



The Good, the Bad, and the Unknown:

A close look at public concerns about GE trees

by Ellen Crocker

Photo courtesy: Kenton Sena

American chestnut trees (above) once dominated our forests but were wiped out by an invasive disease. Now researchers are looking at the possibility of introducing disease-resistant genetically engineered chestnuts. This is just one example of the potential for genetic engineering to impact forestry, but we must decide if and how we want to use this technology.

Editor's Note: *In the last two editions of Kentucky Woodland Magazine we described what biotechnology is and how it is being applied in forestry. In this article we explore the controversy that surrounds genetically engineered forest trees. Our goal with this article is to provide a scientific perspective to enable you to make your own assessments of the risks and benefits posed by various GE trees.*

Genetic engineering is a very contested issue. Look up “GMOs” online and you will find countless articles arguing that they are deadly evils as well as life saving heroes. While the development of genetically engineered (GE) forest trees has lagged behind other agricultural plants, the widespread availability of these trees is closer than most people realize. But, before they are in broad use, it is important for us to assess concerns about GE trees and weigh their potential risks and benefits. Here we will look at the controversy surrounding the use of GE forest trees in both ecological restoration and commercial plantation contexts. There are many unknowns with GE trees, but being informed will help us make better decisions for the future.

Current state of GE trees

Despite the controversy surrounding GMOs, it is important to recognize that GE products have been a part of our lives for many years. These include a wide range of medicines and foods. For example, GE bacteria and yeasts produce most of the insulin used to save the lives of people with diabetes. And, while relatively few species of crop plants have been genetically engineered, GE corn, soybeans, and cotton have dominated production in the United States since the

mid-2000s, although their use is the subject of great public controversy. Currently, over 90 percent of corn, soybeans, and cotton grown in the US are GE. Trees, on the other hand, are only beginning to be genetically engineered by scientists. The limited trees currently approved are largely fruit trees, including virus-resistant papayas and apples that do not brown. But, this is likely to change in the future,



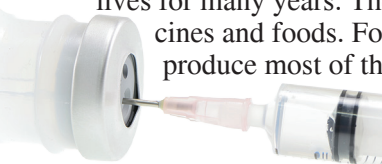
Here you can see chestnut seedlings planted on reclaimed mining land in efforts to restore forests. These projects are increasingly important as invasive insects and diseases kill native trees and land is lost to deforestation.

Photo courtesy: Chris Barton

and several different forest trees are undergoing government approval now. These include native trees for restoration (such as disease tolerant American chestnut trees) and industry-focused plantation trees (such as pines, poplars, and eucalyptus).

What makes GE forest trees different?

Given the rapid adoption of GE crops by farmers, it isn't surprising that people are looking to genetic engineering for forest trees. However, there are several key ways in which



Genetic engineering is very important in the development of medicines. For example, most of the insulin used by diabetics is derived from genetically engineered bacteria and yeast.

forests (and forest trees) differ from agricultural crops that should cause us to carefully consider the potential future use of GE trees. Agricultural crops are grown in highly managed systems, dominated by monocultures of non-na-

Photo courtesy: G. E. Cardon, Bugwood.org



Over 90% of corn, soybeans, and cotton grown in the United States is genetically engineered, with genes for herbicide resistance and insect tolerance added to improve the crops' uniformity and growth in large-scale farming.

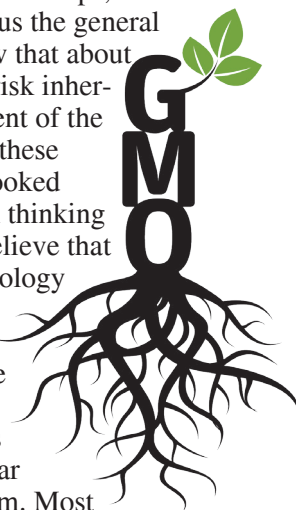
tive plant species that have been carefully bred by humans for thousands of years. Most of our forests, on the other hand, are naturally regenerating and populated by native tree species that play important roles in the ecosystem as well as the economy. The same forests that we rely on for timber and income are also important wildlife habitats and centers of biodiversity.

Increasingly, our native trees are under attack from invasive insects and diseases. From the recently arrived emerald ash borer to the historic American chestnut blight epidemic, native trees are increasingly facing threats they have no defenses against. Also, because resistant trees take much longer to develop than crop plants, traditional breeding programs that have worked well in other systems have been much less effective with trees. Both of these factors make genetic engineering an appealing option for improving forest trees.

