Hardwoods Within the Complete Forest Concept

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Abstract

The Complete Concept, biological and technological investigation of the entire tree from the root tips to the leaf tips inclusive, has been incorporated much more into the management and utilization of hardwoods than softwoods in the past ten years. Mechanized harvesting centered around mobile chip harvesters has increased production per hectare in hardwood stands about 100% by utilizing "tops" as well as small trees of all hardwood species previously not used. All of the traditional uses of hardwood are expanding to meet demand and simultaneously there is increased use for energy, cattle feed and chemicals such as xylitol. With the acknowledged shortage of fossil resources chemists and engineers are now critically examining the forests, our renewable resource, indicating that increased use of hardwoods is certain.

Short rotation of 3-10 years involving thousands of stems per acre, often as a result of coppicing, are now being investigated for a number of hardwood species. This will result in intensive forest management similar to agronomy except that fibre rather than fruit production will be emphasized. Advances in short rotation management of hardwoods will always lag behind hardwood utilization because development times are not the same. Therefore those involved in management will have to stress caution as a means of guaranteeing viable and productive forests while knowledge is accumulating.

Introduction

With the assistance of more than 40 undergraduate and graduate students, the collaboration of 15 university and government scientists, the cooperation of forest owners and the financial support of the University of Maine Experiment Station, two Maine state agencies, one industrial firm and one large forest management company; more than 70 papers and bulletins based on the Complete Tree Concept have been published since 1959. The basic concept has evolved into the Complete Forest Concept which I now define as: biological and technological investigation of all woody shrub and tree species, from the root tips to the leaf tips, for intensive management of some portions of the forest, and utilization to include (a) solid and liquid fuels, (b) food and fodder, (c) cellulose and textile fibres (d) structural material and (e) basic materials for the chemical industries. These plus a host of other publications on the topic have probably quadrupled the literature since

Keays (1971) prepared his magnificent Complete Tree Utilization literature review.

Because of the small size and peculiar shapes of many roots and branches, weight—both fresh and dry, is the most convenient quantitative measure to use for all components (leaves, branches, stem and stump-root system) of woody vegetation. Instead of volume per tree and per hectare for both the standing crop and annual production. Fortunately the familiar dimensions, dbh and height above ground, are readily used to correlate size with weight. Furthermore the accumulated data indicate a closer relationship between tree dimensions and weight than between tree dimensions and volume, indicating that fewer field measurements are necessary when using weight. For general planning purposes (1) one metric ton of oven-dry forest material is the equivalent of a cord, (2) in eastern Canada annual dry matter production per hectare, both above and below ground but exclusive of the leaves or needles, is about 3.3 oven-dry tons and (3) a mature hardwood stand in eastern Canada will contain the equivalent of 175 oven-dry tons per hectare, above and below ground, for all tree and shrub species.

Over time the useful results of the biological and technological investigations of hardwood stands within the Complete Forest Concept become absorbed into forest management, harvesting methods and conversion into products used by society. Development is in progress in all three areas. Utilization developments encourage new harvesting methods and these influence forest management, so they will be discussed in order.

Hardwood Utilization

Puckerbrush pulping studies (Chase, Hyland and Young 1971, 1973) established that usable pulp can be made from the wood and bark of both stems and branches of successional tree species in a shortened cooking sequence in the kraft process. This is equally true of eastern Canadian hardwoods (Hunt and Hatton 1975) and rapidly growing hybrid poplars (Laundrie and Berbee 1972). Short rotation hardwoods (Lonnberg 1976) intended for paper making should (a) grow rapidly, (b) contain little bark and (c) have long fibres. These are factors that can be controlled to some extent by tree breeding.

"Muka", fodder vitamin supplement prepared from foliage, now amounts to more than 100,000 metric tons per year in the Soviet Union (Ilevins et al 1973) and it is expected to double that amount within ten years. The possibilities of extending this use to North America are being

considered (Keays and Barton 1975, Gerry and Young 1977, Apgar et al 1977). If 2-5% Muka can be included in animal feed in North America then millions of tons of grain can be saved for other purposes each year.

The potential of aspen as livestock feed in the form of pellets made from wood, bark and leaves (Kamstra 1976) appears to be very high since aspen has a high protein content (Siren et al 1970). A patented process (Jelks 1976) for hydrolizing cellulosic waste into a nourishing palatable animal feed is now a commercial success. A 50 ton per day plant using oak sawmill waste is in operation, four plants that will produce 400 tons per day are under construction and license negotiations are in process for nine more plants that will produce 1500 tons of animal feed per day from sugar cane bagasse, scrub oak, wheat straw, and cotton gin trash. Mr. Jelks lives in Oklahoma and consults for commercial plants there and in Missouri and Texas. This feed may not differ a great deal from "Masonex" (Galloway 1976) which is a hemicellulose extract of hardboard manufacture that has been on the market for ten years, amounting to more than 90,000 tons in 1975.

