Plantation Certification & Genetic Engineering

FSC’s Ban on Research Is Counterproductive

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ABSTRACT

Genetic engineering, also called genetic modification (GM), is the isolation, recombinant modification, and asexual transfer of genes. It has been banned in forest plantations certified by the Forest Stewardship Council (FSC) regardless of the source of genes, traits imparted, or whether for research or commercial use. We review the methods and goals of tree genetic engineering research and argue that FSC’s ban on research is counterproductive because it makes it difficult for certified companies to participate in the field research needed to assess the value and biosafety of GM trees. Genetic modification could be important for translating new discoveries about tree genomes into improved growth, quality, sustainability, and pest resistance.

Keywords: biotechnology; entomology and pathology; ethics; genetics; silviculture

Genetic engineering, commonly called genetic modification (GM) in much of the world, is the use of recombinant DNA and asexual gene transfer methods to breed more productive or pest-resistant crops. It has been the subject of considerable controversy, with concerns raised from biological, socioeconomic, political, and ethical perspectives. Some of the issues are similar to those raised by the use of molecular biology and genetic engineering in medicine, which we see in the news headlines daily. However, genetic modification in agriculture and forestry raises environmental issues as well.

GM crops, mainly herbicide- and pest-resistant varieties of soybeans, maize, or cotton, have been vigorously adopted by farmers in North America because they are easy to manage and they improve yields, reduce costs, or reduce pesticide ecotoxicity (Carpenter and Gianessi 2001). However, the controversy, primarily embodied in regulatory barriers to trade of GM crops with Europe and Japan, has slowed their adoption considerably in recent years.

If GM trees are used in forestry in the near future, they are likely to occur primarily in intensively managed environments, such as urban forests or plantations. In urban forestry, genetic modification is expected to help trees adapt to the stresses and special demands of human-dominated systems. Examples would be trees that are more tolerant of heavy metals or other pollutants, resist urban pests or diseases, grow slower, or do not produce fruits when these create hazards in street environments (Brunner et al. 1998).

Plantations, although very different from natural forests in structure and function, are considered part of the spectrum of methods in sustainable forest management (Romm 1994). Plantations can relieve pressure on natural forests for exploitation and can be of great social value by supplying community and industrial wood needs and fueling economic development. The environmental role of plantations is recognized by the Forest Stewardship Council (FSC), an international body for certification of sustainably managed forests. FSC Principle 10 states that plantations should “complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests” (FSC 2001).

FSC has certified some of the most intensively managed plantations in the world, including poplar plantations and the intensive pine and eucalypt plantations of the Southern Hemisphere. Although many environmental mitigations are built into these certified plantation systems, within the areas dedicated to wood production they function as tree farms. Such intensive plantation systems often use highly bred genotypes, possibly including exotic species, hybrids, and clones, as well as many other forms of intensive silvicultural management. It is in the context of these biointensive systems that the additional expense of GM trees is likely to be worthwhile.

However, FSC currently prohibits all uses of GM trees, and is the only certification system to have done so

(Coventry 2001; Strauss et al. 2001a). FSC Principle 6.8 simply states the "use of genetically modified organisms shall be prohibited" (FSC 2001). This policy stands in stark contrast to their discriminating, but not exclusionary, allowance of the use of chemicals, including pesticides, exotic biological control agents, and exotic tree species or populations. Like genetic modification, all of these practices can have undesirable environmental consequences, including irreversibility, that are accepted or mitigated to the extent feasible. These practices are allowed because it is felt that they have undergone sufficient research and their environmental or economic benefits outweigh their risks.

In 1999 FSC briefly outlined its reasons for concern over genetic modification (Strauss et al. 2001a). However, none of the problems raised appear insoluble given adequate research, selective deployment, and mitigation when needed. With the rapid growth of FSC certification—now at about 22 million hectares worldwide—this prohibition on research will make it increasingly difficult for industries to participate in research with GM trees and thus poses a significant obstacle to answering the very questions about GM trees that FSC has raised. There are many ways to conduct field research on GM trees with a high degree of environmental safety, including harvest of trees prior to flowering (Strauss et al. 2001a). This concept was supported by a unanimous resolution of the IUFRO Section on Molecular Biology of Forest Trees (2001) at its international meeting in July 2001; the section requested that FSC reconsider its blanket exclusion of GM trees in research.