The great divide:

Public opinions of GE risk vary widely

One of the most striking features of the debate about GMOs, particularly in the context of food crops, is the large difference in how scientists (versus the general public) view their safety. Surveys show that about 88 percent of scientists say there's no risk inherent to GE technology but only 37 percent of the general public shares this view. While these numbers seem at odds, an easily overlooked part of this discrepancy is that far from thinking that all GE plants are safe, scientists believe that any new plant, whether from GE technology or traditional breeding, should be assessed on a case-by-case basis. While GE technology could be dangerous, the risk is in the application of new plants (how these plants interact with humans and their environment) not the particular technique that was used to develop them. Most scientists view genetic engineering as an important part of



the modern tree breeding toolbox but a tool that must be applied wisely.

Common questions about GE plants (and how they relate to forest trees):

Are GE trees safe for human health?

GE plants pose no unique risks to human health. Scientific consensus agrees that there is no evidence that the GE agricultural crops we consume hold any inherent risk for people. This conclusion draws from extensive peer-reviewed scientific literature and investigations by government groups. Given that, in most cases, we won't be in as close contact with forest tree products (other than chestnuts, we don't eat them) the potential for GE tree risks to human health is even lower. However, this doesn't mean that GE applications can't be harmful, just that the GE technology itself is no more dangerous than other approaches.

Is genetic engineering an inherently risky process?

Public opinion of GE technology is that it is risky and more likely to result in problematic errors than traditional breeding. Scientists, on the other hand, say the opposite is true and that GE technology provides more detailed control over genetic changes than offered by traditional breeding. This divide comes down to different understandings about how people have bred plants over time.

While forest tree breeding is a much newer field, the history of agricultural crop breeding can provide perspective. All of the crops we currently depend on, whether organic or GE, are derived from thousands of years of plant breeding. People selected the best plants in their fields, products of random crossing with other plants. Although this type of shuffling of genes may be "natural" it is not very efficient and results in unpredictable outcomes. Farmers depended on chance to develop good gene combinations and had little ability to rapidly respond to changing environmental conditions (drought, insects), resulting in unpredictable good years or devastating famines. Modern breeding, on the other hand, is much more directed and allows for a faster, more targeted response to particular challenges and conditions. Even before GE breeding, scientists were very carefully managing plant breeding, selecting particular genes of interest, making crosses between plants and even randomly mutating



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plants to see if particular DNA changes would be useful.

Scientists see genetic engineering as more precise than traditional breeding because it results in fewer changes to the plant's DNA in general. In traditional plant breeding, you may only be interested in a particular trait (say insect resistance) but hundreds of extra genes tag along in sexual reproduction. In GE plants, on the other hand, only a few genes are altered. There can be no doubt that some amount of uncertainty is unavoidable when developing anything new, plants included. Because of this, many support strict testing of all new plants with novel traits, not just those derived from GE technology as is currently the case.

Are GE trees an environmental threat?

As with other factors, the environmental risks posed by GE trees will vary on a case-by-case basis depending on their interaction with the environment, not the technology used to create them. The issue of potential invasiveness of GE trees is primarily a concern in plantations developed for commercial production, as the goal of most GE restoration tree introductions would be to broadly spread improved trees in the natural environment. For example, one concern with the potential introduction of GE cold-tolerant eucalyptus, given their history of invasiveness in other locations, is that they would also become invasive nuisances in new areas. The potential for these and other newly bred trees to invade native forests and decrease biodiversity is something that some feel should be looked into closely before trees are introduced; however there are ways to reduce this possibility (for example, using trees that have sterile pollen or no seeds).

With agricultural crops, increased dependence on herbicide tolerant-GE plants has resulted in a similar increase in herbicide use, and the same could happen in commercial plantations. Many pine plantations already rely on herbicide to exclude competition from weeds and other trees. Adding to the number of herbicide-tolerant plantation trees available to choose from might increase commercial plantation diversity (enabling a larger variety of trees to be grown) but may also lead to greater herbicide use. It is important to consider the non-target risks of this potential change, including increased herbicide use and herbicide tolerant weeds, as they have become more com-



While insects and diseases can kill forest trees, pesticide application is time consuming and expensive. Breeding trees with resistance to insects and diseases could provide an alternative to decrease these problems.

Photo courtesy: North Carolina Forest Service, Bugwood.org

mon in agricultural crop systems.

Pesticides targeting insects and diseases could be a different story entirely. Since their introduction, GE agricultural crops with insect resistance have decreased the amount of pesticides being sprayed on plants. Because some of these pesticides can be dangerous for humans and the environment, increased use of GE crops has a big benefit for reducing unintended pesticide risk and yield loss from insects. In addition, several studies have shown that insect diversity is actually higher when GE insect-resistant plants are used than when pesticides are sprayed on in the traditional manner. Widespread pesticide use in forest settings is currently rare because of prohibitively high costs. Therefore GE pest-resistant forest trees are unlikely to drastically reduce pesticide rates, but they may provide better options against invasive insects and diseases, particularly in a restoration context.

