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The Giving Trees

by Sharon Levy

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New science explains how forests could help save us from global warming.
Oksana Badrak

SHORT TAKES

The Carbon Exchange
In the carbon cycle, it's not just about the individual tree-the entire forest plays a role. Leaves take in carbon dioxide, converting it to sugar, which is carbon-based. Some of the sugar is used immediately for energy, converted back to CO2, and released into the atmosphere. The rest is stored in living wood or dead matter, such as fallen leaves and branches. Old-growth forests, in particular, store vast amounts of carbon while continuing to absorb CO2.
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For some people forests are measured in board-feet of lumber. For others they're a source of spiritual renewal. But scientists are finding that protecting ancient trees could also be an important new strategy in the fight against global warming.

I climb a long series of ladders that lead to nothing but sky. Wind hums in the struts of the metal tower around me, causing it to vibrate like a giant guitar string and carrying the scent of warm pinesap, which saturates the air of Oregon's East Cascades in late summer. As I move higher, I pass arrays of high-tech gear that swallow samples of air, then analyze the amount of carbon dioxide in each gulp.

How to Plant Trees
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Just behind me, her long, gray-shot hair whipping in the wind, Beverly Law steps onto the tower's topmost platform, 120 feet aboveground. Law, a professor of global forest science at Oregon State University, uses towers like this one, with their whirring gizmos, to track the forest's vital signs and reveal the complex relationship between trees and atmospheric carbon. She is the director of the AmeriFlux Network, an international collaborative project founded in 1996 that tracks the exchange of CO_2, water vapor, and energy in all sorts of biomes throughout the Americas, from the Alaskan tundra to the Amazon rainforest. Her work, and that of the network, challenges conventional wisdom about how forests help to mitigate global warming.

In an era of climate crisis -- perfectly symbolized in the dwindling snowpack on the peaks of the Three Sisters, off to our southwest -- a clearer understanding of the role forests play in absorbing carbon is becoming crucial. Mass deforestation, particularly in tropical countries such as Brazil and Indonesia, accounts for more than 20 percent of annual greenhouse gas emissions. Meanwhile, recent studies show that Northern Hemisphere forests, now beginning to bulk up as they recover from centuries of logging, capture large amounts of CO_2 from the atmosphere. Finding ways to preserve forests-wherever they may be-can buy us precious time to wean ourselves from fossil fuels.

I've spent much of my life surrounded by argument and anger over the fate of forests. For more than a decade I walked the woods as a wildlife biologist, learning to see them through the eyes of spotted owls, salamanders, tree voles-and landowners. My husband, a professional forester for the California Department of Forestry, spent several difficult years working to enforce state environmental regulations governing commercial timberland, taking flak from both loggers and eco-protestors. The people I've met along the way have always valued forests intensely, though often for very different reasons: as a renewable source of lumber and jobs, a haven for endangered wildlife, a source of clean water, a place of spiritual renewal. Now we all need to take a fresh look at how we judge the worth of our forests. The capture of CO_2, an invisible gas, may be just as vital as an owl or a marten moving through the trees, as necessary as the shelters we build out of solid wood.

Plants take in CO_2 and harness the energy of the sun to drive the chemical reaction that melds carbon with water, producing the substance of stem and leaf and releasing oxygen. When darkness or drought bring this process of photosynthesis to a halt, plants respire, just as humans do. That is, plants breathe in oxygen and exhale CO_2. But over the long life span of trees in an undisturbed forest, huge reservoirs of carbon are stored for great stretches of time in the organic matter in soil as well as in living wood.

People who cut down trees for a living tend to measure their value in dollars and cents. Traditionally, the timber industry has seen mature forests, with massive trees left standing and big logs rotting on the ground, as examples of waste; replanted clear-cuts, by contrast, represent an ideal of economic productivity. Now global warming has forced foresters to address the impact of logging on the flow of carbon between forests and the atmosphere, and many in the industry have insisted that stands of young, fast-growing trees capture carbon more efficiently than do older forests. Using a recently developed technology called the eddy covariance method-more commonly known as eddy flux measurement-Bev Law and her colleagues are showing that those assumptions are wrong.

