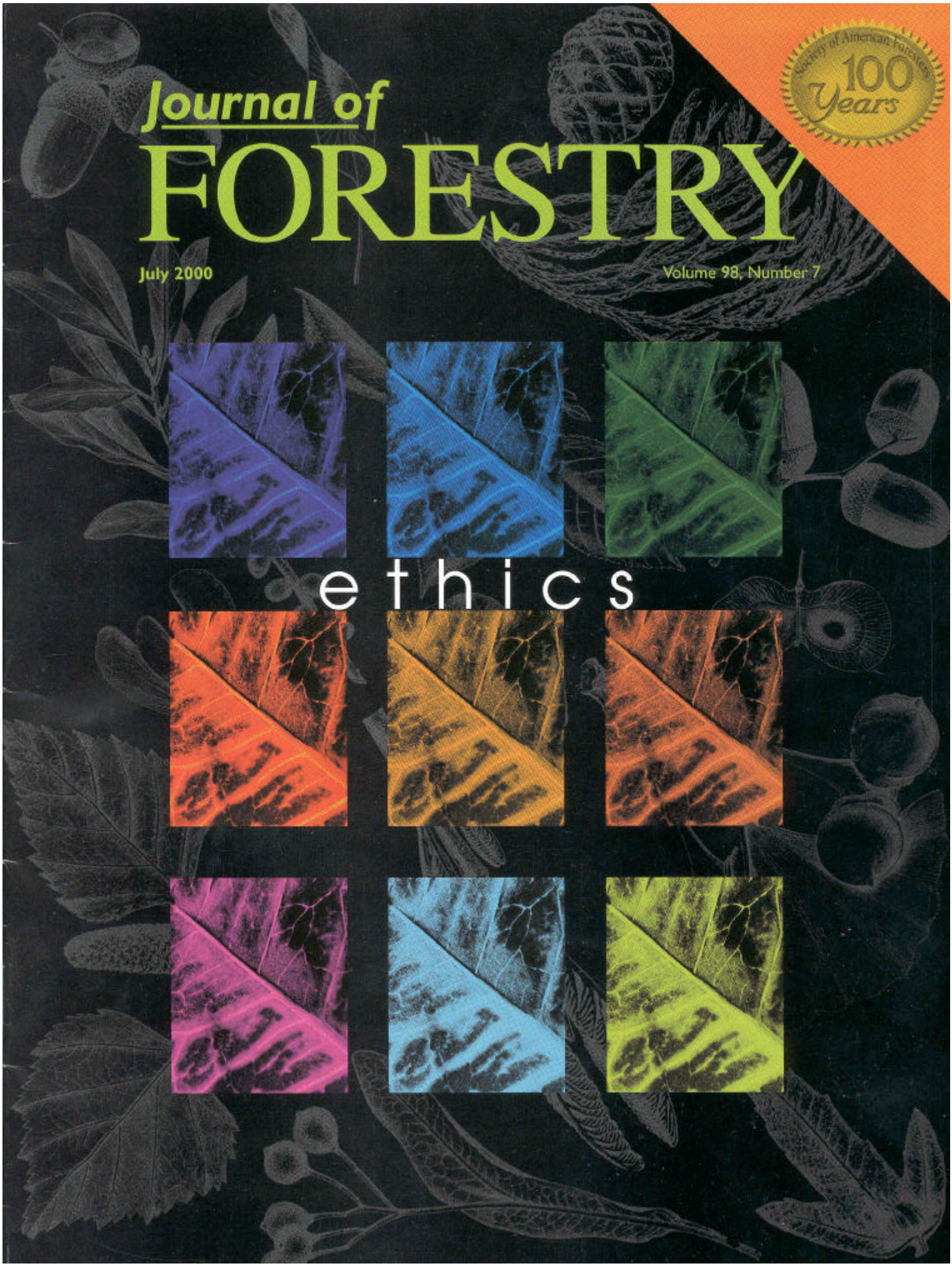
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Perspective

Ethics and Genetically Engineered Plantations

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The current SAF Code of Ethics states that "stewardship of the land is the cornerstone of the forestry profession" and that "member[s] will advocate and practice land management consistent with ecologically sound principles. "SAF ethics imply a responsibility both for active care of natural processes of the land and for scientifically based forestry that enhances the value of the land to people while maintaining and promoting land health. Most foresters would probably agree with these principles; however, they are not practical guidelines for making decisions about the most appropriate forms of management or technology to employ. These decisions are difficult because every alteration of the land intended to enhance some aspect of economic production involves trade-offs with other economic and ecological values.

Foresters and landowners often choose to segregate land uses to varying degrees to minimize inherent conflicts. These choices can be made at the stand, landscape, or regional scales to- ward a variety of goals, including protection of areas rich in biological diversity, preservation of indigenous cultural diversity, and promotion of commodity production. Where intensive forestry is practiced and wood production is emphasized, land is often allocated to plantations that are managed much like agricultural crops. This is where foresters are most likely to be interested in utilizing genetic modification (GM).

