Impacts of Tree Improvement on the Forest Products Industry

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INTRODUCTION

My objective is to discuss the impacts that tree improvement programs have had on the forest products industry in the U.S. South. The period covered is roughly from 1950 to the present, with an occasional reference to the early parts of the 1900s. To assess the impacts, it will be necessary to give a thumb-nail sketch of the changes in the forest industry during that time.

Until about 20 years ago the forest products industry operated without significant competition from abroad. With the exception of Canada, we largely grew our wood and manufactured it into the products that were in demand by society. When the internal economy waned and capacity was high, the excess was exported, but when the reverse occurred we ignored the export market while benefiting from internal consumption. That mode of operation caused foreign buyers to identify us as unreliable suppliers. Those buyers established a lasting relationship with partners on whom they could rely during good times and bad. The relationship of the Nordic countries to Western Europe is the epitome of trust between supplier and buyer (Siry, *et al.* 2005).

In the early 1980s, the U.S. economy deteriorated badly. Nominal interest rates rose to about 20 percent. That phenomenon, in combination with a high monetary exchange rate, sparked a revolution in the forest products industry. Imports from every corner of the globe came trickling into the U.S., and then they became a flood. Conversely, exports of domestic wood products waned to a slow death.

The ailing forest products industry spawned the interest of arbitragers who visualized a financial gain by buying companies at reduced prices and selling the parts for a sum greater than the whole. In some situations, only a modest amount of cash was offered with the remainder being secured from lending institutions that used the land base and the manufacturing plants as collateral. During this time, many of the forest products companies that were household names ceased to exist. Among those names are American Can, Continental Can, Crown Zellerbach, Owens-Illinois and Scott Paper. Others such as St. Regis and Hammermill escaped the arbitragers only by 'white knight' Champion and International Paper coming to the rescue.

In the early 1990s, the economy had righted itself so that the remaining forest products companies prospered to economic highs not seen in the previous 40 years. Northern bleached softwood kraft (NBSK) pulp exceeded $900 per ton, with southern bleached softwood kraft (SBSK) being not far behind. In unison, hardwood bleached kraft pulp, both northern and southern, reached record highs. These good economic times caused a further consolidation within the wood products industry during the late 1990s and the early years of 2000, but this time it was the dominant players in the industry that were swallowing their smaller

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counterparts. Among the fallen were Blandon, Union Camp, Consolidated, Champion, Federal Paper Board, Union Camp, and Willamette.

What does all this amalgamation have to do with tree improvement? In short, it has to do with the land base. Starting in the 1930s, when the pulp and paper industry learned that competitive pulp, paper and paperboard could be made from the high-resin southern pines, thanks to Herty Laboratory, Savannah, GA, there was a rush to build new pulp mills. During 1937-38, 18 new pulp mills came on stream. Those mills stretched along the coast from Eastern Virginia into the pine belt of Texas. Almost without exception, those 18 mills and others began compiling a forest land base for timber support. Only a maverick here and there chose to build a mill without the back-up wood resource. Interestingly, those mavericks survived, largely because of landowner assistance programs and because of the camaraderie among wood procurement managers; the wood-poor mills survived because of the wood-rich ones.

The pulp and paper industry went on a binge in the 1960s by diversifying into businesses that were foreign to their core assets, such as rug, furniture, insurance, farming and home construction. With the minor exception of home construction, those investments failed, largely because the buying companies were operating businesses outside of their areas of expertise. Abutting that costly experience was the advent of the chip-‘n-saw mills. Nearly every company with significant land holdings invested in that business for the dual purpose of leveraging their timber resource for lumber manufacture as well as a ready supply of chips for the pulp mills. Even though grade-pine sawmills were the core of the land base of some pulp and paper companies, others expanded their operations from the chip-‘n-saw operations into high-speed sawmills with production capacities of 80 to 100 million board feet per year, or more. The evolving utilization standards had a significant impact on tree improvement programs because the emphasis shifted to open-pollinated family-block plantings where some families with good growth and tree form were managed for sawtimber rotations, whereas others with fast growth but marginal form were destined for the pulp mill and, later as we shall see, to engineered wood products (EWPs). The open-pollinated family-block plantings have evolved today to control mass pollination (CMP) where the parents are chosen for the attributes specific to the desired end product. The CMPs of today are being eclipsed by clonal forests of tomorrow.

