The Evolution of Forest Biotechnology

— Bob Kellison and Susan McCord

Forests have been an integral part of our planet for over 350 million years. Those first forests and their associated vegetation were very different from those that exist today; vertebrates and invertebrates were also vastly different from the ones with which we are familiar. Gone are the dinosaurs, the mastodons and the types of vegetation on which they fed. Living remnants of the primeval animal population can be found in only a few places in the world, such as the alligator, but their fossilized remains are forever locked into sedimentary rock formations around the world. Similarly, ancient plants have left their telltale presence in horse tail, an old-world species that is a living fossil. Those plants together with marine plankton from the Mesozoic period were converted to petrochemicals by enormously high heat and pressure from the weight of sediments. To our great advantage, petrochemicals have been the energy source that propelled the industrial and technological revolutions of the world. They have also been the bane of the civilized world because of the carbon released to the environment, causing air pollution.

The carbon-based petrochemicals are fast disappearing and nothing is in sight to replace that energy source on a massive scale. Combinations of wind, water, solar, nuclear and biomass sources will help fill the void. The greatest common denominator is biomass, which can be used for direct combustion and, more specifically, for chemical conversion, the products of which will be similar to the petrochemicals lying under the earth's crust. The technology exists to make the conversion, but the economics cannot be justified in today's market place. Helping to offset the high cost will be vigorously growing tree plantations, especially engineered both to extract greenhouse gases from the atmosphere and filter soils that have been chemically contaminated.

To achieve this, species that are adaptable to certain regions of the world have been selected and modified by traditional breeding methods that include genetic selection. In some areas, the species of choice will be indigenous, such as in the southern United States where the southern pines predominate in plantation culture. In other areas, such as in the tropics and subtropics, exotics such as eucalyptus will be favored because of their adaptability, fast growth rate and relative resistance to pests.

The traditional method of genetic improvement is to select the best, crossbreed them to produce a progeny superior to either parent, and then crossbreed the superior progeny to other superior progeny, creating yet another generation of trees. Tree improvement programs were initiated about 50 years ago in various countries to benefit from this method. Success has been achieved in breeding for growth, form, pest resistance, wood properties and adaptability, but the gains have been incremental, largely because many traits are controlled by more than one gene, and improvement for any one trait can be hindered by the inclusion of additional traits. An additional hindrance is the long life cycles of trees, which, depending upon the species, might require 10 to 20 years for the progeny to reach sexual maturity and an equally long time to assess their genetic worth.

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Enter the world of biotechnology. Through gene mapping and the association of a gene or genes to a desired trait, selective breeding of a desired genotype can be achieved without the long time needed for progeny testing. The generation interval can be shortened even further by incorporating genes for early flowering. But that is only the beginning of the options for forest biotechnology. For example, trees can be engineered to resist life-threatening insect defoliation by genetically transforming them with a gene from a soil fungus such as *Bacillus thuringensis.* Other genes can be inserted to modify the cellulose:lignin ratio, allowing the wood to be pulped for the manufacture of paper with significantly less use of chemicals and with greater manufacturing efficiency than would be the case with non-modified wood.

Appropriate use of forest biotechnology has a multitude of benefits, including the restoration of Heritage Trees, such as American chestnut, bioremediation of chemically contaminated soils, filtration of greenhouse gases from the atmosphere, tolerance to pests, control of invasive species and altered cell formation allowing wood manufacturing with reduced environmental impact. But, from the beginning, caution must be exercised in the deployment of forest biotechnology to address any real or perceived negative outcomes. An example would be cross-pollination of genetically modified trees with wild populations of its relatives, creating unwanted offspring that could adversely affect other components of the environment, such as the destruction of indigenous vertebrates and invertebrates by feeding on the modified plants, or by modification of the environment necessary for a balanced ecosystem.

In short, forest biotechnology has the potential for immense benefit to society, from restoration of Heritage Trees, to bioremediation of soil and air, to biomass production for direct combustion and chemical substitutes for petrochemicals, to accelerated tree growth with improved form, pest tolerance, adaptability and wood properties. We can have all these benefits when care is given to deployment of the genetically altered organisms to assure that the targeted ecosystem continues to function to the benefit of society.

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