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With Deaths of Forests, a Loss of Key Climate Protectors

By JUSTIN GILLIS OCT. 1, 2011

WISE RIVER, Mont. — The trees spanning many of the mountainsides of western Montana glow an earthy red, like a broadleaf forest at the beginning of autumn.

But these trees are not supposed to turn red. They are evergreens, falling victim to beetles that used to be controlled in part by bitterly cold winters. As the climate warms, scientists say, that control is no longer happening.

Across millions of acres, the pines of the northern and central Rockies are dying, just one among many types of forests that are showing signs of distress these days.

From the mountainous Southwest deep into Texas, wildfires raced across parched landscapes this summer, burning millions more acres. In Colorado, at least 15 percent of that state's spectacular aspen forests have gone into decline because of a lack of water.

The devastation extends worldwide. The great euphorbia trees of southern Africa are succumbing to heat and water stress. So are the Atlas cedars of northern Algeria. Fires fed by hot, dry weather are killing enormous stretches of Siberian forest. Eucalyptus trees are succumbing on a large scale to a heat blast in Australia, and the Amazon recently suffered two "once a century" droughts just five years apart, killing many large trees.

Experts are scrambling to understand the situation, and to predict how serious it may become.

Scientists say the future habitability of the Earth might well depend on the answer. For, while a majority of the world's people now live in cities, they depend more than ever on forests, in a way that few of them understand.

Scientists have figured out — with the precise numbers deduced only recently — that forests have been absorbing more than a quarter of the carbon dioxide that people are putting into the air by burning fossil fuels and other activities. It is an amount so large that trees are effectively absorbing the emissions from all the world's cars and trucks.

Without that disposal service, the level of carbon dioxide in the atmosphere would be rising faster. The gas traps heat from the sun, and human emissions are causing the planet to warm.

Yet the forests have only been able to restrain the increase, not halt it. And some scientists are increasingly worried that as the warming accelerates, trees themselves could become climate-change victims on a massive scale.

"At the same time that we're recognizing the potential great value of trees and forests in helping us deal with the excess carbon we're generating, we're starting to lose forests," said Thomas W. Swetnam, an expert on forest history at the University of Arizona.

While some of the forests that died recently are expected to grow back, scientists say others are not, because of climate change.

If forests were to die on a sufficient scale, they would not only stop absorbing carbon dioxide, they might also start to burn up or decay at such a rate that they would spew huge amounts of the gas back into the air — as is already happening in some regions. That, in turn, could speed the warming of the planet, unlocking yet more carbon stored in once-cold places like the Arctic.

Scientists are not sure how likely this feedback loop is, and they are not eager to find out the hard way.

"It would be a very different world than the world we're in," said Christopher B. Field, an ecologist at the Carnegie Institution for Science.

It is clear that the point of no return has not been reached yet — and it may never be. Despite the troubles of recent years, forests continue to take up a large amount of carbon, with some regions, including the Eastern United States, being especially important as global carbon absorbers.

"I think we have a situation where both the 'forces of growth' and the 'forces of death' are strengthening, and have been for some time," said Oliver L. Phillips, a prominent tropical forest researcher with the University of Leeds in England. "The latter are more eye-catching, but the former have in fact been more important so far."

Scientists acknowledge that their attempts to use computers to project the future of forests are still crude. Some of those forecasts warn that climate change could cause potentially widespread forest death in places like the Amazon, while others show forests remaining robust carbon sponges throughout the 21st century.

"We're not completely blind, but we're not in good shape," said William R. L. Anderegg, a researcher at Stanford University.

Many scientists say that ensuring the health of the world's forests requires slowing human emissions of greenhouse gases. Most nations committed to doing so in a global environmental treaty in 1992, yet two decades of negotiations have yielded scant progress.

In the near term, experts say, more modest steps could be taken to protect forests. One promising plan calls for wealthy countries to pay those in the tropics to halt the destruction of their immense forests for agriculture and logging.

But now even that plan is at risk, for lack of money. Other strategies, like thinning overgrown forests in the American West to make them more resistant to fire and insect damage, are also going begging in straitened times. With growing economic problems and a Congress skeptical of both climate science and new spending, chances for additional funding appear remote.

So, even as potential solutions to forest problems languish, signs of trouble build.

In the 1990s, many of the white spruce trees of Alaska's Kenai Peninsula were wiped out by beetles. For more than a decade, other beetle varieties have been destroying trees across millions of acres of western North America. Red-hued mountainsides have become a familiar sight in a half-dozen states, including Montana and Colorado, as well as British Columbia in Canada.

Researchers refer to events like these as forest die-offs, and they have begun to document what appears to be a rising pattern of them around the world. Only some have been directly linked to global warming by scientific studies; many have yet to be analyzed in detail. Yet it is clear that hotter weather, of the sort that science has long predicted as a consequence of human activity, is playing a large role.

