SUMMARY VIEWS

Proceedings of the First International Symposium on Ecological and Societal Aspects of Transgenic Plantations, S.H. Strauss and H.D. Bradshaw, eds. College of Forestry, Oregon State University, 2001. pp. 219. www.fsl.orst.edu/tgerc/iufro2001/eprocd.pdf

Policy Perspective

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The objective of enlightened policies is to promote objectives that, in the broad context, should lead to improvement of the generate welfare, in cluding, but not limited to economic welfare. These objectives should are also appropriate for policies related to innovations in forest biotechnology.

In the economic realm, policies are usually designed to promote income, employment and economic growth. Policies focusing on promoting innovation, investments, the efficient use of resources and an equitable income distribution would generally be regarded as contributing to the general welfare. However, attention is given to activities and/or products that may generate negative externalities, e.g., air or water pollution, or unrecognized health and safety risks. These include negative externalities that may be associated with the introduction of biotechnological innovations, including transgenic trees.

Biotechnological innovations in forestry clearly have the potential over the long term of promoting enhanced economic well-being. They can lower costs, improve quality and make goods and services more accessible to humankind. Additionally, they can provide positive environmental services, including the provision of land restoration services to the rehabilitation of almost extinct species, such as the American chestnut. Furthermore, the evidence over the past several decades that wood harvested from plantation forests substitutes for wood that would have been harvested from natural and old-growth forests is compelling, despite the reluctance of some to acknowledge the evidence. Biotechnology can enhance this shift to planted forests.

However, innovations may also involve risks and uncertainties. In forestry, major concerns with transgenics tend to focus on the possibility of unplanned and negative impacts on the natural environment. In order to better understand the nature and magnitudes of these potential risks, a regulatory approach has been created for forestry in which USDA APHIDS bears the responsibility for determining the extent of the externalities that may be present and ultimately the acceptability of a forest transgenic innovation. Under this system various types of tests and trials are undertaken, including field trials, to determine whether the innovation should be allowed to move to commercial applications. The procedure accepts, rejects, or requires resubmission of the innovation for commercial use. It could well be that some transgenic innovations are essentially riskless, and should readily be accepted for commercialization, while others involve risks so great that prudence would suggest delaying the innovation until more information is available and, perhaps, ultimately rejecting indefinitely the commercialization of the innovation.

Finally, one may always ask if the procedures are adequate. However, it must be recognized that no amount of testing will remove all uncertainty. Ultimately the testing procedure requires an informed judgment of whether the testing is adequate and appropriate.

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Ethics Perspective

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This symposium is evidence that scientists working on tree biotechnology are off to a very good start in addressing controversial issues and ethical responsibilities. The papers and working group sessions have brought a number of key topics to the forefront. It is really quite remarkable that these topics should be addressed so thoroughly at this early stage in the development of the science. I would like to offer just a few concluding comments in reaction to what I have seen here.

First, scientists seem prone to two tendencies that cause problems both with respect to public receptivity toward technology and to the discharge of ethical responsibilities. One is a tendency to evaluate technology solely in terms of net outcomes. Clearly outcomes—costs, benefits and risks—matter a great deal. Yet we do not look with favor on others who are too quick to conclude, "the end justifies the means." Even when the end *does* justify the means, we like to believe that others have given due consideration to values not easily characterized as subject to "trade-offs." For example, there should be due consideration given to the intrinsic value of natural ecosystems, and affected parties should have an opportunity to participate in decision-making, and to give or withhold consent. It was distressing to see workshop groups moving toward trade-off rationalization after only a few minutes of discussion.

The other tendency is to analyze controversy in terms of a distinction between real and perceived risk. While it is true that people can and do misjudge either the likelihood or the degree of hazard that is associated with the use of biotechnology, it is also true that the source of controversy can lie elsewhere. There may be different value judgments being made about how to understand the normative importance of uncertainty, for example, or about the socio-economic consequences of using technology. One should be sure that others share one's values before presuming that different judgments of risk can be attributed to a mistake about probability or hazard.

