing public pressure to limit their climate impact, the global market for forest carbon "credits," already worth billions of dollars, is booming. Polluting companies can buy those credits as an alternative to cutting emissions from burning oil, gas, and coal. Such "offsets" have been questioned on many grounds, including whether they actually reduce carbon in the atmosphere.

But scientists are increasingly focused on a new concern: climate change

itself. With trees dying around the globe from droughts, heat waves, pest invasions, and wildfires amplified by global warming, experts say, it's getting tough to count on any particular patch of forest being alive and reliably storing carbon for decades to come.

"Climate change already poses substantial risks to forest carbon, and those risks will go up dramatically in the 21st century," says Bill Anderegg, a forest ecologist at the University of Utah who has studied this issue extensively. "Forest offset protocols have not rigorously or thoroughly grappled with those risks."

Microsoft was more rigorous than most. So was Green Diamond, and a California state agency vetted the forest carbon credits it sold and verified they could legitimately offset emissions.

But a new analysis from carbon-science watchdog CarbonPlan suggests the California offset program, which is among the world's largest, doesn't account for how fast forests are changing. The program allows for the fact that wildfires can release stored carbon—but in less than 10 years, according to CarbonPlan, fires may already have released nearly as much carbon as the state budgeted for the next century.

And flames aren't the only threat to offsets. The study also claims that the carbon losses from a single deadly tree disease—sudden oak death—may eventually be as high as the state projected from all diseases and insect infestations combined.

"If we're going to keep using forests to offset emissions, we need to start being way more realistic about the threats those forests face," says Grayson Badgley, a former postdoctoral researcher in Anderegg's lab and lead author of the CarbonPlan study.

Good intentions

Good intentions

Few understand the stakes better than Willmott. Before joining Microsoft in 2016, she'd spent years working in local government and as an activist trying to get organizations to reduce fossil fuels. With her help, Microsoft is now electrifying its vehicle fleet and purchasing zero-carbon energy. It's going beyond cutting or offsetting its current emissions: By 2050 the company hopes to scrub more carbon from the atmosphere than it has emitted since its founding in 1975. *(Disclosure: My wife works for Microsoft in an unrelated capacity.)*

To that end, and to help jump-start a global industry, Microsoft has promised to invest $1 billion in carbon reduction and removal technologies. The Intergovernmental Panel on Climate Change (IPCC) has said massive carbon removal will be needed to keep global temperature increases to 1.5 degrees Celsius. But most technologies that can scrub carbon from the air are still in development, small in scale, or prohibitively expensive.

What is available today are approaches that rely on nature—mostly trees, which absorb CO2 as they grow. Around the world, voluntary programs now encourage polluting businesses to pay forest owners to grow more trees than they otherwise would have, or to keep more existing trees alive. Most of these programs have no government oversight. And Microsoft, in particular, has been up front about its struggle to find acceptable options.

Last fall, in the journal *Nature*, Willmott co-authored an editorial detailing Microsoft's experience after it solicited greenhouse gas removal ideas. The company received 189 pitches. Combined, the proposals claimed they could remove 170 million tons of CO2—about three times what New York City produces each year. Most of that would have been sucked up by forests.

Few of the pitches could withstand scrutiny; only 2 million tons of projects met Microsoft's criteria for high-quality, long-lasting, and immediate carbon cuts. "Today, there's simply not a lot of really secure forest carbon projects," Willmott says. "We see a problem with that across the U.S. and across the world."

She's not alone in her skepticism. In 2019, the non-profit journalism outfit ProPublica investigated forest offsets in South America and found projects frequently did not offset as much CO2 as promised—if the carbon value could be substantiated at all. In another series of stories, Bloomberg has pointed out that some offsets may give credit for "protecting" forests that aren't actually threatened, which may be good for wildlife or biodiversity but doesn't alter the land's carbon balance. Some offsets have led to carbon "leakage"—even if an offset legitimately protects trees from logging, trees may get cut elsewhere to supply the same markets, resulting in no discernible climate benefit.

