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GREENPEACE

A GREENPEACE BACKGROUND BRIEFING

Pulp Fiction

Genetically engineered trees

Scientists are inserting alien genes into trees in the same way that they are genetically engineering agricultural crops to make them resistant to chemical weed-killers or insects. Trees, which have long life cycles and grow in intricate ecosystems, are in the earliest stages of domestication.[1] Planting genetically engineered (GE) trees poses potentially devastating environmental risks.
Greenpeace is calling for an immediate ban on the release of GE trees into the environment, because of the threat of irreversible genetic pollution.

Forest ecosystems are complex and poorly understood.

Photo: Greenpeace

Forests are among Earth's most complex, extraordinary and least understood ecosystems. More than half of the world's species live in and depend on forests for their survival. Yet very little is known about how trees interact with myriad other species.

The introduction of foreign genes into any organism can cause unintended side effects for ecosystems. The release of genetically engineered (GE) agricultural crops has raised critical concerns about potential harmful effects on non-target species and ecosystems.
For example, GE insect-resistant maize engineered to produce Bt toxin is believed to harm butterflies and other non-target species.[2] If Bt toxin-producing GE trees were released into the environment, countless living organisms would be exposed to this toxin for years, even decades, with unpredictable consequences. These GE trees might also transfer the Bt toxin to wild trees, thereby perpetuating the toxin's production in ecosystems.

Greenpeace is calling for an immediate ban on the release of genetically engineered trees. They could threaten other plants, as well as countless species of forest-dependent birds, mammals, insects and microbes.

■ Concerns about GE trees

Gene Escape

The biggest threat from GE trees, as with any GE organism released into the environment, is the transfer of their alien genes to other organisms, mainly -- but not only -- through cross-pollination, with completely unpredictable results. According to Professors Mullin and Bertrand:

"Physical confinement of pollen, and in some cases even the seeds, from forest trees is for all purposes impossible"[3]

Pollen from conifers, a tree genetic scientists are studying, is known to travel over very long distances to fertilise other trees, thus transferring genes.[4]
Aware of the problems of gene escape, the Biotech industry often claims that engineering tree sterility is a solution that will prevent gene flow to wild trees. But engineering persistent sterility could prove very difficult, and in fact such research constitutes only a tiny fraction of GE tree research.
Furthermore, trees encounter many stresses over their life spans, such as changing climatic conditions. Such stressors have been shown to silence alien genes. For example, in an experiment with plum trees, researchers found that engineered resistance to viruses worked successfully in the first year, but not in the second year.[5] This same trend could affect genes engineered for tree sterility: GE-sterile trees could revert to fertility at any time, and pass genes for sterility onto wild populations.

"There are now many examples of transgenes whose stability is affected by environmental factors and where stability changes over generations." [6]

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In reality, even sterile trees are no protection against the escape of foreign traits to wild relatives. This is not only because engineered sterility could fail, but also because trees have other means of reproducing.
Vegetative propagation, for instance, could be an alternate route of gene escape. For example, poplars sprout vigorously from stems and roots, and branches or short-shoots of some poplar species can break off and float down streams, where they can root and establish new trees.[7]
There is another separate, fundamental ecological problem with engineered tree sterility. Sterile trees would not produce flowers, seeds, fruit or cones, leaving no food for insects and other animals that depend on these food sources. This could reduce species diversity in forests.

Lack of knowledge

Data on the long-term impact of genetically engineered trees is very limited.[8] But we know from GE crops that all GE plants can act unpredictably. Such unwanted and unexpected side effects will be hard to detect in GE trees, due to their long life spans and the difficult-to-control nature of tree plantations.[9]
It may take several years for undesired traits, or instabilities in the desired traits, to express themselves.
Recently, US researchers from Michigan Technological University genetically engineered aspen trees to reduce their lignin content. The genetic manipulation also unexpectedly led to enhanced growth of the trees, a fact that could not be explained by the researchers. Clearly other - unknown - metabolic pathways had been affected by the manipulation.[10]
The longevity of trees makes risk assessment of GE trees even more difficult than that of annual crops. External factors, such as climatic conditions, may change considerably during the life span of a tree and create new risks.