Following the advent of the chip-‘n-saw mills by a decade or so were EWPs, chief among which are oriented strand board (OSB) and laminated veneer lumber (LVL). Those allied industries, together with continuous digestors that allowed sawdust to be manufactured into pulp, and power generating plants that used residual bark and refuse wood for fuel allowed the forest industry to liken themselves to the hog industry where everything from the forest was utilized except the squeal.

The forest land base was considered an asset to the financial well being of a company in the early years. It served as collateral for construction of new pulp mills and other assets. During the high-inflation years of the late 1970s and early 1980s, the land base suddenly became a liability in the eyes of the stock analysts. That is one reason why the arbitragers were so successful in buying the whole for less than the parts. Even companies that survived the onslaught began separating their forest lands into wholly owned subsidiaries. Other forest products companies began selling (and continue to sell) their timberlands to new types of forest-land holding companies such as Timber Management Investment Organizations (TIMOs) and Real Estate Investment Trusts (REITs). The TIMOs are primarily invested in the U.S., but have holdings in New Zealand, Australia, Canada and Brazil. Among the 25 or so organizations that fall into this category, Hancock Timber Resources Group is the standard bearer with about three million acres of timberland. Plum Creek Timber Company is the king among the REIT group, with upwards of eight million acres of timberland. Only a select group of companies continue to hold timberland for wood-resource security. Among those few are International Paper., Weyerhaeuser, MeadWestvaco and Temple-Inland. Even among those giants, non-strategic timberlands are commonly sold to the TIMOs, REITs and others.

FORMATION OF TREE IMPROVEMENT PROGRAMS

During and following the years of World War II, the newly coined pulp mills in the South operated on the second-growth forests of colonized agricultural fields that had once supported extensive stands of longleaf pine (Early 2004). Following the demise of the pioneer forest to naval stores and lumbering (Outland 2004) the land was cleared for agriculture. By 1920s much of the land that was abandoned because of poor agronomic soil husbandry and the pervasiveness of the boll weevil had succeeded to native-seeded forests. Even then data compiled by the USDA Forest Service (Alig 1985) and others showed the timber supply to be unsustainable at current usage. In unison, the industry set about to manage their timberlands. The first effort was to plant open lands and, secondly, to site prepare and plant lands from which the timber crop had been harvested. The open-land initiative culminated with the Soil Bank plantings of the late 1950s in which about three million acres of plantations were established with southern pines.

Site preparation of cut-over woodlands varied in quality during the early years. No one knew the quality of site preparation needed and the heavy equipment and other resources were lacking. Heavy equipment that was designed for earth moving was tried with varying results, and herbicides with and without fire received wide-spread attention. With necessity being the mother of invention, the KG-blade, V-blade and root rake came into being. The site preparation equipment also included the rolling drum chopper that was fashioned from a paper-machine drum onto which were welded cutting blades. That vision originated with Wes Sentell, a forester from Arkansas who culminated his career as Woodlands Manager for Tennessee River Pulp and Paper Company, Counce, TN.

It was during this time, also, that forest tree nurseries were established with abandon. Every state forestry service built one or more of the seedling producing factories, and they were aided by nurseries of USDA Forest Service and forest industry. Even though the optimum seedling grade of the southern pines had been quantified by Dr. Phil Wakeley (USDA Forest Service) in the early 1950s the quality of the seedlings produced in the myriad nurseries was highly variable. Thus, the combination of marginal site preparation, poor quality seedlings, and lack of tipmoth control added to the notion that loblolly pine required about four years to become sufficiently established to start meaningful height and diameter growth. It was that notion in addition to the general absence of tipmoth damage to slash pine that caused foresters throughout the loblolly pine region to favor slash pine. Decades passed before the old-line foresters acknowledged that plantation-grown loblolly pine was the superior species in volume production on most soils outside of the deep South.