Finally, all forest offsets suffer from a mismatch in timescales: The carbon emitted by burning fossil fuels stays in the atmosphere and harms climate for thousands of years, but the benefit of storing CO2 in trees is temporary, because trees die. California's offset program, which allows polluting companies to offset a small amount of their emissions by purchasing credits from forests in any state, requires sellers to demonstrate that carbon will stay locked in trees for 100 years—a long guarantee by international standards.

But that program, too, has faced criticism. Reporting last year by ProPublica and *MIT Technology Review*, based on a previous study from CarbonPlan, showed that the state may have let landowners overstate carbon storage on millions of credits. And last fall, the environmental news site Grist detailed how the state was relying on haphazard projections of

fire risk.

Regulators at the California Air Resources Board, which runs the offset program, are quick to point out it's the only one in the United States linked to a mandatory statewide effort to cut emissions. The state primarily requires businesses to cut emissions directly.

They also point out that offsets provide ecological benefits. "It's creating a mechanism for the protection of forests," says Matthew Botill, division chief for the state's cap-and-trade program. But the question remains of how well it protects climate—especially as threats to forests grow.

In southern Oregon, a few of the trees scorched by the Bootleg fire in 2021 stand alongside an area that was spared the worst. One of the largest wildfires in state history, it ravaged more than 400,000 acres.
PHOTOGRAPH BY CHONA KASINGER, THE NEW YORK TIMES

How much insurance is enough?

Despite a lifetime spent in the woods, John Davis had rarely seen a bigger blaze than Oregon's Bootleg fire. The vice president at Green Diamond would not normally have considered his company's Klamath East lands a major wildfire risk. His trees were young and often spaced far apart. Selling carbon credits made it economical for him to let them grow older, rather than log them now. But southern Oregon had been excessively dry and had just faced a major heat wave. Meanwhile, stands on adjacent U.S. Forest Service lands were thick with deadwood.

"On average, the federal land is not in a healthy state—it's overstocked," Davis says. "There's a high level of fuel loading."

His team spent weeks responding to the blaze. But the powerful fire produced smoky clouds that climbed to 40,000 feet. The front stretched on for miles. At one point swirling winds produced a tornado. When the fire picked up in the afternoons, "all you could do is back off until it laid down," Davis says.

It will be at least this summer before Green Diamond can begin a thorough inventory to assess how much carbon was truly lost. Recognizing that unplanned losses will sometimes happen, California's offset program builds in a backup plan. It requires offset participants to contribute carbon credits toward a state insurance system, called a buffer pool.

When they sell credits on an area of forest, landowners must set aside 2 to 4 percent to cover fire risks; 3 percent to cover losses from insects or disease; another 3 percent for weather risks like droughts or windstorms; and up to 9 percent more for human risks, ranging from unexpected bankruptcy to logging. On average, 17 to 19 percent of credits wind up in the buffer pool, where they are retired if something wipes out that carbon

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But many scientists worry it's not enough. Climate change is already leaving unprecedented marks on forests. In the Sierra Nevada, up to 19 percent of adult giant sequoias, many of which have stood since the days of Aristotle, died in fires in just the last two summers. Five of the eight most abundant tree species in the West have declined significantly just since the year 2000. Using satellite data, archival records, and machine learning, Jon Wang, at the University of California, Irvine, determined that California likely lost nearly 7 percent of its tree cover between 1985 and 2021.

While the Bootleg fire was still burning, a study published by the American Geophysical Union showed that California's forests are likely to decline in the future even under moderate climate-change scenarios—and that offset projects in California are located in "disproportionately vulnerable parts of the state" where risk of losses are "remarkably high and substantially underestimated."

The 2011 drought in Texas killed some 300 million trees—and was very hard on cattle too.
PHOTOGRAPH BY SCOTT OLSON, GETTY IMAGES

Yet California's offset insurance pool, which so far includes forest projects in 29 states, does not weigh risk of fire or drought differently by region, Anderegg wrote in *Science* in 2020—even though risk is far greater in the West than, say, in New England. Risk is increasingly hard to quantify anywhere. In 2011, for example, drought killed an estimated 301 million trees in Texas, one of every 16 in the state. "No one predicted that," says tree physiologist William Hammond, at the University of Florida. "It seems like every time one of these broad-scale events happens, the local ecologists are shocked."

