GENETICALLY MODIFIED TREES

The ultimate threat to forests

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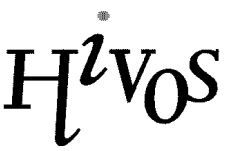
This publication is also available in Spanish

Published in December 2004.

ISBN: 9974-7853-1-6

The elaboration of this publication contents was made possible with support from NOVIB, Hivos (The Netherlands), the Swedish Society for Nature Conservation, and Friends of the Earth. The views expressed, the information and material presented, and the geographical and geopolitical designations used in this product, exclusively imply the opinion of the authors.



Printed in I. Rosgal S.A. - Legal Deposit N° 330349/04 - Dec. 218/996

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The ultimate threat to forests

Chris Lang

World Rainforest Movement

Friends of the Earth

Friends of the Earth International, founded in 1971, is a federation of autonomous environmental organizations from all over the world. FoEI members, in 70 countries, campaign on the most urgent environmental and social issues, while simultaneously catalyzing a shift toward sustainable societies. FoEI is united by the common conviction that environmentally sustainable development requires both strong grassroots activism and effective national and international campaigning. The FoE International Secretariat is headquartered in Amsterdam, The Netherlands.

The **World Rainforest Movement,** established in 1986, is an international network of citizens' groups of North and South involved in efforts to defend the world's rainforests. It works to secure the lands and livelihoods of forest peoples and supports their efforts to defend the forests from commercial logging, dams, mining, plantations, shrimp farms, colonisation and other projects that threaten them. The WRM International Secretariat is headquartered in Montevideo, Uruguay, while its European support office is based in Moreton-in-Marsh, United Kingdom.

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Genetically modified trees: a step forward … in the wrong direction

The debate on Genetically Modified Organisms (GMOs) has until now largely focused on agricultural crops and much less on genetically modified trees. This is understandable, given the fact that there are already several GM crops being commercially grown in many places of the world and given that many of them are aimed at directly or indirectly feeding human beings, whose health is thus potentially threatened.

However, that does not mean that GM trees are less dangerous. On the contrary, the dangers posed by GM trees are in some ways even more serious than those posed by GM crops. Trees live longer than agricultural crops, which means that changes in their metabolism may occur many years after they are planted. At the same time, trees are also different from crops in that they are largely undomesticated and scientists' knowledge about forest ecosystems is poor. This implies that the ecological and other potential risks associated with GM trees are far greater than in the case of crops.

In spite of the uncertainties and potential risks, forestry scientists are busily playing with genes to "improve" trees. Of course, what they do in reality is to change some of the trees' characteristics to better serve the interests of those that fund their research, in order to improve the profitability of the businesses involved.

But from a biological perspective there is no improvement whatsoever. Is a tree with less lignin better or worse than a normal one? It is clearly worse, given the resulting loss of structural strength which makes it susceptible to extensive damage during wind storms. Is a herbicide-resistant tree an "improvement"? It is not, for it allows extensive herbicide spraying that affects the soil on which it stands, at the same time as it destroys local flora and impacts on wildlife. Is a flowerless, fruitless and seedless tree of any use to living beings? It does not provide food to myriad species of insects, birds and species that depend on these as food. Is a tree with insecticide properties an improvement? It is a dangerous hazard to many insect species, which are themselves part of larger food chains.

The fact is that genetically engineering trees constitutes a further step forward … in the wrong direction.

From an industrial profit-making perspective, forests have been consistently perceived as "untidy" and having "low productivity". For many years, forestry scientists and foresters were thus assigned the task of "improving" them. The answer was to establish single-species plantations in straight rows and equal spacing so as to obtain the largest possible quantity of wood per hectare. Forests are thus progressively being replaced by monocultural stands of timber.

Different steps have been taken to "improve" forests. The first step was to carry out research on appropriate trees for different environments and to select those having better qualities for the intended purpose: wood production. The UN Food and Agriculture Organization (FAO) played a central role in this respect, particularly in the case of Eucalyptus. Fast-growth, straight trunks, few branches and adequate wood for industry were some of the chosen qualities. The second step implied the adoption of the also FAO-backed entire Green Revolution package: mechanisation, herbicides, chemical fertilisers, pesticides. The following step was to carry out traditional genetic selection to "improve" the plantations' performance in terms of wood yields, which was soon followed by cloning of the "best" trees. From that reductionist perspective, the obvious next step was to genetically modify trees.

It is precisely this large-scale tree monoculture model which is being increasingly challenged by local communities and organizations throughout the world because of its negative social and environmental impacts. GM tree plantations will only exacerbate those impacts. Water will be depleted more quickly by faster-growing trees; biodiversity will be further destroyed in biological deserts containing trees engineered to be insect resistant, flowerless, fruitless and seedless; the soil will be destroyed at a faster rate through higher biomass extraction, intensive mechanization and increased agrochemical use; more communities will be deprived of their means of livelihoods and displaced to make way for even more of these "green deserts".

In spite of that, forestry scientists are pushing forward, not only at the laboratory and controlled trial level but also in the field as in the case of China, where well over one million insect resistant GM poplars have already been planted. No one knows the exact area planted with GM trees in China and what makes matters even worse is that it is very difficult to trace them, given that a GM poplar tree looks much the same as any other poplar tree. Additionally, poplar trees can be very easily propagated and GM trees are moved from one nursery to another. As a result, GM poplar trees continue spreading out of control.

Instead of stopping dangerous experiments such as this, the response of GM tree proponents is to use the same arguments of traditional plantation promoters that state that "plantations are here to stay, whether we like it or not." by simply substituting the word "plantations" with "GM trees".

That absurd and perverse type of reasoning can be applied to practically everything. It would mean that biodiversity loss "is here to stay"; water scarcity "is here to stay", climate change "is here to stay", poverty "is here to stay", and gender inequity "is here to stay". Whether we like it or not.

However, we -as most people- believe that things can change, precisely when people don't like how things are. That is why governments agree on environmental conventions, human rights agreements, and covenants on Indigenous Peoples', worker's, women's and children's rights, to mention but a few.

In the case of the Convention on Biological Diversity, it is clear that GMOs in general and GM trees in particular, constitute a violation of the convention, which obliges governments to take a precautionary approach towards genetically modified organisms that may cause serious damage to biodiversity.

GM trees are also in violation of the spirit of the United Nations Forum on Forests (UNFF), which was set up to protect the world's forests. It is clear that GM trees pose the gravest of dangers to forest ecosystems and that the UNFF should ban the release of GM trees.

What makes matters worse is that the Climate Change Convention has explicitly allowed the inclusion of GM trees within the framework of the Kyoto Protocol's Clean Development Mechanism. This means that this Convention not only supports the expansion of monoculture tree plantations supposedly to act as "carbon sinks", regardless of their negative social and environmental impacts, but allows those same plantations to be composed of GM trees, thus multiplying the impacts and adding new ones.

We therefore call upon all governments, especially the Parties to the Framework Convention on Climate Change and its Kyoto Protocol, to ban the release of GM trees.

The future is something that we build today. The world can go in one direction or another. It is up to us and not "fate", or genetic technicians, to decide. If we "don't like it" we can and must do something about it.

That is the aim of this book: to do something about this through information and analysis-sharing on the GM trees issue and to thus serve as a tool for people who are trying to steer the world in the right direction. Another world is possible … whether the GM tree industry likes it or not.

Ricardo Carrere
World Rainforest Movement

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1: Introduction

What is genetic modification?

There is a fundamental difference between traditional breeding programmes and genetic modification of plants. Using traditional breeding techniques, plant breeders (whether they are farmers, foresters or laboratory researchers) can only cross plants of the same species or of closely related species. It is not possible to cross fish with eucalyptus trees, for example. Genetic modification allows scientists to modify trees by inserting genetic material from another tree of the same species, from another tree species or from another species of plant or animal altogether. Genetic modification, in other words, allows scientists to insert fish genes into eucalyptus trees.

The genetic information required to build a complete organism from individual cells is contained in a molecule inside cells called deoxyribonucleic acid (DNA). The fact that the information stored in one organism's DNA can be read by any other organism, means that foreign DNA can change the way a plant species grows, functions or reproduces, when it is inserted into the plant's cells.

A gene is a segment of DNA. Genetic modification involves inserting genetic material from another species into a plant or modifying a plant's genes by manipulating the DNA molecule. The total genetic information in an organism is called the genome.

Scientists have developed three techniques for inserting foreign DNA into plants. The first technique involves coating gold particles with DNA and blasting them into plant cells using a "gene gun". John Sanford, Edward Wolf, Nelson Allen and Theodore Klein, scientists at Cornell University, developed the first gene gun. In 1983, Sanford and Wolf used an air rifle to shoot tungsten powder into an onion. Cornell's scientists patented the technology and subsequently sold it to chemical giant DuPont, which had set up laboratories to work on plants in the early 1980s.

A second technique is to use a bacterium, such as *Agrobacterium tumefaciens*, which can transfer some of its DNA into plants. In nature, the bacterium causes swellings, or cancers, on host plants and transfers part of its DNA into host plant cells. Molecular biologists modify the bacterium so that it

contains the desired foreign DNA. Plant cells are then infected with the bacterium and the foreign DNA is transferred to the host plant.

For example, New Zealand biotech company called Forest Research is carrying out research into insect resistant GM trees. “What we have done in the laboratory is taken out the nasty cancer-forming gene and replaced them with our favourite piece of DNA,” Dr Julia Charity of Forest Research told the *New Zealand Herald*. “We get the bacteria to take up the DNA by giving it an electric shock. The cell walls open in absolute horror and the DNA shoots in there . . . the bacteria acts like a shuttle and basically injects its DNA into the plant cell,” Dr Charity explained.

A variation on this technique is to use the fact that some plant viruses insert themselves into a host plant’s DNA. Scientists modify the plant virus by removing the disease-causing genes and replacing them with the genes they want to insert into the host cell. The plant is infected with the virus which then expresses the foreign gene in the host plant.

A third technique is to insert the DNA into a plant protoplast, a plant cell which has had its cell wall chemically removed. The desired DNA is located on a plasmid vector (a self replicating DNA molecule) which is injected into the protoplast. Plant cells are grown in tissue cultures and the vector inserts the desired genes into the host plant’s genome.

None of these techniques is particularly precise and genetic modification can have wildly unpredictable effects. The location of foreign genes in the genome affects their function. Yet there is no way of knowing exactly where the foreign gene might be inserted in the recipient cell’s genome. There is no way of controlling how many copies of the DNA will be inserted or how much (or whether) the foreign genes will affect the plant’s growth. Neither is there any way of knowing whether the insertion will be stable. The foreign genes can interact with the host plant’s genes in unexpected ways. “The process is uncontrollable, unreliable and unpredictable”, as Mae-Wan Ho and Joe Cummins of the Institute for Science in Society put it.

An experiment carried out by the Chinese Institute for Forestry illustrates the problem. Scientists introduced genes from the bacterium *Bacillus thuringiensis* to make poplar trees resistant to insects. The same genes were inserted into all the trees, but scientists observed three different groups of results. In the first group the trees were still affected by the insects. The second group of

trees were insect resistant but the leaves were more yellow and smaller than usual. In the third group, the trees grew normally and were resistant to the insects. Two years later, however, insects which were previously unknown as pests in poplar trees attacked the trees.

Brian Tokar, editor of the book *Redesigning Life?*, points out that adding genes from viruses to a plant can increase the instability of a plant's genome. Genes which are needed for the normal functioning of the plant may be switched off, or silenced. Viral vectors raise the possibility of further transfer of genes to unrelated organisms. GM viruses can combine with other viruses to form new infectious viruses and diseases.

Cloned trees are not necessarily genetically modified. Cloning uses part of a plant to make an exact copy of the original plant and involves no change to the DNA of the plant. Often described as "genetically improved" trees, clones are reproduced from selected parent trees showing a desired trait (such as fast growth, straight stems, fewer branches or whatever trait scientists were looking for). Cloning allows forestry scientists to do something which is impossible in nature: the mass production of trees that are genetically identical to one parent tree.

The simplest form of cloning, which farmers and gardeners have been doing for centuries, is to take a cutting from a plant.

Tissue culture involves growing plant tissue in a laboratory where all inputs such as nutrients, hormones, water and oxygen can be carefully controlled. Somatic embryogenesis is a recently developed process in which scientists grow embryos from the non-reproductive cells of trees. Tissue cultures or embryos can be frozen, allowing researchers to test the material and then defrost the best specimens.