Will GE trees decrease biodiversity?

From a restoration perspective, the goal of GE tree breeding is to increase (or at least maintain) biodiversity. Spreading improved native trees that are able to tolerate invasive pests may help forests regain or retain balance and health. GE forest trees designed for restoration have the goal of restoring key native tree species, thereby supporting the many other species that depend on them for food and habitat. GE genes can spread through pollen, potentially contaminating native tree populations, but there are ways to minimize this risk. In addition, from a restoration perspective, the more genes for resistance to threats are spread into the native population the better, since they will enable the offspring trees to survive.

Monoculture commercial plantations may not provide the same level of biodiversity and ecosystem services as naturally regenerating forests (instead, compare them to highly efficient and highly managed agricultural crops), but they still provide environmental benefits. While plantations can thrive even without GE trees, it is likely that GE trees will play a major role in their future, increasing yields and profits. Proponents argue that plantations are environmentally sound because they require that less land be harvested to achieve the same amount of yield. Others,



Photo courtesy: Jeff Stringer

In addition to restoration, genetically engineered trees are of great interest to the plantation tree industry. For example eucalyptus trees (like those shown here) may become more common in southeastern plantations if the cold-hardy genetically engineered cultivars currently being tested are permitted.

however, doubt whether this trade-off would be realized or if increased commercial plantation profits would instead result in more plantations at the expense of naturally regenerating forests. While the amount of forested land worldwide has decreased, tree plantations have increased and the destruction of naturally regenerating forest in favor of plantations likely results in decreased biodiversity. In addition, in other parts of the world, conversion to plantations has resulted in human rights violations against indigenous people. It is important to note that, while GE trees might play a role in this conversion, they are not necessary for it, and socioeconomic factors, not the technology itself, are the driving forces.

Aren't the other alternatives to GE just as good?

In most cases, scientists turn to genetic engineering only after other approaches have failed. It is far simpler from a regulatory perspective not to use genetic engineering, since expensive testing must be done to for their approval. When GE plants are created it is usually because achieving the same goal would be challenging without the technology. However, it is still important to ask the question of whether the newly developed plant is truly of benefit. For example, despite widespread adoption, GE herbicide resistance has not brought major yield increases for agricultural crops although it has resulted in increased consistency.

The reasons people are excited about the potential for GE trees are in some ways similar to those for agricultural crops, but differ in two main ways:

- 1) trees take a long time to grow and
- 2) our native trees have few natural defenses to lethal invasive threats.

It is very hard to breed trees using traditional, non-GE breeding methods because trees have such long generation times. This means that it can take many decades to make even slight progress in the breeding of native forest trees. Genetic engineering can speed up the tree breeding process, allowing for faster responses to time-sensitive threats, and this can even be done in a way that results in end-product trees that are non-GE



Traditional tree breeding programs are challenging because it takes a long time to grow most of our native trees. In addition, scientists looking to breed increased disease and insect resistance in native trees have been hampered by a lack of natural defenses to invasive threats.

Photo courtesy: John D. Hodges, Mississippi State University, Bugwood.org

(see previous articles in this series). Invasive insects and diseases pose serious threats to forests, and there are currently few options to fight these pests. GE approaches may provide new ways to control these problems in a sustainable manner, a big contrast to the existing pesticide applications that are expensive, can have negative effects on other species, and are not feasible to use in most forest settings.

Why not let nature take its course?

Especially in a naturally regenerating forest, this is a reasonable question. While we may not like the fact that invasive species are drastically changing our forests, in most cases these forests will persevere. At the same time, some may feel an ethical obligation to correct the damage we've done to forests through the introduction of invasive insects and diseases.

Since we caused these major disturbances, do we also bear responsibility to fix them if we can?

It is likely that our eastern forests are still recovering from the removal of American chestnuts due to the human introduction of the chestnut blight fungus. Because very little resistance to chestnut blight has been found in our native trees, it is likely that without our intervention American chestnut will never again be a major component of our eastern forests. With more invasives here and on the way, this scenario could be repeated again and again, calling into question the feasibility of a "leave it to nature" approach in the long-term. Recently, new invasive species are eliminating our ash and hemlock. What happens if oaks are next? It is important to anticipate these future problems so that we can plan a strategy for these potentially devastating scenarios.



Invasive species, like the emerald ash borer shown here, are rapidly changing our forests. It is up to us to decide how we respond in the face of these increasing threats to ensure that our forests continue to provide ecosystem benefits and economic opportunities.

Photo courtesy: Jared Spokowsky, Indiana Department of Natural Resources, Bugwood.org

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