GM technology in the forest sector

A scoping study for WWF

Rachel Asante Owusu
November 1999

WWF Conserves wildlife and the natural environment for present and future generations.

For further information, contact:

Francis Sullivan
Director of Programmes
WWF-UK
Panda House, Weyside Park
Godalming, Surrey GU7 1XR
Telephone: + 44 (0)1483 426444
Fax: +44 (0)1483 426409
E-mail: fsullivan@wwfnet.org
Website: www.wwf-uk.org

Jean-Paul Jeanrenaud
Head of Forest Programme
WWF International
Avenue du Mont-Blanc
CH-1196 Gland, Switzerland
Telephone: + 41 22 364 91 11
Fax: + 41 22 364 53 58
Website: www.panda.org

Contents

Executive Summary

It is becoming increasing difficult to determine how the GM issue will unfold over the next 18 months. In a recent report to WWF, it was stated that "although GM trees posed a risk to biodiversity conservation, the main threat would continue to come from GM agriculture". In the light of this scoping study, such a statement, while probably true, cannot be taken as definite. While biotechnology may be under siege or even in trouble in the food crop sector, it is growing strong in the non-food sector, including industrial forestry. Genetic modification offers the industrial forest sector, with its long-standing limitations on tree improvement, potential for development that would not have been thought possible 15 years ago.

Poorly regulated and controlled commercialisation of biotechnology in the forest sector poses additional risks compared with agriculture. The long timeframe and typically remote locations of plantations mean that additional safeguards are required in national and international biosafety protocols. However, while the real risk of genetic pollution and invasiveness should not be underestimated, more immediate problems associated with the intensification of land use should not be forgotten either. Biotechnology may inadvertently become yet another driver for inappropriate plantation development. Increased soil nutrient and water demand of fast growing species on short rotations could lead to irrecoverable loss of site productivity.

Since 1988 there have been 116 confirmed GM tree trials around the world. Analysis of the data shows that the growth in trials and number of species used has risen sharply since 1995. There is a sharp North-South divide on the type of trial and the research institutions involved. In North America and the European Union, research is typically controlled by government and academia, while in the countries of Latin America, Africa and South-east Asia, research is being driven by the private sector. All the indications are that commercial GM plantations will make their debut in Indonesia, Chile and possibly Brazil. Little information was available from China but it is suspected that transgenic trees will be an important issue there.

As all indications point towards the fact that biotechnology is here to stay, it is recommended that WWF seek to facilitate an agreed set of guidelines between industry, government, NGOs and other stakeholders on environmental regulations and safeguards concerning the testing and commercialisation of GM trees. A complementary work programme is proposed.

1 Introduction

1.1 BACKGROUND TO THE STUDY

Over the past two years, public, media and NGO attention has focused on GM agricultural crops with little consideration being given to transgenic trees. In May 1999, WWF International commissioned a short report entitled *Genetic Modification in Tropical Forestry*[1], whose aim was to establish whether biotechnology was an emerging "forest" issue.

The report concluded that biotechnology was indeed an emerging "forest" issue and highlighted that although transgenic trees are not yet being grown commercially, a series of GM field trials are already under way. The report also drew two more general conclusions concerning biotechnology and the environment: first, that although concern over GM technology at present tends to concentrate on health risks, the more serious environmental and social impacts are being under-estimated. Second, that high profile campaigns (*eg* Greenpeace) on GM technology should be complemented by scientifically-based lobbying and advocacy for watertight monitoring and regulation of GM field trials and international trade. Finally, the report recommended that, as an initial step, WWF should assess the extent to which GM technology impacts upon the forest sector by undertaking a 15-day scoping study.

This report is the product of that study, which included attendance at the Forest Biotechnology 99 symposium at Keble College, Oxford, in July. Its purpose is to provide an informed basis on which a more substantial programme of forest-related policy and advocacy work on biotechnology can be developed. In particular, this report seeks to ascertain the degree to which GM technology has already impacted upon the forest and forest-related sectors, evaluate its future potential and briefly review the adequacy of national and international controls governing testing, production and trade.

This report has been commissioned by the International Conservation Department of WWF-UK and the Forests For Life Programme Unit of WWF International.

1.2 THE ENVIRONMENT AND GM TREES: A CAUSE FOR CONCERN?

Given that biotechnology is an emerging issue in the forest sector, it is appropriate to begin this study by considering whether the utilisation of GM trees represents sufficient risk and uncertainty as to merit prioritisation by environmental NGOs. Is it not strategically more important to deal with GM agricultural crops? After all, tree crop plantations (whether for timber, resins, fruits or other products) only occupy a very small proportion of the world's surface area compared with agriculture.

[1] Genetic Modification in Tropical Forestry is available from the Forests for Life Programme Unit of WWF International. Contact Astrid Bjorvik on abjorvik@wwfnet.org or +41 22 364 9019.

1.2.1 Risk and uncertainty – the time factor

Insertion of a novel (introduced) gene can have collateral impact on the rest of the host's genome, resulting in unintended side effects such as salmon engineered for fast growth also developing green-tainted flesh. Most of the time such collateral effects will be immediately recognisable, but in some instances it may alter the behaviour of **silent** genes, ie those that are activated only under certain circumstances. Of particular concern are the risks associated with collateral alterations to stress-activated genes, for such effects cannot be anticipated until the stress response is actually triggered.

With annual and short-lived perennial agricultural crops the relatively limited cycle can act as an informal, if unsatisfactory, safeguard. Changes in the ecological or physiological behaviour of an agricultural crop will be relatively easy to detect and, given resources, remedial action can take place. However, trees differ from most agricultural crops in that they persist in the landscape for long periods of time. This different timeframe not only increases the probability that any one tree crop will be subjected to a much wider range of stress conditions (*eg* temperature extremes, insect attack, effects of climate change), but also that any stress-induced side-effect of GM technology will be much harder to detect and address.

The time factor also has a bearing on the risk of novel gene mutagenesis (random changes to the genetic code). Current GM technology operates under the assumption that the novel gene is just as stable as those naturally found within the host's genome. However, this is far from certain and scientists are only now starting to understand gene regulation and repair processes. Some recent experience points towards novel genes being inherently less stable. One area where novel gene breakdown is of real concern is plant sterility. In order to allay fears that a GM crop could become a super-weed (and to ensure regular GM seed sales), plant breeders can insert a gene for male sterility along with the desired novel gene. However, should the function of the introduced sterility gene become impaired, supposedly "safe" GM crops will be able to breed and enter the environment. Yet again, the fact that trees have much longer life cycles means that the probability of novel gene breakdown is higher while the chances of detecting such an occurrence are much lower.

1.2.2 Risk and uncertainty – the location factor

A large number of tree plantations are grown on marginal agricultural or forest land in remote locations. Even a high-input, clonal plantation is a lot less intensively managed than the average field of corn. Remote locations and less intensive management regimes mean limited opportunities for monitoring, control and enforcement of regulations while making early detection of unanticipated problems (see 1.2.1) highly unlikely.

Furthermore, while most of the world's agriculture takes place within highly modified landscapes, plantations are often established in close proximity to stands of natural forest. In instances where plantations, or trials, of GM trees species are established close to pools of naturally-occurring wild relatives, the likelihood of genetic pollution will be high. Those who attempt to down-play the risks of genetic pollution are being somewhat disingenuous, for plant breeders have long been concerned with the reverse problem - breeding plot contamination from the influx of wild pollen (*Arriola*). Worryingly, the feasible distance over which gene flow can occur has been revised upwards. Recent studies on both temperate conifers (*Hedrick &*

Savoleinen) and tropical broadleaved species (*Boshier & Billingham*) indicate that long distance dispersal of small amounts of pollen can be considerable. Indeed, given the dynamics of gene flow (pine pollen can be dispersed in excess of 600 km), it would be surprising if some novel gene escape has not already taken place from the GM tree trials that are currently under way.

1.2.3 GM technology as a factor in unsustainable plantation development

Between 1980 and 1995 the plantation area in the developing world doubled and is expected to double again by 2010. This expansion of forest plantations has often taken place at the expense of natural forest and local people's rights. While many NGOs continue to express their concern over industrial plantations (*eg* the Montevideo Declaration) there have also been positive developments such as the increase in area of plantations under FSC certification and renewed interest in the utilisation of native species.