Forestry scientists also use various techniques, including DNA sequencing, gene mapping and gene function studies to match a particular trait, such as fast growth, with DNA sequences. Genetic maps could help tree breeders by identifying the trait out of the huge variation in different trees. For example, researchers at the University of California-Davis in the US are using genetic maps to chart which parts of a tree's genes control traits such as fast growth. The next step is to breed trees (or genetically modify them) for these identified traits, using the information in the genetic maps.

While not in itself involving genetic modification, much research into trees at the genetic level is carried out with an eye on future genetic modification. For example, Forest Research, a biotech forestry firm in New Zealand, is carrying out research into how trees produce lignin, the glue that holds wood cells together and makes trees strong. Among Forest Research's long term goals is to produce GM trees with reduced lignin, or lignin that is more easily removed during the pulping process. Scientists at Forest Research are working on a technique to genetically modify wood cells to introduce specific genes and to analyse the effect on wood cell development.

Companies working on producing a genetically modified tree often also produce "genetically improved" tree clones, using tissue culture and somatic embryogenesis. The sale of these trees provides an income for the company its scientists are working on GM tree development. It can also act as a commercial back up plan, in case the GM tree research fails.

In 2003, scientists at a Tree Biotechnology meeting in Sweden proposed setting up a "Eucalypt Genome Initiative". The beneficiaries of this research are clear from the list of pulp and paper companies that expressed an interest: Aracruz, Nippon Paper, Sappi, Mondi, ArborGen, Stora Enso, Suzano and Oji Paper.

Indeed, much of the research that scientists are conducting into GM trees is primarily of interest to the pulp and paper industry. Faster growing GM trees would in theory allow pulp mills to grow more fibre more quickly. Herbicide tolerance was one of the key areas of initial research into GM trees. Scientists have engineered insect resistant GM poplar, larch, white spruce and walnut trees. Scientists in Japan have produced GM eucalyptus trees which can grow in salty soils. GM trees with reduced lignin would make the pulping process less polluting, which would be useful for pulp industry public relations. Researchers are working on GM disease resistant trees. Large scale monoculture plantations are particularly susceptible to diseases. GM trees engineered to be sterile would grow faster since the trees would focus their energy on growing rather than producing flowers. The pulp and paper industry is also interested in research into GM trees with more uniform fibre, fewer branches and straighter trunks.

Researchers are also looking into ways of engineering trees to absorb and store more carbon, as a supposed solution to climate change. Others are

working on engineering trees to clean up pollution. Physicist Freeman Dyson has even suggested that within 50 years, scientists will be able to genetically engineer trees to make Mars habitable, making it an attractive destination for space tourists.

Since the first GM poplars were planted in Belgium in 1988, there have been several hundred field trials of GM trees – the majority in the US. Two years ago, China's State Forestry Administration approved GM poplar trees for commercial planting. Well over one million insect resistant GM poplars have now been planted in China.

The GM trees are part of the government's plan to cover 44 million hectares with trees by 2012, supposedly in an attempt to prevent floods, droughts and spreading deserts. Chinese forestry scientists see GM trees as a technical fix to the serious damage that insects cause to tree plantations in China. "Recent research on insect-resistant forest tree breeding shows considerable promise," wrote Wang Lida, Han Yifan and Hu Jianjun of the Chinese Academy of Forestry in a recently published book (*Molecular Genetics and Breeding of Forest Trees* edited by Sandeep Kumar and Matthias Fladung).

But neither the government nor the scientists who produced the GM trees have any records of where the trees have been planted.

Huoran Wang represents the Chinese Academy of Forestry in Beijing on the UN Food and Agriculture Organisation's Panel of Experts on Forest Gene Resources. In November 2003, Wang told an FAO meeting that "Poplar trees are so widely planted in northern China that pollen and seed dispersal can not be prevented." Attempts to prevent genetic pollution by maintaining "isolation distances" between GM and non-GM poplars is "almost impossible", Wang added. There isn't even a system in place to monitor the GM plantations that have so far been planted. Wang suggests setting up a system "to monitor the situation of the GM plantations" and their impact on surrounding ecosystems.

The dangers posed by GM trees are in some ways even more serious than those posed by GM crops. Trees live longer than crops, they are largely undomesticated and forestry scientists' knowledge about fragile forest ecosystems is poor. The risks involved are serious enough to justify the demand for a global ban on releases of GM trees.

The origins of GM trees

The development of genetically modified trees can be traced back to the mid-eighteenth century in Europe and the invention of scientific forestry. The purpose of scientific forestry was to produce a single product: timber.

Simplification of forests and ever increasing state and forest department control over forest land went hand in hand with colonisation in the tropics. The vast monoculture tree plantations marching across the Global South are the most extreme form of this model of forestry. The companies backing GM tree research are interested in the supply of large quantities of cheap, homogenous wood fibre to feed their pulp mills. Genetic modification of trees is forestry science's latest offering to its industrial masters.

GM trees are designed to be planted in large, monoculture, industrial tree plantations. These plantations have serious impacts on people and forests and GM trees will increase these impacts. Local people's names for industrial tree plantations illustrate the problems that this model of forestry causes. In Thailand, farmers call eucalyptus the "selfish tree", because eucalyptus plantations remove nutrients from the soil and consume so much water that farmers cannot grow rice in neighbouring fields. Mapuche Indigenous People in Chile refer to pine plantations as "planted soldiers", because they are green, in rows and advancing. In Brazil, tree plantations are called a "green desert", and in South Africa, "green cancer".

Throughout the Global South people and organisations have formed networks opposing industrial tree plantations on their land. In Brazil, a group of more than 100 organisations consisting of villagers, indigenous peoples, workers, trade unionists and environmentalists has formed the Alert Against the Green Desert Network. The Network opposes the encroachment of villagers' land by monoculture plantations for pulp and charcoal production. In April this year, the Movement of Landless Peasants (MST) in Brazil protested against the pulp and paper industry's take over of vast tracts of land. Landless people occupied areas of industrial tree plantations owned by the pulp and paper companies Veracel, Klabin, VCP, Aracruz and Trombini.

In Thailand, villagers have rallied outside town halls, marched in their thousands, pulled up trees and burned down local forestry officials' houses in protest against industrial tree plantations.

GM trees, if commercially developed, would intensify the problems associated with industrial tree plantations. Local people's opposition to GM tree plantations would therefore also be greater.

The next section of this book counters some of the arguments used by proponents of GM trees to promote further research and development of GM trees.

Section 3 describes some of the companies, research institutions and networks behind the development of GM tree technology. Like any other technology, research into GM trees is not neutral. Among the questions that we need to ask about this new technology are: Who is carrying out the research? Who is paying the researchers? Who stands to benefit? And who faces the risks? Ask yourself whether you trust scientists funded by pulp and paper companies to tell the truth about the dangers of GM trees, especially when the results of their research will primarily benefit the pulp and paper industry.

Section 4 explains some of the international and national regulations and legislation. Unfortunately, much of the legislation is inadequate to control the development of GM trees.

The final section outlines some of the campaigns and actions that people have already taken against GM trees. People around the world are saying "NO" to GMOs. Resistance against GM trees is growing!

2: Unravelling the lies: Why GM trees don't make sense

Proponents of genetically modified trees try to convince others that the research into GM trees is a neutral technology developed by scientists to solve some of the world's problems. They put forward a series of arguments which deflect attention from the problems associated with GM trees and industrial models of forestry, including monoculture tree plantations.

Steven Strauss is a professor of molecular and cellular biology and of genetics at the Department of Forest Science at Oregon State University. He is one of the world's leading researchers into GM trees. In 2001, Strauss and colleagues at the Oxford Forestry Institute wrote that discussions about GM trees tend to be "highly polarized":

> In debate, the arguments often shade from biological to ideological, depending on the worldview of the participant. Those against intensive management for wood production, who feel genetic modification is unacceptably unnatural or who object to the highly patent-intensive and thus corporate role in genetic modification, tend to dislike it. Those who believe that growing more wood on less land is an important environmental as well as economic goal, and who accept a continuing major role for technology and large corporations in forestry and agriculture, tend to favor it.

This statement also reveals much about Strauss' worldview and that of his middle-class, male, Northern, highly qualified colleagues. This is a worldview that has little in common with the reality faced by villagers who have lost land and livelihoods to massive industrial tree plantations in the Global South. Or with plantation workers who have seen their co-workers and friends poisoned by the excessive amount of pesticides they have to spray on the plantations. Or with workers who produce charcoal from eucalyptus in horrific conditions in Brazil.

The arguments in favour of GM trees do not address the concerns of villagers living near plantations. Neither are the arguments aimed at anyone who has ever listened to villagers describing their problems since a pulp and paper firm covered their land with a monoculture tree plantation. Instead, GM proponent's arguments are aimed at poorly informed readers who have never seen a

monoculture industrial tree plantation, or if they have, then it was with officials from the firm managing the plantation.

GM tree proponents never discuss land rights, or the rights of local communities to manage their own resources. They do not talk about reducing demand for timber products, such as paper, or the fact that the demand is largely from the North. Their arguments are aimed at deflecting attention from these issues.

1. Faster growing GM trees will not help take pressure off native forests

The argument that planting faster growing GM trees means "growing more wood on less land" appears at a first glance to be convincing. GM tree proponents argue that since world demand for timber products is rising, if more wood is produced in faster-growing GM tree plantations then less will need to be cut in native forests.

However, this overlooks the reality of establishing plantations, particularly in the South. Industrial tree plantations and pulp mills provide few jobs, but destroy local livelihoods. People are forced to move away, including to new forests where they clear land for farming.

Tree plantations are often established after native forests have been destroyed. In Sumatra, for example, vast areas of forests have been cleared to feed pulp and paper mills. To replace the clearcut forests, the pulp mills are establishing acacia plantations. Asia Pulp and Paper's Indah Kiat pulp and paper mill in Riau province has a production capacity of 1.8 million tons of pulp and 654,000 tons of paper. Unresolved land rights conflicts exist on more than 50,000 hectares of APP's concessions. In an attempt to address its serious problems with maintaining fibre supply in the future, Indah Kiat is reported to be working in collaboration with the University of Beijing on GM tree research.

Fast growing tree plantations produce wood that is suitable for the pulp and paper industry, for charcoal or for pit props. Producing more fibre for the pulp industry will not change the demand for high quality decorative tropical hardwoods for the construction industry, which come largely from native forests.

Demand for timber is not the only cause of deforestation. Forests are opened up by roads, submerged by hydropower dams, or cut down for cash crops (such as soya) or cattle ranching. Mining and oil extraction in forests is massively damaging both for the forests and the people that live there. Creating new industrial tree plantations has no affect whatsoever on this destruction.

Any large corporation must continually expand in order to repay debt and investment costs and to keep shareholders content. Aracruz Cellulose is the world's largest producer of bleached eucalyptus pulp, with 31 per cent of world market share. The eucalyptus trees which feed Aracruz Cellulose's pulp mills in Brazil have been bred for fast growth for three decades. Aracruz's monoculture plantations consist of some of the fastest growing trees in the world. But Aracruz continues to expand both its pulp production and its area of plantations, putting more pressure on local people's livelihoods and what little remains of the Mata Atlantica forest in the area. Aracruz is also carrying out research into GM trees.

Trees genetically modified for fast growth are likely to consume even more water than the trees currently used in industrial tree plantations, which will lead to more dried up rivers and streams, more lowering of water tables and more dried up wells. Nutrients will be removed from the soil more quickly, requiring more chemical fertilizers. GM trees will grow faster than native trees and could be highly invasive of surrounding forests, crowding out vegetation and destroying habitat for the animals, birds, insects and fungi that have evolved to live in native forests.

Proponents of industrial plantations and GM trees assume that ever-increasing demand for timber products is an unalterable fact. They ignore the fact that most of the pulp produced in the South is to feed demand in the North. Aracruz, for example, exports 95 per cent of its pulp. Per capita paper consumption in Germany is 70 per cent of that in the US. On average, people in Vietnam consume two per cent of the amount of paper consumed by people in the US. Literacy rates in the US, Germany and Vietnam are almost identical.

Almost 40 per cent of paper is used for packaging. Sixty per cent of the space in US newspapers is taken up by adverts. In 2002, Jukka Härmälä, Stora Enso's chief executive officer, explained in a presentation titled "Achieving our Growth Ambitions" that the key factor in increased paper demand was increased spending on advertisements in newspapers and magazines. Ever increasing paper consumption is neither necessary nor inevitable.

