WOOD QUALITY CONSIDERATIONS IN TREE IMPROVEMENT ACTIVITIES

by

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In this the environmental decade, we are constantly pressured by action groups to lock up our timber resource; by the wood users to cut more timber; and by the general public who appear to question every action taken by the forest manager. Tying up timber sales and proposed wilderness areas in long litigations is now commonplace; and I suspect such practices will continue into the future.

We are in a dilemma, a "damned if you do--and damned if you don't" situation. If we cut timber, the preservationists scream; if we restrict cutting, the price of lumber skyrockets, as it is doing now. The public is really unaware of the key role of wood in the materials market, and they scream in favor of substitutes without fully realizing the adverse effects associated with using already-over-taxed, non-renewable resources. This is really the subject of another talk, but I mention it because I feel a land classification system will eventually emerge with areas designated for timber production. Therefore, tree improvement must be concentrated on planting material that will provide maximum yield of the desired wood quality.

Timber quality, as we know it, may be one thing or a combination of many things: Species, tree diameter, tree height, rate of growth, wood density, or any other physical or chemical characteristic. What then, in succinct terms, do we mean by timber quality--and why is it so important?

In quite simple terms, high-quality timber (and I'm speaking from the purely utilitarian point of view) is timber that will yield a maximum of high quality products, be it lumber, plywood, pulpwood, etc. The importance of wood quality was really not recognized until some 15 years ago when Forest Survey, while revealing that timber growth was exceeding demand, also mentioned that the quality of our standing timber resource was declining. I suspect this revelation led to the Timber Quality Conference that was held at the Forest Products Laboratory in 1957. At that time we became highly committed to wood quality evaluations and a hoped-for-marriage with people like yourselves engaged in tree improvement activities. Our purpose was quite simple--to include in the marriage vows adequate consideration of wood quality characteristics. Our responsibility was to make known the wood characteristics deemed important and to provide some measure of the variability of such characteristics in the wild population.

1 Maintained in Madison, Wis., in cooperation with the Univ. of Wis.

Well, what has been done, and what avenues are we pursuing at the Forest Products Laboratory?

With the present "do your own thing" attitude, it is considered taboo to look or even mention past history or, worse yet, to even defend it. I'm going to violate that premise because I think it interesting, beneficial, and more important, it attests to the keen perception of a man in this room.

I would like to go back to the Timber Quality Conference of 1957. I was a new employee at the Laboratory, with great interest in wood quality evaluation efforts. A paper which caught my fancy was titled, "Forest Genetics and the Production of High Quality Timber." (The author also presented it most colorfully, I might add). I was impressed because it was the first time I had heard or seen a forest geneticist go out on the limb and extol the virtues of improving the wood quality characteristics in standing trees. That paper was 15 years ahead of its time and, in case you haven't guessed, the author was the man we honor at this meeting of NEYTIC--Ernie Schreiner.

Let's look at a summary of the chart (table 1) that was presented by Schreiner; and remember that the year was 1957.

Shown are the characteristics affecting wood quality as he envisioned them, with a plus indicating those characteristics he thought could be improved genetically. In addition you will note the improvement procedure suggested, that is, through genetics, silviculture, or where additional research was needed.

Now if you will look at the column marked "today" you will note the progress we have made in 15 years. In only three characteristics, wood density, percent latewood, and fiber length do we find specific examples of the expected gains that are possible through tree improvement activities. I don't think that record is much to be proud of. We should have heeded the call of this man's recommendations.

As a forester and wood technologist, I'm concerned about the characteristics that affect the performance of the end products. Let us concentrate on some of these characteristics and see how they contribute to efficient product utilization.

Specific gravity is perhaps the best indicator of wood quality we have. Both strength properties and pulp yields are related to specific gravity of wood. For example, a 0.10 decrease in wood specific gravity is accompanied by average decreases of 403,000 pounds per square inch in modulus of elasticity. When pulped, a cord of wood would yield an average of 244 pounds less in dry pulp for the same decrease in specific gravity.