GM versus Conventional Breeding

Genetic modification is similar to conventional breeding in that it seeks changes in the genetic constitution of trees to make them more productive under the environmental conditions of plantation management or urban forestry. However, in contrast to traditional breeding where natural variation is selected based on plant phenotype (appearance), in genetic modification the genes that control desired traits are physically isolated, their DNA sequences determined, and the genes then modified and reintroduced via an asexual process, usually in a petri dish. Genetic modification therefore relies heavily on the nascent but rapidly growing knowledge of genes and genomes. It is also concerned with traits that can be usefully modified with one or a few genes. Because of the conservation of the genetic code, and because at this fundamental genetic level genes from different organisms show striking similarities in their structure and function, genes that were isolated from other organisms can be used. Transfer of one or a few genes from the tens of thousands that make up an organism do not effectively make them hybrids or chimeras—although Frankensteinian metaphors do appear to help promote anti-GM campaigns and sell newspapers.

Traditional breeding, in contrast, tends to focus on complex traits, such as adaptation to environment, that depend on the interactions of large numbers of genes. Genetic modification is therefore not a replacement for traditional breeding but a way to solve specific problems or to add value to the products of an advanced conventional breeding program. It is most easily employed when breeding has proceeded to the stage of clonal propagation, such as in poplars, eucalypts, and some conifers, where it can be applied to already commercially valuable clones.

Genetic modification seeks both to add new traits not available in the native gene pool, such as the new forms of herbicide or pest resistance seen in agricultural crops, and to modify native genes in specific ways to increase productivity or improve management efficiency. The goals of adding new traits are to reduce pest control costs, reduce or avoid pesticide use, improve environmental profiles of herbicides used, or facilitate low tillage systems to reduce erosion and soil damage. At least one of these benefits has been realized, sometimes to a striking degree, with the first generation of GM agricultural crops (Carpenter and Gianessi 2001).

As for modifications to native genes, one application is to alter genes that control xylem development so that the wood produced is better suited to specialized end uses, such as pulping or bioenergy production, allowing higher yields or more economical or environmentally benign processing. Very promising results have already been demonstrated from studies of GM poplars (Dinus et al. 2001). In another example, fertility can be reduced by modifying native genes critical to reproduction. This application is expected to increase wood productivity, aid production of hybrids in bisexual species (male sterility), and reduce the spread of introduced genes to wild populations (Strauss et al. 1995). In addition, when trees are threatened by pests for which native resistance is rare or lacking (e.g., Dutch elm disease and chestnut blight), genetic modification should help to mobilize genes from related species, including other species and genera, that have developed resistance due to long-standing association with the exotic pests. This capability will grow as genomes are better mapped and understood (Adams et al., in press).

In addition to knowledge of genes and genomes, the use of genetic modification depends on asexual transfer of genes into cells and recovery of healthy trees. These methods are well advanced for poplar (aspens and cottonwoods), sweetgum, and a few other species. In poplars, the majority of field trials conducted around the world have shown that GM trees grow well and express their new traits with stability (Pilate et al. 1997; Strauss et al. 2001b). For most tree species, however, substantial additional research is needed.

Like the products of conventional breeding, newly produced GM trees must be vigorously field-tested to identify the most desirable genotypes and to ensure that they provide the required value, adaptation, and environmental safety over a range of conditions. The current regulatory system in the United States, where GM trees are under the control of the US Department of Agriculture and the Environmental Protec-


Courtesy of Jake Eaton, Potlatch Corporation

An FSC-certified, intensively managed hybrid poplar plantation in eastern Oregon. Because of their amenability to gene transfer, facile clonal propagation, and intensive silviculture and breeding, poplar fiber farms such as this one are ideal places for research and possible deployment of genetically engineered trees.

tion Agency, give legal strength to this basic business practice and principle of good forest stewardship.

Politics versus Science

One of the unfortunate consequences of this controversy is the tendency to treat all of genetic modification as a unitary group that is either good or bad. 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. Professional and public opinions can thus become highly polarized (Priest 2000).

However, the biological reality of genetic modification does not support such black-and-white judgments (Strauss et al. 1999). Genes differ dramatically depending on what they do and how they are modified. The health of GM trees varies widely depending on the species, genes, and gene transfer method used. The consequences and safety of the new traits depend on the silvicultural systems in which the trees are managed. Even at the social level, ethical judgments of desirability will depend on assessments of benefit versus risk, which vary with socioeconomic context.

Perhaps the most important consequence of FSC's ban on GM research is that it tends to foster the view that all genetic modification is dangerous to the environment. In contrast, leading scientists, including the National Academy of Sciences and the Ecological Society of America, long ago stated, and recently reconfirmed, that the new traits imparted by genetic modification, not the method, should be the focus of biosafety analysis (Tiedje et al. 1989; National Research Council 2000).