Plantations are already a cause of concern in many regions

Photo: Greenpeace

"Super trees"-- depleting natural resources

One sought-after outcome of GE tree research is species that grow faster. Unfortunately, such trees might quickly deplete soils through unusually rapid uptake of nutrients. In addition, fast-growing super trees might put increased pressure on water supplies, a scarce resource in many regions. Traditional tree plantations are already depleting water resources in several regions, and fast-growing GE trees could accelerate this dangerous trend. Moreover, if the fast-growth trait were transferred to wild relatives, these plants could quickly become pests, outgrowing and out-competing other plants for sunlight, water and nutrients. This is just one example of how the application of genetic engineering to trees could have serious ecological consequences.

Pollution and super weeds

Scientists are also engineering trees to become resistant to herbicides (weed-killers). Such GE trees could result in increased aerial spraying of weed-killers, which would considerably increase the risks of chemicals entering waterways and damaging ecosystems.
Furthermore, herbicide- or insect-resistant trees could transfer their extra "resistance genes" to wild relatives. These plants could become "super weeds". Already tree geneticists are experimenting with Eucalyptus, a tree considered to be a weed in many forests of the world. Releasing GE eucalyptus trees into the environment could cause critical problems.

■ Industry initiatives with GE trees

The genetic engineering of trees is in its infancy, and still concentrates on "model plants" chosen for ease of experimentation rather than economic value. For example, pine and spruce are by far the most important forestry species economically, but genetic engineers still concentrate on poplar and certain other broad-leafed species, because conifer transformation is far more difficult.[11]
In the US, 115 so-called experimental releases of 11 tree species have been approved by the USDA, the most significant ones being poplar and apple trees.[12] Alarmingly, these are grown in the open and present an immediate threat to the environment.
In Europe, at least 30 experimental releases of nine tree species have been approved by national regulatory authorities. The main species under study are poplar, eucalyptus, and apple.[13]
Other countries in which field trials of GE trees have been approved include New Zealand (apple and pine),[14] Australia (apple),[15] Canada (poplar), South Africa (eucalyptus),[16] Chile and Uruguay,[17] and China (poplar).[18]
Thus far, no applications for unrestricted, commercial use of GE trees have yet been filed for forestry.
But some GE trees are already quite advanced -- for instance herbicide-tolerant poplar -- and the first commercial planting of a GE tree could take place as early as 2002-2003.

GE trees with less lignin

In addition to herbicide resistance and insect resistance, lignin modification of trees is being studied. This trait is considered to be an important one for the paper industry.

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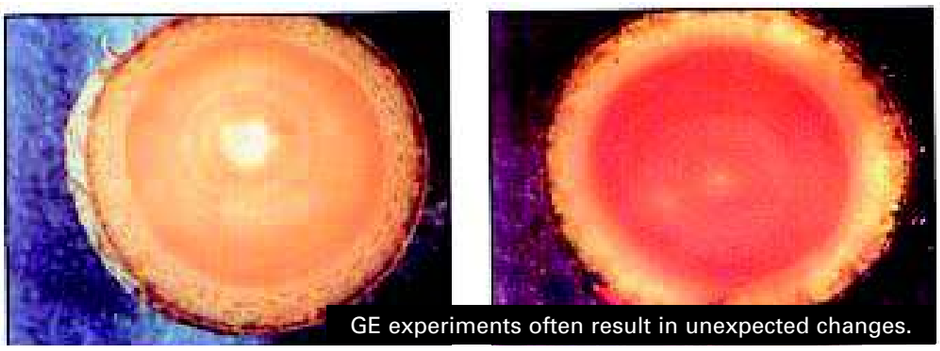

Photo: Michigan Technological University.

The image on the left shows the normal tree colour, while the GE version of the same species on the right shows an unexpected red colour.

