GE Trees: Myths versus Realities

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As the world's supply of wood from native forests is rapidly depleted, free trade agreements, and rapidly increasing paper consumption are leading to an apparently endless escalating demand for raw materials. This is providing the pulp and paper industry with the impetus to link up with the biotechnology industry to create new and "better" trees for pulp and paper production.

Rather than helping reduce consumption of forest products to relieve the growing demand on our forests, the pulp and paper industry has decided to pursue the genetic engineering of trees, a choice that could be catastrophic for the world's remaining native forests. They are painting this new technology as the answer to many environmental concerns, from forest decline, to pollution from paper mills, and the use of chemicals in forestry plantations.1 As we shall see, however, GE trees are anything but "green" and in fact pose what many consider to be the most serious threat to the world's remaining native forests since the invention of the chainsaw. Contrary to industry's "green" assertions, the engineering of trees is about strictly about speculative science and economic return.2

GE Trees: Cornering the market on future timber supplies

Total control over the timber supply and the transformation of tree plantations into agricultural crops are two of the goals of the engineering of trees. Through the establishment of vast plantations of patented trees, timber companies can attempt to assume monopolistic control of the timber market in a similar way that international seed suppliers have used GE seeds to try to control the world's food supply.

Roger Sedjo, in his 1999 discussion paper for the industry think-tank Resources for the Future, emphasizes the regulatory benefits of an agricultural approach to trees:

"One advantage of short rotations is that if they are ten years or less, state law in Washington and Oregon treats the operation as agriculture rather than forestry, and regulations applying to agriculture are typically less stringent than those applying to forestry." 3

In his report, Sedjo provides a comprehensive analysis of the possibilities for genetically engineered trees, primarily centered around economic return, stating, "In 1992...U.S. agricultural crops were worth $111 billion. Timber represented 21% of the value of the total crop and was the largest commodity group, larger than corn, wheat, or soybeans." 4

While the implications of "franken-trees" (whose multi-million year evolution has been suddenly altered for a purpose completely alien to its ecological imperatives), are extremely serious and have the potential to irrevocably damage the ecological integrity of the planet, Sedjo casually dismisses these grave implications by concluding, "the introduction of biotechnology into forestry on a wide scale is simply a continuation of the long-term historical trend away from foraging and toward an increasingly sophisticated cropping mode." 5

Herbicide Resistance

Researchers promoting herbicide resistance in trees make the counter-intuitive claim that engineering trees to resist inundation by broad spectrum herbicides like Roundup will reduce the quantity of herbicides applied to tree plantations.6 This claim is belied by the experience of agricultural farmers who have been using herbicide resistant crops.

A November, 1999 study by the World Wildlife Fund found, "the US Department of Agriculture … revealed that many farmers who have converted to GM production are using just as much herbicide as their counterparts who continued to produce conventional crops." 7

In addition, a study by agricultural researcher Dr. Charles Benbrook found that growers of herbicide resistant soy *increased* their overall pesticide use by 11% with some growers using over 30-60% *more* chemicals than those who do not use these crops.8

The real motivation for industry's manipulation of herbicide tolerance traits is the potential for increased profit. According to Roger Sedjo, the reduced cost of establishing herbicide resistant tree plantations would lead to a global increase in plantations of anywhere from 197,000-562,500 acres annually over what would have been established anyway. 9

In addition to providing the opportunity for increased herbicide use, herbicide resistant trees have other documented negative effects. Monsanto's Glyphosate is the primary herbicide for which resistance is engineered into plants. Glyphosate, being water soluble, has been linked to health problems in humans and fish due to water contamination. 10

Glyphosate binds to soil in the same manner as inorganic phosphates and may take years to break down. Damaging effects on beneficial soil fungi and bacteria have been recorded. The use of these kinds of chemicals also affects beneficial insects such as lacewings and ladybugs, not to mention birds and other animals that rely on a diversity of plant life to sustain their food and shelter needs. 11 Overall, however, very little is known about the long-term environmental impacts of glyphosate and similar broad-spectrum herbicides.