GM super-trees could reverse the modest social or environmental gains in plantation management that have been made over the past decade. Evidence is now emerging that well managed plantations might indeed be sustainable in the "narrow sense" of sustained yield (*Evans, 1999*). This means that given good management practices, plantation tree crops could be grown in perpetuity on the same site without adversely affecting the soil's nutrient status and structure or its hydrological functions. However, the introduction of trees modified for rapid growth could mean shorter, more intense rotations, greater water demand and reduced opportunity for nutrient recycling.

Over the course of two or three production rotations, site productivity would begin to decline, requiring increased fertiliser inputs or - more likely in tropical countries - leading to land abandonment. The land base that would be required to support plantation activities would therefore expand much more rapidly than previously anticipated, possibly impacting on natural forests and other sites of high biodiversity value.

Admittedly there is little direct evidence either to support or reject this scenario - but exactly the same pattern of land use has unfolded with mangrove clearance for shrimp production. Indeed, the main impact that GM technology could have on the environment may not be genetic pollution or super weeds but rather the contribution that it might make to unsustainable land use. Unfortunately, most GM tree trials do not even consider nutrient and hydrological cycling issues.

2 Commercial attractions of biotechnology to the industrial forest sector

For the past 50 years plant breeders have sought to add value to tree crops by increasing the frequency of favourable genes in the commercial planting stock. This has been achieved through laborious and time-consuming techniques that are underpinned by classical Mendelian genetics: isolating individuals with the desired trait, collecting and testing their progeny and crossing high performing individuals. Within the past 25 years advances in vegetative propagation techniques have enabled forest nurseries to produce large quantities of monoclonal planting stock by taking cuttings from the very best individuals: nevertheless, advances in breeding are still limited by the uncertainty that nature provides through sexual reproduction. Furthermore, in many cases the desired traits simply do not exist (or are so rare as to be impossible to isolate) within a species' breeding population. Biotechnology has overcome these limitations.

Although genetic engineering allows for the development of transgenic super-trees, until recently commercialisation was hampered by the inability of biotech companies to produce large numbers of GM planting stock over a short time period at low cost. The mechanisation of a cloning technique called somatic embryogenesis has overcome this last hurdle. Somatic embryogenesis differs from traditional cloning techniques in that it allows very large quantities of seedlings to be produced from very small amounts of plant tissue. However, it initially proved to be too expensive for use in commercial forestry because each cluster of differentiated tree shoots had to be manually plucked from the source tissue before being carefully placed into growth medium. ForBio, an Australian plant biotechnology company, has managed to automate this labour-intensive production stage by using robots, thus allowing the mass production of both GM and non-GM trees from tissue culture to become commercially viable.

It is not inconceivable that biotechnology may offer relatively greater benefits to the industrial forestry sector than to agriculture. Forest scientists will be free to work with only genes of primary interest, delivering improved provenances to the industry in a matter of months rather than years. As there are few direct health concerns it is unlikely that the issue of GM trees will muster the same public opposition as GM food crops have. Indeed, a recent review by Deutsche Bank has declared GM food crops "dead", basically because it foresees a two-tiered marketing system evolve. However, where it advises SELL on companies producing GM food crops, it continues to recommend BUY for those that market other (non-food) GM products. The industrial forest sector, with its long-standing limitations on tree improvement and a global turnover of US$ 400 billion on unprocessed timber alone, may well be the natural ally for biotechnology companies eager to demonstrate the commercial viability of their product away from the spotlight of adverse publicity.

2.1 LIGNIN MODIFICATION

Lignin is a complex organic macromolecule that is a key component of the cell wall. In addition to conferring strength properties it is also a constituent of the tree's defence mechanism and can account for between 15 and 35 per cent of dry weight in woody species. Nevertheless, in the pulp and paper industry, lignin - especially that found in conifers - is undesirable and its removal from wood fibres is a costly and environmentally hazardous process.

Scientists have targeted those genes that code for the enzymes that catalyse the synthesis of monolignols, the building blocks of lignin. This has permitted the development of transgenic poplars with low or modified lignin content. If grown commercially, such trees would reduce pulping costs along with “end-of-pipe” pollution from pulping effluent. But claims of environmental benefits must be considered in the context of the whole production cycle. Modified or lower lignin content may well impair a tree’s pest resistance, requiring the use of additional pesticides. Low lignin can also accelerate wood decay, affecting soil structure and biology and leading to increased fertiliser use. Environmentalists are also concerned that low lignin traits could become incorporated into wild relatives of transgenic species, accelerating their life cycle and thus modifying ecological processes.

2.2 INCREASED GROWTH RATE

Fast growth is an obvious trait targeted by forest biotechnologists. This can be obtained by a number of methods although ForBio is anticipating that the most reliable results can be achieved through the introduction of plant sterility into transgenic tree species. Typically, between 15 and 30 per cent of a plant’s energy supply is used in its reproductive structures such as flowers, cones and fruits. Elimination of these structures would permit additional energy to be redirected towards tree growth. In field trials, transgenic poplars grow at up to four times the rate of the traditional softwood conifers that are used for newsprint.

Companies such as International Paper have argued that higher growth rates allow more wood to be grown on less land and that this has inherent environmental benefits. The reality is that trees modified for rapid growth may well sequester more, and therefore recycle less, nutrients and water, and that this could have a long-term deleterious effect on site productivity. There is also the risk that fast-growing transgenic tree species could become serious invasive weeds, disrupting natural forest ecosystems.

2.3 HERBICIDE TOLERANCE

Herbicide-tolerant crops are already being grown in many countries throughout the world and scientists are now examining whether such properties can be transferred to tree species. As with agricultural crops, the main focus of research is on general systemic herbicides such as Round-Up (glyphosate). The benefits claimed for herbicide tolerance are that it would allow forest managers to reduce the number and intensity of applications, thus minimising maintenance costs at the start of the rotation, especially on difficult sites. On some planting sites, ground preparation could be minimised through better weed control, and this in turn could reduce sediment run-off and soil erosion.

Herbicide-tolerant tree species could eventually pose a threat to other forms of land use and thus people’s livelihoods. If the seed of non-sterile, herbicide-tolerant trees is easily dispersed, the control of woody invasives in some tropical pastureland could become a serious problem. Furthermore, reduced herbicide application may only be a temporary benefit. There is little doubt that regular use of a narrow spectrum of herbicides will augment selection pressure on target weeds in the short run and facilitate herbicide-resistance in the long term. The US Department of Agriculture has recently revealed that many farmers who have converted to GM production are using just as much herbicide as their counterparts who continued to produce conventional crops. USDA divided America into regions and studied the performance of GM cotton, maize and soya beans. It was discovered that in seven out of 12 regions farmers cultivating GM crops were obliged to apply similar quantities of herbicide as those cultivating non-modified crops. Interestingly, the research also indicated that GM yields were not significantly better in 66 per cent of their sample sites.

2.4 INSECT RESISTANCE

One of the most successful agents of biological control, first discovered in the early 1980s, is *Bacillus thuringiensis* (Bt), a bacterium that produces insecticidal chemicals. When ingested, the bacterial spores germinate, producing a toxin that eventually kills the insect. Different strains of bacterium make their own toxin and, to date, scientists have discovered the genetic code for more than 50 Bt insecticides. Several commercial crops have been genetically modified to contain Bt insecticide, including corn, potato and cotton. Field trials of Bt-modified poplar, spruce, walnut and apple have already taken place.

There are several claimed advantages of the Bt insecticide over conventional pesticides. The use of GM insect-resistant plants reduces the necessity for conventional pesticide, and as the Bt toxin quickly denatures in ultraviolet light it will not persist long enough to pollute soil and water. Bacterial toxins are also claimed to be more species-specific and therefore safe for non-target plant-feeding species. However, this claim has been brought into doubt by recent research on monarch butterflies, a non-target species found to be susceptible to the pollen of Bt maize.

Scientists openly acknowledge that Bt crops will augment the selection pressure placed on target pests and that this will inevitably lead to an increased frequency of Bt-resistance genes within the insect's gene pool. In order to counteract this threat, biotechnology companies such as Monsanto advocate that farmers adopt a **refuge strategy**. This consists of establishing a discrete outer buffer of a non-Bt crop around the Bt crop of the same species at a 1:5 ratio. The idea is to create a sufficiently large enough non-Bt feeding ground so that Bt resistance confers no real long-term advantage within the target insect population.

Research published by the University of Arizona has now cast doubt on the long-term efficacy of Bt-insect resistance in crops, even where a refuge strategy is rigorously pursued. It has been demonstrated that Bt-resistant and Bt-susceptible pink bollworms (a cotton pest) mature sexually at differential rates. Therefore Bt-resistant insects are more likely to breed among themselves and, contrary to the conventional wisdom that underpins the refuge strategy, a Bt-resistant insect population will quickly develop. Given that Bt-crops eliminate some competition from other insect herbivores, this new population should rapidly expand.

