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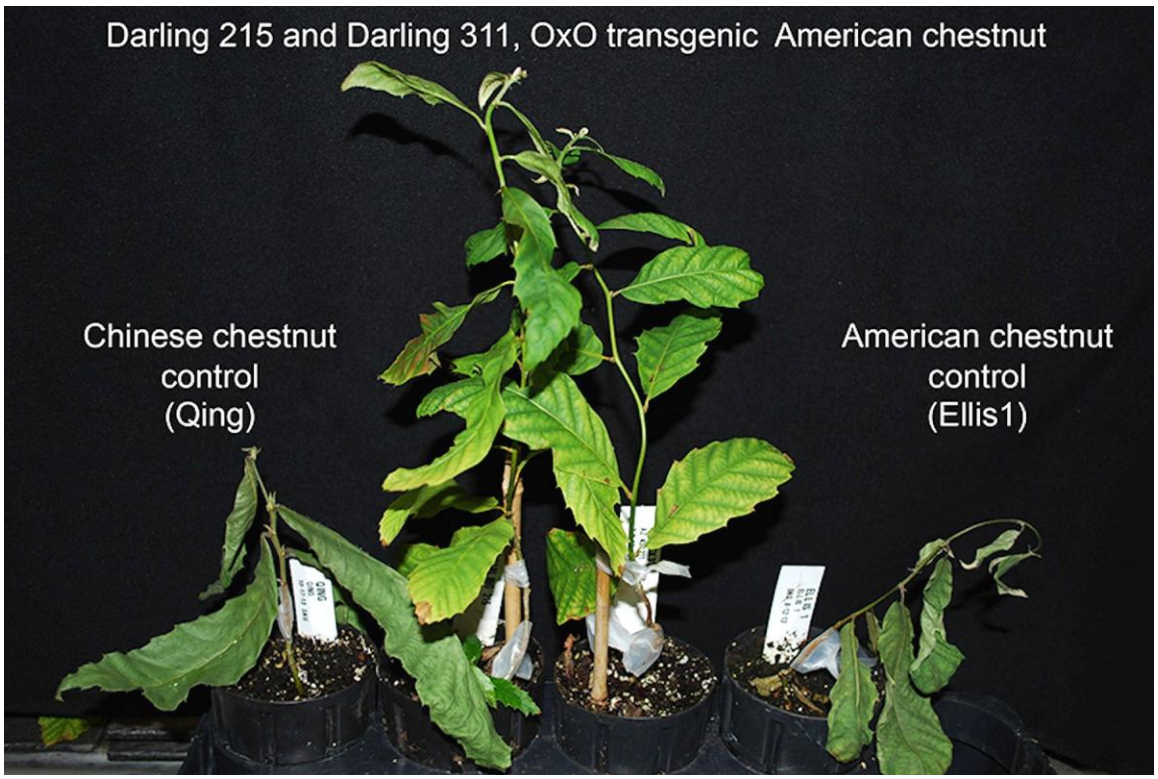
National Academies: Biotechnology Has Potential to Mitigate Forest Threats

By Steve Wilent

According to a report issued in January by the National Academies of Sciences, Engineering, and Medicine, "Biotechnology has the potential to help mitigate threats to North American forests from insects and pathogens through the introduction of pest-resistant traits to forest trees." The report, *Forest Health and Biotechnology: Possibilities and Considerations,* recommends research and investment to assess and improve the utility of biotechnology—genetic engineering and similar technologies—as a forest-health tool (see tinyurl.com/ybor9ou4).

At the request of the US Department of



William A. Powell, a professor at SUNY ESF, has produced transgenic American chestnuts (*Castanea dentata*), called Darling 215 and 311, center, that are resistant to chestnut blight. Left: a blight-resistant Chinese chestnut (*C. mollissima*). Right: a blight-susceptible wild American chestnut. All of these seedlings were inoculated with the blight fungus, *Cryphonectria parasitica*. Powell's research shows that the transgenic American chestnuts may have even higher resistance to the blight than the Chinese chestnut. See www.esf.edu/chestnut/resistance.htm

Agriculture (USDA), the US Environmental Protection Agency (EPA), and the US Endowment for Forestry and Communities, the National Academies assembled a Committee on the Potential for Biotechnology to Address Forest Health to investigate the potential use of genetic engineering in trees to address forest health; this report is the product of their work. The committee was not asked to examine the potential for biotechnology to reduce threats to forest health by altering the pests affecting North American tree species. Committee members and the numerous reviewers of the report were experts with diverse backgrounds primarily from academia and nonprofit groups.