GM is the insertion of new, human-modified genes into chromosomes to impart specific new traits that cannot be readily achieved through conventional breeding. The traits that have been demonstrated in trees that might justify commercial uses are herbicide resistance, insect resistance, increased growth rate, enhanced bioremediation of polluted soil, and modified chemical composition of wood. The trees produced by this process are referred to as "transgenic," although only a minute fraction of their DNA is new (e.g., 10 parts per million in poplar). The genetic considerations that are important in GM concern the genes inserted, the traits they impart, and the physiological processes affected. Ecological considerations include the prediction and monitoring of the environmental con- sequences of the new genes, both in- side and outside of plantations. Social considerations include the distribution of risks, costs, and benefits that result from using these new kinds of trees, and the extent of public acceptance for their introduction on the landscape.

Although the question has been raised as to whether transgenic plants are unacceptably "unnatural," and thus cannot be used ethically in agriculture or forestry, it is our belief that it is impossible to make such a categorical judgment based on science alone. Nearly all facets of modern life depend on a vast array of technologies that have little precedent in the nonhuman world. Moreover, all human cultures have modified their environments to varying degrees, using tools they have devised for this purpose. Some of our crops have been so extensively modified via breeding that they barely resemble their wild relatives. In plantation forestry, many unnatural genetic technologies are currently employed, including selective breeding, exotic species, interspecific hybridization, population movement, and cloning.

Given these precedents, how are we to decide where, or if, transgenic trees should be used? We do not think it is possible to circumscribe, technically, what kinds of practices are ethical in using GM trees. The numerous combinations of genes, species, environments, and management regimes pre- sent new and distinct benefits, ecological risks, and social contexts. Instead, we propose that certain conditions should be met for any use to be ethically acceptable.

First, the process of evaluation is critical. Because these trees will occupy the environment and they or their transgenes may persist and spread irreversibly outside of plantations, their use should be agreed to by the public either directly or indirectly (e.g., via representative democracy). This also means that use should be preceded by scientific research, education, and open, public discussion. Moreover, the interest groups, companies, governments, citizens, and scientists that participate in this discussion have an ethical obligation to back up their views with credible information that promotes rational debate. Public evaluation of GM that is informed by sound scientific principles is required for determining whether, when, and where the use of GM trees is appropriate.

Second, the economic, utilitarian values of the transgenic traits to be introduced, including the sustainability and distribution of benefits and costs, should be studied to inform social evaluations. The extent to which the technology will materially affect multinationals, regional companies, rural economies, and citizens are important dimensions of benefit evaluation for any technology, but it is especially critical for GM because its patent-intensive nature tends to favor very large companies. This generates concerns that decisions will be made with insufficient regard to the needs of local economies and environments.

Third, the environmental impacts and risks from use of transgenic trees should be evaluated prior to commer-

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cial deployment. These assessments should carefully separate risks that are inherent in the technology (e.g., a result of specific genes) from those that transcend the technology (e.g., impacts of plantations), and consider how methods of deployment can aggravate or mitigate risks. For example, single gene forms of pest resistance in trees might be used sustainably if they are part of an integrated pest management system, but they are likely to be ecologically unacceptable without such a system. Because uncertainties about ecological effects will necessarily persist, adaptive management associated with ongoing public research should continue if commercial introduction occurs.

Finally, evaluations of all risks, costs, and benefits-economic, social, and environmental-need to be integrated and holistic in nature. For ex- ample, if there were stand-level reductions in biological diversity associated with transgenic plantations, they may be socially acceptable if they translate into greater net ecological and economic benefits at regional or national levels (e.g., if transgenic plantations were to help make renewable bioenergy crops economically competitive for the benefit of rural economies, or promote global carbon sequestration). Likewise, although the use of GM plantations may be socially or ecologically unacceptable if their economic efficiency promotes the large-scale conversion of wild forests to plantations, they may be supported if they are introduced in concert with land-use controls that maintain critical habitat.

The challenges to ethical uses of GM trees in forestry reside not in the process by which they are created, but rather in how their new characteristics and use will affect the environment and society. Substantiated benefits have been documented in laboratory and field experiments. However, there are reason- able ecological and social concerns based on precedents from other kinds of agricultural technology. The key problems are deciding when our knowledge base is adequate, when there has been sufficient public discussion, and when there is adequate social consensus that the net effects for proposed uses are positive. If the process of public evaluation is scientifically sound and democratically rigorous, it should be possible to enjoy a continuing flow of new products from this rapidly maturing technology for the benefit of forestry in coming decades. If it is not, the technology may remain on the shelf in spite of its technical merits.

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