There are also the concerns about the glyphosate resistance gene itself. In soybeans, the herbicide resistance trait led to a 20% increase in the lignin content, causing the soybeans to become brittle and susceptible to fungal infection. This led to a 5% yield decrease compared to non-GE soy. The impacts of herbicide tolerance in trees are as yet unknown. 12

Insect Resistance

As with herbicide resistance, industry has made the dubious "environmental" claim that engineering trees to produce the bacterial pesticide Bt Toxin (Bacillus thuringiensis) will eliminate the applications of toxic chemicals on tree plantations.13 There is no evidence that this is true. Companies merely use different amounts of a new variety of chemicals, as the development of Bt trees ultimately leads to Bt-resistant super-insects.

Industry further asserts that the toxin denatures quickly in ultraviolet light, not allowing for it to persist long enough to pollute ground water or soil. There is, however, a growing body of evidence that seems to negate these claims. According to the journal *Nature*, Bt was found by researchers to bind to soil, and to remain in an "active, lethal state" for more than seven months. 14

The implications of these findings are largely unknown but could be enormous. It is not known how naturally occurring Bt-toxins or genetically engineered Bt-toxins can affect organisms present in the soil or the soil community as a whole. It could impact nutrient cycling and uptake, soil microbes and pathogens and other little-understood soil processes. It is also not known how Bt-toxin production will alter the rotting process of dead Bt trees.

There are many other concerns with this technology. There was the famous case of Bt corn killing non-target species like the monarch butterfly, for example.15 Among the greatest concerns about the use of Bt, though, are the creation of "super-pests"16 and killing of beneficial insects,17 as well as the displacement of insects from GE trees to unprotected or more vulnerable species.

World Wildlife Fund reports,

"Scientists openly acknowledge that Bt crops will augment the selection pressure placed on target pests and that this will inevitably lead to an increased frequency of Bt resistance genes within the insects' gene pool. The industry has attempted to address this issue by suggesting that this effect can be effectively slowed down through the use of strategic buffer systems." 18

In this context, a major threat is the escape of Bt tree genes to native trees, via seed dispersal or cross pollination. Such an escape of toxin producing genes into wild trees will lead to an ecological disruption of unknown magnitude. Imagine a forest of trees that kill insects. Insects, at the base of the food chain are a critical piece of the ecological web. Without them, the ecology of the forest collapses in far-reaching ways that cannot be predicted. And like a contagious virus, once those genes escape, there is no way to stop the spread.

Salt, Cold, Wet & Drought Tolerance

While industry claims trees engineered for salt, wet, cold or drought tolerance could help to restore ruined lands,19 in fact, industry is merely looking for trees which can grow where land is cheapest. Yet the mechanisms and complex gene interactions of stress tolerance are only partly understood. Stress tolerance involves multiple genes. Geneticist
Dr. Ricarda Steinbrecher describes potential complications of gene stacking: the insertion of multiple genes necessary to engineer growing condition tolerances such as those desired by industry.

"While 'simple' traits such as herbicide resistance or insecticide production already interfere with the plant's own internal biochemical pathways and gene regulation, creating unpredictable side effects, this is likely to be exacerbated for complex traits."20

One example of the difficulty in predicting responses to genetic manipulation, particularly in trees is the case of aspens engineered for increased growth rates. These aspens were genetically manipulated to respond differently to day length, and grow in daylight as short as six hours. However, the trees lost their ability to cope with cold temperatures.21

Other concerns related to salt, cold, wet and drought tolerance include the use of foreign or exotic species that could become invasive, as well as the overtaking of formerly inhospitable landscapes by species existing nearby, thus displacing native species.

Trees have evolved over millennia to play a complex role in their landscape. The manipulation of trees to enable them to grow into the winter, or to exist on desert sands, is to drastically alter the entire ecology of that area, in ways that can be neither predicted nor reversed.

Disease Resistance

Serious concerns about the use of disease resistant traits have also been raised. Corner House, the prestigious British research organization notes three main areas of concern regarding disease resistance. First, "trees genetically modified for resistance to disease are likely to cause fresh epidemics." Just as engineering Bt into trees will lead to Bt-resistant insects, engineering trees to be resistant to disease will likely lead to diseases more potent than the original.

Second, "fungicide production engineered into GM [genetically modified] trees to help them counter such afflictions as leaf rust and leaf spot diseases may dangerously alter soil ecology, decay processes and the ability for the GM trees to efficiently take up nutrients…" Mycorrhizal fungus and other soil fungi are a critical part of forest ecology. As with the pesticide Bt, fungicides engineered into trees are likely to be exuded by the roots into the soil, killing beneficial soil fungi and damaging soil ecology.

