THE COMPLETE TREF CONCEPT: A CHALLENGE TO THE FOREST GENETICIST[1]

Harold E. Young[2]

INTRODUCTION

It is difficult to trace the origin of an avenue of investigation for many factors are involved of which only some are recognized. As a freshman at the University of Florida in 1933, I do recall reading a forestry book containing a table showing that we use a third or less of each felled tree which I tucked away in my memory. A major continuing influence has been my wife, who lives her philosophy of New England frugality and simplicity every day. With effort a lengthy list of other factors could be tabulated. It was, however, an administrative decision within the Chemical Engineering Department made for totally different reasons than the impact on me that brought about the first actual studies that led to the Complete Tree Concept which has evolved over

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[2] Professor, School of Forest Resources, University of Maine, Orono, Maine 04473.

the years. This paper will briefly summarize the developing phases of the basic concept and then present the Complete Tree Concept as a challenge to the forest geneticist.

The national needs of the United States in terms of its forests can be stated as follows:

1. Air, water, recreation, and material products are essential for human life in our sophisticated affluent society.
2. Despite a decrease in per capita consumption, the total use of wood will continue to increase. Within this framework, the use of solid wood products is decreasing and the use of reconstituted products is increasing.
3. The total forest land in the USA has decreased 500,000,000 acres in the past 350 years due to agriculture, urban expansion, airports, transportation and transmission systems, etc. This will continue for the same reasons, plus an increasing amount of forest land being set aside for watershed management and recreation further reducing the forests for forest products.
4. Accidental or deliberate brush burning causes air pollution. Chemical spraying of brush causes water pollution. Due to public sensitivity to all forms of pollution, it is likely that legislative action will eliminate these forms of brush disposal requiring alternative methods.

It does not seem possible that we can continue present practices and achieve our national requirements from the forests. Alternative proposals, such as the concepts based on the Complete Tree Concept appear essential in order to maintain the health, vigor, and usefulness of our forests and simultaneously continue to meet our national needs.

THE COMPLETE TREE CONCEPT

Pulping, biomass, and nutrient studies were initiated in 1959. By 1964, the Complete Tree Concept (4) had crystallized, based on the available data. This concept is biological and technological investigation of the entire tree from the root hairs to the leaf hairs, inclusive. This is in sharp contrast to the Concept of the Merchantable Bole, which is currently in vogue. A series of papers and bulletins (1, 2, 3, 5, 6, 7, 8, 9, 10) show the following:

1. Regardless of size of species, the distribution of wood fiber is approximately: bole (65%), unmerchantable top (5%), branches (5%) stump (15%), and roots (10%).
2. Approximately 50 percent of each of the 15 essential elements in a tree is in the merchantable bole with about half in the wood and the remainder in the bark.
3. Pulp made from the wood of the logging residue is similar in yield and physical properties to pulp made from the wood of the merchantable bole, except for the branches which have a lower yield and poorer physical characteristics.
4. Use of all of the logging residue would increase yield from the forest by 50 percent.

The merchantable bole is commonly measured in board feet or cords, two units of cubic measurement. The varied size, shape, and abundance of branches and roots excluded volume measurement because of the time and errors that would occur. It was necessary to use weight in the complete tree studies because of the simplicity, rapidity of measurement, and limited source of errors. Inasmuch as all components of the tree were measured in the same units, attention was focused on the complete tree rather than the merchantable bole. This made it possible to look at the forest from a broader perspective, eventually leading to consideration of the standing crop in terms of dry matter production similar to wheat, corn, and other agricultural crops.

THE COMPLETE FOREST CONCEPT

Regeneration for the next crop is obtained in present forest management in one of two ways. One is by deliberately leaving a portion of the stand as seed trees, and the other by clear cutting and planting. The former is by far the dominant method on a world-wide basis. From the perspective of the complete tree concept, both methods leave much to be desired. In the selective logging method, many small trees are incidentally destroyed, and in the clear cutting method, all trees not harvested are deliberately destroyed prior to planting. Awareness of the smaller trees and shrubs led to studies of smaller trees and shrubs (2, 9) which led to the Complete Forest Concept in 1967. This concept is biological and technological study of all of the shrubs and trees with a view to intensive management of selected areas similar to agriculture production and utilization similar to the cattle and hog industries. The latter claim that they use everything but the "oink" and the "moo", and in the same vein, the Complete Forest Concept suggests using everything but the rustle of the wind as it passes through the leaves and needles of the shrubs and trees.

PUCKERBRUSH PRODUCTION AND UTILIZATION CONCEPT

Up to this point, the major thrust of the research has been with seedlings, saplings, and mature specimens of commercial tree species with minor effort on a few woody shrubs. In other words, little attention has been put on the noncommercial trees and shrubs. In Maine alone, there are more than 50 species of noncommercial hardwood tree and shrub species. These commonly grow in dense stands with literally thousands of stems per acre and are commonly called "puckerbrush." Inasmuch as"the bush" is a common term for commercial forests in several countries, the term "puckerbrush" can be usefully applied to presently noncommercial tree and shrub stands which occur as successional species on every continent.

Overseas travel visually demonstrated the ecological principle of plant succession on a global scale. Species vary from continent to continent, but similar kinds of species occur at each successional level. The successional stage prior to the climax forest consists of woody shrubs and trees that usually have no commercial value today. These species generally have light seed that spread quickly, grow rapidly, and are short-lived. In the southeastern USA, the pines are successional species that are highly preferred at the present time to the climax species: oak and hickory. In the northeastern USA, gray birch, red maple, aspen, pin cherry, alder, and willow are some of the more common successional species, but none of these are as desirable today as the climax species, spruce and fir. Such observations as these led me to believe

that biomass and pulping studies of puckerbrush species might lead to heretofore untouched sources of raw material for reconstituted woody products.