It turns out that forests hundreds of years old can continue to actively absorb carbon, holding great quantities in storage. Resprouting clear-cuts, on the other hand, often emit carbon for years, despite the rapid growth rate of young trees. This is because decomposer microbes in the forest soil, which release CO2 as they break down dead branches and roots, work more quickly after a stand is logged. On the dry eastern face of the Cascades, for example, where trees grow slowly, a replanted clear-cut gives off more CO2 than it absorbs for as much as 20 years. "That's a long time," Law observes, "during which microbes respiring in the soil, rather than trees photosynthesizing aboveground, dominate the carbon balance."

Can we develop a new model of forest economics that draws on this knowledge -- a model that makes sense to foresters as well as the policy makers and conservationists who are now taking the first steps toward developing a viable market in forest carbon? Depending on how we treat forests -- whether and for how long we allow them to grow -- they can be either major emitters of CO2 or highly efficient "sinks" that remove the greenhouse gas from the atmosphere. Because financial pressures drive deforestation, the hope is that putting a cash value on the carbon captured and stored by living trees will one day provide an alternative economic incentive to those who do the cutting.

From our windy perch atop the tower, Law and I look down on a 90-year-old stand of ponderosa pine quietly baking in the midday sun. These trees won't pack on much more girth in the next couple of decades, and in the eyes of a typical forester or timberland owner, they're more than ready for market. The conventional view is that this forest is also past its prime in its ability to sequester carbon dioxide.

Since the mid-1990s Law has monitored the movement of carbon in the ponderosa pine forests here along the Metolius River in the central Oregon Cascades, starting with a rare stand of ancient trees that contains pines as old as 250 years. She studies the forest ecosystem on every level, from the workings of a single leaf to sweeping landscape images produced by remote sensing satellites. She recently coauthored a study, published in the journal *Biogeosciences*, which tracks the exchange of carbon between land and air for the whole state of Oregon from 1980 to 2002. Earlier studies suggested that during the 1970s and early 1980s, publicly held Douglas fir forests in the West Cascades were being harvested so heavily that they emitted more carbon than they absorbed. After years of intense controversy over the loss of habitat for the northern spotted owl and other species that depend on old-growth trees, the federal Northwest Forest Plan curtailed most logging in the region's national forests, starting in the early 1990s. By the end of the decade the balance had tipped; on average, forests were offsetting up to 50 percent of the CO2 generated by Oregon's fossil fuel emissions each year.

Eddy flux measurement is one of Law's most crucial tools, enabling her to track the exchange of CO2 and water vapor between forest and air over large swaths of landscape, and at a level of detail that's never before been possible. The automated gas analyzers mounted on the eddy flux tower we're standing on measure CO2 concentrations 20 times per second. Meanwhile a sonic anemometer, a three-pronged device that resembles a robotic claw, tracks wind speed and direction. The combination of these two data sets reveals the shifting flow of carbon in and out of a forest, day or night, winter or summer. Law notes with pride that all the technology at this research site is powered by photovoltaic panels.

Other tools provide Law with additional insights into the flow of carbon through the intricate pathways of the forest. To photograph root growth, she slides a remote-controlled camera into a clear tube sunk belowground at a tree's base. Set on the forest floor are instrument-laden cylinders that hum to life every five minutes, lower themselves like miniature flying saucers, settle onto a patch of earth, and record the amount of carbon coming out of the soil.

Law's data show that this 90-year-old forest is, in fact, at the peak of its ability to absorb carbon. The uptake of carbon by ponderosa pines increases gradually, then reaches a plateau at some point between 50 years and 90 years. Once this plateau is reached, the trees and the soil will together continue to form a rich bank of stored carbon that cannot be equaled by any newly sprouted stand. During her work in California and the Pacific Northwest, she's found forests as old as 800 years that continue to absorb more carbon than they release.

Eddy flux technology has made it possible to set up a standardized way of tracking carbon in any ecosystem, anywhere in the world. More than 90 separate sites are now part of the AmeriFlux Network, studying jack pine and old-growth maple and birch in Michigan, loblolly and slash pine in North Carolina and Florida, and a Massachusetts hemlock forest, among others.