The third, and perhaps most significant, concern raised by Corner House is that the evolution of new, more pathogenic viruses may be accelerated by GE tree viral resistance traits.22 Dr. Steinbrecher elaborates on the potential for genetically engineered viruses to recombine with other viruses to create new, more deadly viruses.

"The potential of such newly recombined viruses to overcome the defenses of related wild plants, or even be able to infect new host plants, is a serious concern. In laboratory experiments infecting viruses have also swapped their protein coat for that of another virus that had been engineered into a plant...the new coat enabled a virus to travel between plants, carried by aphids."23

Lignin Reduction: Wobbly Trees

Apart from the innovations to trees that have been adapted from research with agricultural crops, there have also been developments in tree genetic engineering to address structural qualities of trees. One of the most prominent modifications to tree structure is the repression of lignin biosynthesis. Lignin is the substance that gives rigidity to plant cell structure of and plays a vital role in the tree's natural defense system. It comprises about one third of the dry weight of wood and presents a major obstacle to the pulp and paper industry.

The process of making pulp for paper products requires the extraction of this substance through a very costly and toxic process. Industry claims that their primary motivation in developing reduced lignin trees is to create a cleaner, more efficient paper-making technology.24 However, there are substantially cleaner, safer, and more efficient methods of lignin extraction already available, such as closed-loop delignification. The pulp and paper industry, however, with rare exception is not interested in these new cleaner technologies which require significant financial inputs to re-tool or re-build mills.25

In addition, Billy Stern, of Sunflower Consulting points out,

"Attempting to engineer trees with weakened lignin is yet another example of backwards thinking by the pulp and paper industry. Enough low lignin fiber already exists, in the form of agricultural by-products from wheat, rice, barley, corn and other food crops, to satisfy all of the world's paper needs."26

A 1999 study published in *Nature Biotechnology* reports that significant reductions in lignin can be accompanied by 9-15% increases in cellulose content. Researchers claim this would be sufficient to compensate for the reduced structural integrity resulting from a decrease in lignin content. However, the samples tested were actually only ten months old and cannot be considered a realistic depiction of how this trait may behave in older, more mature trees.27

Lignin is recognized as an integral part of the tree's ability to defend itself, and little is known about how these trees will respond to normal stresses such as insect infestation or disease. Corner House reports, "lignin reduction may weaken trees structurally, and some researchers have reported stunted growth and collapsed vessels, leaf abnormalities and an increase in vulnerability to viral infection." 28

They also note the likelihood that the technology will encourage an increase in pesticide use due to increased susceptibility to insect damage. Perhaps the greatest fear associated with this technology is the high probability that, "low-lignin trees will also rot more readily – affecting soil structure, fertilizer use, and forest ecology – **and will release carbon dioxide more quickly into the atmosphere." 29**

Researchers at Oregon State University have also cited numerous unintended side-effects of suppressing lignin production, including decreased seed survival, increased browsing by animals, changes in the feeding patterns of defoliating insects, and alterations in soil fertility from changes in wood decomposition rates. **30** Other industry researchers have pointed out that, due to shared biochemical pathways, suppression of lignin biosynthesis could weaken trees' defenses against pathogens and suppress the development of the trees' reproductive organs.**31**

Terminator Trees

Industry is now in the process of adapting the controversial "terminator technologies" (engineering plants to produce sterile seeds) that are so vehemently opposed in conjunction with agricultural biotechnology to GE forestry. They insist this research is being done to provide a 'solution' to issues of genetic drift and contamination. However, a forestry industry truly concerned about genetic drift would not be releasing field trials of modified trees into the environment when genetic escape is virtually assured.32

The ability of these technologies to actually function as intended, however, appears to be hit and miss with no evidence of long term success in trees.

A field trial of genetically modified aspens in Germany that had been engineered to be sterile, were given a five year permit with the understanding that the tree typically flowers around year seven. Thus the trees would be harvested before flowering to prevent gene transfer. However, the engineered aspens inexplicably began to flower after only three years. 33

Trees are one of the most complex organisms the biotechnology industry has yet taken on, some with a genetic code significantly longer than even the human code. 34 With the complex inter-working of different genes to express different traits, plus the fact that genes activate and deactivate at various times in a tree's life due to external and internal stresses, the prospect of scientists being able to manufacture a permanently sterile tree is practically nil. Plus, the ability to reproduce is of key importance to any species and there are numerous examples, ranging even into the animal kingdom, where under abnormal stress conditions, or conditions where suitable mates cannot be found, an organism has found a way to compensate.