Pulping Studies

This phase is conducted by Professor Andrew Chase of the Chemical Engineering Department and Professor Fay Hyland of the Botany Department. The former has two part-time technicians who do the pulping studies. The latter is responsible for the anatomical studies. The studies of 1970-1971 can be summarized as follows:

1. Only 30 minutes at temperature and pressure in the kraft process are required to pulp juvenile wood and bark instead of the 120 minutes required by mature softwood. Thus, fewer chemicals are required and there is less waste liquor.
2. There is about a 41 percent yield of pulp made from the wood and bark of stems and branches (about 45 percent with spruce and fir wood) in the kraft process. Four-stage bleached pulp has a brightness of 82 as compared with the industry standard of 88.
3. The physical characteristics of puckerbrush pulp (wood and bark) compare favorably with conventional pulp (wood only).
4. Puckerbrush fibers are shorter than the fibers of mature hardwoods.
5. It appears that a variety of useful paper and paperboard products can be made from pulp prepared from the stems and branches (wood and bark) of puckerbrush species.

Biomass Studies

Field work is accomplished by a two-man crew working under the direction of the author. The biomass studies (11) for 1970-1971 have established the following:

1. Fully stocked puckerbrush stands in Maine, regardless of species or species composition and ranging from 5 to 45 feet in height above ground will produce about 1.2 tons of dry matter above ground exclusive of leaves per acre per year.
2. It appears that puckerbrush in Maine grows about the same amount per acre per year as the commercial tree species, recognizing that a ton of dry matter is the equivalent of a cord and only the merchantable bole is included in current inventories.
3. In fully-stocked puckerbrush stands in Maine, dry matter accumulates about 0.8 tons per linear foot of average stand height.
4. Regardless of species or species combination, puckerbrush produces about 1.0 ton of leaves (oven-dry basis) per acre per year without regard to stand age after the first few years.

Woody Fiber Farming

Because puckerbrush species are of such negligible commercial importance, there are no reliable estimates of forest land covered with puckerbrush

species. Of the 17,500,000 acres of forest land in Maine, at least 2,000,000 acres are always in puckerbrush and this may extend to 4,000,000 acres as the result of abandoned farms, forest fires, and heavily logged road. It is quite likely that there are more than 25,000,000 acres of puckerbrush in the USA and at least ten times that amount in the entire world. In addition to these estimates, transportation and transmission systems have right-of - ways of more than 22,000,000 acres, of which at least 6,000,000 pass through forested land in the USA alone. Utilization of some or all of the puckerbrush species would not only reduce or eliminate brush burning or spraying chemicals on brush on right-of-ways, but would provide an alternative source of raw material for reconstituted products reducing the pressure already being exerted on forests recognized for their commercial value.

Woody Fiber Farming can be accomplished by two different approaches. One, the method of opportunity, is to harvest puckerbrush stands that have grown in naturally on abandoned fields, burned over, cut over, or right-of-ways with the intent of harvesting every 10 to 15 years thereafter. The other, the plantation or seeding method, is based on planting genetically superior stock or distributing genetically superior seed on right-of-ways or abandoned fields. The intent in the second method would be to harvest the succeeding coppice stands on a 10-to 15-year cycle. The first method requires no investment in the crop and, consequently, should not be expected to have a high yield. The second method requires, initially, research followed by the cost of seed orchards and nurseries, but in return should provide higher yields that more than offset the additional cost.

THE CHALLENGE TO FOREST GENETICISTS

The Merchantable Bole Concept, which is the use of the merchantable bole of merchantable species in merchantable stands, has dominated forestry and the forest industries for hundreds of years. Therefore, it was appropriate for foresters to charge forest geneticists with the responsibility of producing rapidly growing individual trees with specific characteristics concerning the branches and internal characteristics of the bole. In sharp contrast, the Complete Tree Concept is concerned with the entire plant for all species of trees and shrubs, regardless of size. This concept emphasizes dry matter production per acre and, in addition, is concerned with tree and shrub improvement in terms of desired anatomical characteristics. The Complete Tree Concept presents two distinct challenges to the forest geneticist. One is a more precise quantitative measurement technique for field and laboratory studies. The other is the perspective of consideration of all trees and shrubs in the forest in terms of dry matter production per acre per year.

The principle field measurements in forest genetics studies are breast height diameter, height above ground, and measurements permitting calculation of growth and volume of the merchantable. These measurements are useful in all phases of forest management, but were not designed for scientific purposes. Thus, the sophisticated scientific aspects of genetics research are somewhat downgraded by the field measurement techniques. These measurement techniques should be used to relate the scientific work to forest management, but should not be the basic quantitative measurements for genetics studies. The fresh and dry weight of each of the Complete Tree components is a more precise way to establish the effectiveness of a tree improvement study. Weight is much more time consuming than the few simple measurements required to estimate

volume. Consequently, only a very few trees could be measured in one day, but the increase in accuracy of the data should more than justify the added cost and the reduction in number of trees measured. Change is always awkward, particularly when it increases cost. If a few venturesome geneticists would use biomass methods, I am confident that their published papers will stimulate others to follow suit.

Up to the present, foresters have told geneticists which species were important and the geneticists have dutifully studied those particular species. Now, we are all faced with the proposition of studying all of the woody vegetation, thus presenting the major challenge to the geneticists. Obviously, all species cannot be studied simultaneously, and probably all will never be studied in detail. At least a cursory study will have to be made of many with major concentration on those species that will produce the greatest dry matter per acre per year with the desired internal characteristics. What "weed species" of today will become of prime consideration in the future?

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