The Institute of Dentistry at the University of Turku, Finland (Makinen 1976) has established that xylitol, a natural sugar found in many plant species but particularly in birches, is not toxic to the body and actually reduces dental cavities. Industrial plants in Finland, the Soviet Union, Italy and Germany (Young 1977) are producing 7,000 metric tons of xylitol a year. If experiments with children, similar in nature to those with university age adults in Finland, have similar results then we can expect a rapid increase in xylitol production in the western world. White and gray birch (Saeman and Young 1977) have about as much xylanase as the European birches, indicating that xylitol may become an important North American product.

When the product is to be veneer or boards, the bark is removed as soon as possible from the log and in most mills is considered useless unless burned in a boiler. Use of hardwood bark, however, is rapidly coming to the foreground. In Finland (Snellman 1973) studies have shown that hardwood bark can be used in particle board in the core with wood chips on the surface. There is now a shift in the use of sawdust and planer mill shavings from livestock litter to raw material for pulp mills, but studies (Labosky et al 1977) show that hardwood bark can be used as poultry litter. Poultry manure and bark (Mater 1977), two by-products which are frequently disposal problems, have the potential, when composted together, to become a valuable agriculture product.

The shaping-lathe headrig (Koch 1975, 1976) produces cants that are rectangular, hexagonal or trapezoidal as well as square, octagonal or round from round logs. This machine will make it possible to produce either whole or half crossties, posts, rails, pallet deck-boards and stringers from the butt logs of hardwood trees too small, too branchy and too crooked for traditional products.

In addition all of the waste material that accumulates from the use of the shaping-lathe headrig can be used for pulp, particleboard or poultry litter.

Goldstein (1975) is confident that the conversion of wood into chemicals for the production of most of our synthetic plastics, fibres and rubbers is technically feasible. He believes that fulfilling our polymer needs from wood would not place an impossible burden on our forests since our polymer needs can be met from forest residuals and mill residues.

The energy crisis appears to be as important a topic of conversation as the weather, even during the unusually cold winter of 1976-77 when this is being written. There is very little evidence that the energy potential of the forests is being realised on a regional basis despite the fact that the price of oil, gasoline and all other petroleum products have markedly increased. There isn't even significant interest in reliably estimating the biomass of the complete forest (Young 1975, Young et al 1976) which is basic to fully appreciating (1) the total tonnage of the standing forest, (2) annual productivity in tons per hectare on a national level, (3) the need for new efficient harvesting equipment and (4) the efficiency and economics of scale in plants for conversion of forest material to energy or fuels such as methanol (Barr and Parker 1976). Every forest industry with large timber land holdings is seriously considering conversion from oil to wood for energy. Some have already done so and at least one has arranged to put the surplus on the local utilities lines. An expansion of such cooperative arrangements between private industry and utilities in regions with large forest areas can be most helpful.

The previous paragraph was concerned with the potential of the standing forests and their natural productivity to produce energy. There is considerable evidence (Brown 1976) that this potential can be increased 10-15 fold in some places and 2-4 fold in others by intensive forest management involving the use of genetically superior tree and shrub species, fertilization, thinnings and other well known techniques. Without reliable biomass estimates we do not know the potential of the forests and until intensive forest management occurs we won't have a reliable estimate of the maximum potential of our forests.

Hardwood Harvesting

Following World War II the rapid and widespread use of chainsaws and rubber tired skidders heralded the advance of mechanization in forest harvesting. The kingpin in the rapid advance was the development and commercial use of mobile chiparvestors in 1970, now known as total tree chiparvestors. The largest model can take the entire above-ground portion of a tree 22" in diameter at the butt end and in slightly more than a minute reduce it to chips that are immediately blown into an adjacent van. A completely mechanized harvesting system may consist of one or two feller-bunchers, one or two skidders, a mobile

chiparvester, a number of tractor-vans and appropriate personnel. Such a set of equipment will cost up to \$500,000 and with efficient personnel can produce 125 cord equivalents in a normal working day. Today more than 500 mobile chiparvestors of various sizes have been purchased and used primarily in hardwood stands. This system not only utilizes the tops of merchantable size hardwoods, but also utilizes hardwoods of less than traditional merchantable size and the puckerbrush species (gray birch, pin cherry, red maple, and aspen.) that formerly weren't used at all or were used very little. The increased production per hectare in hardwood stands is about 100% (Keays 1975).