One of the problems with Bt resistance is that, despite claims to the contrary, it behaves as a fairly wide-spectrum pesticide. Biotechnologists are now looking at engineering much more specific resistance into trees. Genfor SA and the Forest Research Institute of New Zealand are presently developing a transgenic *Pinus radiata* that is resistant to the European shoot moth, a pest of great economic importance for the Chilean forestry industry. Similarly, the University of Dundee is seeking to reverse the damage and landscape-level impact caused by Dutch elm disease through introducing pathogen-tolerant genes into *Ulmus procera* and *U. glabra*.

2.5 PRODUCT UNIFORMITY

One of the main problems with wood as a raw material is that it is an inherently variable product. From the production point of view, plantations have a major advantage over natural forest in that they offer large amounts of material whose sawing, seasoning and other working properties are largely predictable and uniform. However, even in plantations, lack of product uniformity can be a commercial drawback.

While differences in tree height, trunk diameter, branch spacing and tendency to branch can all be controlled by silvicultural interventions, this demands time and resources. Obviously trees that could deliver a similar or even more uniform product for less effort/expenditure would offer a large commercial advantage. Consideration as to how this might be achieved is still in its infancy, and to date no known field trials have been established. Indeed, it is likely that a number of modified genetic characteristics would have to be inserted into target tree species to obtain the desired effect - for example improved self pruning and maintenance or enhancement of any growth advantage.

In conclusion, while product uniformity may be the most elusive to obtain, it may also provide the greatest commercial dividends. But from the social point of view, it would mean less opportunity for local employment, as forests could be managed with even smaller work forces. Environmentally, it could further simplify the structure of plantations and thus further reduce their ability to deliver an already limited range of ecological and social forest functions.

2.6 CARBON SEQUESTRATION

Although the rules for the sequestration and storage of biotic carbon have not been fully agreed by the United Nations Framework Convention on Climate Change, the possibility of utilising trees as “carbon sinks” that could slow the rate of global warming has been the focus of much speculation and debate. As a consequence of this, some CO_2 emitting industries have already turned their attention towards the feasibility of engineering tree species that can sequester and store high levels of carbon.

Since 1993, Toyota, the Japanese car manufacturer, has established several field trials in Japan to test the efficacy of transgenic carbon sequestering trees. While there has been an observable increase in carbon sequestration and storage, Toyota scientists also reported an unacceptable increase in water consumption. Toyota has currently turned its attention away from transgenics towards tetraploidy (doubling the number of chromosomes that a plant naturally carries). Tree breeders have known about tetraploidy for many years but its commercial applications have been mainly limited to the development of ornamental shrubs and trees. One reason why it has not entered mainstream tree breeding is that, although it confers some advantages such as vigorous growth (*ergo* higher rates of carbon sequestration), the quality of the wood is notoriously weak (*Wright*). If this problem cannot be resolved, Toyota’s “designer” trees will fail in their principal objective: to sequester and *store* carbon. It is therefore probable that those seeking to develop trees with enhanced rates of carbon sequestration will return to GM technology sooner rather than later.

2.7 NON-COMMERCIAL DESIRABLE TRAITS

In addition to commercial advantage, trials are also under way to introduce characteristics that do not add value *per se* to the host organism. These non-commercial desirable traits may be necessary either as a prerequisite for wild release or as an unavoidable stage in the manipulation process.

2.7.1 Sterility

Although sterility may confer commercial advantage under some conditions (see section 2.2), it may also become a prerequisite for GM release. Many advisory bodies such as English Nature believe that before GM crops can be released they must be made sterile to prevent novel gene escape into wild populations. However, as discussed earlier, the behaviour of essentially "silent" genes is problematic, especially over the time-scales involved in plantation forestry. For example, transgenic aspens grown in Germany to evaluate herbicide tolerance also displayed precocious flowering at year three. Normally, flowering in poplar is not expected before year eight.

Many concerns over unstable or incomplete sterility arise from the fact that engineered sterility is usually gender-specific. ForBio is the first biotechnology research institution to genetically engineer total sterility into trees by blocking the development of both male and female sexual structures at very early stages of growth. It is fair to say that this development will lessen (though not eliminate) the likelihood that the sterility safeguard could break down in the future. However, some ecologists are horrified at the prospect of sterile trees, for although plantations are poor imitations of natural forest they may be the only repository of remnant, forest-dependent insect life in a particular locality. Remove the flowers, fruits and cones - and the plantation, to all intents and purposes, becomes sterile itself.

2.7.2 Non – "antibiotic resistant" marker genes

Contrary to the image portrayed by biotechnology companies, novel gene transfer can be a hit and miss affair. At one stage in the transfer process, when the novel gene has been inserted into bacteria to facilitate replication, it is necessary to distinguish those bacteria that possess the desired gene from those that do not. To distinguish between the haves and the have-nots, an additional marker gene accompanies the novel "desired" gene. Often this marker gene is for antibiotic resistance, so that only the bacteria with the "novel gene plus marker" construct will grow on a medium containing the antibiotic. This makes antibiotic-resistant markers very useful in GM technology, by saving time that would otherwise be spent verifying the presence of the new gene construct.

Unlike GM food crops, the safety of antibiotic resistance markers in tree species is debatable. Theoretically, there is a risk that trees could transfer this resistance horizontally (via asexual mechanisms) to biomedically significant micro-organisms - but such risks are exceptionally small. Even so, companies may not wish to attract adverse publicity, especially when the use of antibiotic-resistant markers is unnecessary. Innocuous alternatives are now available, such as the GUS (ß-*glycuronidase*) reporter gene which monitors the expression of novel gene constructs by showing blue when positive.

2.8 OVERALL UTILITY OF GENETICALLY MODIFIED TRAITS TO THE INDUSTRIAL FOREST SECTOR

Table 2.1 summarises how the industrial forest sector perceives the utility of those modified traits discussed above. While environmental claims may be the most frequently cited utility, this must be treated with the utmost caution as the real driving force is that of the industrial forest sector's "bottom-line". The expense and effort of biotechnology will only be justified for those traits that are economically important and which cannot be delivered by conventional plant breeding techniques within a reasonable period of time. It is perhaps worthwhile reiterating that industrial forestry has been limited by conventional tree improvement, and that the prospect offered to it by biotechnology may be too good to turn down. One credible scenario for the development of biotechnology in the forest and agriculture sectors over the next two years is that investment in GM food crops, especially in developed countries, declines while investment in GM tree crops in Chile and Indonesia, and possibly Brazil and China, develops rapidly.

Table 2.1 Perceived utilities of genetically modified traits to the industrial forest sector

	Perceived utility of traits					
Modified traits	Cost saving at plantation establishment	Environmental based marketing and publicity[2]	Insurance against market/ environmental uncertainty	Ability to regenerate desired species in plantations	Reduced costs of pulp production	Expanded manufacturing opportunities
Lignin modification		•			•	•
Increased growth rates	•		•		•	•
Herbicide tolerance	•	•				
Pest/disease resistance	•	•	•	•		
Product uniformity			•		•	•
Carbon sequestration	•	•				
Sterility		•				
Non-antibiotic markers		•				

[2] A distinction has to be drawn against claimed envrionmental benefits that would be used primarily for marketing and advertising, as opposed to *actual* environmental benefits. Until adequate, transparent and properly controlled field trials take place, supervised not only by industry and government, but also civil society, such claims must be treated with the utmost caution.

3 Growth and development of GM technology in the forest and related sectors

3.1 GLOBAL TRENDS

The following analysis is based on reliable data sources only. It has been drawn from databases maintained by governments and/or multilateral organisations such as OECD (Organisation for Economic Cooperation and Development), reports in scientific papers and conference proceedings, and direct communication with research institutes. Partial information - for example, general articles in the popular press - has not been used unless it has been verified by a reliable independent source. Unapproved applications for wild release have not been included either. It is therefore important to understand that the following information represents an under-estimate of the extent that GM trees species have been released into the environment. Given the rapid growth in the number of field trials, it is also important to realise that this information will be out of date within three to six months from the time of writing.

Given the limited period of this study, it proved impossible to ascertain whether any field trials or commercial release of GM tree species had taken place in China or India. However, given the advanced state of biotechnology in both countries and the growing internal demand for forest products, field trials may have already started.