The polarization of views about genetic modification can have serious consequences. It gives license to stringent regulatory regimes based on method and may encourage broadscale attacks against all GM research and development, even when research is oriented toward biosafety methods (Kaiser 2001). The May 2001 arson attack against the University of Washington Program in Urban Horticulture, which destroyed much of an entire building and the work of diverse researchers (and which easily could have taken lives) is a particularly tragic example of where this polarization can lead.

Moving Forward

It is not surprising that the qualitative genetic changes allowed by genetic modification can have substantial value. The biological demands on plantation trees, particularly those managed for specific fiber, energy, chemical, or solid wood products, are very different from the demands on wild trees. For example, changes in wood chemistry that might have deleterious effects on long-lived, wild trees are likely to be tolerable in highly managed, short rotation systems. Even minor changes in feedstock quality can yield tremendous economic and environmental benefits (Dinus et al. 2001). Such changes are also likely to domesticate rather than invigorate trees, making them less able to compete in wild environments.

Precisely what kinds and degrees of alterations to woody quality, as well as other traits, are biologically acceptable and deliver significant value can only be determined by research, particularly field trials. However, because of the costs, regulatory demands, proprietary issues, and long-term nature of field trials, industry participation is usually required. Therefore, as more companies become certified by FSC, conducting the needed research to evaluate GM trees will become increasingly problematic.

The public, not to mention many professionals, often are confused by the comparison of GM trees to infamous invasive exotic species such as kudzu vines and gypsy moths. GM plants are indeed "exotic" in the sense that they deliver new traits that are rare or absent in wild gene pools. However, they are not exotic in that they are not biological novelties in ecosystems. When exotic organisms are disruptive it is generally because they occupy a new niche, possess novel and complex adaptations, and have many new, interacting genetic networks not present in native species. They also generally leave behind hundreds of pests when they depart their native ecosystems. The simple, limited genetic alterations imparted by genetic modification bear little resemblance to this panoply of novelties.

The relative precision of GM trees allows much more predictability of their ecological consequences compared to exotic species, and intensive field testing and progressive deployment allows poorly adapted genotypes to be discarded. For traits whose spread outside of plantations is undesirable, such as might be the case for herbicide-tolerant trees, methods such as engineered infertility combined with vegetative propagation should allow the rate of spread to be drastically reduced or avoided entirely. This would also reduce ecological impacts from the spread of exotic and conventionally bred trees. Although the technology for engineered sterility systems has already been demonstrated in transgenic agricultural crops, the efficiency and biosafety of this option requires field study in GM trees.

As tree genomes are better understood, the options for using detailed genetic information to more precisely tailor trees to intensive production systems are growing rapidly. Because of the limitations imposed by the long life cycle and outbreeding system of mating for trees—which greatly slow the rate of progress or limit breeding options—genetic modification may present an important future means for making genetic improvements. A key avenue for progress would therefore be foreclosed if biopolitical pressures, such as are embodied in FSC's ban on genetic modification, impede significant research in this area.

Instead of slowing research, what would be most socially valuable would be for FSC and other certification systems to help ensure that GM trees are studied and deployed responsibly. This would be most important in developing countries, which often do not have substantial regulation and associated infrastructure. The stewardship obligations that should accompany genetic modification are very similar to those involved with use of other technologies such as chemicals and exotic or biocontrol organisms and could be readily adopted as parts of certification assessments (Strauss et al. 2001a).

Ethical Challenges

Biotechnology in medicine and agriculture presents a variety of biological and social complexities. The potential benefits from applying detailed genetic knowledge are obviously great, but there is much social debate about what constitutes sustainable and ethical application in various sectors. In forestry, the obvious near-term applications are in highly intensive systems, such as plantation and urban forestry. However, even these applications require considerable research to define safe and productive uses. Because of the long time period required for tree research, it seems wise to conduct research in parallel with the social debate about safe and appropriate applications of genetic modification in forestry. Demonstrations of benefit and safety ultimately will be required for ethical judgments of desirability in specific circumstances (Thompson and Strauss 2000).

We suggest that certification systems, including FSC, promote (or at the very least not prohibit) research to identify productive and safe uses of genetic modification in intensive forest management. With the wealth of scientific possibility provided by the genomics revolution, the great uncertainty about stresses on future forests and societies, and the diversity of needs and management problems, prohibiting all applications of genetic modification, and particularly field research, is neither wise nor precautionary.