Dr. Steinbrecher states,

"Trees are not an annual crop, but live hundreds of years, exposed to many stresses such as frost, fire, drought, storm and insect attacks. No risk assessment can predict the interference that genetic engineering will have on the stress response and the aging of trees."35

Even industry researchers admit that sterile GE trees are a lost cause. At a 1992 conference on GE trees, GE Trees sterility researcher J.L. Hamrick stated, "genes will escape, based on what we know about trees. At what rate, we don't know yet."

Sterile Trees: A No Win Situation
Engineering trees to be sterile is a lose-lose proposition. Should industry fail to engineer permanently sterile trees, engineered pollen will infect native forests, passing along traits that will cause irreversible ecological disruptions. Should they succeed, the result will be biologically sterile plantations incapable of supporting wildlife. The probable scenario is a vast plantation of tree clones devoid of seeds, nuts, fruit or pollen, thus incapable of supporting birds, animals and insects that depend on flowering trees for sustenance. In this sterile plantation are a few trees that manage to flower anyway, contaminating surrounding native forests, passing along the gene for sterility along with the genes for insect resistance or whatever other traits the tree was engineered for.

This prospect is especially troubling given the fact that in northwest India, windborne pine pollen was found 600 kilometers away from the closest pines.36 This means one genetically altered pine has the potential to spread its engineered genes over more than 1,130,400 square kilometers of land, infecting any native forests in that area.

Dr. Ricarda Steinbrecher illuminates the severity of the problem,

"If you wanted to design a means to scatter a gene far and wide throughout the environment and its species, the best way to do it would be to put it in a plant which has lots of wild relatives and pollen that travels well. Increasingly scientists agree that risk assessment should not focus on the likelihood of a gene escaping, but on the impact that this gene will have when it escapes."37

Small and modest buffer zones proposed to protect local native species from cross pollinating are hopelessly inadequate, and engineered sterility traits, tested for short periods then applied to beings which may live for hundreds of years are bound to lead to unforeseen problems.

London's Daily Telegraph reported, in 1999 that scientists were condemning sterile plantations saying,

"'TERMINATOR' trees, genetically engineered never to flower, could ensure a silent spring in the forests of the future. Such trees will grow faster than before, but will be devoid of the bees, butterflies, moths, birds and squirrels which depend on pollen, seed and nectar."38

The WWF notes, "Remove the flowers, fruits and cones – and the plantations, to all intents and purposes, becomes sterile itself." 39

Finally, sterile trees could grow significantly faster than trees devoting one-third of their energy to reproduction. Faster growing trees lead to problems with rapid loss of soil nutrients and ground water.40 As a result, the ecologically "sterile" plantations of modified trees rapidly move from de facto deserts to actual deserts, requiring the clearing of new land to compensate for the degraded land.

Pollen Pollution= Patented Pines and Poplars
In a case with chilling implications for forests, a Canadian court ruled in March, 2001, that Saskatchewan farmer Percy Schmeiser violated Monsanto Corporations patent rights, when his fields were contaminated by pollen carrying the genetically engineered seed from neighboring fields.

The judge ruled that the origin of the seed, whether from pollen carried by wind or insects from neighboring fields, is immaterial.41

The implications of this ruling are staggering. In essence, any canola, that has been contaminated with Monsanto pollen now belongs to Monsanto.

This ruling theoretically could also apply to native trees contaminated with engineered tree pollen. Native trees contaminated with modified genes could become the legal property of the corporation which modified the genes. Because the escape of tree pollen, once it occurs, is impossible to stop, one can easily envision a future where all of the world's forests are the property of multinational pulp and paper corporations.

This leads to yet another lose-lose scenario for the forests, where either the corporations are allowed onto the National Parks, Wilderness Areas or private lands to harvest "their" trees, or the trees are allowed to stand, in which case they become the new generation of contaminants.

Trees for Toxic Clean Up?
In a bizarre new twist on toxic waste clean-up, researchers are now looking into the potential of engineering trees which will suck up toxic waste—called phytoremediation.