3.1.1 Global overview

Based on a preliminary survey there have been 116 confirmed field trials, involving at least 24[3] tree species, in 17 countries since 1988. The survey incorporated tree species for both fruit and timber production, although 76 per cent fell into the latter category. A map illustrating the distribution of GM tree field trials, by country, is presented as Figure 3.1.

Based on the data collected for this survey, there have been no confirmed reports of commercial production of GM trees. However this situation is far from clear; Shell Forests believes that there is still a significant body of development to be carried out to prove that the technology is sound, environmentally acceptable and economically worthwhile. In its view, the commercial application of GM trees is still several years away. Nevertheless three important consortia have been formed over the past four years (see box 3.1) and indications are that commercial production may soon begin in Indonesia, with Chile following closely behind.

[3] It was not possible to determine the exact number of species used in trials as common names or the genus were only cited on a few occasions.

Box 3.1 Forestry-biotech joint ventures: a prelude to commercial production

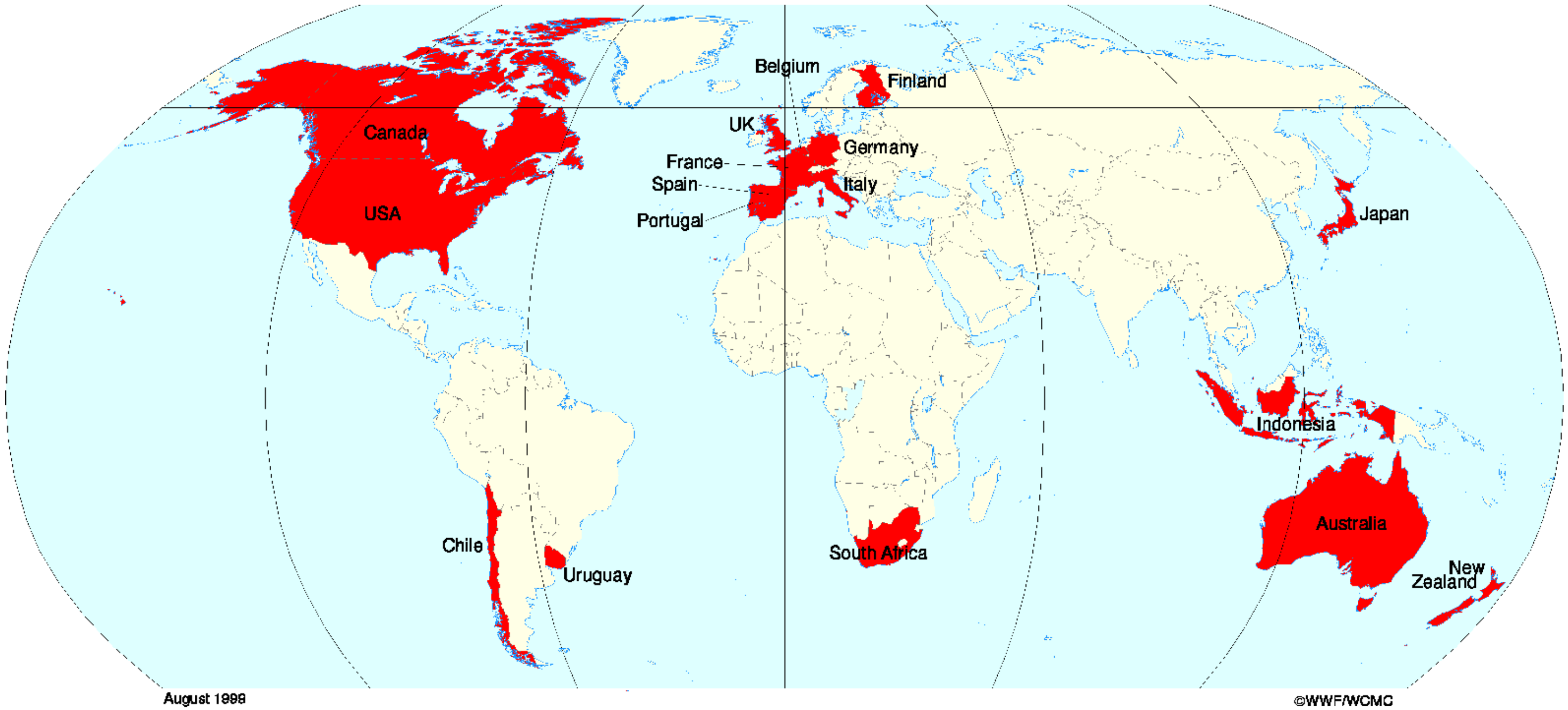
Over the past four years, three important joint ventures between forestry and biotech companies have been agreed. While the formation of these consortia has passed relatively unnoticed, their significance should not be underestimated, for it represents the transition of forest biotechnology from minor to major league.

Fletcher Challenge Forests, International Paper, Monsanto and Westvaco Announced 6 April 1999 and worth US$ 60 million over five years, this joint venture is perhaps the best known of the three forest-biotech consortia. The joint venture will seek to acquire genomic forestry intellectual property rights from universities, independent labs and others in order to position itself to market new advances in forest biotechnology. Obviously, its main area of interest concerns plantation species such as poplar, radiata and loblolly pine and eucalyptus. Targeted genetic improvements are herbicide tolerance, improved growth rates and product uniformity (especially fibre quality). Of all three consortia, its primary objective would appear to be the capture, application and marketing of genetic patents.

Monfori Nusantra Established in 1996, this Indonesian company is a joint venture between Monsanto and ForBio, an Australian plant biotechnology company. The primary objective is wood fibre production and a new automated plant that enables mass propagation of planting stock from tissue culture has already been opened. The aim is to produce 10 million seedlings per year. Five trial sites have been established in Sumatra and Kalimantan, and initial results indicate that the rotation for species such as teak, acacia and eucalyptus could be halved. Little has been heard of the initiative over the past year and its plans may have suffered as a result of the Asian economic crisis. Nevertheless, the ForBio website still publicises the relationship.

GenFor SA Announced on 10 March 1999 and worth an initial investment of US$ 5 million, this is a joint venture between Fundación Chile, Interlink Associates (USA) and Silvagen Inc (Canada). The consortium is partly financed by the Chilean Development Agency (Corfo) and seeks to focus primarily on the development of transgenic radiata pine that has enhanced pest and disease resistance, faster growth rates and better pulping qualities. The first field trials of transgenic radiata pine will probably be for resistance to the European shoot moth and are due to start in early 2000.

Countries where field trials of GM tree species have been conducted



Countries where field trials of GM tree species have been conducted

Australia >1	Japan >1
Belgium 4	New Zealand 2
Canada >2	Portugal 1
Chile >2	Spain 4
Finland 3	UK 5
France 8	USA 69
Germany 1	Uruguay >1
Indonesia >6	South Africa >1
Italy 5	
	Total >116

The material and the geograhical designations in this report do not imply the expression of any opinion whatsoever on the part of WWF concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries.