Hammond should know. In a study published just last month, he pinpointed 675 tree mortality events around the world from 154 studies and tracked down their precise location and the climate circumstances that precipitated the die-offs. “What I want everyone to get is that this is coming to a forest near you—and sooner than you think,” he says.

“The big, big question here is, ‘What should that buffer pool look like, and is the current pool adequate?’” Anderegg says. “We have a lot of signs that it probably is not.”

Shelby Livingston, a manager with the offsets program for California’s Air Resources Board, says she remains confident. The pool continues growing as more projects come in. “When we do a protocol update, we will take into account the latest science and make any necessary adjustments,” she says.

But Anna Trugman, an assistant professor at the University of California, Santa Barbara, says she’s not quite sure how. “I’m a forest ecologist and thinking right now on a 100-year time scale of what forests will look like—it’s really hard,” she says. “‘Best science’ can’t tell you what this buffer pool should be. You’d need some infinite fudge factor.”

The Castle fire killed this giant sequoia tree in Sequoia National Forest, California, last year. In just the last two years wildfires have killed up to one-fifth of the huge trees, which live only in the Sierra Nevada.
PHOTOGRAPH BY DAVID SWANSON, BLOOMBERG, GETTY IMAGES

Burning the buffer

It was in part to try and answer these questions that scientists with CarbonPlan undertook their latest investigation.

As of earlier this year, California had issued roughly 190 million forest credits, each representing one metric ton of carbon. Of those, roughly 30 million were held in reserve as insurance within the buffer pool. Since the state's program began, at least six major wildfires have struck lands

representing carbon credits. On two the state has already retired 1.1 million credits. The remaining four fires happened so recently that independent assessments of the corresponding carbon loss have not yet been submitted to the state.

So CarbonPlan performed its own analysis. Using state records of carbon stocks in each offset and standard metrics used by the Forest Service, they estimated carbon loss after fire, even accounting for storage of carbon in wood products made from dead trees logged after the fire. They estimated that in the first 10 years of the program, fire loss on offsets was already 5.7 to 6.8 million metric tons. That represents 95 percent or more of all the fire-related contributions to the buffer pool.

“That means we messed up our calculations so badly that in less than 10 years we’ve blown through 100 years of credits,” says Danny Cullenward, policy director for CarbonPlan.

His team took a different approach when assessing disease risk. *Phytophthora ramorum,* the invasive pathogen that causes sudden oak death, already has killed more than 40 million trees in California and Oregon. It disproportionately kills tanoak, a tree native to the coast. CarbonPlan found that 20 offset projects hold roughly 14 million tons of CO2 in tanoak—and that anywhere from 4.7 to 9 million tons of that could be lost to *Phytophthora* in this century. That would be 82 to 159 percent of the buffer pool earmarked to cover all forest diseases and insect outbreaks, lost to a single pathogen and a single tree species.

The CarbonPlan research was published as a pre-print; it has not yet been peer-reviewed. But several experts reviewed the work for *National Geographic*. Daniel Sanchez, who runs the carbon removal laboratory at the University of California, Berkeley, calls it “a robust analysis that answers an important question.”

Whereas the study's assessment of fire risk was based on a tally of actual events, the projection of disease risk is a projection, says Matteo Garbelotto, director of the University of California, Berkeley's forest pathology lab. "But the take-home message from the research is for-sure correct," he says. "Within 100 years, it is more likely than not that most of those areas will see the arrival of sudden oak death. And in five, or at maximum 10 years, 80 percent of the tanoak will be dead."

Max Moritz, a wildfire specialist with the University of California Division of Agriculture & Natural Resources, says it's not clear how representative the last few intense fire seasons will be of the future. But "even if the authors have very large uncertainties around their estimates," Moritz says, "the lack of what is needed for 100 years of 'permanence' appears to be a serious challenge."

California state officials declined to comment directly on the research until after it had been formally peer reviewed. But they pointed out that credits are pooled precisely so that losses from fire, for example, don't necessarily have to be paid out solely from credits paid in to cover fire. They just come out of the overall buffer pool—which will grow as new offset projects are added.