The economic implications of variation in specific gravity in the manufacture of wood products, where strength or pulp yield is important, can be easily understood. So we truly are interested in improving the specific gravity of wood in standing timber for those products where strength is an important consideration--namely, structural lumber.

Table 1.--Important characteristics affecting wood quality.

Characteristics Affecting Wood Quality	Estimated Heritability 1957	Estimated Heritability Today	Improvement Procedure
Wood Density	+	(2-9%)	Genetics & Silviculture
Percent Latewood	-	(2-6%)	Research Needed
Fiber			
Length	+	(7-11%)	Genetics
Diameter	-	(+)	Research Needed
Cell Wall Thickness	-	(+)	Research Needed
Percent Heartwood	?	(+)	Research Needed
Other Anatomical Characteristics (Rays, vessels, etc)	+	(+)	Genetics
Chemical Composition			
Cellulose	+	(?)	Genetics & Silviculture
Lignin	+	(?)	Genetics & Silviculture
Extractives	+	(?)	Genetics & Silviculture
Pulp & Paper Qualities	+	(+)	Genetics & Silviculture

Further importance of specific gravity is evidenced by our efforts over the past 10 years on wood density surveys of the standing timber resource. This nationwide effort has resulted in the most complete and up-to-date information ever assembled on the specific gravity of the western conifers, all the southern pine species, Maine conifers, and most recently, the Lake States timber resource. In each case nondestructive sampling permitted relocating and additional sampling by forest geneticists of suspected high-density trees. In some instances the confirmed high-density trees provided scion material for regional tree improvement programs.

When we speak of modifying or improving specific gravity, we must be aware of the attributes that contribute to the specific gravity of wood. The specific gravity of solid wood substance is essentially the same regardless of species. Differences in specific gravity between pieces of wood reflect differences in cell wall thickness, cell diameter, cell length, amount of extractives, and volume of mechanical tissue. This is the reason the characteristics shown in table 1 are important and that maximum effort should be directed to improving growth.

Our principal role, therefore, has been directed to uncovering the anatomical patterns of variation within the tree and to assessing the effects of silvicultural practices and environmental factors on such patterns.

In the fiber characteristics area, a recent Laboratory report on western species showed some interesting results. Of primary concern was how fiber morphology affects pulp characteristics and properties of paper. That there is a limit to high density is clearly evidenced in table 2.

Table 2.--Influence of fiber characteristics on pulp sheet physical properties.

(Unbleached Kraft Pulp)

Species	Density g/cm^3	L / T	Tear Factor	Tensile Strength p.s.i.	M E 1,000 p.s.i.	Burst Factor
Western Larch	0.527	1,020	163	3,560	487	27
Douglas-fir	.458	1,040	188	4,640	599	36
Western White Pine	.383	1,170	119	8,150	875	64
Western Redcedar	.312	1,475	146	10,800	900	84
Ponderosa Pine	.406	1,080	167	6,880	753	60
Lodgepole Pine	.426	1,142	138	6,700	822	57

L/T is ratio of pulp fiber length to cell wall thickness.

With the exception of tearing strength, pulp quality was adversely affected beyond a wood density of 0.450 gram per cubic centimeter. Only two species, western larch and Douglas-fir, had density volumes exceeding 0.450 g/cm^3; but the decrease in strength qualities was marked. This study also suggests the importance of the ratio of tracheid length to cell wall thickness in determining the ultimate strength of pulp--hence a good indicator for assessing the papermaking potential of a given pulp.

When we get to the hardwood species, where utilization is increasing almost daily, we are surprised at the paucity of data relative to potential genetic gains. Some geneticists feel that high inheritance values for fiber length are possible. If true, this would be a fruitful area, since fiber length limits utilization of hardwoods.

When we think of heartwood, some of us naturally turn to the highly prized black walnut. What a "boon" it would be if we could control or regulate heartwood content in that species. In addition, think of those species where preservative treatments are seriously impeded by the heartwood present. This is another ripe area for genetic improvement. In our efforts thus far, we have developed quantitative and qualitative values for color, have shown that geographic location influences color, and that soil properties do in fact contribute to heartwood color in black walnut.

