

## The Boston Globe **Trees by design**

### **What happens when genetic engineering comes to the forest?**

By Susan Freinkel | December 23, 2007

IF EVER THERE was a tree that has inspired devotion, it's the American chestnut, once one of the most common trees in East Coast forests. Thoreau considered it among the "noblest" trees he encountered in his walks through the Lincoln woods, while settlers in the southern Appalachians found the nuts and timber such valuable allies in their struggle to survive that the tree became a regional icon. When an imported plague, the chestnut blight, all but eradicated the tree in the early 20th century, people mourned from Georgia to Maine.

Since that time, ardent fans have struggled to pull the chestnut back from the brink. Most of their efforts have relied on old-fashioned breeding techniques - investing the tree with blight-resistance genes from other species of chestnut through the laborious and lengthy process of hand-fertilizing flowers, planting the resulting seeds, cultivating trees, and culling inferior specimens. And then doing it all over again. But a pair of forestry scientists at the State University of New York in Syracuse are now exploring a different idea: that genes from other plants, and even from animals, might provide the chestnut with completely new weapons to thrive again in the Eastern forests.

The technology they are using is the genetic engineering that has transformed medicine and agriculture - and triggered intense controversies - over the last three decades. But now it is being applied to trees, raising new possibilities for industry and conservation, as well as new kinds of environmental safety concerns.

Advocates of forest biotechnology say that with a few snips and tucks of the molecular scissors and tweezers, it may be possible to quickly, and even radically, revise the way a tree grows. Scientists could create a tree that repels bugs, resists weed-killers, or better weathers winter freezes. They could change the composition of wood, manipulating the levels of lignin, the cellular glue that holds wood fibers together, in order to fashion the tree of a lumberman's or a paper manufacturer's dreams. They could solve pressing environmental problems with designer trees that can pull toxic chemicals from the soil, suck greenhouse gasses from the atmosphere, or serve as a source of green energy. Or, perhaps most sensationally of all, they could save trees that face extinction.

But modifying the genes of trees also poses special threats. The concerns environmentalists have raised about traditional agriculture - that genes will "leak" into the wild, with unknown and irreversible consequences - are magnified with trees. Unlike engineered corn or soybeans, a genetically altered tree could live for decades, if not centuries. And trees are far hardier and better able to survive in the wild than most crops. If seeds or pollen from a genetically modified poplar escaped, they could grow and spread the new gene, as well as contaminate natural poplars in the forest. Wildlife, insects, and other plants in the forest ecosystem could be affected as well.

Until recently, the field progressed slowly, hobbled by technical challenges, political controversy, and financial problems in the timber industry. But that's starting to change, thanks, in part, to surging oil prices and a rising interest in biofuels.

The field "has exploded in the last year," says Adam Costanza, president of the Institute of Forest Biotechnology in Raleigh, N.C., a nonprofit group established by industry and academic interests

to act as a watchdog of the field. Of the nearly 200 permits to field-test transgenic trees granted by the US Department of Agriculture so far, almost half were issued in the past year.

The debate over transgenic trees has even divided environmentalists. Some are focused on the dangers, while others see an innovative way to reverse the damage humans have caused.

"This is a different kind of biotechnology....It's biotechnology for the environment," says one of the leading researchers in the field, Ronald Sederoff, a professor of forestry at North Carolina State University. "That's why I'm involved in it."

For most of American history, the nation's timber needs were supplied by native forests or lightly managed plantings of wild trees. The forests remained largely beyond the hands of domestication. Technological advances came mostly in the post-harvest process, using kilns and chemicals and glues to make the raw material of wood more amenable to human needs.

Since the 1950s, though, forestry experts have been developing increasingly sophisticated ways of breeding timber trees, drawing on genetics and agricultural experience to grow Monterey pines, for instance, that are taller and thicker, or loblolly pines that are more easily pulped for paper.

That process of domestication entered a new phase when in the mid-1980s researchers produced the first transgenic plant, a tobacco plant containing a new gene. Instead of deploying the natural processes of pollination and fertilization to transfer the genetic instructions of a trait, the researchers had used enzymes and bacteria to break into the plant's tight coils of DNA and insert a novel set of instructions for an entirely new trait. It was a plant that could only have come from a lab.

Biotechnology, say advocates, is just a faster, more efficient form of domestication. The science helps in the drive to grow trees more and more like agricultural crops. Indeed, most of the wood the world now consumes comes from vast mechanized plantations of trees so carefully bred with industrial end-uses in mind that they often bear little resemblance to their wild cousins. If trees can be engineered to grow straighter and faster and take up even less space in plantations, that will further reduce the pressure on natural forests, says Costanza.

So far, only a few transgenic trees are in commercial use. China is the only country that has approved a genetically modified forest tree. As part of an ambitious countrywide reforestation program, it reportedly has planted 1 million poplars outfitted with an insect-resisting gene lifted from the common soil bacterium, *Bacillus thuringiensis*, the same natural pest control that organic gardeners use. Federal regulators in the United States have given the green light to two transgenic fruit trees: A papaya engineered by Cornell researchers to resist ring-spot virus, a scourge that had threatened to wipe out Hawaii's papaya industry, and a plum tree designed by USDA scientists to resist plum pox.