Very little has been done about commercial harvesting of hardwood stump-root systems although several pieces of suitable equipment exist and are being studied. The Palleri Stumparvester (Hakkila and Makela 1973) removes softwood stump-root systems so well in the frost-free months that more than 40 are in use in the Scandinavian countries. There are no obvious reasons why it shouldn't work well with hardwood stump-root systems. The Koch-Rome complete tree harvester. (Fig. 1). (Koch 1974) has been successfully tested on hardwoods up to a stump diameter of 8.0". The L.B. Foster Company (Young 1976) has tested the hydraulic vibrator system on softwood stump-root systems in Maine with good results. When this system is developed into a self-propelled unit it should work as well with hardwood as with softwood stump-root systems or complete tree removal. The stump-root systems of a mature hardwood stand will contain about 35 oven-dry ton equivalents per hectare.

Fernow (1913) has shown that the practice and intensity of forest management in each country is conditioned by economic factors that do not occur simultaneously in all countries. Thinnings became a practical measure in Europe many years ago because the population was large, stumpage was high and labor costs low. The conditions in North America are similar today except that labor costs are high, encouraging mechanized thinnings as a means of increasing forest productivity by utilizing what would otherwise be lost as dead material. Practical thinnings on a large scale in this mechanized era will require the development of new equipment such as (1) a small single stem harvester that will not damage the residual stand, (2) multistem harvesters for very dense stands (Silversides 1975, Koch and McKensie 1976) and (3) smaller chiparvestors than the 12' model recently put on the market by Morbark Industries Inc. Complete mechanization usually requires some biological compromises such as the "third row" thinning system developed in Australia. In Maine young natural fully stocked hardwood stands (Young 1977) have about 10,000 stems per hectare with about 33 oven-dry ton equivalents in the standing crop in the above ground portion. If half could be efficiently and effectively removed in thinning, a tremendous tonnage on a province-wide basis would be available for energy or other

uses.

It has seemed to me that the design of harvesting equipment has been principally influenced by logging contractors rather than forest land owners or managers. Contractors are seriously concerned with the rising cost of both labor and equipment and stress efficiency of harvesting in order to remain in business. The time has come for forest land owners and managers to encourage the development of small machines for thinnings to use material that otherwise would be lost. Most forest owners will never be in a position to buy any large harvesting equipment but virtually all will be able to buy one or more thinning machines and related equipment and those with holdings in multiples of 50,000 hectares will probably buy many.

Hardwood Forest Management

Many hardwood species grow rapidly as juveniles. This natural trait has been enhanced by geneticists whose goal has been to produce sawlog and/or pulpwood size trees in the shortest time possible. Short rotations ranging from 2-15 years (McAlpine et al 1966, Steinberg 1973, 1976, Ribe 1975) are being studied widely. Virtually all of these studies began with the goal of producing trees smaller than traditional size for the pulpwood market but the energy crisis has extended the concept to include pulpwood and energy. In some instances energy production is the only objective. There has been such a concentrated effort by geneticists on hybrid poplars that most research in short rotation forestry (Einspahr 1976, Dawson 1976, Anderson and Zsuffa 1975, Zsuffa, Bowersox and Ward, 1976, Siren 1976) has been with this species. A number of research workers have achieved annual dry matter production of 10.0 tons per hectare with hybrid poplars in short rotations — more than three times 3.0 dry tons per hectare of natural hardwood stands in Maine (Young 1971). In Morocco, Riedacker, (1965) found that the productivity in the fourth ten-year coppice rotation of *Eucalyptus* was only half of the first three rotations indicating a possible future problem in hybrid poplar coppice.

Short rotation hardwood forestry is only in its infancy and should be encouraged because of its tremendous potential. Investigators must learn (1) both the optimum biological rotation as well as the optimum economic rotation period, (2) ideal spacing and fertilizer treatment, (3) the number of coppice rotations before the stump-root systems must be removed and (4) the potential, both biological and economic, of controlled environments for short rotation forestry. Maximum sustained yield (Samuelson 1976) is being questioned because it may differ markedly from economic sustained yield. Short rotation forestry poses a challenge to forest economists.

Summary and Conclusions

The rapid distintegration of outmoded ideas concerning the minimum size of trees for harvesting and the number of hardwood species commercially useful has resulted in an expanded use of hard-

woods. Mechanization of harvesting centered around mobile chiparvestors has increased production per hectare in hardwood stands about 100%. The increased utilization of hardwood species and mechanized harvesting have stimulated short rotation forestry on an unprecedented scale. The traditional uses of hardwood species are expanding simultaneously with increased use for energy, feed and chemicals. Chemists, chemical engineers and mechanical engineers are beginning to critically examine the forests, or renewable resources. Consequently the achievements of the past 25 years will probably appear small when compared with those of the next quarter century.

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