2. GM trees cannot help reverse climate change

In December 2003, the ninth Conference of the Parties (COP-9) to the UN Framework Convention on Climate Change reached a decision allowing Northern companies and governments to establish plantations in the South under the Kyoto Protocol's "Clean Development Mechanism" (CDM). These carbon sinks are intended to absorb carbon dioxide and to store carbon. COP-9 allowed the use of plantations of GM trees as carbon sinks.

The idea that planting trees can help reverse climate change is based on the false assumption that one ton of carbon released by burning coal or oil is the same as one ton of carbon contained in a tree.

Carbon stored in the form of fossil fuel under the earth is stable and unless corporations dig it out and burn it, it will not enter the atmosphere. Tree plantations, in order to remain as a carbon store, have to be protected from catching fire, from being destroyed by pests, diseases or being logged. Trees have to be prevented from dying and rotting. Local communities have to be persuaded not to try to reclaim the land they lost to the plantations by cutting down the trees.

In terms of the impact on the climate, these are two different types of carbon which cannot be added to, or subtracted from, each other.

Including GM trees in the CDM makes a bad situation worse. In 1993, Japanese car manufacturer Toyota started field trials to test trees which had been genetically modified to absorb more carbon. While carbon absorption increased, Toyota's scientists also noted a dramatic increase in water consumption.

3. Genetically modifying trees for reduced lignin is no solution to pulp mill pollution

To produce bleached kraft pulp, trees are chipped, cooked under pressure, washed and then bleached. Toxic chemicals are used in the cooking process to remove lignin, a glue-like substance that holds wood cells together and makes trees strong. As lignin causes yellowing of paper, any lignin remaining has to be bleached.

Forestry scientists argue that by genetically modifying trees to have less lignin they have found a way of making pulp mills less polluting. "The costly

portion of the pulp and paper making process, from both an economic and environmental perspective, is attributable to the removal of lignins. Therefore, it is highly desirable to develop means by which lignin content is decreased, or make lignins more extractable," explained forestry scientists from Oxford University and Oregon State University in a paper published in *Plant Biotechnology Journal* in 2003.

The risks associated with reduced-lignin GM trees include trees which are weakened structurally and which are more vulnerable to storms. Reduced-lignin trees are more susceptible to viral infections. Reducing lignin can reduce trees' defences to pest attack, leading to increased pesticide use. Low-lignin trees will rot more readily, with serious impacts on soil structure and ecology.

If reduced-lignin GM trees were to cross with forest trees these impacts would not be limited to plantations. Although reduced lignin GM trees might be less competitive than native trees, the GM trees would be planted in vast numbers. If the plantation was near to a small population of native trees of the same species, the GM trees could overwhelm the reproduction of same-species native trees. Trees that cannot resist storms and which are at risk from attack by pests and viral infections could take over ecosystems and wipe out same-species native trees locally. They could also lead to a rapid increase in insect populations.

Focusing narrowly on lignin as the cause of pollution from pulp mills, GM proponents can argue that reducing the amount of lignin in trees is a reasonable solution. They overlook other possible solutions such as using crops like hemp which have lower levels of lignin than trees. Growing plantations of GM trees with reduced lignin fail to address any of the environmental and social problems that industrial plantations cause to local communities. Rather than asking questions about the nature of the global pulp and paper industry for which they are working, forestry scientists are asking whether genetically modifying trees for reduced lignin will work.

4. Insect-resistant GM trees will not lead to decreased pesticide use

Monoculture tree plantations face a permanent threat of insect attack. When that happens, the only solution is very often to apply chemical pesticides. Biotechnology offers the possibility of GM trees that are insect resistant, usually achieved by introducing genes from the bacterium *Bacillus*

thuringiensis (Bt). The resulting GM trees produce their own insecticide, which kills insects that try to feed from the tree. Scientists at Forest Research in New Zealand have genetically modified radiata pine in this way. GM tree proponents claim that this development will lead to less need to spray plantations with pesticides.

However, pests are more likely to develop resistance to an insecticide that is always present. Genetically modified Bt cotton has been widely planted in China. While it has initially led to reduced pesticide use, there are signs that the cotton bollworm is developing resistance to Bt cotton. Liu Xiaofeng from Henan Agriculture Department's cotton office recently told *Reuters* that the bollworm would no longer be affected by genetically modified Bt cotton trees in six or seven years' time.

If pests became resistant to GM insecticide producing trees, plantation managers' "solution" would be to spray yet more pesticides.

Until pests develop resistance, GM Bt trees may have an advantage over forest trees which are vulnerable to insect attack, thus increasing the risks of Bt trees invading surrounding forests. If they did so, GM Bt trees would disrupt insect population dynamics in natural forests as well as in plantations.

5. Herbicide-tolerant GM trees will not lead to decreased herbicide use

In 1995, Monsanto produced a herbicide-tolerant GM eucalyptus in Brazil. "We estimated that the modification would cut weed-control costs in half and would increase final yield by 10 per cent," David Duncan, Monsanto's former head of forestry, told journalist Casey Woods in 2002. Scientists at Forest Research in New Zealand have produced herbicide resistant GM spruce and pine trees. The trees are currently being tested in field trials.

Glyphosate is the active ingredient in Monsanto's Roundup herbicide. Monsanto boasts that its glyphosate products "are among the world's most widely used herbicides." Monsanto describes its glyphosate herbicides as "broad-spectrum, non-selective herbicides." In other words, glyphosate herbicides will kill just about anything green with which they come into contact.

As Viola Sampson of Eco-Nexus and Larry Lohmann of the Corner House point out that "Trees genetically engineered to be tolerant of herbicides will

further entrench the use of the chemicals in corporate and state attempts to create wooded landscapes free of 'extraneous' species."

Plantations of GM herbicide-tolerant trees could result in increased use of herbicides, for two reasons. First, the fact that the trees cannot be damaged by the herbicide could encourage irresponsible use of herbicides by plantation managers. GM tree plantations could be sprayed at any stage in the growth of the tree.

Second, GM trees which are tolerant of Roundup are designed to be used in plantations where Roundup is used as the herbicide. Using a single herbicide to remove weeds increases the chances of the weeds developing resistance to that herbicide. As scientists from the University of Abertay Dundee in Scotland and the Max Plank Institut für Chemische Ökologie in Germany explain, "Resistance to herbicides, such as Round-Up or glyphosate, the most commonly quoted in anti-GM literature, can only become a significant problem if we rely on it as a sole source of killing weeds". The scientists are advocating using a cocktail of chemicals to deal with weeds in plantations. In this case, GM trees which are designed to be tolerant of a single herbicide would be of little benefit.

Still more herbicides would be needed, if herbicide resistant GM trees were to cross with related trees outside the plantation, or if herbicide resistant GM trees were to spread outside plantations as weeds.

Herbicide tolerant weeds have started to appear in farmers' fields. In 2003, Bob Hartzler, Professor of Agronomy at Iowa State University, produced research indicating that in the past seven years five weed species had become tolerant of the herbicide glyphosate.

In Argentina, 11 million hectares have been planted with genetically modified soya since 1996, covering half the country's arable land. The GM soya is resistant to Monsanto's Roundup herbicide. Between 1996 and 2001 Monsanto halved the price of Roundup in Argentina. Use of glyphosate in Argentina has exploded, up from 13.9 million litres in 1997, to 150 million litres in 2003. Farmers have to use more and more herbicides in an attempt to control weeds which have also become tolerant of Roundup. As a result, in Colonia Loma Senes in northern Argentina, livestock have died and small farmers have lost their crops as pesticide spray spread from neighbouring GM fields. Families report skin rashes and smarting eyes.

In response to criticism of GM soya use in the country, Argentina's council for biotechnology, Argenbio, argued that GM soya has allowed farmers to avoid using a cocktail of chemicals on their crops. Gabriela Levitus, the executive director of Argenbio, told the UK's *Daily Telegraph* that "damage had been caused by some farmers' reluctance to practice crop rotation, but that would be true of any monoculture, whether the crop was genetically modified or not". However, GM soya seeds which grow after being dropped during harvesting cannot be killed by applications of normal amounts of Roundup. Syngenta has run adverts in Argentina stating "Soya is a weed". Syngenta suggested that a mixture of paraquat and atrazine should wipe out the invasive GM soya.

6. GM trees will not clean up pollution

Scott Merkle and Richard Meagher at the University of Georgia have produced GM cottonwood trees which can remove mercury from contaminated soil. The scientists modified *Escherichia coli* bacterium genes and inserted them into the cottonwood trees. The GM trees are designed to suck up the mercury from the soil and release it to the atmosphere. In July 2003, the scientists planted a field trial of 60 GM cottonwood trees at the site of a 19th century hat-making factory in Danbury.

Professor Joe Cummins, a geneticist at the University of Western Ontario in Canada, questions whether the GM trees will actually improve the situation. "The mercury 'remediation' will . . . simply move the pollution to the atmosphere, from which it will be redeposited over the cities of the Northeast and the lakes and waterways of northern USA and Canada", he wrote in *Science in Society* magazine. "Such 'remediation' is no remediation at all, it is just moving the problem from one place to another!" he concluded.

David Salt, of Northern Arizona University, expressed his concerns about using trees to clean up pollution back in 1995. "Would we simply be exchanging soil pollution for air pollution?" he asked.

7. Risks of genetic pollution

"Outcrossing", the term that scientists use for trees in plantations crossing with forest trees, is one of the biggest risks associated with field trials and commercial plantations of GM trees. In a paper published in 2003, Malcolm Campbell and colleagues at the Department of Plant Sciences at Oxford

University acknowledged this risk: “Because most [plantation] trees have an abundance of wild or feral relatives, outcross, and display long-distance gene flow via pollen and sometimes seed, there is likely to be considerable activist and public concern about large-scale use of genetically engineered trees.”

Forestry scientists’ solution to outcrossing is to produce GM trees which will not flower. The prospect of sterile monoculture plantations might look good from the corporate perspective, but if the trees were indeed sterile, this would mean thousands of hectares of trees without flowers, pollen, nuts or seeds. No birds or insects could live in such a plantation and the biodiversity of the plantation would be even lower than in today’s monoculture tree plantations.

Much has been written about “terminator” technology in food crops, in particular the dangers it presents of allowing a small number of multinational corporations to control the world’s food supply. Less discussed is whether the technology actually works. There is not a single published study that investigates whether sterile GM crops remain sterile under field conditions, according to Norman Ellstarnd, a professor of genetics at the University of California.

Whether GM trees are in fact sterile, and would remain that way throughout their lifetimes is almost impossible to prove. Trees have very long lifespans and the only way of knowing that trees genetically engineered for sterility will remain sterile for their entire lifespan is by repeatedly conducting trials lasting the hundreds of years of a tree’s lifespan.

Scientists admit that there are problems with attempts to engineer sterile trees. For example, Ron Sederof, a botanist at North Carolina State University, and Simcha Lev-Yadun, a plant geneticist at the University of Haifa in Israel, wrote in a letter to *Nature Biotechnology*:

> The most common strategies to suppress gene flow are based on suppression of genes essential for the development of reproductive structures, especially pollen and seeds. These approaches are limited in two ways. The first problem is that suppression of the activity of the target genes may not be complete; and second, the transgenes themselves may undergo gene silencing resulting in reversal of suppression.

The term “gene silencing” refers to the fact that genes can be switched on or off at different times during a tree’s life, as a result of stresses such as extremes

of heat or cold, drought, storm, disease or pests. Ricarda Steinbrecher, co-director of Econexus, a UK-based NGO, points out that "No risk assessment can predict the interference that genetic engineering will have on the stress response and the aging of trees."

As Steinbrecher explains, scientists long since stopped discussing whether it would be possible to prevent genes from GM plants from escaping into the wild. Instead they are arguing about what the impact of the genetic pollution might be, with many of them denying that there is a problem. For example, Kevan Gartland from the University of Abertay Dundee in Scotland and colleagues argue that "There is currently no clearly compelling evidence of significant damage due to limited amounts of GM tree pollen being able to spread within the environment." The argument is disingenuous. Gartland and colleagues need to refer to research which proves that GM trees are safe, rather than point at a lack of evidence when few (if any) independent research tests have been carried out. Moreover, it is hardly in the interests of the pulp and paper industry (or the scientists whose work the industry supports) to carry out research which might indicate a serious danger with GM trees.