On the other side of the country, in Petersham, Massachusetts, atmospheric chemist Steven Wofsy of Harvard University, another member of the AmeriFlux Network, studies a site that even more dramatically defies the theory that trees lose their ability to soak up carbon with age. Wofsy began the world's first long-term, large-scale eddy flux study at Harvard Forest in 1989. Since it was flattened in a 1938 hurricane, the stand has been increasingly dominated by red oak, a large tree with dense wood that absorbs impressive amounts of carbon.

"All the ecological models said that temperate forests stop their net carbon uptake at about 50 years," Wofsy says. "Eddy flux data has clearly shown that this is not true." At the start of the study, when the trees were a half century old, the researchers found that Harvard Forest was absorbing about 0.8 tons of carbon per acre every year. After 15 years the rate of carbon uptake -- expected to decline with age -- had instead doubled. It's too soon to tell how long that trend will continue in Harvard's forest of oak and maple; the Northeast has none of the intact older forests that Law is able to study out West.

Working with CarboEurope and other networks collecting eddy flux data, AmeriFlux researchers have been able to piece together a global picture of the interactions between the greenhouse gas and natural landscapes. While biological differences between one kind of forest and another may mean that the rate of continued carbon uptake will vary, an important general principle holds true. "Across forest types globally," Law says, "we find that the amount of carbon stored is high in older forests, and that live carbon [the carbon in living wood] continues to accumulate for centuries." AmeriFlux's findings are now publicly available online, and climate modelers are beginning to use the data to forecast the ways forest growth-or forest loss-could affect climate. Such models are used in simulations by the Intergovernmental Panel on Climate Change, whose authoritative reports shape climate policies worldwide.

But these findings are news to the foresters I know. All of them remember, from college textbooks, a graph of tree growth that shows young trees bulking up rapidly over the first few decades of their lives, reaching a peak at 60 years to 70 years. After that, growth rates drop off. This pattern, which indicates that the most profitable point at which to harvest timber comes before the trees reach a century of growth, is deeply ingrained forestry wisdom. Since individual trees grow by taking in CO2 during photosynthesis, most foresters believe that the same pattern that maximizes marketable timber also applies to overall carbon absorption by the forest as a whole. But the intertwined workings of trees, the microbes thriving in the soil, and the creatures who feed and shelter among them are much more complex than that.

"Young trees ‘eat' atmospheric carbon like teenagers devour pizza," wrote forester William Wade Keye in a recent opinion piece for the *Sacramento Bee*. "Mature trees store carbon, but does old growth capture more atmospheric CO2 than younger timber stands? No, it doesn't. Old forests have many ecological values, but they're essentially geriatric wards when it comes to their net growth."

Keye's argument ignores the importance of the large amounts of carbon held in the living wood and fertile soil of old forests. When such stands are cut, about a third of the carbon is captured in marketable timber; the rest is rapidly released into the atmosphere. Like most foresters, Keye appears unaware of recent studies by Law, Wofsy, and their colleagues. Eddy flux measurement, supplemented by careful accounting of the carbon absorbed and released from leaves, the live roots burgeoning beneath the soil, and the rotting detritus of the forest floor, reflects the life of forests in far greater detail than traditional forestry analyses, which are based on measuring only those trees that are large enough to produce marketable timber.

Today, market forces are intensifying the timber industry's impact on climate. "To compete with much cheaper supplies of fiber and wood from overseas, U.S. landowners have been harvesting more and more aggressively," says Laurie Wayburn, president of the Pacific Forest Trust, a nonprofit group based in San Francisco that focuses on conservation of privately held forests. "Pressure for timberland to deliver faster profits has transformed this industry from a long-term investment strategy for many owners to one that has to deliver an 18 percent to 20 percent return. The only way to accomplish that is through selling off land for development."

These trends can erase the ability of commercial forests to act as carbon sinks. In the fertile woods of the Oregon Coast Range, it was once common practice for landowners to wait until stands were 50 to 80 years old before logging. Now they are cutting timber as young as 30 or 40 years old. Law has found that as a result of the accelerating pace of harvest, the region no longer has any net value as a carbon sink.