But various types of other transgenic fruit and forest trees are growing in test plots in at least 16 countries, including the United States, Canada, Japan, and most of the major European countries. Many have been designed with plantation needs in mind. Indeed, the first, developed in 1987, was a poplar that was outfitted with a gene to resist the weed-killer Roundup.

The biggest push these days is for trees with lower levels of lignin, the chemical compound that gives wood its strength and helps trees resist insects. Paper and pulp companies have long sought trees with lower lignin, since its removal is the most expensive part of making paper. Now energy companies and the Department of Energy have joined the quest, as they search for new sources of biofuels. Trees hold enviable amounts of cellulose, the fibrous part of plants that can be used to make ethanol. But lignin is a barrier to getting it out.

ArborGen, a seven-year-old South Carolina-based company, is developing a low-lignin eucalyptus that it hopes to sell in Brazil, where the trees are already widely used for pulp and paper. Brazilian industry, says chief technology officer Maud Hinchee, "sees the value in using biotechnology to improve trees for industrial applications."

For this country, ArborGen also is working on a more cold-tolerant version of the tropical species, so it can be planted in southern states where pulp and paper plants are located. Currently the trees are being field tested in Alabama. She predicts the company will have some type of transgenic tree on the market in the next five years.

Though commerce, not conservation, is the prime driver of forest biotech, there are intriguing environmental applications underway. University of Georgia researchers are working on a transgenic poplar that can pull mercury out of contaminated soil. Historically, the toxic metal was used in making felt for hats, so the trees are being tested on the site of an old millinery factory in Danbury, Conn. Meanwhile, researchers sponsored by the Department of Energy are trying to modify the architecture of tree cells so the trees can store more carbon dioxide in their roots, keeping it out of the atmosphere, where it would otherwise contribute to global warming.

And, of course, say SUNY scientists Charles Maynard and William Powell, the technology could be used to save trees threatened by exotic pests, such as the chestnut, butternuts, beeches, hemlocks, and dogwoods. Indeed, Powell and Maynard have already developed elm trees that contain an antimicrobial gene to ward off Dutch elm disease and another fungal pest. (The trees contain a gene based on one found in African clawed frogs.)

Some proponents hope that the chestnut will be the first transgenic forest tree to confront federal regulators. (Forest trees, unlike the bioengineered plum and papaya, pose special issues because they have relatives in the wild.) They see it as a good test case because the chestnut is a tree that the public genuinely desires, and the environmental risks are lower since few chestnuts still exist in the forests.

As Robert Kellison, former head of the Institute of Forest Biotechnology, put it in a 2006 interview: "We need to get something through the system so we can set an example."

That's exactly what many experts and environmental activists worry about. Genetic engineering, they say, represents such a fundamental departure in the way we manipulate plants that we should be extra cautious as we go. It's not clear, they say, that the possible benefits outweigh the potential risks. Yet if transgenic trees become widely planted and problems emerge, it will be tough to turn the clock back. The Sierra Club and a dozen other American and European environmental groups have joined forces to push for a moratorium on further development of genetically modified trees.

"You cannot recall a genetically engineered organism," says Neil Carman, a scientist on the Sierra Club's genetic engineering committee.

Douglas Gurian-Sherman, a senior scientist at the Union of Concerned Scientists, thinks that one of the most pressing issues is figuring out how to test the safety of genetically modified trees. To test a tree properly, it would have to be grown in the environment, for a long period of time, but the test itself would be risky. "I don't think the kinds of risk assessments that need to be done have been done by any means," says Gurian-Sherman.

To address environmental concerns about gene leak, researchers have been working on a variety of containment strategies, such as inserting additional genes to render them sterile or delay their flowering to thwart inadvertent cross-pollination with their counterparts in the wild. Yet progress has been slow, mainly because it's been hard to raise money for the research, says

Steven Strauss, a professor of forest science at Oregon State University.

The debate now revving up over transgenic trees in general has been simmering among devotees of the American chestnut. Some members of the leading restoration group, the American Chestnut Foundation, strongly support Maynard and Powell's work.

But others insist classical breeding methods are all that's needed to develop a blight-resistant chestnut tree - and without courting controversy or the risk of unknown consequences. "It's a plant improvement system that ain't broke, so why fix it?" says Donald Willeke, a longtime member of the group's board. Indeed, while Powell and Maynard are still trying to perfect a bioengineered chestnut tree and face years of regulatory tests, the American Chestnut Foundation has already harvested what it hopes are its first crop of fully blight-resistant chestnut seeds.

Powell and Maynard first began trying to bioengineer a blight-resistant chestnut nearly two decades ago. At the time they thought they'd be done in five to 10 years. Yet they still believe genetic engineering offers the tree its best shot at staging a comeback. Equipping the tree with genes from other species that the blight has never seen before - they're currently testing one drawn from wheat - could provide even stronger defenses than what's possible through natural breeding programs, they say.

Last summer they planted 15 saplings outfitted with the wheat-based gene in test plots. It's too early to say if the new gene will work as well as the two scientists hope. But even if it falls short, Powell's not worried. "We have," he says, "other genes waiting in the pipeline."

*Susan Freinkel is a freelance writer in San Francisco and author of "American Chestnut: The Life, Death, and Rebirth of a Perfect Tree." This article was adapted from that book. She can be reached at [freinkel@mindspring.com](mailto:freinkel@mindspring.com). ■*

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