Although the capabilities of bioethics should not be overstated, including philosophers or others with training in bioethics throughout the research and development process for technology is one way to hold such tendencies in check. One would hope that at least four or five bioethicists attach themselves to the emerging field of tree biotechnology early on, and that they are welcomed and included both at scientific meetings and at fora, such as this one, where social, ethical and public issues are the primary topic of discussion. A good way to make this happen would be for a few far-sighted deans to create positions in bioethics within forestry or environmental science programs at their universities, and to provide support for publication and teaching on the ethical issues of tree biotechnology. And may I conclude with the hope that this remarkable beginning becomes a standard practice for the emerging field of tree biotechnology.

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Industry Perspective

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We extend sincere thanks to Steve Strauss and Toby Bradshaw for organizing this important symposium and inviting our participation. The potential benefits of forest biotechnology have been clarified and re-affirmed. Good progress has been made in developing a more integrated community view of ecological and economic opportunities.

The symposium has outlined important uncertainties and challenges in the future of forest biotechnology, with considerable emphasis on ecological concerns. Rather general discussions of ecological risks indicate a need for research focused on specific technology applications with careful attention to characteristics of the transgenic trees themselves; characteristics of environments in which transgenic trees might be deployed; and the design and expected effectiveness of risk reduction measures.

Several speakers have provided useful insights into social, economic, ethical, and regulatory issues associated with forest biotechnology. These issues require substantial and sustained attention even though the path forward is often unclear and potentially treacherous. The complex implications of forest biotechnology seem to require new approaches and unconventional partnerships such as those envisioned by the Institute of Forest Biotechnology.

We and others at the symposium have discussed the potential value of biotechnology to the forest products industry. It is clear that strategies and perceptions vary greatly among companies and stakeholders. In general, requirements for commercialization of forest biotechnology will include:

(a) Expectations of superior returns to shareholders with acceptable risk relative to alternative uses of capital

(b) Environmental performance will be maintained or enhanced

(c) Social and market acceptance issues have been evaluated thoroughly.

Further investments in R&D are critical to realizing the potential of forest biotechnology. An important economic hurdle is reducing costs associated with vegetative propagation of important softwood species such as loblolly pine. Accelerated research on ecological concerns and risk management options (e.g., flowering control) will be needed to satisfy environmental and social requirements.

Research organizations, both public and private, have essential roles and enormous opportunities in forest biotechnology. In the United States, inadequate government support for pre-competitive research is a significant obstacle to progress.

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Ecological Science Perspective

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It was widely accepted by presenters from a broad range of backgrounds that genetic engineering of plantation trees can offer some significant environmental benefits. These include reductions of pesticidal inputs, reduced pressures on wilderness areas arising from increased productivity of intensively managed plantations, and increased response capability to biological invasions. Whether these potential benefits can be realized will depend largely on whether potential risks can be managed. A common theme throughout many of the talks concerned the issue of scale: How can we extrapolate from short term experiments under controlled conditions to scientifically reasonable projections of long term consequences at the landscape level? This issue remains unresolved, and should be a major area of focus. Each person's approach to this question reflects, to some extent, the level of biological organization at which they commonly work. Molecular biologists often find that resolution of difficult scientific problems is achieved by deeper understanding of specific mechanisms, and by improved techniques for approaching intractable questions.

Ecologists, in contrast, often find that resolution of difficult scientific problems is achieved by recognizing which factors originally perceived as outside their unit of study are in fact exerting strong feedback on the system. These experiences color the extent to which biologists working at different scales trust that extrapolations from laboratory and small field studies to long term and landscape projections can be made. In some ways, however, these differences offer an opportunity, by identifying how differing approaches can best be integrated. For example, ecological approaches can help identify what types of feedback processes might yield negative unintended consequences (biotype evolution, alteration of ecosystem processes, gene escape). But in many cases possible remedies to these concerns can be substantially improved by molecular methods (plant sterility, localized expression, exogenously triggered expression, etc.).

Some immediate suggestions for improving the environmental safety of genetically engineered trees include:

1. Limit deployment to plantation trees, as opposed to suggestions (not made at this meeting) of using insect vectors or other means for naturally regenerated trees.

2. Limit deployment to sterile trees, and conditions under which spread of vegetative material can be prevented.

3. Employ biotype prevention tactics when pest resistance genes are employed.

4. Employ risk assessment procedures used to evaluate planned releases of biological control agents as a template.

5. Recognize that short-term risk assessment programs favored by current funding approaches bias our understanding in a direction that underestimates ecological risk.