"If people got paid for all the biomass in a forest rather than just the part that can be made into two-by-fours, that would be different," says Bill Stewart, a forestry specialist at the University of California at Berkeley. "If carbon comes to have real cash value, that will change the way everyone does business."

Inducing foresters and landowners to manage forests for their carbon value, as well as for their timber, will take a revolutionary shift in both mind set and economics. Eddy flux studies like Law's provide solid evidence that letting forests grow longer can lead to real climate benefits, but creating financial incentives to make that shift a reality is a complex proposition.

Ten years ago the Kyoto Protocol established a system for capping emissions of greenhouse gases, setting up a "cap and trade" carbon market. The basic idea is that governments limit the total amount of greenhouse gases that can be released, divvying up pollution rights among regulated industries. Those industries can then buy and sell carbon allowances. Over time the cap becomes more stringent, eventually leading to a significant overall drop in emissions. By 2006 the global market in carbon allowances, governed by Kyoto and the European Union Emissions Trading Scheme, had reached $30 billion, and it is growing rapidly.

Polluters who can't manage to reduce their own emissions can also compensate by buying a carbon emission reduction credit, or offset -- that is, paying for someone else to either lower emissions or increase CO_2 capture. Sellers of offsets are supposed to meet strict standards that show their actions really are reducing the amount of atmospheric CO_2 in a way that would not happen without the incentives offered by the carbon market.

Rewarding the conservation of forests is especially tricky, and the Kyoto -E.U. market did not create any way to do so, despite the alarm at the original Kyoto conference over the headlong destruction of tropical forests. The problem is that while power plant emissions are easy to measure, the market in forest carbon could easily become a shell game, with all-too-real CO2 emissions being traded for possibly illusory increases in forest carbon storage.

Independent of Kyoto and the E.U., a busy market in unregulated carbon offsets has sprung to life, and its shortcomings are apparent. About $5 billion worth of these offsets were traded in 2007, more than a third of them based on forest conservation projects. But it's difficult to know what these were worth in terms of real climate mitigation. In Brazil, one infamous project, supported by the World Bank, has marketed carbon credits based on a vast commercial plantation of nonnative eucalyptus trees that required heavy loads of pesticides and fertilizers, without producing any demonstrable increase in carbon sequestration. "The voluntary carbon offset market is truly a Wild West," Wayburn says. "The buyer must look carefully to find out if these projects are permanent, if they'll store more carbon than a business-as-usual approach, if what they claim to be doing on the ground is verified."

The idea of marketing the carbon held in tropical forests was much discussed at the United Nations Forum on Climate Change in Bali last December, and delegates floated several models. Some proposed allowing nongovernmental organizations, governments, or private entrepreneurs to develop conservation projects and to sell carbon offsets based on the deforestation they prevent. Others suggested creating a fund to provide incentives for forest protection without involving any trade of offsets for pollution allowances.

The boldest effort yet to create a viable carbon offset market for forests has been in California, where the California Air Resources Board (CARB) recently adopted a new forest protocol that aims to provide financial incentives for increasing carbon storage. The protocol is one of a series of new policies sparked by the California Global Warming Solutions Act of 2006, which mandates reduction of greenhouse gas emissions in the state to 1990 levels by the year 2020.

Wayburn, who helped shape the CARB forest protocol, says that it sets up "a standardized system that recognizes the climate value of standing forests for the first time globally." California's flagship offset project is the van Eck Forest, a 2,100-acre tract of Humboldt County coastal redwoods. Governor Arnold Schwarzenegger, Assembly speaker Fabian Nuñez, and speaker of the U.S. House of Representatives Nancy Pelosi have all personally bought van Eck offsets to balance out the emissions generated by their jet travel. And Pacific Gas & Electric, California's major power supplier, offers its ratepayers the chance to pay a "Climate Smart" surcharge on their energy bills, which will go in part toward buying the carbon in living trees at van Eck.

Yet van Eck illustrates some of the pitfalls and limitations of the CARB scheme. The forest, which had been cut over in the 1950s, was bought in 1969 by New York investment banker Fred van Eck, who loved the woods and didn't need to milk them for money. The forest is now owned by a foundation set up in van Eck's will and managed under a conservation easement held by Wayburn's Pacific Forest Trust.