Scientists at Oregon State University have monitored gene flow from non-GM poplar plantations. They found gene flow from the plantation poplars took place more than 10 kilometres away from the plantation. The researchers consider that gene flow is inevitable if GM plants are grown close to their relatives. Determining a "safe" distance from wild relatives is difficult, because of the huge distances that pollen can travel. Pine tree pollen has been found in India 600 kilometres from the nearest pine tree.

Some trees can re-grow from broken twigs and others send suckers up from their roots. Seeds can float down rivers. Trees, whether genetically modified or not do not respect international boundaries. It is conceivable that GM trees (or genes from those trees) planted in one country could spread into neighbouring countries, regardless of international legislation on importing GMOs.

8. GM elm trees are no solution to Dutch elm disease

Scientists at the University of Abertay in Dundee, Scotland have produced GM elm trees which are resistant to Dutch elm disease. In the US, scientists at Cornell University are working on GM American chestnuts which are resistant to chestnut blight fungus.

The wild populations of both of these trees have in the past been devastated by fungal diseases. Research which promises to replace trees almost completely lost to the British and US landscapes is almost bound to be popular with the public.

Some GM tree proponents see this type of research as a possibility to improve the image of GM tree research with the public. For example, Don Doering, a senior researcher with the World Resources Institute, a Washington DC-based think tank, told *Science* magazine that genetically modifying the American chestnut to be resistant to blight fungus is an opportunity to "speak directly" to the public to demonstrate biotech's societal benefits.

However, if GM elms are designed to resist the latest outbreak of the fungus, this is of little value if the fungus returns in a more destructive form. This has happened in the past. Dutch elm disease appeared in the northwest of Europe around 1910. Thirty years later the epidemic died down. In the 1960s it was back. Europe's elms had almost no resistance to the disease and millions of trees were killed.

Moreover, the dangers with this sort of research are similar to those for any other type of GM trees. The engineered genes might escape if the trees were to breed with wild relatives. The results are unpredictable.

Another problem is that when forestry scientists breed trees, they produce vast numbers of trees but with very narrow genetic diversity. For example, Radiata Pine is one of the plantation industry's favoured trees. There are four million hectares planted with the tree worldwide, but only five radiata pine forests left anywhere in the world: three on the Californian coast and two on islands off the coast of Mexico. Scientists from Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) are desperately collecting seeds from the few remaining wild radiata pine trees left. As CSIRO's Colin Matheson points out, "Australia's radiata plantations are much less diverse than the native populations although they occupy a much greater area."

GM breeding programmes (even more so than non-GM breeding programmes) could lead to a similar squeezing of genetic diversity of elm and American chestnut trees. In the long run this would make the trees more vulnerable to disease rather than less.

9. Do GM trees make economic sense?

Apart from widespread public concern about GMOs in general, an important reason why GM trees have not yet been commercially planted except in China, is that GM trees simply do not make economic sense, at least for the time being.

In 1999, Roger Sedjo of the conservative think tank Resources for the Future wrote that "forestry is on the threshold of widespread introduction of genetic engineering". Sedjo estimated that herbicide tolerant GM trees could save industry US$975 million a year worldwide. The source for the figure on which Sedjo based his calculations of potential savings is a report produced by a pro-biotech consulting company called Context Consulting (now called the Context Network). When I asked Sedjo for a copy of the report, he replied, "I don't think it was publically [*sic*] available. . . . I guess I would suggest that you contact the successor company to see if they will provide you with a full copy of the study." Context Network did not reply to my repeated requests for the report.

In 2003, Sedjo was still using the same source for his estimates of the potential economic benefits of GM tree plantations. Sedjo now seems a little sheepish about his enthusiasm about the savings that herbicide tolerant trees could present the plantation industry. "In more recent work, papers not yet in print . . . I suggest reasons why that full potential is unlikely to be reached although I don't try to recalibrate the figure to provide an 'actual' estimate," he told me.

In fact, several companies which were at one time involved in GM tree research have since pulled out. Weyerhaeuser has apparently withdrawn from GM tree research because of the long wait before the research will generate a profit. "When you have to wait 20 to 30 years to get payback," Todd Jones, director of Weyerhaeuser forest biotechnology, told *Science* magazine in 2002, "you have to have something that looks like it's going to have some real economic potential. If we look at economic models for some of the genes that do appear to be out there, there aren't that many that make that hurdle." Regarding herbicide tolerance, Jones pointed out that applying herbicides "is not that large of an expense" in the forest industry.

Weyerhaeuser's publicity material includes the following statement: "Weyerhaeuser's genetically improved trees, both in the past and in the foreseeable future, are not altered by direct manipulation of DNA or the use of

genetically modified organisms (GMOs)." I wrote to Frank Mendizabel, Weyerhaeuser's director of media relations, to ask some questions about Weyerhaeuser's involvement in GM tree research, including whether the company had ever carried out any field trials of GM trees. Mendizabel declined to answer my questions, but repeated the statement from Weyerhaeuser's publicity material. Clearly Weyerhaeuser and Mendizabel have forgotten that in 1997 the company planted 400 hectares of herbicide tolerant GM eucalyptus trees in Washington State.

Oil giant Shell has closed down its research programme into GM trees, also for economic reasons. In 1998, Shell produced GM eucalyptus trees and carried out trials in Britain, Uruguay and Chile. Shell's researchers planted 600 square metre field trials in Uruguay and Chile. Trials in Britain were in greenhouses. By the end of 1999, Shell had pulled out of GM tree research. "It was a stage when there was an extremely bad reaction to the technology, and I think many companies were very wary at that point," Stuart Christie, Shell's forestry technology manager for South America told journalist Casey Woods in 2002.

In December 2000, Shell Forestry confirmed that its decision to stop its GM tree research programme was because the research made no economic sense:

> Although Shell Forestry has, in the past, conducted carefully controlled GM trials under clear regulatory guidelines, we have concluded that significant further development is still required over a number of years to demonstrate that the technology is sound, environmentally acceptable and economically worthwhile. For our own forestry activities, this further work is not commercially justified and we have therefore stopped our research programme in to genetically modified trees.

Shell later made a "business strategy decision" to sell off its involvement in forestry according to Jeroen van den Berg in Shell's Renewables department. The company sold off its forestry companies between 2000 and 2004.

During the 1990s, Monsanto carried out GM tree research, but has since pulled out. In 1996, together with ForBio, an Australian tree biotech company, Monsanto set up a joint venture in Indonesia called Monfori Nusantara. Monfori's US$6 million factory in Bogor had the capacity to produce 15 million plants a year. Both Monsanto and ForBio were at the time conducting research into GM trees. In 1995, Monsanto produced a GM herbicide tolerant eucalyptus tree in Brazil. ForBio's work included research into sterile trees and GM trees

engineered for herbicide tolerance and insect resistance. Several reports appeared which stated that Monfori was planting GM trees. In June 2004, Monfori's Suzi Madjid told me that "Monfori never produced GM trees". Monfori now produces "high quality 'elite' microplants of Teak, Acacia and hybrid Eucalyptus for Indonesian plantation forestry" as well as ornamental flowers, according to the company web-site. During 1999, ForBio went bankrupt and Monsanto sold its shares in Monfori. In April 1999, Monsanto was one of the founding members of a GM tree research joint venture called ArborGen. Monsanto pulled out six months later. By the end of the year, Monsanto had dropped all its involvement in forestry.

Stora Enso, the world's second largest pulp and paper company, stated in 1999 that the company had "decided to refrain from any commercial use of controversial genetic engineering techniques on trees or any other organisms".

> [G]enetic engineering involves profound ethical questions. The fundamental issue is that genetic engineering modifies the very 'code of life' through an artificial, asexual process. We must ask ourselves whether we have the right to do such things to ourselves or to any other living things. From a moral point of view it is equally important to weigh the likely benefits of this technology against the potential risks – and to assess which groups stand to gain or lose out.

Nevertheless, Stora Enso continued to carry out research into GM trees, "to keep up to date with developments". Stora Enso Celbi, which is 100 per cent owned by Stora Enso has been involved in GM tree research through its involvement in a European Union-funded research project called IntelFibre.

Oregon State University's Steven Strauss told me that there is no "pressing need for the technology [of GM trees] at present in the USA". He explained that this is "due to a lack of tax incentives for intensive tree-based pulp and bioenergy plantations, low world pulp prices, etc." However, he added, "This of course could change radically overnight if the world were to get serious about carbon emissions control and sequestration."

The decision reached in December 2003 at the ninth Conference of the Parties to the UN Framework Convention on Climate Change allowing Northern companies and governments to establish plantations of GM trees in the South under the "Clean Development Mechanism" might be precisely the subsidy that the GM tree proponents have been looking for to make GM trees appear economically attractive.

Several companies with very deep pockets are involved in ongoing research into GM trees, including International Paper, Meadwestvaco, Potlatch Corporation, Aracruz, Suzano, Nippon Paper and Oji Paper.

10. Do scientists know what they are doing? And should we trust them?

Genetic modification of plants is something completely new. It allows scientists to produce plants containing genes that could not possibly occur in nature. As with anything new, the potential risks and dangers cannot be known beforehand. Recent history is littered with products and discoveries which scientists assured us were safe, and whose use was widespread, before the dangers of these products became widely known: nuclear power, x-rays, chlorofluorocarbons (CFCs), dioxin, asbestos, dichlorodiphenyltrichloroethane (DDT), thalidomide, polychlorinated biphenyls (PCBs), polyvinyl chloride (PVC), to name a few.

This is not an attempt to argue that science is wrong or that everything new is automatically bad. However, when scientists announce that a new discovery or process is "safe" we would be wise to ask questions about the validity of the claim, particularly when the scientists are funded by the industry that stands to benefit from the new discovery.

James Hancock is the director of the Plant Breeding and Genetics Programme at Michigan State University. In a 2003 paper, published in *BioScience*, he argued that GM trees will inevitable cross with wild relatives. "The factors limiting gene flow between compatible relatives can be largely ignored, as transgenes will eventually escape into the natural environment if there is a compatible relative near the transgenic crop, unless the transgenic crop produces no viable gametes or has a system incorporated that prevents embryo viability," he wrote.

Steven Strauss at Oregon State University commented on Hancock's article in the same issue of *BioScience*: "We can also predict with high confidence that the genetic confinement systems Hancock refers to will not provide absolute containment." Strauss continued by discussing how much gene flow might be acceptable and concludes that "the difficulty is in deciding how little is little enough. Unfortunately, for some novel genes, estimating 'negligibility' is anything but a little task."

Neither Hancock nor Strauss argues for a ban on releases of GMOs. Instead they argue for the reverse: a weakening of regulation of GMOs. They argue that GM trees are no different to any other trees and as genes will in any case escape, regulators should focus on whether plants crossed with the GMOs might spread as weeds or whether the novel genes might harm the plants with which they cross.

Yet there is considerable uncertainty within the ranks of GM tree proponents as to how the dangers of GMOs should be assessed. In a pro-GM paper published last year in *The Plant Journal* a group of scientists pointed out that GMOs present "a relatively new area of research". They explained that when it comes to GM tree research, "what to measure and how to measure it are still being debated".

In other words the scientists don't even know what problems to look for. If they do decide what to look for (which they are currently not sure how to do), they don't know how to measure the problems they will find.

Viola Sampson and Larry Lohmann point out that

> [M]uch of the data which adequate risk assessment of GM trees demands is unobtainable. For instance, in practice it is not possible to measure accurately to what extent GM plants or their genes might spread, simply because of the sheer size of the area which would need to be thoroughly examined for migrants. Second, serious risk assessment would exclude GM trees from precisely those uses for which they are being principally developed. For example, Professor Kenneth Raffa at the University of Wisconsin suggests that risks related to the evolution of insect resistance can be limited if large or homogenous plantations are avoided – a recommendation inherently at odds with the industry's requirements.

Nevertheless, Strauss is in favour of going ahead with commercial plantations of GM trees as a way of learning by doing. "As with other forms of novel breeding, the extent of testing needed will be determined empirically – via adaptive management – during early commercial applications," Strauss wrote in 2002. "Commercial applications" would involve planting millions of GM trees. Once GM trees from these plantations have crossed with forest trees, and the impacts are all too visible, it will be too late to recall the genes to the laboratory. Perhaps this is precisely what Strauss and his colleagues want.

3: A web of actors: Some of the research institutions and companies involved

There is no conspiracy to impose GM trees uninvited on an unwilling world. There are no smoky rooms where evil men in business suits get together behind locked doors to plot their next move. Neither do white coated technicians huddle over plans to produce mutant super trees which will take over the world.