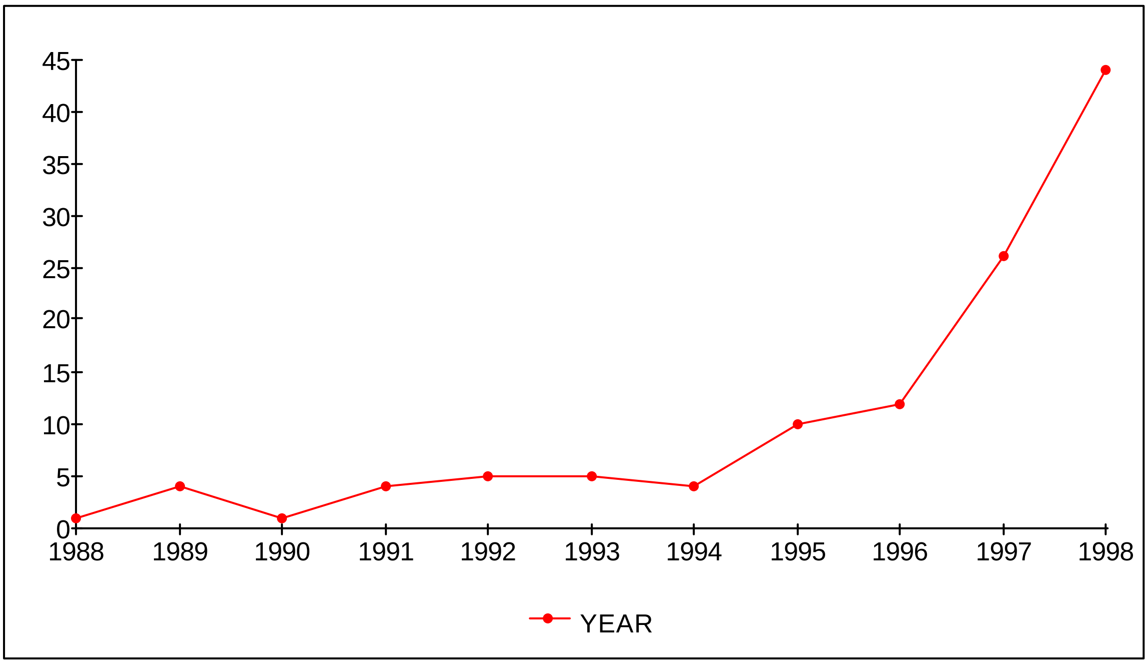
WWF

Compiled by: M Edwards at WCMC, Cambridge, UK

3.1.2 Global growth in GM-tree field trials

The first confirmed record of a wild release of a genetically modified tree species is that of a poplar trial in Gent, Belgium in 1988. The first half of the 1990s witnessed a modest growth in research trials that never exceeded five per year. However, over the same period biotechnologists had extended their trials to incorporate 11 tree species, although they continued to focus on a narrow range of traits, namely herbicide resistance and disease/pest resistance. The latter half of the 1990s has seen an exponential increase in the number of trials and in the number of species tested. In 1998 alone - the last year sampled - there were 44 new trials, an increase of more than 50 per cent on the cumulative total of all preceding GM tree trials.

Figure 3.2 Number of new GM tree (timber & fruit) releases per year



3.1.3 GM tree species

There are now at least 24 species that have been subject to transgenic modification and released into the environment, albeit through controlled field trials. Table 3.1 gives details of the species that have been modified and field tested, including the first recorded year of their release. It is interesting to note that the last three years (1996-1998) saw the number of trial species more than double. Other sources have reported more extensive lists of transgenic tree species, including almond (*Prunus amygdalus*), cocoa (*Theobroma cocoa*), coffee (*Coffea arabica*), elm (*Ulmus spp.*), larch (*Larix spp.*) and pear (*Pyrus communis*). However, no independent verification of field trials for these species could be obtained, and it is likely that some of these additional reports refer only to greenhouse trials.

Table 3.1 GM tree species that have been released into the environment through field trials.

Common name	Scientific name	First year of release
*European aspen	*Populus tremula*	1988
American black walnut	*Juglans nigra*	1989
*Poplar	*Populus spp.*	1989
Papaya	*Carica papaya*	1991
*Apple	*Malus domestica*	1991
*European sweet chestnut	*Castanea sativa*	1992
Plum	*Prunus domestica*	1992
*Red river gum	*Eucalyptus camaldulensis*	1993
Black spruce	*Picea mariana*	1993
Sweetgum	*Liquidambar styraciflua*	1994
*European black poplar	*Populus nigra*	1995
*Silver birch	*Betula pendula*	1996
American chestnut	*Castanea dentata*	1996
*Sweet orange	*Citrus spp.*	1996
*Tasmanian blue gum	*Eucalyptus globulus*	1996
*Norway spruce	*Picea abies*	1996
Pine	*Pinus spp*	1996
*Scots pine	*Pinus sylvestris*	1996
Acacia mangium	*Acacia mangium*	1997
Monterey pine	*Pinus radiata*	1997
Teak	*Tectona grandis*	1997
Flooded gum	*Eucalyptus grandis*	1998
*Olive	*Olea europea*	1998
Pine	*Pinus spp.*	1998
Eastern cottonwood	*Populus deltoides*	1998
Quaking aspen	*Populus tremuloides*	1998
*Cherry	*Prunus avium*	1998

(* Denotes modified species grown in Europe)

3.2 GM TECHNOLOGY AND FORESTS IN THE EUROPEAN UNION

There have been 31 releases of GM tree species since 1988 in the European Union, distributed among eight member states (Belgium, Finland, France, Germany, Italy, Portugal, Spain and the United Kingdom). The EU holds a comprehensive database of transgenic releases and member states are obliged to update it. The vast majority of trials have been initiated by either academic or state research institutions. However, three private companies, Shell Forestry, Zeneca Ltd and Stora Celbi have also established trials. Environmental activists destroyed two of Zeneca's poplar trials at its site in Jealott's Hill in a recent protest attack.

Approximately 40 per cent of the trials have been designed to evaluate marker genes (a genetic modification of an organism so that it produces a substance not occurring naturally by which the presence of the novel gene constructs can be traced), while a further 25 per cent examine herbicide tolerance. Other traits being investigated include male sterility, enhanced growth, lignin modification and insect and disease resistance. With the exception of *Eucalyptus camaldulensis* and *E. Globulus,* the other 11 species are either native to, or have been naturalised within Europe. Among these are poplar, olive, birch, Norway spruce and Scots pine. Two thirds of all releases have occurred since 1995.

3.3 GM TECHNOLOGY AND FORESTS IN CANADA AND THE US

By far and away the largest number of GM tree releases via field trials has taken place in the United States and Canada: 61 per cent of the worldwide total. Between 1998 and 1999, 71 confirmed releases have taken place. Like the European Union, the USDA maintains a comprehensive database that contains information and status reports on all GM release applications (whether approved or denied). All but one of the confirmed North American releases have taken place in the United States, and by far the majority of these (over 56 per cent) are located in Oregon, California and Washington State. Ten other states, principally in the North-east, have also established trials. Like Europe, the majority of trials are under the auspices of government or academic research institutions, and only 13 per cent are directly under the control of four private sector companies (Union Camp, Westvaco, Weyerhauser and Monsanto).

Interestingly, compared with Europe, there has been a marked difference in terms of modified traits. The majority of the releases in Canada and the US have been designed to evaluate insect or disease resistance (53 per cent) and herbicide tolerance (17 per cent). There appears to be limited interest in traits such as sterility (4 per cent), although engineered sterility is often used by GM proponents as an example of how the industry has built environmental safeguards into their trials. There is also a more limited species range being tested than in Europe. Only eight tree species have been confirmed as being transgenic, and of these three are fruit trees. Half of all trials have been on poplar species, followed by American black walnut (14 per cent). Four trials of Papaya have been released in Hawaii. Finally, 80 per cent of all trials in North America have been released since 1995.

3.4 GM TECHNOLOGY AND FORESTS IN ASIA AND OCEANIA

Asia and Oceania provide an interesting comparison with North America and the European Union. Like Latin America and Africa there are relatively few trials, but most are directly under the control of the private sector. Of the 10 confirmed trials in this region, only 30 per cent originate from government or academic institutions. However, this split should be interpreted with caution for there was not sufficient time to make contact with reliable sources in China and India. If there are GM tree trials under way in those two countries, then it is highly likely that they are state-funded. There has also been a sharp increase during 1999 (a year excluded from analysis as it is difficult to distinguish between applications and established trials) in applications for GM tree trials in New Zealand. These came from an even mix of academia and the private sector.

Five tree species have been recorded as being modified: apple, radiata pine, eucalyptus, teak and *Acacia mangium*. All the trials, with the exception of an apple trial in Australia, have been established since 1995. Another area in which Europe/North America differs from Asia/Oceania is the type of traits that are being tested: 41 per cent of trials are field evaluations for growth performance while another 37 per cent are designed to test trees modified for sterility. These two traits are compatible and, in some cases, are being examined in the same field trial. In part, this can be explained by the fact that ForBio, an Australian biotechnology company that has pioneered total plant sterility, is involved in the trials. It also reflects the fact that many of these trials are explicitly commercial in nature.

In conclusion, it may be the case that GM tree trials are much more extensive in Asia than are highlighted in this report. China and India may well have a GM tree programme, while commercial production of transgenic trees species may have already started in Kalimantan and Sumatra. It is probably safe to conclude that GM tree trials can be found beyond the confirmed reports in Australia, Indonesia, Japan and New Zealand.

3.5 GM TECHNOLOGY AND FORESTS IN LATIN AMERICA

Latin America has only three reported trials of GM tree species *Eucalyptus globulus*, *Pinus radiata* and *Eucalyptus grandis*, which are limited to Chile and Uruguay. It was not possible to obtain information from Argentina, but there is reason to suspect that GM tree species field trials, supported by New Zealand’s Forest Research Institute, will soon be established there. Shell has applied for permission to establish trials in Brazil but this is being delayed by a conflict between state and federal government over GM releases. Like Asia, GM trials are being financed and directly supervised by the private sector. From confirmed reports received, there is no government or academic involvement, although again it must be emphasised that a comprehensive survey of the region could not be carried out in the time available. The traits being examined are lignin modification (40 per cent) and herbicide tolerance (40 per cent).

