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Energy and Chemicals from Trees

An analysis of presentations at a conference on "Biomass Substitutes for Liquid Fuels," held on 9 to 12 February at Campinas, Brazil,* shows that a combination of factors will guarantee the increasing importance of the culture of trees and the applications of forest products. Some factors—such as the need to develop renewable alternatives to oil and the growing requirements for food and energy—are well known. Less widely appreciated is the need to decrease soil erosion by growing vegetation that will hold the soil in place. Agricultural practices have led to loss of about one-fourth of the topsoil in the world as a whole and about one-third in the United States. Much of the erosion has occurred on hilly terrains, which should be protected with perennial vegetation such as grasses, shrubs, or trees.

One impediment to forestation has been economics. Individual farmers have been able to obtain a considerably larger return from an annual crop than from trees, and typical yields of wood from natural forests have been small. However, in the Pacific Northwest, hilly land devoted to timber produces a return far above what it would yield in annual crops. Moreover, we are in the early phases of improvement in biomass yield from trees. For example, before 1960 the natural annual growth of loblolly pine in South Carolina was 3 dry tons per hectare. Through selection of superior stock and better forest management, the annual growth has been increased to 11 tons per hectare; yields of 18 tons are in prospect and 30 tons is an ultimate possibility. In Brazil, growth of a *Eucalyptus* species is being evaluated. This species has a 7-year growth cycle. In a forest occupying 40,000 hectares, annual yields initially were 23 tons per hectare. With selection the second rotation improved to 33 tons, while a third rotation produced 40 tons. The five best clones would produce 61 tons per hectare and a target of 100 tons seems reasonable. Such improvements can be conducted on a large scale, for instance, by selecting and planting superior seedlings. In addition, techniques for tissue culture cloning of trees are well developed in both the United States and Brazil.

A factor that could lead to greater emphasis on growth of trees is the possibility that the market value for wood will experience a long upward trend. Wood is considerably more valuable when processed to make lumber or paper than it is when used directly as a fuel. An important challenge for scientists is to discover and develop better methods for exploiting the chemical potentials of wood.

In terms of organic matter, wood is approximately 50 percent cellulose, 20 percent hemicellulose, and 30 percent lignin. A number of schemes are being employed to separate these components for various uses. One method is solvent extraction of the lignin followed by removal of the hemicellulose leaving the cellulose. Another is a short exposure of the wood to steam followed by explosive decompression and removal of the lignin by dilute alkali. Lignin can be used as an adhesive, and at present it commands as much as $400 a ton in this application. It can also be used as a filter in plastics and, when pyrolyzed, it forms a superior metallurgical coke.

Cellulose can be used directly as cattle feed or converted to glucose by acid hydrolysis or use of an enzyme. The enzyme method gives the highest yields and is becoming less expensive. Thus, prospects are good that large quantities of glucose derived from wood will become available. This product could be used as food for humans, as a carbon source for microbial formation of protein, or as a feedstock for fermentation processes yielding liquid fuels, chemicals, and pharmaceuticals.

For a brief period of human history oil dominated the energy and chemical scene. Wood is in the process of resuming its ancient central role, but on a broader scale as science and technology point the way to more effective production and use.—PHILIP H. ABELSON

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