However, the companies, research institutions and universities involved in GM tree research work together closely. Companies fund university research departments, and influence what type of research is carried out. Companies, government departments and universities have formed research networks in some countries and commercial ventures in others. Industry-friendly scientific publications, think tanks and mainstream media are always happy to publish pro-GM information. Professional networks, conferences and workshops provide the opportunity for like-minded scientists to get together to discuss their work.

Perhaps because they spend so much time in the company of like-minded people, researchers into GM trees tend to take criticism of their work personally. “Everyone is doing this [research into GM trees] because they believe it will help the environment of the world,” Oregon State University’s Steven Strauss told the *Portland Business Journal* in 1999, “We’re all terribly offended that some activists have defined what we do as horribly offensive,” he added. Similarly, Malcolm Campbell, at Oxford University’s Department of Plant Sciences, told the *Calgary Herald* in 1999, “I don’t get up in the morning and try thinking about who I’m going to step on. I go to work trying to make the world a better place for my kids.”

I wrote to Campbell with some questions about his research. Although he declined to answer my questions he was keen to show me what a nice chap he is: “On the basis of the tone of the questions you have asked me, I think that you may find that your perspective of me is at odds with who I actually am”. He pointed out that his family has not owned a car “as a matter of choice, for 8 years, and we do everything by public transport – including transporting my wife’s Fair Trade stall from site to site.” While this is all very commendable, I had not asked Campbell whether he took the bus into work. Among the questions I did ask him was whether he had ever conducted any

research into the impacts of large-scale industrial tree plantations on local communities in the South, and whether he had visited any local communities without representatives of the company responsible for managing the plantations.

Criticisms of research into GM trees are not directed at a personal level at the researchers or their lifestyles. They are directed at an economic and politic system and a model of forestry that together are responsible for massive destruction of the world's forests and the livelihoods of local communities.

This section looks at some of the institutions involved in promoting GM trees: the commercial firms, universities and professional networks.

International Union of Forest Research Organisations (IUFRO)

IUFRO is the glue that holds together the network of forestry scientists, academic researchers, company and government officials. IUFRO organises up to 90 meetings a year. Aspects of industrial forestry form the theme of many of these meeting, which have titles like "Eucalyptus in a changing world" and "The Economics and Management of High Productivity Plantations".

Formed in 1892, IUFRO is the largest and most well known international body in forestry research. IUFRO today has 689 member organisations from more than 100 countries.

In November 2004, a IUFRO conference will take place in South Carolina titled, "Forest Genetics and Tree Breeding in the Age of Genomics: Progress and Future". According to IUFRO, "This international conference is to bring together geneticists, breeders, applied and basic scientists, managers and professional foresters to exchange the latest information on forest genetics and tree breeding related topics." The conference sponsors include North Carolina State University, IUFRO, and GM tree firms ArborGen and Cellfor. Field trips after the conference are to Meadwestvaco and ArborGen's GM tree research centres.

IUFRO has a task force on Forest Biotechnology which is currently working on a report on "The whole set of benefits and costs linked to forests biotechnology and genetically modified trees". The report is to be presented at the IUFRO World Congress 2005 to be held in Brisbane, Australia.

As an organisation, IUFRO is pro-GM trees. IUFRO's web-site states its position on GM trees:

> Deployment of genetically modified organisms (GMOs) in forestry is controversial because of the possible risks involved. Although annual crops using GMOs are accepted in some parts of the world, and extensive research is undertaken, some environmental groups try to stop research on Forest Biotechnology, even acting aggressively. Trials and experiments certainly need to be carefully planned so that biosafety is not compromised, but research as such should not be stopped or restricted. What is needed is more research, laboratory experiments, and extensive field testing within a comprehensive approach to fully evaluate genetically modified trees.

ArborGen, US

ArborGen is the world's biggest GM tree company. Formed in April 1999 as a joint venture between Monsanto, International Paper, Westvaco and Fletcher Challenge, ArborGen is a US$60 million marriage between agribusiness and industrial forestry. Monsanto pulled out of ArborGen six months after it was formed. In January 2000, Genesis Research and Development, New Zealand's biggest biotechnology company, joined the joint venture. Genesis and Fletcher Challenge had been working together for five years on herbicide tolerant GM eucalyptus, poplar and pine. In 2001, Rubicon bought Fletcher Challenge's biotechnology and South American forestry operations and took over its commitments to ArborGen. Westvaco has since merged with Mead Paper Company to form Meadwestvaco.

In April 2003, Genesis announced a new plant science subsidiary: AgriGenesis Biosciences. AgriGenesis takes over Genesis' involvement in ArborGen. AgriGenesis' chief executive officer is Peter Lee, who previously held senior positions with International Paper and Mead Paper Company.

International Paper owns more than 3.3 million hectares in North America. It is the largest landowner and one of the worst polluters in the US. The company sells more tree seedlings than any other firm in the world. International Paper funds GM tree research at Oregon State University.

ArborGen currently has 51 field trials of GM poplar, eucalyptus, pine, sweetgum and cottonwood trees in the US. ArborGen's scientists have genetically

manipulated trees to have less lignin, to grow faster and straighter, to be sterile or to be resistant to disease or herbicide. In 2003, an ArborGen official told journalist Jack Lyne that the company was eight to 10 years away from launching commercial products.

Horizon2, New Zealand

Horizon2 was formed in March 2003 from a merger of Carter Holt Harvey Forest Genetics and Rubicon's Trees and Technology. Carter Holt Harvey is a New Zealand timber firm, which is 50 per cent owned by International Paper. Rubicon was formed from the break up of Fletcher Challenge Forests and is part of the ArborGen joint venture.

Horizon2 is carrying out research into GM eucalyptus and radiata pine. The research is aimed at trees engineered to have less lignin, to have increased cellulose, to grow faster, to be resistant to insects, to be stress tolerant and to have altered flowering behaviour.

In one application to New Zealand's regulatory body, the Environmental Risk Management Authority, Horizon2 described its GM tree research as "Improvement of selected, high-value strains of Eucalyptus bred for plantation forestry, to better meet the requirements of foresters and pulp mills in regions overseas where Eucalyptus is a primary source of fibre." In another application, Trees and Technology stated: "Dispersal of transgenic pollen into the environment is widely considered as undesirable . . . The applicant considers the main benefits of the research will be to allow the safe trialling and release of transgenic Eucalyptus in New Zealand and in other countries."

Horizon2 has a research contract with ArborGen. Horizon2 is "providing services to ArborGen to help improve the pulping characteristics of eucalyptus destined for the Brazilian market." A company press release states that Horizon2's future plans include a "market presence" in Chile.

GenFor, Chile

Chilean-based company GenFor hopes to have its insect resistant GM radiata pine trees ready for commercial release by 2008. Two years ago, Monsanto's former head of forestry predicted that Chile would be the first country to produce GM trees commercially.

Formed in 1999, GenFor is a joint venture between Chilean technology think tank Fundación Chile and Cellfor (Canada). The company was partly financed by the Chilean Development Agency. A US biotechnology company, Interlink Associates was initially part of the joint venture, but has since sold its share in the venture.

GenFor's main research focus is GM radiata pine which makes up 80 per cent of Chile's plantations. GenFor's researchers aim to create a GM pine resistant to the European shoot-tip moth, a pest which currently costs plantation companies in Chile $3 million a year to control.

The start of the GenFor partnership illustrates the high-tech nature of modern industrial tree plantations. Seven years ago, scientists at Biogenetics, a joint venture between Interlink and Fundación Chile, began research into the shoot-tip moth. At first, they aimed to set up a non-GM breeding programme for resistance to the moth. Biogenetic's scientists contacted Canadian company Silvagen (now called Cellfor) which sold a patented somatic embryogenesis propagation technology, which allows scientists to produce millions of trees from a single parent, without having to wait for the parent tree to seed. Instead of selling the somatic embryogenesis equipment it wanted, Silvagen formed the GenFor joint venture with Biogenetics.

Cellfor has entered into collaborations with a series of universities, including Oxford, Purdue, British Columbia, Alberta and Victoria. Cellfor has also worked with the Institute of Molecular Agrobiology in Singapore and SweTree Genomics in Sweden. The research which led to Cellfor's patented somatic embryogenesis technology was carried out by Stephen Attree at the University of Saskatchewan. Attree is now Cellfor's chief of research.

In addition to its research on insect resistant GM radiata pine, GenFor is working on increasing the level of cellulose and reducing the amount of lignin in radiata and loblolly pine.

Aracruz Cellulose, Brazil

Aracruz's three pulp mills produce a total of two million tons of pulp a year. The company's eucalyptus plantations were established on the lands of the Tupinikim and Guarani indigenous peoples and other local communities.

In 1997, Aracruz produced a statement explaining its position on GM trees:

> Genetics are becoming a powerful tool in modern societies, leading to breakthroughs that improve the overall quality of life and the environment. Many sectors such as agriculture are using genetics, and there is no reason to impose a genetic prohibition on the forestry industry, which, for plantations, follow the same basic concepts as any food crop. The use of genetically modified organisms should be allowed, subject to compliance to national and international regulations.

Gabriel Dehon Rezende, Forest Improvement Manager at Aracruz confirmed that Aracruz is currently carrying out GM tree laboratory research but that "Aracruz does not use Genetically Modified Organisms (GMOs) in its field trials or commercial plantations."

Nippon Paper Industries, Japan

In 2002, Nippon Paper, Japan's largest paper manufacturer announced that it had developed a GM salt-tolerant eucalyptus tree. Nippon Paper's scientists grew the trees in laboratory tests in salt solutions one third as salty as seawater. The company stated that it "hopes that this basic research in biotechnology will contribute to the development of plants and trees for afforestation in deteriorated areas, as well as for papermaking materials."

Nippon Paper's work on GM trees spans more than a decade. In 1993, the *Nikkei Weekly* reported that Nippon was working on GM poplar trees which would be resistant to polluted environments.

In 1995, Nippon signed an agreement with Zeneca to work on modifying lignin in pulp trees. Activists destroyed Zeneca's GM tree field trial in England four years later, but in 2001, the *Nikkei Weekly* reported that Nippon Paper had developed a GM eucalyptus tree which produced 20 per cent less lignin, 10 per cent more cellulose and five per cent more pulp than non-GM eucalyptus trees.

Oji Paper, Japan

Oji Paper is one of the largest pulp and paper companies in the world. The company has an active research programme into GM trees. Oji Paper's scientists are working on GM trees with reduced lignin, GM trees which can tolerate salty soils and GM eucalyptus that can grow in acidic soils.

Oji Paper owns 190,000 hectares of forests and plantations in Japan and a total of more than 130,000 hectares of plantations in Australia, China, Brazil, New Zealand, Vietnam and Papua New Guinea. In 2003, the *Asahi Shimbun* reported that Oji Paper would start trials of its GM eucalyptus within a year in a massive domed research facility in the US.

Takashi Hibino is a research scientist at Oji Paper's Forestry Research Institute working on producing GM salt-resistant eucalyptus trees. He told me that Oji Paper is not currently planting GM trees and that his research with GM trees is carried out in sealed glasshouses. In response to a question about the potential risks of GM trees he replied:

> It cannot be denied to influence an existing plant environment by the pollen dispersal of GM tree. We advance the development of the method of controlling the pollen formation at the same time as developing a profitable GM tree, and do not execute commercial afforestation until these can be solved.

In 2001, Japanese newspaper *Nikkei Weekly* reported that Oji Paper began a one hectare field trial of GM eucalyptus in Vietnam in 1998. Oji Paper planned to fell the trees at the end of 2001 and conduct a comprehensive evaluation of the trees, including their environmental impact. Oji Paper declined to reply to questions about the company's activities in Vietnam.

Tree Genomics, Biotechnology, and Breeding Programme, Oregon State University (US)

Oregon State University's forestry researchers are working on GM trees for herbicide tolerance, sterility, resistance to fungus and insects and reduced lignin.

The Tree Genetic Engineering Research Cooperative (TGERC) at Oregon State University was launched in 1994. TGERC received funding from several pulp and paper companies, including Aracruz, Weyerhaeuser, International Paper, MacMillan Blodel and Potlatch Corporation. Other funders include the National Science Foundation and Oregon State University.

TGERC has now been absorbed into Oregon State University's Tree Genomics, Biotechnology, and Breeding Programme.