3.6 GM TECHNOLOGY AND FORESTS IN AFRICA

Confirmed GM trials in Africa are limited to one in South Africa. This is a pine modified for sterility and is financed and supervised by Shell Forestry. However, unconfirmed information from other sources indicates that this is not the true situation, and that the industrial forest sector in South Africa (and possibly Zimbabwe) is exploring the use of GM tree species. Furthermore, if specific transgenic technologies were developed for southern Africa, it is not unreasonable to expect that they would quickly spread to other countries in the region.

In conclusion, more attention should be focused on ascertaining the full extent of GM technology within the Asian, Latin American and African forest sectors. While their contribution to the global whole may appear modest, it is in these regions that private companies have declared their intention to establish commercial GM plantations. Conversely, it is anticipated that field-based research will continue in North America and Europe for several more years before any decision about scaling-up to commercial production is taken.

4 Regulations for the testing and commercial production of GM tree species

Being based on OECD guidelines, the regulatory frameworks put in place to oversee the experimental and commercial release of genetically modified organisms are broadly similar in most industrialised countries. The OECD published recommendations in 1986 concerning the safety of transgenic organisms, and although these are not binding on any member state, they have influenced regulations in many countries including Germany, Japan, the Netherlands and the US. Conversely, many developing countries lack even an elementary regulatory framework for genetic engineering, presenting an opportunity to those multinationals that wish to invest in GMOs but are restricted by regulations in industrialised countries.

In September a workshop organised by the Norwegian Institute for Nature Research was convened in Trondheim on behalf of the OECD's *Working Group on Harmonisation of Regulatory Oversight in Biotechnology* to consider environmental implications of GM trees. Its principal objective was to examine whether environmental considerations surrounding genetically modified trees were sufficiently different from those concerning other GMOs as to merit the establishment of separate guidelines. The intended output of the workshop was a set of recommendations on GM trees that would be submitted to the OECD's biotechnology working group. The workshop was important inasmuch as any recommendations produced could be included in future OECD guidelines, and these could form the basis of national regulations on GM trees.

A full assessment of the safeguards and loopholes provided by each set of national regulations lies outside the scope of this study. However, one area of concern is that all regulations for transgenic species were designed principally to control the wild release of annual and short-lived perennial agricultural crops. There has been little consideration of tree crops and the biosafety issues that are peculiar to them. While there is little direct evidence to suggest that this situation presents an immediate environmental risk, it makes good sense that governments should begin to deal with this issue now rather than wait until an unforeseen problem emerges.

Central to the formulation of appropriate regulations for GM tree crops are properly controlled, long-term field studies designed to examine not only novel gene stability and transgenic behaviour but also tree crop-induced fluxes in soil nutrient status and soil water availability. The New Zealand Forest Research Institute has applied to undertake a 22-year study of sterility in transgenic radiata pine - but such long-term thinking is the exception rather the rule.

4.1 A BRIEF OVERVIEW OF EUROPEAN UNION REGULATIONS

In 1988 the European Union published a framework for the regulation of biotechnology to help member states harmonise their own national legislation. This led to the 1990 Directive 90/220/EEC on the Voluntary Release of Genetically Modified Organisms into the Environment. All member states have now passed legislation that is in line with this directive.

Within the EU most of the responsibility concerning the release of GMOs lies with the individual member state. It is its prerogative to decide the character and extent of experimental trials that take place within its national territory. Once a GMO release has been approved, member states are then obliged to monitor its human health and environmental impacts. Interestingly, consent for the marketing of products consisting of or containing GMOs within the EU, or any of its member states, can only be obtained from the Commission (shared between DGIII – Industry and DGVI – Agriculture). Similarly, transport of GM products within the EU is controlled by DGVII (Transport).

Any company or institution wishing to undertake deliberate release of a GMO must first submit notification to the competent authority within the member state. This notification must include a technical dossier that contains a full risk assessment and appropriate safety and emergency response measures. In the case of the manufacture or distribution of GM products, precise instructions and conditions for use must be provided in the dossier, along with a proposal for labelling and packaging. On receipt of notification, the national authority is required to respond within 90 days. Each member state must also the send the Commission (DGXI – Environment) a summary of each notification within 30 days of its receipt. The Commission then forwards these summaries to the other member states for information and, where appropriate, for comment.

Within the past 18 months the Commission has proposed two important initiatives on GMOs. The first, presented in February 1998 and approved by the Parliament (subject to amendments) in March 1999, was to review and amend Directive 90/220/EEC (governing the deliberate release of GMOs into the environment). The proposal sought to:

1 make the procedure for granting consent to companies wishing to market GMOs more efficient and more transparent, limited to a fixed period and conditional of compulsory monitoring of health impacts; and
2 make provision for a common methodology to assess the risks associated with the release of GMOs into the environment and a mechanism which would allow the release of any GMO to be modified, suspended or terminated where new information on the risks of such release became available.

Once the proposal is adopted, the Commission will be obliged to consult the competent scientific committees on any question which may affect human health or the environment upon the release of any GMO.

The second proposal sets out minimum requirements relating to the genetic characters and external quality of forest reproductive material marketed within the EU. Member states will be obliged to develop a register of approved source material for tree species that are planted commercially within its territory. Should the source material be transgenic by nature, an environmental risk assessment will be mandatory in line with standards laid out in Directive 90/220/EEC. Individual member states will then be required to make this information available to the Commission and other countries within the Union.

4.2 THE REGULATORY FRAMEWORK IN THE UK

Both the marketing and deliberate release of GMOs in the United Kingdom is subject to the Environmental Protection Act and the Genetically Modified Organisms (deliberate release) Regulations. Release into the environment may only take place if there is prior consent from the Secretary of State for the Environment and from the Ministry of Agriculture, Fisheries and Foods.

Fifteen advisory committees have been established to assist the government on various aspects of biotechnology. The Advisory Committee on Releases to the Environment (ACRE) is responsible for determining the safety of GMO field trials and the marketing of GMOs. ACRE is required to assess each new application and provides advice on the risks that it may pose to human health and the environment. It will recommend to the government whether consent should be granted for the application and the degree of risk management required as a condition of release. ACRE has faced mounting criticism for its links with the biotechnology industry, and in April 1999 the government undertook to replace 10 of its 13 members in order to broaden the committee's membership and restore public confidence.

The Prime Minister recently set up a new cabinet committee to oversee developments in the biotechnology industry, with the aim of ensuring that there are no gaps or unnecessary overlaps in the UK framework of regulatory and advisory committees. As a result of its deliberations, two new commissions have been created. The Human Genetics Commission will advise on genetic technologies and their impact on humans, while the Agricultural and Environmental Biotechnology Commission will focus on biodiversity and other environmental issues associated with GM plants and crops.

4.3 THE REGULATORY FRAMEWORK IN THE US

The agencies primarily responsible for regulating biotechnology in the United States are the US Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and the Food and Drug Administration. GM products are regulated according to their intended use, with some products falling under the remit of more than one agency. In the case of GM trees the agency responsible is the USDA; however, where modified traits may have an environmental impact - for example, insect resistance (Bt plants) or herbicide tolerance - the EPA will also conduct a regulatory review.

The USDA regulates novel plant release through its Animal Plant Health Inspection Agency (APHIS). Applicants for GM releases must provide details of the organism, the genes transformed, their products and the purpose of release. In the case of field trials the experimental design and precautions against accidental escape of the GMO must also be included in the application. APHIS may also demand special precautions such as closed containers for transport to field site and field cages to minimise the risk of pollen escape. APHIS permits for release into the environment are usually issued or denied within 120 days and during that time state officials will inspect the facilities to determine security and operating conditions. Permits for field trials are renewed annually.

Before commercialisation, genetically engineered plants must conform to standards set by State and Federal marketing statutes. There are no national requirements for varietal registration of new plants.

4.4 THE REGULATORY FRAMEWORK IN NEW ZEALAND

The Environmental Risk Management Authority (ERMA) controls the development, import, testing and release of genetically modified organisms in New Zealand. GMOs are regulated under the Hazardous Substances and New Organism Act, the purpose of which is to protect the environment and public health. Before granting approval for the release of any GMO, ERMA must take into account the sustainability of all native and “valued” plants; the intrinsic value of the ecosystem; and the economic and related benefits to be derived from the product.