Customers who pay for offsets at van Eck "are buying a product that has already been developed, delivered, registered, and certified," Wayburn says. "The carbon is already there on the ground." That may sound good, but it's a roundabout way of saying that the sale of offsets is not linked to any real change in forest management. Wayburn's group forecasts that the van Eck Forest will achieve more than 500,000 tons of CO2 emission reductions over the coming century. But that figure is based on comparing projected carbon storage at van Eck with the amount of CO2 the land would retain under the most aggressive harvest regime permitted by California's Forest Practice Rules-rules that, admittedly, are tougher than those of many other states. There's no question that van Eck stores far more carbon than the clear-cuts that surround it. But the worst-case scenario is not a fair measure of its value as a carbon sink. It's a paradox: if your habit is to chop down every possible tree, it's easy to show that changing your behavior will increase carbon storage. But because van Eck has been managed to a higher standard for decades, marketing its existing carbon may not be justified.

Still, the architects of the CARB protocol hope to use examples like van Eck to grow a market in forest carbon that's strong enough to combat the pressures pushing development and overharvesting throughout the state and to set an example for the world. To ensure that offset projects provide a permanent increase in carbon uptake, the protocol demands that landowners set up conservation easements that prevent land from being sold for development. In terms of climate mitigation, that policy is essential, but many in the timber industry see it as a nonstarter. Unless the landowner is already as wealthy and conservation-minded as Fred van Eck was, says Bill Stewart, the Berkeley forestry expert, "Why would anyone else want to lock up a stand of timber with a conservation easement? Because the price of carbon right now is about one-eighth the price of redwood lumber."

Wofsy, however, sees hope in the idea of marketing forest carbon. He explains that older, larger timber is ultimately more valuable; the key is to compensate owners for the loss of short-term profits while they wait for their trees to grow. "If we find ways to pay people for allowing carbon to accumulate," he says, "we can have a big effect, for a relatively small sum changing hands. There have been studies both here in the Northeast and in the Amazon that give us hard numbers that show you can log your trees, get a good economic return, and still have them be quite efficient at taking CO2 out of the atmosphere."

Bev Law leans against the broad trunk of an old-growth ponderosa pine, describing a morning when she came out to run physiological tests on the tree and found a bat huddled in the craggy bark at its base, snoozing in the first light of day. Far above our heads a white-headed woodpecker, a bird drawn to old, high-elevation pine forests, hammers away at a neighboring pine.

Law has been around the woods since she was a toddler, long enough to know that the timber industry is a necessary part of the picture. She lives in a wooden house, as do I.

Law groans when she hears foresters talk of harvesting 40-year-old stands in Oregon's Coast Range. "We could be storing much more carbon than we do now," she says. There's no single answer to the problem of forest destruction and overharvesting, but she knows where she'd like to start. "If I had the power to change things," she says, "I would increase the length of forest harvest rotations so that more carbon is stored on the ground for longer periods." That basic step -- waiting a few decades longer before cutting down trees -- makes sense if you look at it from the sky above the forest canopy or through the eyes of the creatures that find shelter beneath it.

For now, the power of the market easily overwhelms that perspective. Countering commerce in lumber with commerce in carbon may be part of the solution, but if so, it will be a winding way through the woods. Still, armed with their high-tech wizardry, Law and her colleagues have opened a new window into the intimate workings of forests. Their findings lay to rest the hoary notion that old-growth forests are worthless in the fight against global warming. On the contrary, they are an essential part of the struggle.

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TAGS

carbon cycle | carbon offset | forestry | forests | global warming | trees

COMMENTS

Clint Trammel ...

> Good information here. Over all the web site is well constructed. I would, however, suggest you change the orange(?) to some other color. The orange is hard to read.

Jason Sohigian ...

> Thank you for this article--it's important to acknowledge the role that non-tropical forests play in carbon sequestration. Our organization is working on tree planting and environmental education programs in the Republic of Armenia, and we appreciate new research such as this that helps the public and even foresters to better understand these important ecosystem dynamics.
>
> Kind regards,
>
> Jason Sohigian
> Armenia Tree Project

www.ArmeniaTree.org

Comment on this article