Steven Strauss, Professor of Forest Science and Genetics at Oregon State University, is tireless in his efforts to promote GM trees and to play down the risks. Strauss describes Friends of the Earth and Greenpeace as "extremist environmental groups". In 2000, he told the *Washington Post* that "The main risk of working with engineered trees is not a biological risk, it's a political risk because of the hysteria around the world."

Strauss acknowledges that "absolutely complete containment [of GM tree genes] is impossible." However, he argues GM trees would be unlikely to survive in competition with non-GM trees. He told *Scientific American* that "[Transferred] genes in the wild will have very, very little effect".

In 2003, researchers at Oregon State University announced that they had found a way of producing shorter GM trees with fat trunks and more usable timber. The trees' growth would be controlled by using "commercially available growth-promoting sprays". Strauss argued that because shorter trees could not compete with wild trees, they would pose no threats to forests.

Oak Ridge National Laboratory (US)

Scientists at Oak Ridge National Laboratory (ORNL) are working on producing GM trees which would store carbon. The US Department of Energy is funding a three year, US$5.1 million research project into the possibility of using poplars to store carbon. ORNL is collaborating with the Universities of Florida, Oregon and Minnesota as well as the National Renewable Energy Laboratory and the US Forest Service. Researchers at Oregon State University are working on the actual genetic modification of trees to store more carbon. ORNL is also looking into the possibility of planting poplars to produce ethanol or other fuels. "We're talking about millions of acres" ORNL's Stan Wullschleger told the *Knoxville News Sentinel*.

ORNL was set up in 1942, as part of the Manhattan Project – one of three sites in the US which were to develop the atom bomb. Today, according to ORNL's director Alvin Trivelpeice, ORNL is a "government-sponsored institution managed by a private corporation to advance science and technology in partnership with universities and industrial firms". Since 2000, UT-Battelle, a non-profit joint venture between the University of Tennessee and Battelle, has managed ORNL for the US Department of Energy. Battelle is a science and technology firm with annual revenues of US$1 billion.

North Carolina State University (US)

Ron Sederoff and Vincent Chiang head the Forest Biotechnology Group in the Department of Forestry at North Carolina State University. Chiang and his colleagues have produced a GM aspen tree which has around half the lignin content of non-GM aspen. The trees also have more cellulose and they grow faster.

While Chiang acknowledges that "There is a need for more data concerning the environmental effects and field performance of transgenic trees," he adds that "four-year field trials of such trees in France and the United Kingdom show that lignin-modified transgenic trees do not have detrimental or unusual ecological impacts in the areas tested." Four years is clearly not long enough to determine the impact on ecosystems over the lifespan of the tree.

Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Scientists at CSIRO's Forestry and Forest Products are conducting several research projects into GM trees. For example, CSIRO's Simon Southerton is working on producing GM eucalyptus trees that grow faster, produce better wood and which are sterile. CSIRO's scientists, far from worrying about reduced biodiversity in GM tree plantations, acknowledge that plantations of sterile trees will be less attractive to animals. However, they argue, this is an improvement over non-GM tree plantations. According to CSIRO, plantations with fewer animals mean reduced impacts on wildlife when the plantation is logged.

About 75 per cent of CSIRO's funds come from government and the remainder from industry and other groups. In 2004, the Australian government announced a three-year agreement to give CSIRO US$1.1 billion in core funding.

Dr Geoff Garrett, CSIRO's Chief Executive Officer explained in a press release in May 2004 that "CSIRO's strategic objectives . . . are all about producing the best possible research outcomes for the benefit of all Australians. We must continue to help Australia grow, both economically and socially."

Forest Research, New Zealand

In March 2004, CSIRO Forestry and Forest Products and Forest Research announced plans to merge their operations. The joint venture will have a turnover of US$30 million a year and will consist of half of the 180 staff of CSIRO Forestry and Forest Products staff and one-third of Forest Research's 340 staff.

Forest Research is a government-funded research organisation with "approximately" 12 staff using GM technology according to Forest Research's Christian Walter. They are looking at wood formation, flowering and the environmental impacts of GM. Forest Research has several GM tree research projects including GM pine trees modified for insect-resistance and improved wood quality, GM fir trees engineered for pest and pathogen resistance, gene coding for wood quality traits, antibiotic and herbicide resistance genes, and genes involved in reproductive development. Forest Research is also carrying out research into the formation of lignin in trees.

In 2002, Christian Walter at Forest Research stated, "Forest Research does not have intentions to release genetically modified trees. Nor do we intend to produce trees for release."

However, in July 2003, Forest Research planted GM pine and spruce trees in two field trials in New Zealand. The GM trees are designed to be resistant to the herbicides Buster and Escort and the reproductive cycle of the trees had been altered – thus affecting wood growth. Before it approved the trials, the New Zealand regulatory body, Environmental Risk Management Authority, received more than 700 submissions about Forest Research's application of which 96.5 per cent opposed the trials.

Forest Research is conducting a study, with funding from the UN Food and Agriculture Organisation "on the status and trends of the development of genetic modification in forest trees, and the application of genetic modification in forestry." The study will be based on a questionnaire sent to forest management and research institutions and on public sources of information. In June 2004, FAO's Pierre Sigaud told me that the report would be released "in the next few months."

Chinese Academy of Forestry, Beijing

Forestry scientists at the Chinese Academy of Forestry started research into GM poplar trees in the late 1980s. From 1990 to 1995, they were helped by an FAO-run project which provided capacity building, technology transfer and laboratory support. The $1.8 million project was funded by the United Nations Development Programme.

The Chinese Academy of Forestry is working with the College of Life Sciences at Beijing University on a research project looking at the genes involved in wood formation in *Populus tomentosa* trees. Lu Meng-Zhu of the Research Institute of Forestry at the Chinese Academy of Forestry told me "My research involves transgenic work for producing insect tolerance and modified wood property trees, of course, transgenic research is also a tool in our basic research in wood formation at the molecular level."

For more than ten years, the Federal Research Centre for Forestry and Forest Products at Waldsieversdorf in Germany has maintained close contact with Chinese forestry scientists working on GM trees. Hu Jianjun of the Chinese Academy of Forestry was based at the Research Centre in Waldsieversdorf for several months in 2004.

Department of Plant Sciences, Oxford University, England

Forestry education at Oxford University was a product of the British Empire. Willhelm Schlich, then-Inspector General of Forests in India set up the Royal Engineering College at Coopers Hill in the south of England in 1885. Ten years later Schlich founded and became the first director of the Imperial Forestry Institute, which became part of Oxford University. In later years the name was changed to the Oxford Forestry Institute and today the OFI no longer exists, apart from as a building within the Department of Plant Sciences.

Before being absorbed into the Department of Plant Sciences, research at OFI gradually focussed more and more on the molecular level. Corporate funding increased, and included funding from Shell Forestry. In July 1999, OFI hosted the International Union for Forestry Research Organisation's "Forest Biotechnology '99" meeting at which 190 of the world's top forestry scientists spent a week discussing GM trees. The conference was sponsored by Monsanto and Shell.

Malcolm Campbell is one of the world's foremost researchers into lignin in trees and into GM trees engineered for reduced lignin. Before his move in August this year to the University of Toronto, Campbell was based at Oxford University's Department of Plant Sciences. Much of the research carried out under Campbell at Oxford involved poplar and eucalyptus trees – two of the pulp industry's favourite fibre sources.

4: Legislation, regulation and market forces

In 1999, the International Union of Forest Research Organisations (IUFRO) produced a document titled "Position Statement on the Benefits and Risks of Transgenic Plantations". In it they argued against excessive restrictions on the use of transgenic organisms on the grounds that this might stifle the realisation of the benefits. Oregon University's Steven Strauss was one of the authors of IUFRO's position statement. He told journalist Kristina Brenneman that "We deal with regulators all the time. With the level of regulation we have now, if it got any more onerous it would be society saying it would be dangerous."

The reality is that in many countries the regulation of research into GM trees is far too weak. There is no international legislation specifically relating to GM trees. Instead, the international legislation relating to GM trees covers all GMOs (or living modified organisms as they are referred to in international law). Much of the legislation has been produced with GM food crops and seeds in mind, and does not necessarily cover the problems presented by long-lived GM plants such as trees.

One of the crucial aspects of the international law on GMOs is that GMOs are not like chemicals, which can in principle be withdrawn if they are found to be damaging. GMOs, once they are released into the environment, can self-replicate and cross with relatives, making withdrawal of a product all but impossible.

That this is not merely a theoretical problem was illustrated in April 2003, when Monsanto and The Scotts Company filed a request with regulatory authorities in the US for commercial approval of a GM grass to be used on golf courses. Among the comments received was one from the Union of Concerned Scientists, which pointed out that GM grass is unlike other GM crops in that it is not an annual crop and can establish itself in a wide range of habitats. GM grass can reproduce through seeds, pollen and by growing horizontal stems which produce roots. The US regulatory body has not yet reached its decision on whether to approve Monsanto's GM grass or not. Although it has decided to produce an environmental impact assessment, it must reach its decision without the benefit of clear guidelines on how to deal with long-lived GM plants.

Since December 2003, GM trees are specifically referred to in the international climate change treaty, the Kyoto Protocol. Kyoto Protocol rules now state that countries on the receiving end of GM tree carbon dumps should "evaluate, in accordance with their national laws, potential risks associated with the use of genetically modified organisms by afforestation and reforestation project activities."

The potential risks and problems of GM trees are rarely raised in international fora. In April 2004, for example, three United Nations Secretariats (of the conventions on Desertification, Biodiversity and Climate Change) held a workshop in Viterbo, Italy on forests and "Promoting Synergy in the Implementation of the three Rio Conventions". Among the issues that the 200 delegates discussed were threats to forests, benefit sharing of forest resources, technology transfer, poverty reduction and carbon sequestration. Yet the final report of the workshop made no mention of GM trees. Neither is there any discussion about the threats that industrial tree plantations pose to people and forests. The word "plantations" was mentioned only twice in the report.

In May 2004, the fourth meeting of the UN Forum on Forests (UNFF-4) presented another opportunity to discuss the issues raised by GM trees. Yet in his presentation on the third day of the two week meeting UNFCCC's Henning Wuester failed to mention UNFCCC's decision to include GM tree plantations in the Clean Development Mechanism. In fact, there was no discussion of GM trees at UNFF-4, apart from in an NGO-organised side event.

Forestry scientists are clear that genetic pollution from GM tree plantations is inevitable. "Genes will eventually get out" as Oregon State University's Steven Strauss puts it. This has potentially serious legal implications. In May 2004, the Canadian Supreme Court ruled that Monsanto had the right to prosecute farmers who have crops containing Monsanto patented genes on their land. Pat Mooney director of the Action Group on Erosion, Technology and Concentration explained the implications of this ruling: "They can now say that their rights extend to anything its genes get into, whether plant, animal or human. Under this ruling spreading GM pollution appears to be recognized as a viable corporate ownership strategy."

The prospect of GM trees crossing with wild relatives resulting in feral GM trees containing patented genes growing outside plantations, raises a number of legal questions, including the following:

- Will the company that owns the patent on the gene have ownership rights (or any other rights) over any trees which contain this gene? Might forest owners find that the trees on their land in fact belong to International Paper or Meadwestvaco because they contain the company's patented genes?
- Who will be liable, if gene pollution proves to have damaged trees in natural forests? Will it be the plantation manager, the company that sold the GM tree seedlings, the company that developed the GM tree using the patented gene, or will it be the owner of the patent on the gene?
- How is "damage" to trees in natural forests to be determined? Who will decide what constitutes damage? Trees and forests are sacred in some cultures and although superficially there may appear to be no harm done, changing the genetic makeup of wild trees could, in some cultures, be considered in itself to be damage.
- Seeds can be (and are) easily smuggled across borders. No legislation in the world will prevent this from happening. If GM trees were to become weedy and start invading forest ecosystems as a result of smuggled seeds, who (if anyone) would be liable?

International law covering GMOs is at present focussed on issues relating to trade. There are two institutions which currently provide rulings covering international trade in GMOs, the Convention on Biological Diversity and the World Trade Organisation.

Convention on Biological Diversity (Cartagena Protocol)

The member governments of the Convention on Biological Diversity adopted the Cartagena Protocol on Biosafety in January 2000 and it came into force in September 2003. The Cartagena Protocol is the only source of international law specifically relating to GMOs. The Protocol provides regulations for transboundary movements of GMOs. When Guatemala ratified the Protocol in October 2004, the total number of Parties reached 110.

The Cartagena Protocol was drawn up in accordance with the precautionary principle and therefore recognises a government's right to ban imports of GMOs when insufficient information is available to carry out an assessment of the risks. The burden of proof of safety is pushed back to the country or company exporting the GMOs.