Many scientists had hoped that serious forest damage would not set in before the middle of the 21st century, and that people would have time to get emissions of heat-trapping gases under control before then. Some of them have been shocked in recent years by what they are seeing.

"The amount of area burning now in Siberia is just startling — individual years with 30 million acres burned," Dr. Swetnam said, describing an area the size of Pennsylvania. "The big fires that are occurring in the American Southwest are extraordinary in terms of their severity, on time scales of thousands of years. If we were to continue at this rate through the century, you're looking at the loss of at least half the forest landscape of the Southwest."

The Carbon Dioxide Mystery

In the 1950s, when a scientist named Charles David Keeling first obtained accurate measurements of carbon dioxide in the atmosphere, a mystery presented itself. Only about half the carbon that people were releasing into the sky seemed to be staying there. It took scientists decades to figure out where the rest was going. The most comprehensive estimates on the role of forests were published only a few weeks ago by an international team of scientists.

As best researchers can tell, the oceans are taking up about a quarter of the carbon emissions arising from human activities. That is causing the sea to become more acidic and is expected to damage marine life over the long run, perhaps catastrophically. But the chemistry is at least somewhat predictable, and scientists are reasonably confident the oceans will continue absorbing carbon for many decades.

Trees are taking up a similar amount of carbon, but whether this will continue is much less certain, as the recent forest damage illustrates.

Carbon dioxide is an essential part of the cycle of life on Earth, but geologic history suggests that too much can cause the climate to warm sharply. With enough time, the chemical cycles operating on the planet have a tendency to bury excess carbon.

In the 19th century, humans discovered the usefulness of some forms of buried carbon — coal, oil and natural gas — as a source of energy, and have been perturbing the natural order ever since. About 10 billion tons of carbon are pouring into the atmosphere every year from the combustion of fossil fuels and the destruction of forests.

The concentration of the gas in the atmosphere has jumped 40 percent since the Industrial Revolution, and scientists fear it could double or even triple this century, with profound consequences.

While all types of plants absorb carbon dioxide, known as CO_2, most of them return it to the atmosphere quickly because their vegetation decays, burns or is eaten. Every year, during the Northern Hemisphere growing season, plants and other organisms inhale some 120 billion tons of carbon from the atmosphere, then exhale nearly the same amount as they decay in the winter.

It is mainly trees that have the ability to lock carbon into long-term storage, and they do so by making wood or transferring carbon into the soil. The wood may stand for centuries inside a living tree, and it is slow to decay even when the tree dies.

But the carbon in wood is vulnerable to rapid release. If a forest burns down, for instance, much of the carbon stored in it will re-enter the atmosphere.

Destruction by fires and insects is a part of the natural history of forests, and in isolation, such events would be no cause for alarm. Indeed, despite the recent problems, the new estimate, published Aug. 19 in the journal Science, suggests that when emissions from the destruction of forests are subtracted from the carbon they absorb, they are, on balance, packing more than a billion tons of carbon into long-term storage every year.

One major reason is that forests, like other types of plants, appear to be responding to the rise of carbon dioxide in the atmosphere by growing more vigorously. The gas is, after all, the main food supply for plants. Scientists have been surprised in recent years to learn that this factor is causing a growth spurt even in mature forests, a finding that overturned decades of ecological dogma.

Climate-change contrarians tend to focus on this "fertilization effect," hailing it as a boon for forests and the food supply. "The ongoing rise of the air's CO_2 content is causing a great greening of the Earth," one advocate of this position, Craig D. Idso, said at a contrarian meeting in Washington in July.

Dr. Idso and others assert that this effect is likely to continue for the foreseeable future, ameliorating any negative impacts on plant growth from rising temperatures. More mainstream scientists, while stating that CO_2 fertilization is real, are much less certain about the long-term effects, saying that the heat and water stress associated with climate change seem to be making forests vulnerable to insect attack, fires and many other problems.

"Forests take a century to grow to maturity," said Werner A. Kurz, a Canadian scientist who is a leading expert on forest carbon. "It takes only a single extreme climate event, a single attack by insects, to interrupt that hundred-year uptake of carbon."

It is possible the recent die-backs will prove transitory — a coincidence, perhaps, that they all occurred at roughly the same time. The more troubling possibility, experts said, is that the die-offs might prove to be the leading edge of a more sweeping change.

"If this were happening in just a few places, it would be easier to deny and write off," said David A. Cleaves, senior adviser for the United States Forest Service. "But it's not. It's happening all over the place. You've got to say, gee, what is the common element?"

Tracking an Ebb and Flow

So far, humanity has been lucky. While some forests are starting to release more carbon than they take up, that effect continues to be outweighed by forests that pack carbon away. Whether those healthy forests will predominate over coming decades, or will become sick themselves, is simply unclear.