Our efforts to identify the physiological and biochemical mechanisms controlling wood formation will also be of interest to you. I am sure you are familiar with Karl Wolter's work at the Forest Products Laboratory and his success in maintaining tissue cultures of excised cambial cells. With proper manipulation of nutrients and hormones, he was able to produce a plantlet complete with roots and shoots. Currently, we are attempting to establish prediction criteria in species selection for intensive culture systems to product high yields and top quality fibers.

Of all the properties that could be screened, we have selected growth rate and its relationship to lignin and cellulose production. In cooperation with Iowa State University and the multi-project unit of maximum fiber yield, we hope to correlate the interacting systems of plant growth regulators and enzymes which control growth rate and differentiation, and thereby characterize enzyme patterns (e.g., lignin content, extractives, etc.). Identification of enzyme patterns could be a useful tool for assessing progeny potential for maximum growth and wood quality.

The last area I would like to mention concerns another problem of interest to all of us -- extending our timber supply. To this end, we have proposed a program which we call Project STRETCH, aimed at increasing the efficiency and yield of solid lumber-type products. For those skeptics who say solid lumber will shortly be a thing of the past, let me remind you that half of all the roundwood cut last year was used as sawlogs for lumber.

Project STRETCH will develop and adapt modern technological concepts to each step in the process of breaking down a log into products, further manufacture of these products, and finally the most efficient use of these products. Project STRETCH guarantees to increase the yield and usefulness of the products from each harvested tree and thereby conserve wood.

Prompting this action program was a disturbing paradox--that the Nation's largest material resource is processed and used at a technological level far below that of other primary manufacturing industries. For example, the current yield of dry finished lumber from a typical sawlog is low; about 40 percent. The remainder of each log is used for lower-value products or is wasted with attendant pollution. This low yield can no longer be tolerated.

STRETCH begins with quality evaluation of the raw material. Involved is the development of an accurate and rapid method for sensing and locating defects in lumber and logs. As defect sensing is being evaluated, we are also developing computer software to make processing decisions correctly at required production speeds.

Under new and improved processing systems, STRETCH provides alternative ways to convert logs to improved lumber-type products. Included is "Best Opening Face" sawing (BOF), a computerized system for sawing small-diameter logs that guarantees to increase the lumber yield by at least 10 percent. Another alternative is an Edge-Glue-and-Rip System (EGAR), in which logs are sawn into unedged lumber flitches approximately 2 inches thick. This lumber is kiln dried, edged to maximum width, and then edge-glued into panels which can be computerized rip-sawn into construction lumber. Such a system promises an increased recovery of at least 15 percent. Another innovative system is Press-Lam, where logs are knife-cut by a rotary process into a sheet approximately 1/2 inch thick. The thick sheets are instantly dried in a hot press, promptly coated with adhesive, and assembled into the desired product. Entire processing time is 15 minutes and the yield is about 60 percent.

In STRETCH, product quality assurance involves development of improved grading technology. Such a grading system combines visual defect detection with piece-by-piece machine testing. In this case, each board will be evaluated on its own merits and will eliminate such present difficulties as species and geographic differences.

The other facet of this program is engineering design, which ties together the processing system and product quality, and will guarantee high-performance structural products. It will involve designing STRETCH products to meet specified structural requirements. This, in capsulized form, is our project STRETCH, a program to extend our Nation's timber supply through increasing the efficiency and yield of lumber-type products.

In closing, let me appeal for more reliable estimates of genetic gain for the wood quality characteristics so aptly presented by Schreiner over 15 years ago. Such estimates are essential in economically evaluating the potential gains in wood properties. We at the Forest Products Laboratory welcome the opportunity to cooperate in your tree improvement activities. We have the people and equipment for any wood quality evaluations needed.

With our dwindling land base, we must achieve the full productive capacity of our timber lands. This means genetically improved growing stock is a must. To this end we offer our full cooperation. Together, we may see the goal reached -- growing more and better wood to satisfy the needs of people.