It was no accident that plantation forestry of the southern pines developed in parallel with tree improvement programs. In fact, Dr. Bruce Zobel was hired as a silviculturist by Texas Forest Service, not as a tree breeder. His foray into forest genetics resulted from a public lecture in Houston, Texas by Dr. Åke Guftasson, a plant breeder from Sweden. The result was the first tree improvement cooperative, with equal participation between public and private agencies. That program, organized in 1951, continues to exist as the Western Gulf Tree Improvement Cooperative. It was joined, in succession, by the University of Florida Cooperative Forest Genetics Research Program and the North Carolina State University-Industry Cooperative Tree Improvement Program. Other tree improvement initiatives were organized by public agencies, *viz.,* USDA Forest Service, Tennessee Valley Authority, and various state forestry services. Many of these programs have waned and others, especially those housed within state forest services, have united with the cooperative programs at Texas A&M, Florida and NC State. The occasional industrial tree improvement program that was not originally aligned with one of the cooperatives has come into the fold, largely because of the wide genetic base maintained by the cooperatives.

LAND MANAGEMENT

To sell the tree improvement concept to cooperative members, Bruce Zobel promised a gain in volume production of five percent at the end of a rotation relative to a plantation with unimproved genetic material. Realizing that it would be 10 to 15 years before his promise could be verified and realizing that members of the cooperative would become apprehensive while awaiting the results, the entrepreneurial scientist began studies of wood properties of the southern pines and, to a limited extent, of southern hardwoods. The initial studies showed variability among and within species, and within trees from pith to bark and base to top of crown. Subsequent data eventually showed some of the wood properties, such as specific gravity, to be highly heritable. Thus, the original stop-gap initiative became an integral part of the weighted index for genetic improvement of the southern pines.

As the tree improvement programs progressed, the cooperators learned that the effort included more than just the selection of superior trees and establishment of seed orchards. The next step was progeny testing. The original idea was to evaluate the genetic worth of the selected trees by open-pollinated progeny tests, but flowering in seed orchards at an earlier age than expected, four to six years from establishment, resulted in the decision to forego open-pollination testing in lieu of controlled crossing. A dictum handed down by Dr. Zobel was that the progeny tests were to be established on land that had been site prepared following harvest of the parent stand. In short, tests were not to be established on old fields[2].

With the rather crude methods of site preparation that were common to the time, performance of the progeny was highly variable. The dictum was then communicated that best performance of genetically improved plant material had to be in concert with the best silvicultural practice, inclusive of site preparation, and that the tests were to be on 'average' sites, avoiding the most

[2] Because of the high genetic correlation between trees grown in intensively managed research plots relative to those grown in commercial plantations the strategy today is to test the genetic material on the best sites regardless of previous land use.

fertile and least fertile soils. With development of the progeny, comparisons were made with the performance of the genetic material against the trees in commercial plantations. The relatively better performance of the trees in the genetic tests, inclusive of the common check, caused the cooperating members to improve their site preparation methods accordingly. Even though there are many components to site preparation, and no system is optimum for every situation, today's example might include shearing, piling, disking and planting.

In conjunction with the establishment of first-generation seed orchards, it became obvious that plantations established on old fields were superior in tree growth and volume than comparable stands established on cut-over lands. A large part of that difference was attributed to the lack of woody competition, and to residual nutrients from agronomic cropping. Herbicides specific to forestry were developed that were effective in controlling all competing vegetation, and others were specific to the control of competing woody vegetation. Continued evaluation has allowed the herbicides to be prescribed for today's use by type, amount and timing.