Lignin is the tough tissue that makes up one third of wood's dry weight. Crucial for plants, it plays a role in trees' pest resistance and structural integrity. Yet lignin makes it harder to pulp wood for paper, which is why biotech companies are seeking to genetically engineer it out of trees.
Estimates indicate that the US pulp and paper industry alone could save more than a billion dollars annually if the requirement for breaking down conifer lignin was lowered to the level of degrading hardwood (broad-leafed tree) lignin.[19]
The economic importance of engineering lignin content is also reflected in US patent applications. About 50 per cent of patents that specifically address GE trees deal with lignin modification.
However, lignin metabolism is little understood, and lignin-modified GE trees will probably not be available before 2007-2010.
So far, genetic modification of the lignin pathway has also resulted in negative side effects on growth or plants' structural integrity,[20] as well as altered wood colour.[21] (See box.) Furthermore, genetically engineering trees with low lignin content may cause them to degrade quicker. This could deprive many other forest organisms of their natural habitat: slowly rotting wood.

"...any alterations [to lignin content] might affect feeding and population growth rates of defoliators [leaf and tree eaters]. Finally, lignin retards litter [leaf and wood] degradation by microbes and slows decomposition. Modified lignin biomass could therefore affect soil structure and fertility." [22]

If the low-lignin trait were to escape to wild tree populations, the above problems could also occur in wild forests. Some companies claim it would be cheaper to produce low-lignin GE trees than to construct cleaner pulp and paper mills. However, debating the costs of cleaner mills versus re-engineering nature is irrelevant, when the impact of GE trees on ecosystems is incalculable.

■ Which companies are involved in GE trees?

The following are some of the biotech, paper and forest companies that are pursuing the development of GE trees:

* The largest GE tree research programme, called ArborGen, is a joint venture. It includes International Paper, the world's largest forest and paper company, and Fletcher Challenge Forests (part of New Zealand's largest industrial company, Fletcher Challenge Limited). It also includes Westvaco, another large US multinational forest products company, and Genesis Research and Development, a New Zealand-based biotechnology firm. This 60 million-dollar joint venture was signed in1999.[23]

* Also in 1999, Interlink Associates Inc. (USA), Fundacion Chile and Silvagen Inc (now Cellfor, Canada) founded GenFor SA to develop and field test GE trees.[24]

* Nestlé, the world's biggest food producer, is involved in genetically engineering coffee.[25]

The GE Tree Lottery:

Examples of Unpredictability

During a 1996 experiment in Germany, researchers attempted to change the leaf shape of Aspen trees through genetic engineering. Researchers were surprised to find that some of the trees flowered after just three years, four years earlier than they would naturally. In addition, two per cent of the trees unexpectedly reverted back to their natural form.[27] This is a prime example of gene silencing -- where a genetically engineered plant unexpectedly closes down the alien gene.

Another experiment with Aspen trees, this time conducted at Michigan Technological University, focused on ways to reduce the trees' lignin content. Researchers discovered that the altered genes turned the wood of some trees red and mottled, rather than the natural white. They could not explain why "variations occurred from tree to tree in hue, intensity and design."[28] Such unexpected outcomes are common in genetic engineering experiments.

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■ What should be done?

GE trees pose a huge environmental risk. Genetic pollution is living pollution, and once something goes wrong, it will be irreversible. Greenpeace is calling for an immediate ban on the release and commercialisation of GE trees, and demands that companies end their financial support for the commercialisation and planting of GE trees.

Stora Enso, one of the world's biggest forestry companies, has already announced that it will not use Genetically Modified Organisms (GMOs) in its forests or products, noting that "Economic and social systems may also be threatened where fundamental biological processes are interfered with".[26] Stora Enso is among a growing number of forestry companies worldwide that are implementing the Forest Stewardship Council's internationally recognized Principles and Criteria of ecologically responsible, GE-free forest management. **Whether you are buying as an individual or as a company, ask your suppliers for FSC certified forest products.**

The Forest Stewardship Council (FSC)

Formed in 1993, the FSC is an independent, international, non-profit organisation that promotes environmentally appropriate, socially responsible and economically viable management of the world's forests through its voluntary certification and labelling system.

The FSC's internationally recognised principles and criteria for well-managed forests require assessments of social, economic and environmental issues. The FSC states that it "does not endorse the certification of forests containing or using GMOs in research or management." The market for FSC labelled products is growing and now exceeds $15 billion per year. It offers a real incentive to forestry companies to go GE-free and to implement ecologically responsible forest management.

The FSC has 400 members in more than 50 countries, balanced between economic, social and environmental interests.

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October 2000