The Cartagena Protocol covers three important areas:

- **Liability:** who will be responsible for escape of GMOs and who will pay for any damage? A Working Group has been set up under the Protocol with a four-year mandate to produce international rules and procedures for liability and redress.
- **Compliance:** who will check countries against the Protocol and how? A Compliance Committee has been created under the Protocol. The Protocol does not rely on self reporting of compliance and third parties can report non compliance.
- **Identification**: How should shipments of GMOs be labelled? Under the Protocol, all shipments of GMOs are to be labelled as "may contain GMOs". Countries can refuse a shipment if clear information is not provided. Issues to be resolved include the percentage of GMO that a shipment can contain and still be considered GMO-free. This is to be considered in 2005, at the next meeting of the Parties to the Protocol.

The US, Canada and Argentina, three major exporters of GMOs, have not ratified the Cartagena Protocol. Environmental lawyer Mariam Mayet points out that the Cartagena Protocol skips the issue of whether it takes precedence over WTO rules, by stating that the two should be "mutually supportive".

World Trade Organisation (SPS Agreement)

Under the World Trade Organisation (WTO) governments can be penalised for putting in place legislation, such as banning GMOs, if the WTO rules that this is an unnecessary barrier to international trade.

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) entered into force in January 1995, when the WTO was established. The SPS Agreement covers food safety and animal and plant health regulations. As such, it also applies to GMOs. According to the WTO, the purpose of the agreement is to prevent governments from restricting trade (and therefore protecting their own food producers) by applying restrictions on food imports which "go beyond what is needed for health protection." In setting their laws, to comply with the SPS Agreement, governments must assess the risks involved, rather than use the precautionary principle. The WTO explains that "Countries must establish SPS measures

on the basis of an appropriate assessment of the actual risks involved, and, if requested, make known what factors they took into consideration, the assessment procedures they used and the level of risk they determined to be acceptable."

In May 2003, the US, Canada, Argentina and Egypt filed a complaint with the WTO against the EU's legislation on GM foods. (Egypt withdrew two weeks later.) A year later, in its first submission to the WTO in response to the complaint, the EU argued that "The Biosafety Protocol is the international agreement which is most directly relevant to the matters raised by the present proceedings."

The EU stated:

> As far as scientific complexity is concerned, the arguments put forward by the Complainants are simplistic and largely ignore the scientific and regulatory issues which have dominated debate on GMOs over the past five years. They argue, for example, that there is no difference between GMOs and their conventional counterparts, in terms of risks to human health and the environment. The international Community has clearly rejected that view: between 1996 and 2000 a specialised international convention – the Cartagena Protocol on Biosafety ("Biosafety Protocol") – was negotiated, which is premised on a clear understanding that the inherent characteristics of GMOs require them to be subject to rigorous scrutiny so as to ensure that they do not cause harm to the environment or human health, or cause socio-economic disruptions.

Greenpeace made the point more concisely: "The WTO does not have the legitimacy to decide what Europeans should eat. Neither should it enact decisions that interfere with environmental laws enshrined in multilateral environmental agreements, such as the Cartagena Protocol on Biosafety."

Dr Tewolde Egziabher, Director General of the Environmental Protection Authority in Ethiopia, was one of the architects of the Cartagena Protocol. Regarding the US complaint to the WTO he wrote,

> We in African countries, who have fought long and hard for the agreement and ratification of the Biosafety Protocol, feel that US actions are intended to send a strong and aggressive message to us: that should we choose

> to implement the Protocol and reject the import of GM foods, we may also face the possibility of a WTO challenge. We cannot help but perceive that US actions are a pre-emptive strike on the Biosafety Protocol and developing country interests.

Kristin Dawkins, author of a book titled *Gene Wars*, commented: "Fundamentally, this battle is also about the rights of nations to set up their own regulatory systems to protect human health and the environment."

Some GMO legislation from around the world

There are two ways of regulating GMOs. The first approach is to adopt the precautionary principle. This puts the burden of proof on the institutions or companies developing GMOs and requires that they prove that the product is safe. The most extreme application of the precautionary principle is to ban GMOs. Several countries have placed outright bans or moratoria on GMOs, including Algeria, New Zealand, Peru, El Salvador and Australia (except Queensland and the Northern Territory). In addition, several regions in Europe and one county in the US have voted in bans on GMOs. Thailand has banned 49 GM plants.

A second approach to regulating GMOs accepts that some level of risk is inevitable and acceptable. In the US, where most of the world's research into GMOs is taking place, the government has adopted the second approach and GM plants are regulated to determine that they present "no significant or unreasonable adverse risks", according to Roger Sedjo of Resources for the Future.

For several years, the US and Argentinean government have been putting pressure on other countries to water down their legislation and accept imports of GMOs. In December 2001, Friends of the Earth International (FoEI) released leaked documents revealing that the US and Argentinean governments were threatening WTO action against countries with strict legislation against GMOs. FoEI pointed out that countries like Bolivia and Croatia faced "overwhelming pressure". Bolivia was forced to retract a GMO ban after pressure from Argentina and its biotech industry.

The US Agency for International Development (USAID) is spearheading a campaign to introduce GM crops and food in the South, especially Africa. For example, USAID is funding the African Agricultural Technology Foundation

(AATF), which is also supported by biotech firms Monsanto, Dow Chemicals, DuPont and Syngenta. Environmental lawyer Mariam Mayet is concerned that "AATF may be a vehicle to use poverty and the urgent need for food security strategies in Africa to push for the opening of markets by sharing patents and seeds and taking control of African agricultural research." In Nigeria, USAID will provide US$2.1 million over three years to fund an initiative titled the Nigeria Agriculture Biotechnology Project. The US embassy's Rick Roberts told the *Daily Times* that "Nigeria stands to benefit greatly from biotechnology" and he "charged Nigeria to embrace biotechnology as a means of improving agricultural productivity, reducing the use of pesticides and improving nutritional quality of food products". USAID is also funding various projects aimed at producing biosafety regulation in African countries. USAID's Agricultural Biotechnology Support Project has set up a partnership with seven countries in southern Africa to provide training in biosafety regulatory implementation. USAID is explicitly promoting WTO rules as a basis for regulation rather than the Cartagena Protocol. USAID has awarded US$14.8 million to the Program for Biosafety Systems to assist countries in the South improve their Biosafety policy and research. The Program for Biosafety Systems aims to help government regulate and carry out GM field trials.

Meanwhile, the UN Environment Programme is carrying out a programme involving more than 120 countries to prepare "National Biosafety Frameworks in accordance with the relevant provisions of the Biosafety Protocol". Rather than encouraging bans on GMOs, UNEP's advice encourages these countries to draft flexible rules to allow GMOs into their territories.

At the national level, various countries have attempted to put in place controls on imports and use of GMOs on their territories.

In June 2004, the German parliament passed a new law regulating GMOs. The law limits the area on which GMOs can be grown and calls for a national register of GMOs. The law also makes farmers liable for damages if their GM crops contaminate crops in other farms. After the law was announced, Georg Folttmann, a spokesperson for Germany's largest seed supplier KWS Saat told the *Tagesspiegel* that because of the government's strict liability regulations "nobody will plant genetically modified plants in Germany".

For two years, up to 31 October 2003, the New Zealand government imposed a moratorium on all field trials or releases of GMOs. The moratorium allowed the government to implement the recommendations of a 2001 Royal Commission

on Genetic Modification. The Royal Commission concluded that "New Zealand should keep its options open". The commissioners stated that "It would be unwise to turn our back on the potential advantages on offer, but we should proceed carefully, minimising and managing risks." However, a poll carried out for the *New Zealand Herald* in August 2003 revealed that more than two-thirds of the people surveyed opposed lifting the moratorium on GM releases.

Applications for importing, development or field testing of GMOs in New Zealand must be filed with the Environmental Risk Management Authority (ERMA). New Zealand-based GM company Forest Research describes ERMA's regulations as "the strictest in the world". In 2004, ERMA introduced new rules which according to a report in the *New Zealand Herald* are strict on safety, give more weight to Maori views on GMOs and give consideration to "the lost opportunity to do other more valuable research". Between the end of the moratorium on GMOs in October 2003 and May 2004, ERMA received no applications for commercial releases of GMOs.

In March 2004, at a biotechnology forum in Aukland, Rubicon's vice-president Bruce Burton said, "ArborGen is looking to start developing GE radiata [pine], and one of the questions it has is that the regulatory environment here is too tough," Rubicon is part of the ArborGen joint venture, with US firms International Paper and Meadwestvaco. "Our US partners say the costs and the potential threats of the greenies are too high, so we'll carry on doing tests in the US and Brazil," Burton added.

In Brazil, President Luiz Inacio Lula da Silva has made a series of decrees allowing the marketing of illegally grown GM soya, despite a moratorium on GMOs in the country. Lula's administration has also produced a Biosafety Bill to replace a 1995 law. The Senate passed the Bill in October 2004. Meanwhile Brazil's National Committee on Biosafety has issued several permits for research into GM trees in Brazil, including to pulp firms Aracruz and Suzano.

Chile's regulation of GMOs amounts to little more than a green light for the biotech industry. Chile's draft policy on biotechnology is titled, "Biotechnology as a tool for development and wellbeing". The policy includes plans to increase the use of biotech processes in forestry.

China's regulatory system depends on risk assessment. According to Roger Sedjo of Resources for the Future, new plants (including GM plants) are

assessed against a risk scale: no risk, low risk, medium risk and high risk. Regulations cover only those plants considered to be medium or high risk. Plants considered to be no risk or low risk are not covered by any regulation.

Regulation of GMOs in China is covered by the Biosafety Act for GMOs in Agriculture, adopted by the State Council in May 2001. Before GM trees can be planted an expert panel organised by the State Forestry Administration carries out a technical assessment. The National Committee for Biosafety of GMOs in Agriculture bases its decision whether to approve the GM trees for release on the panel's report. A lack of coordination between the Ministry of Agriculture and the State Forestry Administration has resulted in bureaucratic confusion. Even worse, the State Forestry Administration has no specific regulations covering GM trees. "Special regulations are in the pipeline," according to Huoran Wang of the Chinese Academy of Forestry in Beijing. In July 2004, at a meeting on GMO safety in Beijing, Chinese scientists called for stricter regulations of GMOs in China.

The country with the most research into GM trees, the US, has a woefully inadequate regulatory system. Three regulatory bodies are responsible for regulating biotechnology: the US Department of Agriculture (USDA), Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA). Within USDA, the Animal and Plant Health Inspection Service (APHIS) is responsible for regulating importation, movement between states or field testing of GMOs. The three institutions sometimes have overlapping authority. GM trees with reduced lignin only need approval from APHIS, whereas insect resistant or herbicide tolerant GM trees need approval from EPA as well as APHIS.

Once they have carried out field trials, companies can petition APHIS to request nonregulated status. If granted, nonregulated status means that GMOs can then be planted just like any other crop. APHIS has no mechanism for regulating commercial GM tree plantations once it has approved them. Faith Campbell of the US NGO American Lands Alliance asks, "It is widely recognized that any plantations of GE trees allowed to be planted must be managed according to strict criteria to minimize the risks – but who will develop the standards and ensure that they are met?"

US-based ArborGen is the world's biggest forestry biotechnology company. The company currently has 51 field trials of GM poplar, eucalyptus, pine, sweetgum and cottonwood trees in the US.

ArborGen is a joint venture of timber giants International Paper, Meadwestvaco, Rubicon and New Zealand-based biotechnology company Genesis Research and Development. ArborGen aims "to position itself to market new advances in forestry biotechnology to the world's tree growers in the shortest possible time", according to a 1999 press release.

If ever there was a company that needed to be carefully regulated, ArborGen is it. Yet the USDA has only turned down one of ArborGen's applications for GM tree field trials and that was on a technicality. ArborGen has not had to submit an environmental impact assessment for any of its GM tree field trials.

It gets worse. The regulators face a conflict of interest, in that the "experts" that they turn to for advice are the very scientists who are doing the research into GM trees. For example, when US regulator Environmental Protection Agency wanted a study of the risks associated with GM trees, it turned to the Tree Genetic Engineering Research Cooperative (TGERC) to carry out the study.

TGERC is a consortium of timber and pulp companies conducting research into GM trees at Oregon State University. Companies involved include Potlatch Corporation, Weyerhaeuser, International Paper, Alberta Pacific and Aracruz. Since 1997, TGERC has conducted more than 60 field trials of GM trees in the US.