In concert with the control of competing vegetation, plant nutrition was found to be limiting tree growth on most sites. The most notable example was the sites in the Coastal Plain that were phosphorus deficient. Treatment of those sites with phosphate at time of planting was found to be essential for acceptable tree growth. Additional studies across the range of sites common to loblolly pine plantations showed that an application of nitrogen in combination with lesser amounts of phosphorus gave economically attractive returns when applied at time of crown closure (7 to 10 years from planting), and at about 10-year intervals, in combination with thinning, until rotation age is reached (Allen *et al. 2005)*. Some soils have been found to be deficient in potassium, and others in boron and copper. Prescriptions fertilizer applications are now the rule with loblolly pine plantations. More that 150,000 acres receive treatment annually, and more that two million acres of forest plantations, inclusive of repeat treatments, have been treated since the practice was initiated in the 1980s (Allen *et al.* 2005).

This combination of factors: genetically improved planting stock, optimum site preparation, use of quality seedlings, competition control, optimum plant nutrition and stocking control has increased productivity of loblolly pine plantations from about 3 tons/acre/year in natural stands and 5 tons/acre/year in the original plantations, to as much as 15 tons/acre/year in the most recently established plantations. Tree improvement programs of the southern pines that have progressed through the third generation of breeding, are showing 30 to 40 % volume improvement over the common check. The added productivity is being realized from the best genetic stock benefiting from optimum silvicultural practices.

SUMMARY and CONCLUSION

The next step in the improvement of forest trees, in conjunction with continued tree breeding, will involve molecular genetics. Molecular genetics is an extension of tree improvement; the difference is that attention is given to the gene rather than to the genotype. Even then, molecular genetics has multiple uses rather than just genetic engineering. The three components are: (1) vegetative propagation of undifferentiated cells (embryogenesis), (2) gene mapping for marker-aided selection and breeding, and (3) genetic engineering (Yanchuk, 2001).

A segment of forest industry has supported university initiatives in biotechnology research since about 1980, even to the point that some initiated in-house projects. More recently, those separate in-house programs have formed alliances with their competitors, largely because of the cost of the separate programs and the competition encountered in developing intellectual property. The best example of the collaboration among competing companies is ArborGen. That stand-alone company consists of the biotechnology resources of International Paper and MeadWestvaco of the U.S. and Rubicon and Genesis Research of New Zealand. The plant material emanating from ArborGen will accrue first to the sponsoring companies, and subsequently to buyers of the plant material.

Considerable controversy is associated with the release of genetically modified trees, even though some years will elapse before commercial plantations of forest trees are established. To provide a platform for open communication around the benefits and risks of forest biotechnology, a new organization was formed, the Institute of Forest Biotechnology (IFB). IFB is an independent organization that has the objective of working for societal, ecological and economic benefits from appropriate uses of forest biotechnology on a worldwide basis. A major cornerstone of IFB is Heritage Trees®. Heritage trees are defined as those that are threatened, endangered or have intrinsic historic or economic value. American chestnut is the poster child of that initiative. Working with The American Chestnut Foundation (TACF), IFB has convened a group of scientists from Syracuse (ESF), Penn State, NC State, Clemson, Georgia, and USDS Forest Service, to identify the genes in Chinese chestnut that connote resistance to chestnut blight. The results of that research will be used for directing breeding programs (marker-aided selection) and for insertion of the identified genes into American chestnut to give the desired fungal resistance. Programs such as Heritage Trees® are important in that they provide a mechanism for direct social benefit from a new technology. In this vein, regulatory agencies are immune to placing value on a product, whereas society demands a favorable risk/benefit ratio such as provided by the Institute of Forest Biotechnology.

The model envisioned by Bruce Zobel over 50 years ago, for public and private agencies to work together, still lives on. The difference today is that we are equally concerned about a protein produced from a DNA contig as were the silviculturists (geneticists) of yesteryear being concerned about the proper source of seed for plantation establishment. We've come a long way, baby!

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