Applications for the development of GMOs in containment at universities and research centres are defined as low risk developments. In these cases ERMA can delegate approval to special committees established by research organisations. The committees must keep detailed records and report their actions to ERMA.

While the New Zealand regulatory framework is thorough in many aspects there are also elements that give cause for concern - for example, designated “low risk developments” are not publicly notified. Furthermore, while ERMA may attach conditions on field trials of GM trees, such safeguards cannot automatically be extended to transgenic plantations approved for commercial production on the basis that HSNO declares consent for general release as unconditional. Therefore, ERMA has no control over future use of the GM product.

4.5 THE REGULATORY FRAMEWORK IN JAPAN

Regulation of GM trees in Japan is the responsibility of three ministries. The Ministry of Education, Sport and Culture controls all experimentation in university research facilities while the Science and Technology Agency oversees all other research in private sector and “non-academic” institutions. Applications for commercial production of GM trees must be addressed to the Ministry of Agriculture, Forestry and Fisheries.

Before any GMO is released for field trials or commercial production it must first be grown in a simulated environment and assessed for biosafety. In the case of GM trees no minimum time requirement is given for biosafety to be ascertained. Under these artificial conditions GM trees are not allowed to propagate naturally or influence plants in the outside area via pollen. There is insufficient information to ascertain the strengths and weaknesses of this regulatory framework.

4.6 AN OVERVIEW OF NATIONAL REGULATIONS

With the exception of the European Union, no other regulatory system has made provision for the additional complications posed by the long-term persistence of GM trees in the landscape. The feasibility of managing gene flow and minimising the risks of genetic pollution appear only to have been considered in the US and Japan, and only under certain conditions. Nevertheless, even in these cases the risk of eventual pollen release, due to either act of God or human error, must increase significantly over time. Furthermore, the impact on non-target organisms has not been satisfactorily addressed with GM agricultural crops and - given the lifespan of trees - this issue becomes more pressing.

Some of the regulations are decidedly short-term, allowing trials to be strictly managed yet failing to make provision for the same safeguards at general release. Perhaps most worrying is the fact that while the regulations are rightly concerned with biosafety issues, they tend to overlook the impact that fast-growing, long-lived plants may have on-site productivity. While the prospect of horizontal transfer of Bt genes into other organisms or genetic pollution running rampant through wild relatives grabs the headlines, it is likely that GM trees may first manifest themselves as a problem in more mundane ways. GM super trees possess all the characteristics of a good weed and risk becoming invasives, and very fast growing, nutrient-demanding plantations operated on short rotations could drive inappropriate plantation development.

5 Regulating the international trade in GM forest products

5.1 INTERNATIONAL TRADE IN GMOs

There are two main issues that concern GMOs in international trade: the protection of intellectual property, and the regulation and control in the movement of novel (artificial) life forms. However, there are two sides to the intellectual property argument when it comes to genetic material, and the way that it has been dealt with illustrates the imbalances that pervade the global economic system.

5.1.1 Life form patents and intellectual property

The General Agreement on Tariffs and Trade (GATT) came into being in 1948 to encourage free trade. The main objective of its first seven rounds was the reduction of conventional trade barriers, but at the eighth (Uruguay) round negotiations were extended to include issues such as the protection of life form patents. Obviously, guaranteeing someone's right to benefit from the innovation that they have invested in and developed is a key aspect of ensuring free trade, and applies as much to plant breeders as it does to microchip manufacturers. Rules concerning intellectual property were further strengthened by the WTO under the TRIPS (Trade Related Aspects of Intellectual Property Rights) agreement, helping to ensure that companies holding patents on new life forms had exclusive worldwide rights.

The current TRIPS agreement demands that all countries put legislation in place to ensure the "effective" protection of plant varieties, including trees. TRIPS went into full effect for industrialised nations at the conclusion of the talks in 1995, but in the case of developing countries full implementation was delayed for an additional five years. Furthermore, under this agreement some poorer countries were originally excluded from recognising life form patents. TRIPS comes up for review in 1999 and there is mounting pressure on developing countries to accept patents on life forms.

In August Kenya, on behalf of the African group of WTO members, issued a proposal on TRIPS as part of the preparations for the Seattle Ministerial Conference to be held November 1999. The proposal asked for clarification that plants, animals and micro-organisms should not be patentable. It also called for TRIPS to be harmonised with the Convention on Biological Diversity (CBD) and the FAO's International Undertaking on Plant Genetic Resources.

The call to harmonise TRIPS with CBD is important because it extends the concept of intellectual property from the novel to the original life form and thus broadens the issue of who should benefit from the manipulation of genetic material. The CBD addresses intellectual property with respect to the prospecting of biological material. Article 15 of the CBD requires signatories to seek permission before prospecting for genetic resources in a third country, and provides for agreements to share the benefits of any resulting commercial development. The CBD also encourages the transfer of biotechnology to developing countries in order for them to make use of their own genetic resources. However, key countries such as the US are not signatories to the CBD and, unlike the WTO, the CBD does not have an effective dispute settlement mechanism and is thus largely unenforceable.

5.1.2 Regulating the international movement of genetically modified material

The second big issue with respect to GMOs and international trade is controlling the movement of GM material. Negotiations on a global protocol to regulate international trade in GMOs broke down in February 1999. The main reasons for failure was the insistence by the Miami group of grain exporting countries led by the US, that countries be allowed to export genetically modified commodities without seeking permission from the importing country. The Miami group also insisted that the protocol should not conflict with existing trade agreements. EU member states along with most developing countries and environmental groups wanted the protocol to be an independent legal document. Developing countries were keen that socio-economic impacts of GMOs be taken into account during any assessment of their environmental risks, along with the provision for compensation in the event of accidents involving the transport of GMOs.

In response to the breakdown in negotiations, a few African countries led by Ethiopia have now decided to take the initiative and introduce national biosafety legislation. These countries are to be asked to introduce legislation that would make it illegal for a country to export genetically modified (GM) food without first seeking permission from the importing country. The draft African legislation also states that any person or organisation intending to export GM food or use GM organisms in laboratory or field trials must first carry out an evaluation of the risks to the environment, biological diversity and human health. Such an evaluation must also include socio-economic risks, such as the impact on jobs. Approval shall not be given unless there is firm and sufficient evidence that the GM organism, or the product of a GM organism, poses no risks to the environment, biological diversity or health.

However, introducing Africa-wide legislation is fraught with difficulties. One reason is that trade and foreign ministries in many countries are not likely to support any proposed law that may antagonise France - a country which maintains considerable influence in the continent - or the United States. Furthermore, neither trade nor foreign ministries are likely to agree to a set of measures that mount a direct challenge to the international trading system.

5.2 WTO LIMITS ON PROTECTION OF THE ENVIRONMENT AND/OR HUMAN HEALTH

The degree to which an individual country can restrict imports of GM products is limited by WTO rules although Article XX of GATT allows for measures that are necessary to protect public morals, human, animal and plant life. “Trade Related Environmental Measures” (TREMS) refers to any trade instrument aimed at protecting the environment. But as WTO looks unfavourably on any restriction of trade, countries that seek to apply high environmental standards must use very strong scientific justification if they wish to limit the import of products they consider an environmental threat. Furthermore, any limitations must be based on the impact of the product and should not discriminate on the means of production used. For example, if GM timber could be proved to be a health risk - say by containing large amounts of residual toxins - then trade discrimination would be legal. Nut a country would find it very difficult to ban the import of GM timber solely because it was worried about the impact that

GM plantations may have on the country of origin's environment. This principle is know as PPM – production and process methods.

Environmentalists are concerned that in the rush to remove trade barriers, it is becoming too easy to override national environmental standards. In 1997 the US Environmental Protection Agency weakened its regulations on contaminants in imported petrol in order to comply with a WTO ruling that found such rules to be an unfair trade restriction. The WTO tends to put the onus on the importing country to prove that the contested article is unsafe.

The WTO does permit member countries to take precautionary measures such as a moratorium when a government considers that insufficient scientific evidence exists to allow a final decision on the safety of a process or product. This of course runs contrary to the precautionary principle. For example, Principle 15 of the Rio Declaration states that *where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation*. In this case principle 15 is at odds with WTO philosophy.