The other day, deep in a healthy New England thicket of oaks, maples and hemlocks, two young men scrambled around on their hands and knees measuring twigs and sticks that had fallen from the trees.

"What was the diameter on that?" asked Jakob Lindaas, a Harvard student holding a pencil and clipboard.

Leland K. Werden, a researcher at the university, called out a metric measurement, and they moved to the next twig. It was one of thousands they would eventually have to measure as part of an effort to tell how fast the wood, knocked off the trees in an ice storm in 2008, was decaying.

The debris they were cataloging would not have struck a hiker as anything to notice, much less measure, but the Harvard Forest, 3,000 acres near Petersham, Mass., is one of the world's most intensively studied patches of woods. The work the men were doing will become a small contribution toward solving one of the biggest accounting problems of modern science.

In every forest, carbon is constantly being absorbed as trees and other organisms grow, then released as they die or go dormant. These carbon fluxes, as they are called, vary through the day. They vary with seasons, with climate and weather extremes, with the health of the forests and with many other factors. Across the world, scientists are struggling to track and understand this ebb and flow.

A 100-foot tower stands in the middle of the Harvard Forest, studded with instruments. Put up in 1989, it was the first permanent tower of its kind in the world, built to help track the carbon fluxes. Now hundreds of them dot the planet.

Meticulous measurements over the decades have established that the Harvest Forest is gaining weight, roughly two tons per acre per year, on average. It is characteristic of a type of forest that is playing a big role in limiting the damage from human carbon emissions: a recovering forest.

Not so long ago, the land was not a forest at all. Close to where the men were working stood an old stone fence, a telltale sign of the land's history.

"When the European colonists came to America, they saw trees, and they wanted fields and pastures," explained J. William Munger, a Harvard research fellow who was supervising the measurements. So the colonists chopped down the original forest and built farmhouses, barns, paddocks and sturdy stone fences.

By the mid-19th century, the Erie Canal and the railroads had opened the interior of the country, and farmers plowing the thin, stony soils of New England could not compete with produce from the rich fields of the Midwest. So the old fields were abandoned, and trees have returned.

Today, the re-growing forests of the Eastern United States are among the most important carbon sponges in the world. In the Harvard Forest, the rate of carbon storage accelerated about a decade ago. As in much of the world, the temperature is warming there — by an average of 2.3 degrees Fahrenheit in the last 40 years — and that has led to longer growing seasons, benefiting this particular forest more than hurting it, at least so far.

"We're actually seeing that the leaves are falling off the trees later in the fall," Mr. Werden said.

Scientists say that something similar may be happening in other forests, particularly in cold northern regions that are warming rapidly. In some places, the higher temperatures could aid tree growth or cause forests to expand into zones previously occupied by grasslands or tundra, storing more carbon.

Forests are re-growing on abandoned agricultural land across vast reaches of Europe and Russia. China, trying to slow the advance of a desert, has planted nearly 100 million acres of trees, and those forests, too, are absorbing carbon.

But, as a strategy for managing carbon emissions, these recovering forests have one big limitation: the planet simply does not have room for many more of them. To expand them significantly would require taking more farmland out of production, an unlikely prospect in a world where food demand and prices are rising.

"We're basically running out of land," Dr. Kurz said.

Even in forests that are relatively healthy now, like those of New England, climate risks are coming into focus. For instance, invasive insects that used to be killed off by cold winters are expected to spread north more readily as the temperature warms, attacking trees.

The Harvard Forest has already been invaded by an insect called the woolly adelgid that kills hemlock trees, and managers there fear a large die-off in coming years.

Wildfires and Bugs

Stripping the bark of a tree with a hatchet, Diana L. Six, a University of Montana insect scientist, pointed out the telltale signs of infestation by pine beetles: channels drilled by the creatures as they chewed their way through the juicy part of the tree.

The tree she was pointing out was already dead. Its needles, which should have been deep green, displayed the sickly red that has become so commonplace in the mountainous West. Because the beetles had cut off the tree's nutrients, the chlorophyll that made the needles green was breaking down, leaving only reddish compounds.

Pine beetles are a natural part of the life cycle in Western forests, but this outbreak, under way for more than a decade in some areas, is by far the most extensive ever recorded. Scientists say winter temperatures used to fall to 40 degrees below zero in the mountains every few years, killing off many beetles. "It just doesn't happen anymore," said a leading climate scientist from the University of Montana, Steven W. Running, who was surveying the scene with Dr. Six one recent day.

As the climate has warmed, various beetle species have marauded across the landscape, from Arizona to Alaska. The situation is worst in British Columbia, which has lost millions of trees across an area the size of Wisconsin.