Forestry certification and GM trees

Given the failure of many governments to provide adequate legislation on the development of GM trees and the lack of discussion of GM trees at international fora such as the UN Forum on Forests, the idea of using market mechanisms to promote non-GM forestry might appear to be an attractive proposition.

Consumers could vote with their dollars by refusing to buy paper, for example, that comes from GM tree plantations. Instead of hoping for governments to produce adequate international and national legislation, consumers could send a message to the pulp and paper industry that this technology is something that they do not want.

An independent certification system which guarantees that products carrying its label are from forestry operations which exclude GM trees would (in theory at least) reward companies that do not plant GM trees and provide consumers

with the information they need to avoid products made from GM trees. At present, the Forest Stewardship Council is the only certification organisation that excludes the use of GMOs in its certified forestry operations. Among the criteria by which FSC judges whether a forest or plantation operation is well managed is the statement: "Use of genetically modified organisms shall be prohibited." FSC's supporters argue that this is an incentive for companies who want to get certified not to use GM trees.

However, FSC has certified millions of hectares of large-scale industrial non-GM tree plantations. FSC does not differentiate between industrial tree plantations and forests: "Plantations are included in the FSC definition of forests", according to an FSC leaflet published in November 2003. An FSC label on photocopy paper, for example, does not explain whether the company that produced the paper grew its raw material on thousands of hectares of monoculture of exotic eucalyptus trees or whether it bought the wood from thousands of small-scale farmers growing trees in mixed native woodlands on their own lands. Consumers know through buying paper with an FSC label that no GM trees were involved in the production of the paper, but this is little consolation for farmers in the South who have seen their lands and livelihoods devastated by massive industrial tree plantations.

In addition, FSC does not rule that certified companies should not carry out GM tree research, simply that no GMOs should be used in the certified forestry operations. Potlatch Corporation, for example, has received an FSC certification for its 7,000 hectares of poplar plantations in Oregon. In 2000, when Potlatch made the decision to seek FSC certification, the company had a 1.2 hectare field trial of GM trees, in a partnership with Oregon State University.

Before the certificate was issued, FSC's assessors, Scientific Certification Systems insisted that the GM trees were removed. SCS's public summary of their August 2001 assessment states: "As part of Potlatch's commitment to FSC they severed their long-term relationship with Oregon State to research genetically modified hybrid poplars on the . . . plantation." However, Potlatch continued to support GM tree research at Oregon State University. In 2002, Potlatch research manager Jake Eaton told *Science* magazine: "We just can't do it on our farm."

Scientific Certification Systems also carried out an assessment for FSC of Fletcher Challenge Forests in New Zealand. At the time that the certificate

was awarded in October 2000, Fletcher Challenge Forests had worked for five years in partnership with Genesis Research and Development Corporation on research into GM trees. The year before the certificate was awarded, Fletcher Challenge Forests joined the US$60 million ArborGen GM tree research joint venture.

SCS's assessment team also had links with GM trees as well as with the company they were assessing, calling into question the independence of the assessment. SCS hired four assessors to conduct the assessment of Fletcher Challenge Forests' plantations. Three of them worked for the New Zealand company Forest Research which at the time ran projects funded by Fletcher Challenge Forests and has its own research programme into GM trees. Forest Research established New Zealand's first GM tree field trials in 2003. Perhaps not surprisingly, the assessors dismissed any concerns about Fletcher Challenge Forests' GM tree research. "All materials are classed as low risk and the laboratory is fully compliant with regulatory requirements", stated SCS's public statement.

But the most serious problem with any certification system as a potential means to control the use of GM trees is the fact that certification is voluntary. In addition to FSC, several other certification systems are available, none of which object to the use of GM trees. If a company, such as International Paper, decides it does not want to bother with the hassle of getting certified it can plant as many GM trees as it wants. FSC, in common with all other forest certification systems, contains no mechanism for penalising a company that breaks its rules.

5: Resistance is fertile: Protests against GM trees

Most protests against GMOs have been against GM crops, for the simple reason that GM crops are already commercially planted. GM trees, if they were to be commercially planted, would present even greater risks to the environment than GM crops.

Much of the media attention on protests against GM trees has focussed on a handfull of actions by small groups of activists calling themselves names like Reclaim the Seeds or the Genetix Goblins. In the past six years, activists have destroyed 12 GM tree trials, in Britain, Canada and the US. The Earth Liberation Front has burned down offices and research laboratories.

Many people and organisations are involved in other types of activities against GM trees. Protests against GM trees have taken many forms and have included banner hangs, press conferences, meetings, letters to newspapers, petitions, articles, campaigns to persuade companies not buy products from GM trees, research into the companies and institutions involved, and campaigns for GMO free zones.

Several NGOs have formed alliances to campaign against GM trees. Probably the first was the GE Free Forests Coalition (GEFF), formed in Britain in April 1999. Three months later, GEFF organised a demonstration at IUFRO's Forest Biotechnology '99 conference in Oxford. Rod Harbinson, a GEFF spokesperson, told *The Guardian*:

> The science is moving so fast they are not considering the effect on the environment. Trees are much closer to the wild than genetic engineered crops which have been interbred for centuries. Trees have an urge to spread their genes. There has already been a case with GM aspens in Germany flowering when they were supposed not to be able to. We are alarmed that these trees will pollute the environment. These companies meeting in Oxford are looking for profits and are out of control. Reducing the amount of lignin affects the trees' resistance to insects. We have no idea what pests and diseases will be let loose which can spread to our natural forests.

In 2000, a group of NGOs formed the Global Alliance Against Genetically Engineered Trees. Action for Social and Ecological Justice (ASEJ) was among

the founding organisations. In July 2001, ASEJ organised North America's first public demonstration against GE trees in Washington State during a conference on genetically engineered trees.

Beginning in autumn 2002, ASEJ organised four meetings in the US, in regions where scientists were carrying out GM tree research, followed by a national meeting which included participants from Rainforest Action Network, Dogwood Alliance and Forest Ethics. The campaign's aim is an international ban on the release of GM trees, including field trials and commercial plantations.

In 2003, another alliance was formed, called the Stop GE Trees Coalition. The coalition includes Sierra Club, Rainforest Action Network, WildLaw, Global Justice Ecology Project, Polaris Institute, Forest Ethics, Northwest Resistance Against Genetic Engineering, Dogwood Alliance, American Lands Alliance and Institute for Social Ecology's Biotechnology Project.

In June 2003, the Stop GE Trees Coalition launched a campaign against International Paper with a demonstration at an Xpedx store, which is owned by International Paper. Some activists wandered around dressed as old growth trees while others held a banner reading "Stop GE Trees". The same month, three protesters were arrested after chaining themselves inside a University of California-Davis building in a protest against GM tree research.

Around 80 NGOs have signed on to a statement titled: "A Common Vision for Transforming the Paper Industry". The Common Vision emerged from a November 2002 meeting of more than 50 NGOs working on paper, pollution and forest issues in the US. The Common Vision includes the demand to the paper industry: "Stop the introduction of paper fiber from genetically modified organisms, particularly transgenic trees and plants with genes inserted from other species of animals and plants."

In 2003, US photocopy paper giant Kinko's announced that it would not buy from suppliers selling paper manufactured from GM trees. Several companies have made commitments to purchase only Forest Stewardship Council certified timber. For example, US companies Alexandria Moulding and Golden State Lumber have committed not to buy any radiata pine from Chile unless it is FSC certified. Many other companies state a "preference" for FSC timber.

The Environment and Conservation Organisations of New Zealand (ECO), a group with 65 member organisations, is attempting to use the Forest

Stewardship Council's exclusion of GM trees from FSC certified tree plantations, in their campaign against GM trees. Cath Wallace, ECO's co-chair stated in 2003: "Planting genetically engineered radiata pine and spruce trees is a waste of time and money because their products will not be acceptable under international plantation standards to which New Zealand companies are intending to work."

Another strategy, which has appeared in various forms around the world, is to campaign for legislation banning GMOs from specific areas. GM free zones have appeared all over the world, even in the US. In March 2004, residents in Mendocino County voted to ban the use of GMOs in the county. Mendocino County is the first county in the US to ban GMOs, but votes on similar bans will take place in four other Californian counties in November 2004.

Also in March 2004, senators in Vermont voted 28-0 to pass a bill to hold biotech companies liable for genetic pollution of conventional or organic crops. "The Farmer Protection Act is a pre-emptive strike to stop predatory lawsuits against Vermont's family farmers by biotech companies like Monsanto," said Ben Davis of the Vermont Public Interest Research Group (VPIRG). VPIRG is part of a coalition of groups leading a campaign for the first GM free state in the US.

In December 2003, the *Süddeutsche Zeitung* reported that the Austrian province of Kärnten had passed a law which stated that GMOs cannot be planted within three kilometres of natural and cultural areas that are worthy of protection. Approximately 20 per cent of Kärnten's land is organically farmed. On the grounds that organic farming is worthy of protection, in practice the authorities will give no permits for planting GMOs.

In Britain, 14 million people live in areas with a GM-free policy. Twelve counties have passed GM-free resolutions in addition to more than 30 towns, cities, districts and national park authorities. In France, more than 1,250 mayors have issued GM free declarations for their towns. Friends of the Earth Europe has launched a GMO-free Europe campaign, aimed at supporting regions to go GM-free.

After the UN Framework Convention on Climate Change decided in December 2003 to include GM trees in the Clean Development Mechanism, the People's Forest Forum in Finland launched a petition calling for a global ban on GM trees. People's Forest Forum consists of the People's Biosafety Association,

the Union of Ecoforestry and Friends of the Earth Finland. The petition is to be presented to the UNFCCC at the tenth conference of the parties in Buenos Aires in December 2004. People's Forest Forum states: "The course taken in Milan was a wrong one. We do not need plantations of genetically modified tree clones on our planet. Plans like this are in direct contradiction to the terms of the Rio Convention on Biodiversity."

What you can do:

Forestry scientists working on GM trees often argue that more research is required, but the kind of research they are talking about is more and bigger field trials. Some scientists even talk of the need for widespread releases of GM trees, in order to find out what the problems might be. In fact the kind of research that we need, as opponents of GM trees, is political research into the actors involved in promoting and developing GM trees. We need to understand why they are interested in GM trees, where their financing comes from and how they hope to benefit from GM trees. We need research which explores the conflicts of interest between regulators and scientists. This is the kind of research that forestry scientists do not carry out. It is the kind of research they would prefer that no one carried out.

The actors, particularly corporations, involved in research into GM trees are often reluctant to release any details about their research, because they do not want a public debate about what they are doing. This report details some of the activities of some of the companies involved, but there are many more. Research into these companies can help expose some of their involvement in developing GM trees.

Governments cannot be allowed to write legislation for the benefit of their corporations. Even worse, the US government cannot be allowed to meddle in other government's legislation for the benefit of US corporations. Yet this is precisely what it is attempting to do around the world.

We can dismantle the political machinery that produces GM trees piece by piece. Every time we raise the issue in public we win a victory. Every time we raise a banner against GM trees we win another victory. Every time we protest outside meetings of forestry scientists we win another victory. Every time we stop or even slow down the development of an industrial tree plantation, we are helping create political space to stop GM trees. Here are some of the things you can do:

1. Find out whether there are any GM tree field trials in your country or region of your country. Find out what legislation covers such trials. Demand environmental impact assessments and any other documentation that companies have to provide before they can carry out trials.

2. Publicise any information you find out – either by setting up your own web-site, or by sending the information to World Rainforest Movement (wrm@wrm.org.uy) and to Friends of the Earth International (web@foei.org) and we will post it in our website!

3. Write to local newspapers, politicians and regulatory authorities opposing the development of GM trees (using a pen-name if necessary, if, for example, it is not safe in your country to oppose the government).

4. Form your own groups, networks and alliances to oppose GM trees.

5. Set up your own GM free zone. See http://www.foeeurope.org/GMOs/gmofree/.

Networks of people and organisations around the world are coming together to oppose GM trees. People opposing GM trees are linking up with organisations and people around the world: with networks that have opposed the spread of GMO crops in their countries; with organisations working on climate change; with anti-globalisation activists; with human rights activists and indigenous peoples; with local communities and organisations that are resisting industrial tree plantations and other forms of industrial forestry. The resistance to GM trees is growing!

Notes and sources

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1: Introduction

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Section 3: A web of actors: Some of the research institutions and companies involved

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