Literature Cited

ADAMS, J.M., G. PIOVESAN, S.H. STRAUSS, and S. BROWN. In press. Genetic engineering of forest trees against introduced pests and diseases. *Conservation Biology.*

BRUNNER, A.M., R. MOHAMED, R. MEILAN, L.A. SHEPPARD, W.H. ROTTMANN, and S.H. STRAUSS. 1998. Genetic engineering of sexual sterility in shade trees. *Journal of Arboriculture* 24:263–73.

CARPENTER, J.E., and L.P. GIANESSI. 2001. *Agricultural biotechnology: Updated benefit estimates.* Washington, DC: National Center for Food and Agricultural Policy. Available online at www.ncfap.org/pup/biotech/updatedbenefits.pdf; last accessed by staff October 2001.

COVENTRY, P. 2001. *Forest certification and genetically engineered trees: Will the two ever be compatible?* OFI Occasional Paper 53. Oxford, UK: Oxford Forestry Institute. Available online at www.plants.ox.ac.uk/ofi; last accessed by staff October 2001.

DINUS, R.J., P. PAYNE, M.M. SEWELL, V.L. CHIANG, and G.A. TUSKAN. 2001. Genetic modification of short rotation poplar wood properties for energy and fiber production. *Critical Reviews in Plant Science* 20: 51–69.

FOREST STEWARDSHIP COUNCIL (FSC). 2001. *Principles and criteria.* Available online at www.fscoax.org/principal.htm; last accessed by staff October 2001.

IUFRO SECTION ON MOLECULAR BIOLOGY OF FOREST TREES. 2001. A request to the Forest Stewardship Council that it reconsider its position on field research with genetically modified trees. Resolution passed at Tree Biotechnology in the New Millennium, July 22–27, Stevenson, Washington. Available online at www.fsl.orst.edu/tgerc/strauss/fsc_pnt.pdf; last accessed by staff October 2001.

KAISER, J. 2001. Words (and axes) fly over transgenic trees. *Science* 292:34–36.

NATIONAL RESEARCH COUNCIL (NRC). 2000. *Genetically modified pest-protected plants: Science and regulation.* Washington, DC: National Academy Press.

PILATE, G., D.D. ELLIS, and S. HAWKINS. 1997. Transgene expression in field grown poplar. In *Micropropagation, genetic engineering, and molecular biology of* Populus, eds. N.B. Klopfenstein, Y.W. Chun, N.-S. Kim, and M.R. Ahuja, 84–89. General Technical Report RM-GTR-297. Fort Collins, CO: USDA Forest Service.

PRIEST, S.H. 2000. US public opinion divided over biotechnology? *Nature Biotechnology* 18:939–42.

ROMM, J. 1994. Sustainable forests and sustainable forestry. *Journal of Forestry* 92(7):35–39.

STRAUSS, S.H., W.H. ROTTMANN, A.M. BRUNNER, and L.A. SHEPPARD. 1995. Genetic engineering of reproductive sterility in forest trees. *Molecular Breeding* 1:5–26.

STRAUSS, S.H., W. BOERJAN, J. CAIRNEY, M. CAMPBELL, J. DEAN, D. ELLIS, L. JOUANIN, and B. SUNDBERG. 1999. Forest biotechnology makes its position known. *Nature Biotechnology* 17:1145.

STRAUSS, S.H., P. COVENTRY, M. CAMPBELL, S. PRYOR, and J. BURLEY. 2001a. Certification of genetically modified forest plantations. *International Forestry Review* 3(2):87–104. Available online at www.fsl.orst.edu/tgerc/pubs/Strauss_2001_International_Forestry_Review.pdf; last accessed by staff October 2001.

STRAUSS, S.H., S.P. DIFAZIO, and R. MEILAN. 2001b. Genetically modified poplars in context. *Forestry Chronicle* 77(2):1–9.

THOMPSON, P.B., and S.H. STRAUSS. 2000. Research ethics for molecular silviculture. In *Molecular biology of woody plants,* eds. S.M. Jain and S.C. Minocha, 585–611. Dordrecht, Netherlands: Kluwer Academic Publishers.

TIEDJE, J.M., R.K. COLWELL, Y.L. GROSSMAN, R.E. HODSON, R.E. LENSKI, R.N. MACK, and P.J. REGAL. 1989. The planned introduction of genetically engineered organisms: Ecological considerations and recommendations. *Ecology* 70:298–315.

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