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Forest Biotechnology Perspective

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Based on plenary lectures and discussions, we believe there was strong support from most meeting participants for the following conclusions:

1. Increasing human demand for wood and fiber will be increasingly met from intensively managed plantation forests. As the Earth's human population grows by 50% (to 9 billion in 2050) and standards of living increase, there will be a commensurate rise in demand for the forest products. This wood and fiber must be produced in a manner that is economically and ecologically sustainable. Plantation forests, intensively managed with the best tools of modern agriculture—irrigation, fertilization, weed control, and genetic improvement—will supply much of the world's wood needs and spare native forests by concentrating wood and fiber production, particularly that for industrial uses, on just 1%–10% of the land area now used for timber harvest. The growing science of genomics—where the structure and function of large numbers of genes are analyzed and compared across species—will provide many new opportunities for the use of genetic engineering to aid in the rapid domestication of trees, including increasing yield and the customization of woody feedstock qualities for various fiber and energy uses.

2. Novel aspects of genetically engineered plantation forests require long-term multidisciplinary field research. Intensive plantation forestry, while making use of many methods derived from agriculture, differs from agriculture in several important ways; the longevity of trees, their lack of domestication, and the frequent proximity of wild relatives are three such differences. There is a great deal of knowledge and experience to be gained from starting "medium-scale" experiments (tens to thousands of hectares) with GM trees in plantation forests. Such field trials would allow issues such as stability of trait expression, tree health, degree of genetic containment, and non-target effects to be monitored on ecologically relevant temporal and spatial scales. Risks and benefits could therefore be quantified. As in many other forest research areas, the paradigm of "adaptive management," where economic and ecological issues are examined during initial stages of use, and adjustments made to management based on results, will be important for GM trees if economic and ecological issues are to be studied adequately.

3. Fertility reduction will be important for many applications. Systems for fertility reduction ("sterility") will be critical for many commercial uses of GM trees, to minimize gene flow into natural ecosystems. Because several options exist for achieving fertility control, mounting an aggressive research program, including long-term field trials with carefully chosen species, genes, and environments, seems warranted. Developing a partnership with ecologists, population geneticists, evolutionary biologists, regulators, companies, and interested environmental NGOs to assist in study design will be necessary and desirable.

4. Domestication traits pose less environmental risk. There are clear biological distinctions among most traits being considered for genetic engineering with respect to risk assessment. Some are clearly domestication traits, in the sense that they may improve productivity within tree farms but are highly likely to enfeeble trees in the face of natural selection (and thus pose no risk of increased invasiveness). Sterility, dwarfism, and lignin modification are examples. Other traits may have benefits in wild populations, or reduce efficiency of human control; examples are insect resistance based on novel toxins, or herbicide resistance, respectively. For situations where significant wild populations are adjacent to plantation forests, gene flow of domestication transgenes pose little ecological concern, and thus do not warrant the same degree of empirical scrutiny as possible fitness- or weediness-related genes. For these genes, uncertainties can likely be resolved via adaptive management (see above).

5. Biological analogy between invasive exotics and transgenics is specious. There was strong consensus that the analogy between invasive introduced organisms and transgenic organisms is of little biological merit. Because of the vast differences in the degree of genetic and ecological novelty between novel species and transgenics with one or a few novel genes, the ecological risk from invasive exotics is much larger and less predictable than for transgenics with well-characterized genes. The well-established methodology for assessing risks of exotics, however, can be useful for helping to guide risk assessments of transgenic trees.

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Environmental NGO Perspective

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Environmentalists hold a great diversity of views about GE trees; we are presenting our personal views, not the “NGO position”. In this context, we note the small number of environmentalist participants in this conference.

The potential role of GE trees is part of a larger discussion about forestry and resource use issues. There are likely to be alternatives to the GE paradigm—alternatives that we urge be explored thoroughly.

This conference represents a small step toward both reaching out to various viewpoints and exploring the wider resource use issues and alternative approaches.

However, the statements this morning indicate that few have absorbed the qualms raised by ecologists speaking here. We hope that people will continue to think about the issues we and others have raised.