The committee noted that "challenges remain: the genetic mechanisms that underlie trees' resistance to pests are poorly understood, the complexity of tree genomes makes incorporating genetic changes a slow and difficult task, and there is a lack of information on the effects of releasing new genotypes into the environment." It recommended research and investment in three areas:

1. Knowledge about tree genetics related to resistance
2. Data and tools for impact assessment
3. Management approaches that take into account disciplines beyond biotechnology

Numerous recommendations and conclusions are offered in the 200-page report, including:

- Conclusion: Substantial literature supports the need for sustained investment in prevention and eradication as the most cost-effective and lowest impact approaches for managing introduction of nonnative insect pests and pathogens.
- Conclusion: Using biotechnology to introduce resistance to threats in forest trees has been hampered by the complexity of tree genomes, the genetic diversity in tree populations, and the lack of knowledge about genetic mechanisms that underlie important traits. However, recent technological developments have improved functional genomic tools, facilitating the potential for biotechnology to help address forest health problems.
- Recommendation: More research should be conducted on the fundamental mechanisms involved in trees' resistance to pests and adaptation to diverse environments, including a changing climate.
- Recommendation: Sufficient investment of time and resources should be made to successfully identify or introduce resistance into tree species threatened by insects and pathogens.
- Recommendation: Research should address whether resistance imparted to tree species through a genetic change will be sufficient to persist in trees that are expected to live for decades to centuries as progenitors of future generations.

"We didn't start out with a conclusion that biotechnology should be used to address forest health, but we felt very strongly that it needed to be looked at," Carlton Owen, president and CEO of the US Endowment for Forestry and Communities. "We felt that this study, as a capstone to the work on

biotechnology that [the Endowment] has done or supported over the past 10 years, was crucial. We felt that we needed an independent voice like the National Academies to weigh in."

Owen noted that the report was evenhanded in its recommendations and conclusions.

"I don't think anybody in either camp, pro or con, can say that it isn't a balanced report," he said. "We had people with a very wide range of interests at the table, some of whom were not biotech supporters. But what we had in common was that we don't like losing tree species or seeing swaths of dead forest."

Although further research into the technology is crucial, time is of the essence, Owen said.

"A phrase that I often use is that we need tools that serve at the speed of need, and our current tools don't do that," Owen said. "Time does matter. When we look at the challenges of forest health—and there are challenges in every region of our nation, as well as the rest of the world—we don't have 30, 40, or 50 years to think about things when we're losing entire species. We've lost the elm and the American chestnut, and we're losing the ash. And, of course, there are a number of other threats, such as oak wilt disease and walnut canker. We just don't have tools that are responding at the speed at which we're facing new challenges."

"Doing something is a risk and doing nothing is a risk," Owen added. "If we choose not to deploy biotechnology, are we willing to accept the consequences?"

Poplar and Chestnut

To date, the report states, American chestnut and hybrid poplars were the only two tree species on which biotechnology research has been conducted for forest-health purposes in the US; both are undergoing limited field trials.

William A. Powell, a professor and director of the Council on Biotechnology in Forestry at State University of New York College of Environmental Science and Forestry (SUNY-ESF), has conducted extensive research on American chestnut, a species once widespread in the eastern US that has been all but wiped out by a fungal blight introduced more than a century ago. Powell is codirector of the American Chestnut Research & Restoration Project. He was named the 2013 Forest Biotechnologist of the Year by the Institute of Forest Biotechnology (IFB).

"Generally, I think the committee did a good job. They pointed out that there are opportunities for the use of biotechnology, but that there are still a lot of challenges out there and still some unknowns. Of course, we can't learn about those unknowns until we can actually test some trees under field conditions."

Like Owen, Powell said that time is a critical factor in addressing current forest-health problems.

"It doesn't take much searching on the web to find out how challenged our forests are right now. We have many different types of invasive pests and pathogens out there—the hemlock woolly adelgid, the emerald ash borer, thousand cankers disease on walnut, sudden oak death out in California—the list goes on and on," he said. "And all of these problems are probably going to be exacerbated by climate change. With chestnut, we're worried that *Phytophthora* root rot, which is a problem in the southern part of the tree's range, will move northward with warmer temperatures."

The report notes that under the 1986 Coordinated Framework for the Regulation

of Biotechnology, as many as three federal agencies—USDA, EPA, and the US Food and Drug Administration (FDA)—may have a role in the regulatory oversight of a biotech tree developed to address forest health. Working through three separate regulatory processes takes a great deal of time, Powell said.