The species Dr. Six was pointing out, the mountain pine beetle, has pushed farther north into Canada than ever recorded. The beetles have jumped the Rocky Mountains into Alberta, and fears are rising that they could spread across the continent as temperatures rise in coming decades. Standing on a mountain plateau south of Missoula, Dr. Six and Dr. Running pointed to the devastation the beetles had wrought in the forest around them, consisting of a high-elevation species called whitebark pine.

"We were going to try to do like an eight-year study up here. But within three years, all this has happened," Dr. Six said sadly.

"It's game over," Dr. Running said.

Later, flying in a small plane over the Montana wilderness, Dr. Running said beetles were not the only problem confronting the forests of the West.

Warmer temperatures are causing mountain snowpack, on which so much of the life in the region depends, to melt earlier in most years, he said. That is causing more severe water deficits in the summer, just as the higher temperatures cause trees to need extra water to survive. The whole landscape dries out, creating the conditions for intense fires. Even if the landscape does not burn, the trees become so stressed they are easy prey for beetles.

From the plane, Dr. Running pointed out huge scars where fires had destroyed stands of trees in recent years. "Nothing can stop the wildfires when they get to this magnitude," he said. Some of the fire scars stood adjacent to stands of lodgepole pine destroyed by beetles.

At the moment, the most severe problems in the nation's forests are being seen in the Southwestern United States, in states like Arizona, New Mexico and Texas. The region has been so dry that huge, explosive fires consumed millions of acres of vegetation and thousands of homes and other buildings this summer.

This year's drought came against the background of an overall warming and drying of the Southwestern climate, which scientists say helps to explain the severe effects. But the role of climate change in causing the drought itself is unclear — the more immediate cause is an intermittent weather pattern called La Niña, and research is still under way on whether that cycle is being altered or intensified by global warming, as some researchers suspect. Because of the continuing climatic change, experts say some areas that are burning this year may never return as forest — they are more likely to grow back as heat-tolerant grass or shrub lands, storing far less carbon than the forests they replace.

"A lot of ecologists like me are starting to think all these agents, like insects and fires, are just the proximate cause, and the real culprit is water stress caused by climate change," said Robert L. Crabtree, head of a center studying the Yellowstone region. "It doesn't really matter what kills the trees — they're on their way out. The big question is, Are they going to regrow? If they don't, we could very well catastrophically lose our forests."

Stalled Efforts

Scientists are coming to a sobering realization: There may be no such thing left on Earth as a natural forest.

However wild some of them may look, experts say, forests from the deepest Amazon to the remotest reaches of Siberia are now responding to human influences, including the rising level of carbon dioxide in the air, increasing heat and changing rainfall patterns. That raises the issue of what people can do to protect forests.

Some steps have already been taken in recent years, with millions of acres of public and private forest land being designated as conservation reserves, for instance. But other ideas are essentially stymied for lack of money.

Widespread areas of pine forest in the Western United States are a prime example. A scientific consensus has emerged that people mismanaged those particular forests over the past century, in part by suppressing the mild ground fires that used to clear out underbrush and limit tree density.

As a consequence, these overgrown forests have become tinderboxes that can be destroyed by high-intensity fires sweeping through the crowns. The government stance is that many forests throughout the West need to be thinned, and some environmental groups have come to agree.

But the small trees and brush that would be removed have a low commercial value, especially in a weak economy. With little money available to subsidize the thinning, the Forest Service is reduced to treating only small sections of forest that pose the biggest threat to life and property.

On an even larger scale, experts cite a lack of money as endangering a program to slow or halt the destruction of tropical forests at human hands.

Deforestation, usually to make way for agriculture, has been under way for decades, with Brazil and Indonesia being hotspots. The burning of tropical forests not only ends their ability to absorb carbon, it also produces an immediate flow of carbon back to the atmosphere, making it one of the leading sources of greenhouse gas emissions.

Rich countries agreed in principle in recent years to pay poorer countries large amounts of money if they would protect their forests.

The wealthy countries have pledged nearly $5 billion, enough to get the program started, but far more money was eventually supposed to become available. The idea was that the rich countries would create ways to charge their companies for emissions of carbon dioxide, and some of this money would flow abroad for forest preservation.

Climate legislation stalled in the United States amid opposition from lawmakers worried about the economic effects, and some European countries have also balked at sending money abroad. That means it is not clear the forest program will ever get rolling in a substantial way.

"Like any other scheme to improve the human condition, it's quite precarious because it is so grand in its ambitions," said William Boyd, a University of Colorado law professor working to salvage the plan.

The best hope for the program now is that California, which is intent on battling global warming, will allow industries to comply with its rules partly by financing efforts to slow tropical deforestation. The idea is that other states or countries would eventually follow suit.

Yet, scientists emphasize that in the end, programs meant to conserve forests — or to render them more fire-resistant, as in the Western United States, or to plant new ones, as in China — are only partial measures. To ensure that forests are preserved for future generations, they say, society needs to limit the fossil-fuel burning that is altering the climate of the world.

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