At the end of November the WTO will meet in Seattle to consider, among other issues, the accelerated liberalisation of forest product trade. This will take place amid a series of continuing trade disputes over environmental and health issues. For example, in July 1999 the US imposed $117 million of trade sanctions on EU products ranging from truffles to bacon after the WTO ruled that the EU ban on hormone-treated beef was in breach of its regulations. Furthermore, the US Ambassador to the EU claimed that the Union is again on the verge of breaching WTO rules over export restrictions on GM crops. A moratorium on marketing GM produce has been declared by the Commission until a tougher system of safety standards is finalised and approved.

5.3 LABELLING GMOs AND FOREST CERTIFICATION

A potential trade dispute is set to develop over the issue of labelling GM products in general, and transgenic food crops in particular. Under the agreement on Technical Barriers to Trade (TBT), labelling of certain products can be interpreted as a restriction to trade and as such fall foul of WTO rules. The WTO TBT committee in June 1999 discussed issues surrounding the EU regulation for the labelling of GM corn and soybean. The US and Canada complained that their exports of corn and soybean had been adversely affected by the labelling requirements and that the EU measure was not based on a clear rationale. Canada also produced a written complaint concerning 11 GM product labelling schemes operating in Australia, Japan, New Zealand and Norway. Ottawa claims that such labelling schemes will apply to foods that are essentially no different from their conventional counterparts.

Product labelling with respect to the forest sector has also been discussed. The United States International Trade Commission (USTIC) is currently investigating conditions of competition with respect to US forest product trade. Special emphasis is being given to forest practices that may constitute trade barriers and distort domestic and international markets in Asia and Latin America. As highlighted earlier in this report it is probable that Asia and Latin America will be the first major sites for GM plantations, backed by North American capital. As part of the enquiry, evidence was considered on issues relating to FSC certification and labelling. While the issue of trade restriction due to labelling in the forestry sector is not before a WTO committee, it is worth noting that this may be the next step if it is felt that US forest trade is being adversely affected.

At present GM tree products are excluded from the FSC certification process. Although many international forest product companies are funding GM tree trials in Asia and Latin America, few have openly declared a position on the commercial use of such trees. The increasing popularity of certified forest products may be perceived as a brake on investment opportunities in otherwise profitable GM plantations, and large companies may start lobbying governments to move against certification as a trade barrier. If such labelling were deemed contrary to WTO regulations, would other companies now reluctant to endorse GMOs go back on what they have declared publicly and begin to use transgenic planting stock?

6 Conclusions: WWF's response to biotechnology in the forest sector

6.1 THE FUTURE OF BIOTECHNOLOGY

It is becoming increasing difficult to determine how the GM issue will unfold over the next 18 months. Three months ago, this author maintained that while "GM trees posed a risk to biodiversity conservation, the main threat would continue to come from GM agriculture". In the light of this scoping study, that statement, while still probably true, cannot be taken as definite. Indeed, many might argue that the whole GM issue is a "dead duck", that companies have had their fingers well and truly burnt with the commercialisation of the technology and will now leave it alone. Recent reports that Monsanto is considering pulling GM trials out of the United Kingdom would seem to indicate that the high-profile campaign conducted by Greenpeace and others is set to result in a decisive victory.

Such conclusions are ill considered, for while some biotechnology companies have suffered a number of setbacks in recent months - most notably from falling stock prices - neither the science of biotechnology nor the opportunities to commercialise innovation will go away. This has been recognised by many governments and may partly explain why a populist British government has, on this issue, set its face so firmly against a public which (mistakenly) believes that GM food crops pose a greater health risk than BSE. Governments are sure that biotechnology is one of the industries of the future and are particularly anxious not to lose the "innovation" race to other countries.

The prospect of a quick media victory in Europe against GMOs should be treated with caution by the environmental movement. If Monsanto decides to pull out of the UK it is unlikely that the company will simply lick its wounds, sell off investments in biotechnology and return to the agrochemical business. It is more likely that GM technology will be driven more quickly into countries such as China and Brazil. While Asia has become the focus for calls for labelling of GM food products (Australia, Japan, New Zealand and South Korea), China is reported as being more interested in the potential that biotechnology holds for an agricultural system required to feed and clothe over a billion people. Last year alone China is reported as planting over a million hectares of GM cotton. More worryingly, the Brazilian Association of Seed Producers (Abrasem) has estimated that illegally imported GM soybean seed might account for up to 10 percent of Brazil's upcoming crop. Brazil currently has a moratorium on the commercial production of GM crops.

It is also important to realise that much of the apparent success against the commercialisation of biotechnology is limited to food crops. While the British press made much of Deutsche Bank's recent prognostication that "GMOs are dead", what they failed to report was that the same review recommended that investors buy shares in biotechnology companies involved in the development and distribution of non-food crops.

6.2 BIOTECHNOLOGY AND THE FOREST SECTOR

Although there is little to point to in the way of commercial production, biotechnology has already made its mark on the industrial forest sector. One can expect to see transgenic planting stock being released some time within the next couple of years. Even if the biotechnology/forest alliance picks up some collateral damage from the GM food crop debacle in Europe, this will largely be irrelevant as GM trees are probably set to make their commercial debut in Latin America and South-east Asia. In addition to Chile, Indonesia and possibly Brazil, the country to watch will be China. Its decision earlier this year to call a moratorium on the logging of natural forests and plantations in key water catchments has already had a knock-on effect within the region. It would be highly surprising if China has not already established a programme of research to help make good its internal timber deficit.

While there are many similarities between the environmental threats posed by transgenic trees and those from GM agricultural crops (genetic pollution, invasiveness, effects on biodiversity and so-on) there are also six important issues that have largely been ignored:

1 The time and location factor (*ie* trees as crops are long-lived perennials often located in remote areas where constant vigilance against unanticipated problems is difficult, if not impossible). GM forests may be managed in the centres of origin or close to natural species, increasing the likelihood of cross-pollination;

2 The effect transgenic trees will have on long-term site productivity; and

3 the potential threat posed by international trade in transgenic roundwood to forest certification.

4 Trees are likely to be keystone species in their environment and support more biodiversity than agricultural crops.

5 Unlike agricultural crops, trees have not been subject to the same degree of domestication and research, and current knowledge regarding the biology and ecology of tree species is inadequate. More independent research is needed into tree biology, forest ecology and the time and location factor.

6 The vast majority of current field trials only examine the direct effects of the manipulated traits. Wider questions concerning the environmental impact of accelerated growth or completely sterile trees are not considered, yet it may be that these associated risks are more likely to occur (a common feature in the history of land use intensification) and therefore pose the greatest ecological threats.

The whole situation concerning GM labelling and trade is unclear at present. It is therefore unwise to speculate just how a “three-way tango” between international trade, certification and transgenic roundwood might be played out, although it is well to recognise that the band has already struck up the tune. It is clear that the FSC will have to take the whole biotechnology issue very seriously over the next two or three years. With Home Depot recently indicating that it wants to source its timber from well-managed sources by 2005, there may soon be pressure from all sides (not just the US Department of Trade) for explicit reasons why the FSC precludes transgenic trees from certification.

6.3 RECOMMENDATIONS

In May 1999, WWF formulated a position statement on GMOs. It called for a moratorium on the use or release of GMOs until ecological interactions are fully researched; transparent comprehensive environmental impact assessments of planned releases; and properly regulated monitoring and control of gene technology. The position paper was considered and balanced. The following recommendations will help resolve whether biotechnology has a role in the forest sector.

General

1 It is far too early to judge whether biotechnology can make a safe and effective contribution to the forest sector. Governments should therefore declare a moratorium on the commercial release of genetically modified tree species until i) properly agreed national and international safeguards have been put in place and ii) the risks concerning the behaviour of both novel traits and modified tree species, over time, have been fully quantified.

2 Governments and industry must pursue a more open and honest policy on biotechnology in the forest sector. Transparency and inclusiveness should be key features of both regulation setting and supervision, and this can only be achieved through involving civil society in a public debate.

International regulation

3 At the international level, governments should undertake to break the deadlock on the Biosafety Protocol within the Convention on Biodiversity. They should accept the Convention as the foremost international agreement on GMOs and until more reliable information is available international regulation must be of a precautionary nature.

Research

4 With a few exceptions, there is a lack of knowledge concerning the genetics, physiology and ecology of most tree species. In such cases, modification of a tree species' genome must be complemented by auxiliary research that addresses the basic biological gaps in our knowledge concerning that species.

5 Continuing field trials must be re-designed to examine not only the behaviour of the introduced trait but also the broader environmental impact of the modified tree species.

6 Research must be continued over a sufficient period of time to enable researchers to quantify risk throughout a standard rotation period.