Powell and his colleagues are currently working with USDA to achieve regulatory approval for field testing of American chestnut with an introduced wheat gene that produces a detoxifying enzyme that prevents the blight-causing fungus from killing the tree's cells, thus preventing the expansion of the cankers caused by the fungal pathogen. (see his TEDx talk, "Reviving the American Forest with the American Chestnut," at youtube.com/watch?v=WYHQDLCmgyg).

"We did a preliminary completeness check with [USDA], and now we're editing our 188-page document, which includes 3,000 references, and we hope to resubmit that by the end of this month. And we've been talking with people at the FDA [Food and Drug Administration], which has an interest because people, livestock, and wildlife eat chestnut nuts, and we'll probably submit an application sometime this spring. And we are also working with the EPA to determine whether they have regulatory authority over our chestnut. EPA regulates pesticides, but the gene we've used isn't pesticidal—it doesn't actually kill the fungus, but it detoxifies the acid that the fungus makes that hurts the tree."

To streamline the process, Powell suggests that a single agency be made responsible for regulating GM trees.

"The original purpose of the Coordinated Framework was that they didn't want anything slipping through, and they designated the three agencies so that at least one of them would regulate any genetically engineered product. That means [researchers] may have to jump through the same hoop three times, and each of the agencies has different criteria. That puts a big burden on researchers. So I think they should narrow it down to one agency and let that agency become very good at what it does. My preference would be that the USDA be that agency, since they oversee our field-trial permits—USDA is involved with our trees even before we formally apply for nonregulated status."

Powell suggests that the regulatory process could be further simplified with the use of preliminary reviews that will determine whether a GM tree ought to be subject to the full regulatory process.

"You could write a 20 page paper that explains why the product is safe. The agency would review that and, most of the time, would probably decide that the product doesn't need regulation. In some cases, the agency would determine that there is a need for further testing," Powell said. "I'm not for no regulation, but I want a more simple, straightforward process."

The regulatory process, he added, "should be based on the phenotype, or what you're changing in the tree, and not on the process, on the method that was used to make that change."

No-Spread Poplar

Steve Strauss, a professor of forest biotechnology at Oregon State University, has developed a hybrid poplar tree that produces sterile flowers or no flowers (see "Study: Trees Can Be Genetically Engineered Not to Spread," *The Forestry Source*, October 2018). He received the Barrington-Moore Memorial Award from SAF in 2001, which recognizes outstanding achievement in biological research leading to the advancement of forestry.

“The report was put together because the federal agencies can’t figure out how to deal with biotech trees. The agencies’ regulatory regime is really oriented toward annual crops that are pretty easy to contain and aren’t intended to go into wild environments. That regulatory regime is a huge obstacle,” Strauss said.

The report suggests that adaptive-management techniques could be used to test, assess, and improve the use of biotechnology as a tool to mitigate forest health threats, but Strauss says doing so under the current regulatory environment is difficult.

“You’ve got to do adaptive management under real forestry conditions, whether that is in a plantation or in a wild environment, if you want to learn anything—you can’t do it in an isolated, artificial environment, like a greenhouse. But you can’t do most of those experiments, because the regulatory regime requires that you completely contain everything, just because you use the recombinant DNA [rDNA] method. You could be tweaking a native gene for disease resistance, which is far more precise compared to breeding, but it’s considered guilty until it is proven through extensive studies and applications to be safe. So you really can’t do the adaptive research they call for. It’s very difficult, very expensive. Almost nobody does it.”

Forest practices and forest products certification by third parties also is a sticking point. The report points out that “some forest certification programs applied in the United States [have] prohibited the use of biotechnology”—that includes the Sustainable Forestry Initiative, the Programme for the Endorsement of Forest Certification, and the Forest Stewardship Council (see sidebar).

“Basically, that means that nobody can use GMO trees, even for research,” Strauss said.

Strauss and a handful of colleagues recently drafted a petition that calls on the certifying bodies to accept genetically modified (GM) trees:

“Given the rapidly growing threats to forests, the need for expanded production of sustainable and renewable forest products and ecological services, and the growing power and precision of biotechnologies, we believe that rDNA research should not be precluded from certified forests. We call for an immediate review of these policies to bring them in line with current scientific evidence, and call for appropriate action taken to rectify them.”

The petition “does not endorse all uses of rDNA in forestry, nor does it advocate for unrestricted use in all cases. These technologies are one option to help forests maintain their health, productivity, and provision of ecosystem and social services. They are new tools that require scientific research to evaluate and refine them on a case-by-case basis. We believe that such discovery, development, and analysis should be encouraged, not forbidden, in certified forests.”

