TREE PLANTING: NOT A SIMPLE SOLUTION

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There's no doubt about it. Planting trees has caught the attention of the American public. In his 1990 State of the Union address, President Bush proposed planting a billion trees annually for the next ten years. Inspired by the potential for trees to reduce greenhouse gases and mitigate global climate change, tree-planting programs such as TreePeople and Global ReLeaf are organizing campaigns at the local and national levels for a massive re-greening of America.

The formula seems simple and certain: plant a tree and stand back. But without further consideration, such advice could create serious environmental damage. The reason has to do with genetics. The first genetic decision is made when a particular species is chosen for planting in an area. The unique combinations of genes that define a species are not just random collections of DNA, but the end products of long evolution and adaptation to particular environments. Species are fine-tuned genetically to their environments, and if planted in environments outside of their native ranges, they can react unpredictably. Perhaps the safest consequence to the local native ecosystems is that the exotic trees die. Another consequence is that, being freed from insect and pathogen checks that coexist with them in their native range, such trees not only survive, but proliferate widely, displacing native species, altering soil and water balances, and creating ecological chaos. Examples of such invasion by exotics abound, including black locust, tamarisk, and tree of heaven. Once established, exotics often are extremely difficult to eliminate.

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Some of the most ambitious national programs, such as Global ReLeaf, sponsored by the American Forestry Association, have gone only partway in addressing the species issue. To meet economies of scale, they have selected a handful of species for replanting nationwide. These are usually chosen with regard to the local environment of the planting site, but for most areas, the planted trees will not be native. Although species may be chosen that have the greatest likelihood of surviving, the impact of an exotic species on native local plant communities is not alleviated.

Recognizing the potential problems with exotic species, many local tree-planting programs promote planting native species. The route to ecologically appropriate planting, however, does not end with choosing a native species. Potentially as damaging as planting exotics is the situation wherein native species are selected, but the genetic source of planting stock is ignored. High genetic variability characterizes most tree species. For the most part, genetic variation is not randomly distributed within species, but hierarchically partitioned. High variability among individuals occurs within local stands and results from mating systems that promote outcrossing. Genetic variation also exists among groups of individuals that occur in different environments and groups of trees that are geographically distant from one another. These differences result from the action of natural selection which, over time, creates populations that are adapted to the various environments in which they evolved. This means that genes and environments are more or less matched, and that the genes of a plant and its offspring affect their ability to survive and grow in a given environment.

A failure to understand these points when planting native species can have undesirable consequences to the ecosystem. If inappropriate genetic stock is planted, one consequence is that introduced stock may die soon after planting. This commonly occurs if the planted trees come from an environment that was quite different from the planting site. If planted trees survive the early years, another common consequence is delayed death. This is especially true in long-lived organisms such as trees, whose genetic profile must include adaptations

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to cyclic or episodic events like droughts or pest epidemics. Stands of trees that evolve near the planting sites generally are adapted to be able to handle such cyclic or episodic events, whereas trees from distant stands are likely to be adapted to different regimes. Finally, if a planted tree of inappropriate genetic origin is able to survive, it may live its life as an unhealthy individual, growing in a sickly condition for many years.

A far worse consequence than the survival and health of the individual planted tree is the potential for genetic contamination of native communities. Pollen from planted trees of inappropriate genetic stock can pollinate flowers of local native trees and become incorporated in seeds of those trees. Making the situation worse is the fact that planted and stressed trees may produce more pollen than they would under normal conditions. Such pollen may inseminate nearby native trees massively. Trees that result from these seeds carry the genes of the ill-adapted planted trees, and may in turn pollinate large areas of wild plants through a leap-frog effect. In this way, contamination from pollen can erode the health of generations of once-adapted forests insidiously.

The key to successful planting, as U.S. Forest Service researcher Rowan Rowntree said, is "to plant the right tree in the right place." Finding both the right species and the individuals with the right genes is not simple. We offer the following guidelines as a beginning to ecologically-appropriate planting:

- Use native species. Natives are proven; exotics are not.
- Encourage natural reproduction from native trees. In cases where mature native trees exist in the site to be regenerated, it may be possible to encourage natural reproduction. Fallen fruits and young seedlings can be protected from herbivory and watered as necessary.
- Plant only trees of known origin. Tree-planting programs and nurseries should document the origin of seedlings and label them accordingly. Maintain information about the source of the seedlings through to the planting stage, and document this information so that future planters and restorationists can distinguish local trees from those which are not native to the area.
- If truly local native populations can't be found, try to collect from local populations and match environments. The most conservative advice is to collect seeds from known native trees in the close vicinity of the site where they eventually will be planted. Since significant variation can occur over short distances, guidelines about actual geographic distances are rarely reliable. Ecological distance is more important than physical distance, and often they are not the same. Equally important as geographic proximity is matching the seed-collecting site with the planting site in such factors as elevation, slope, aspect, soil, rainfall, annual temperature patterns, frost dates, and associated vegetation. To avoid potential problems from inbreeding, it is better to collect from trees that are in forests or stands rather than from isolated trees or from groups of a few trees. Avoid situations that are near planted trees of unknown origin, such as landscaped developments or gardens and arboreta.
- Collect from many trees. To ensure genetic variability in the planting site, it is almost always better to expend energy collecting few fruits from each of many trees than many fruits from a few trees. Maintain near-equal representation from all collection trees in the final plantings, *i.e.*, similar numbers of fruits collected per tree and similar proportions of seeds planted.

Organizers of tree-planting programs and eventual tree planters need to be educated about the genetic consequences of their actions. The biggest responsibility rests on the planners and organizers to ensure that appropriate trees are offered, and that planting instructions contain the genetic message. The guidelines that we have suggested may appear to be expensive to these large programs. However, genetically-appropriate planting can be done, as has been demonstrated by the reforestation efforts of such large forest managing agencies as the U.S. Forest Service. In the long-term, the costs of doing the job right will be far less than the fiscal and ecological damage wrought if genetic diversity and appropriate genetic structure are ignored in tree-planting programs.