Scott Merkle at the University of Georgia reports, "We have shown the ability of genetically altered yellow poplar trees, possessing a "merA" gene ... to grow in the presence of normally toxic levels of ionic mercury."42

David Salt, a chemistry professor at Northern Arizona University states, "this trick raises the possibility that trees may soon be able to remove poisonous mercury from soil by blowing it into the atmosphere, a process aptly named phytovolatilization (from the Greek word for plant and the Latin word for flying)." However, Salt raises a key question about what happens to the pollutants once they leave the soil. "We may soon be using trees to heal the hurt inflicted on the Earth. But would we simply be exchanging soil pollution for air pollution?"43

One of the nation's largest phytoremediation experiments is being conducted in Oregon. In 1984, a tanker truck skidded on icy Interstate 5 near Central Point, spilling hundreds of gallons of TCE, a toxic solvent. Conventional cleanup efforts spanning thirteen years failed to remove the solvent, a suspected carcinogen, from the surrounding soil and groundwater. In 1997, University of Washington scientists planted 800 hybrid poplars. The results will not be available for several years.44

While on the surface using trees to remove toxic contaminants from the earth may sound promising, the unanswered questions about where the pollutants will ultimately end up, and what will happen to the trees upon long term exposure to these chemicals make the technology extremely suspect. In addition, one must wonder whether industry, with a "green" solution to pollution, will simply use it as an excuse to pollute at will.

GE Trees and Native Forests
Industry has made numerous claims about the benefit to native forests that will result from the utilization of genetic engineering, foremost the claim that GE tree plantations will result in an end to old growth logging and logging of native forests. That the very industry that has wiped out native forests around the world should now claim to offer the salvation to those forests demonstrates their unscrupulous and cynical opportunism.

Sarah Tyack, of Friends of the Earth, stated,

"The idea that intensively-managed plantations take pressure off natural forests is a myth. What is happening is that natural forest is being cleared to make way for intensive plantations. GM trees will accelerate that process." 45

Roger Sedjo, in his report, sheds a more accurate insight into the motivation to engineer trees. While discussing the potential economic gains of GE tree technology, Sedjo points out that it will only be after native forests have been essentially eliminated that GE tree technology will become economically viable:

“It makes little sense to invest in activities that produce more rapidly growing trees when there are large volumes of mature timber that are already available for logging.” 46

He then goes on to explain that now is the time to move ahead with tree genetic engineering because:

“the old-growth overhang has largely disappeared, due to both its physical reduction and also due to increasing pressures to establish protected areas that will either not allow timber harvests or allow only limited harvesting.”47

Finally, GE tree plantations threaten native forests in all of the ways previously mentioned, from infection by alien engineered pollen, to infestations by super-insects or new viruses, to decimation of native forests for the establishment of new or expanded plantations, to logging in previously protected areas due to “patent violations.”

Conclusion

Our understanding of the complex relationships between trees, understory plants, insects, animals, fungi, bacteria and micro-organisms in the soil is only beginning to take shape. At best we have an outline of ideas and principals by which these organisms interact, but by no means do we have a complete picture. This lack of knowledge combined with the inherent uncertainty of genetic engineering means that any large scale use of genetic engineering (trees, crops, etc.) is very dangerous.

The threats posed by genetically engineered trees are simply too great to allow them to be released into the environment, much less to allow them to be mass cultivated in huge plantations.

Industry’s claims of ecological benefits from the engineering of trees are strictly directed at public relations, and bear little if any resemblance to reality. The more accurate picture is one of engineered plantations of trees cloned from a few individuals, with toxic soil, no understory plants, no insects except insecticide-resistant super-pests, and no wildlife of any kind. Further, because these trees are engineered to grow faster than ever, the soils and ground water will be rapidly depleted, leading to desertification of the land. More native forest will then need to be cleared to make way for the replacement plantations. And should these genes escape, a similar fate awaits our remaining native forests.

The fact that the timber industry is running out of forests to plunder is beyond dispute. However, there are myriad alternatives to opening the Pandora’s Box of GE trees. Consumption reduction, alternative fibers, better and greater recycling of paper and mining of landfills all are very basic steps which can be taken to make significant and rapid impacts to reduce the amount of forest which is plundered to drive the wheels of our society.

EndNotes

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