But each of those new projects would need to reflect a very different assessment of risk, or "adding new projects only makes the problem worse," Cullenward says. "You can't pay off old bad debt with new bad debt. That is the very definition of a Ponzi scheme."

For now, all eyes are on Green Diamond as officials await assessment of last summer's losses. But the experience already has Microsoft believing fire risks are underweighted. "We are in the universe of imperfect solutions here," says Rafael Broze, carbon program manager at Microsoft.

In the meantime, Green Diamond is at work trying to get back lost carbon. Last week workers were already out replanting, sowing the first of 1.3 million new trees the company aims to plant in the footprint of the fire.

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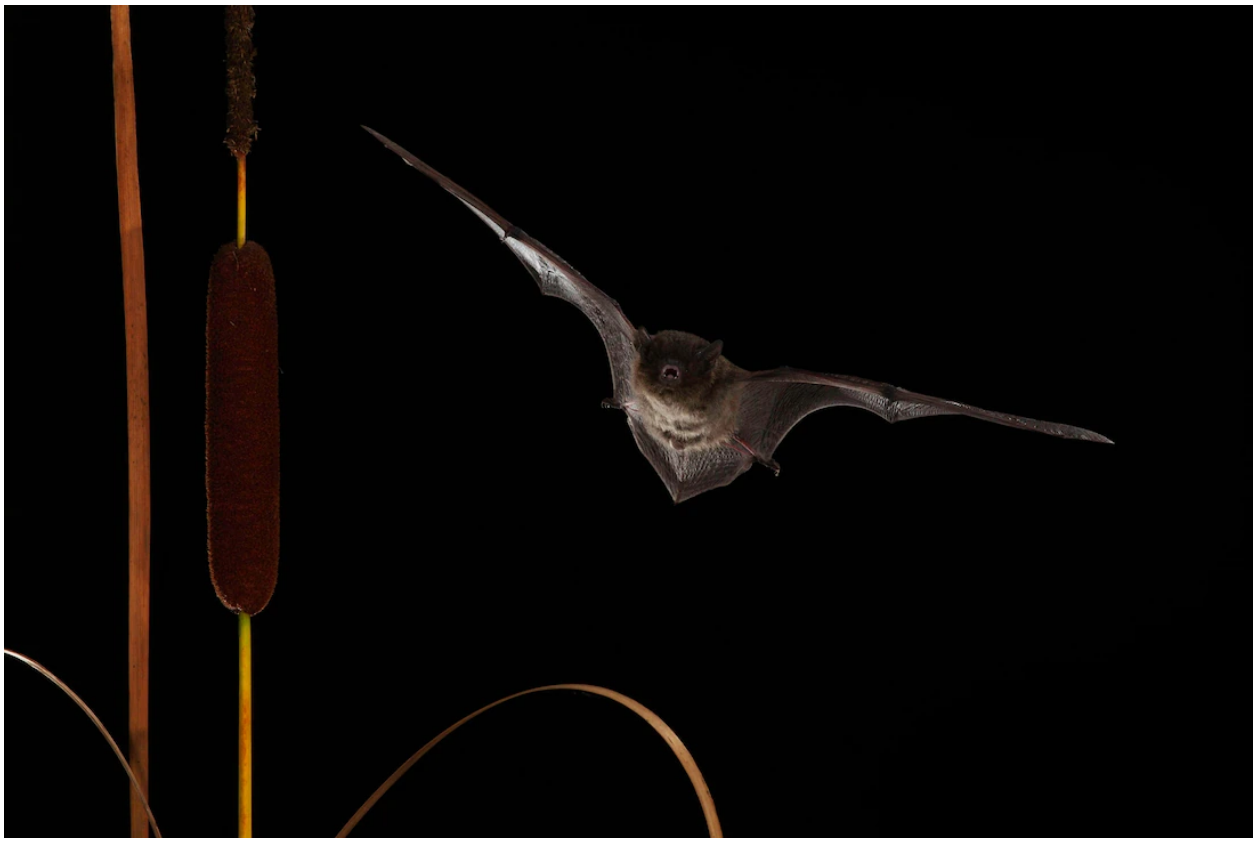

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