The petition is available at biotechtrees.forestry.oregonstate.edu.

Strauss said that the two obstacles to deploying biotech trees—“the nonfunctional regulatory system” and prohibitions under key certification standards—make it difficult or impossible to use biotechnology to address forest-health issues.

“If we’re going use biotech, we need to be able to be pretty nimble with it,” he said. “You can’t do 30 years of risk studies to see if something might be okay to plant a real field trial.”

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SIDEBAR 1

Opposition to GE Trees

Some groups disapprove of the use of genetically engineered or modified trees. In response to Strauss's study at Oregon State University, a joint statement from the Global Justice Ecology Project, Indigenous Environmental Network, Rural Coalition, Biofuelwatch, and Canadian Biotechnology Action Network asserted that "the risks of genetically engineering trees are too great and can never fully be known."

"Trees are extremely complex, and fertility, which is one of the most important functions of any living organism, has been evolving in trees for millions of years. It is incredibly arrogant and dangerous to think that through genetic engineering we can override such a fundamental function as reproduction. Far from allaying fears, this research opens up serious new concerns," said Anne Petermann, executive director of Global Justice Ecology Project and coordinator of the international Campaign to Stop GE Trees, in the August 2018 statement.

Under the Forest Stewardship Council's US Forest Management Standard, "genetically modified organisms (GMOs) are not used for any purpose" (Indicator 6.8.d). The FSC-US standard also states that "Genetically improved organisms (e.g., Mendelian crossed) are not considered to be genetically modified organisms (GMOs) (i.e., results of genetic engineering), and may be used. The prohibition of genetically modified organisms applies to all organisms including trees."

In addition, although FSC notes that GM trees may have significant benefits, the risks of potential unintended consequences outweigh those benefits. "Research is continuing to develop safeguards to minimise the risks of these hazards…. The difficulties of avoiding the spread of transgenes, and the potential negative impacts, indicate that much of this research must be conducted in laboratories or in extreme isolation." FSC's policy is that "not even research into GMOs may be included in certified forests." See FSC's explanation at tinyurl.com/ybo98rnr.

The Programme for the Endorsement of Forest Certification (PEFC) also prohibits the use of biotechnology: "As the scientific evidence of potential benefits and dangers of genetically modified organisms (GMOs) and its impact on biodiversity remains insufficient and the society has not completed its debate, the PEFC General Assembly has determined that GMOs cannot be considered as part of PEFC certified material."

The Sustainable Forestry Initiative's 2015–2019 Forest Management Standard prohibits the use of wood from GM trees: "The use of fiber from genetically engineered trees via forest biotechnology is not approved for use in SFI-labeled products." SFI notes that GM forest products are not commercially produced in North America. As for research, SFI's policy is that "Research on genetically engineered trees via forest tree biotechnology shall adhere to all applicable federal, state, and provincial regulations and international protocols ratified by the United States and/or Canada depending on jurisdiction of management."

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SIDEBAR 2

SAF Position Statement

Regulation of Genetically Modified Trees

The Society of American Foresters (SAF) supports and encourages scientific advancements in forest tree biotechnology and its use to improve forest productivity, wood quality, and forest health, including the use of appropriately regulated genetically modified organisms (GMOs). SAF believes that well-studied applications of appropriate biotechnology methods for forest tree improvement have the potential to enhance the quality, productivity, and value of plantation forests managed for wood, pulp, and bioenergy; protect tree species from serious insect and disease problems; and provide other social, economic, and environmental benefits.

SAF supports science-informed government regulatory oversight of biotechnology applications, including genetic engineering (GE, also called genetic modification), and encourages consideration of both the benefits and risks of forest biotechnology applications. SAF supports GMO regulation that is focused on the products' safety and environmental impact. While GE potentially allows for greater novelty than traditional breeding techniques (e.g. production of novel phytochemicals), we believe that the degree of novelty of the GMO, and the potential threats that novelty creates, should drive regulation rather than simply the type of biotechnology used to achieve the modification.

SAF recognizes that discovery, development, and understanding the impacts of appropriate GE technologies can be accomplished only through both laboratory and field testing. Given the rapidly growing costs and risks of regulatory compliance for GE field studies and proposed trade/marketplace barriers for many GMO products, SAF urges government regulators to consider and balance the cumulative opportunity cost to society of compliance with GE regulations for companies and public-sector researchers. Regulations that make field tests excessively costly, onerous, or limited in duration may impede the conduct of economically and ecologically significant research and, thus, the timely understanding or realization of the benefits or costs to society.

The full position statement, background information, and references are available at tinyurl.com/y7lssrtl/.