CHANGING UTILIZATION OF HARDWOODS

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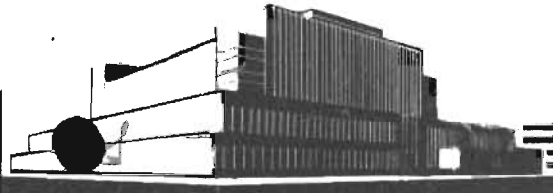

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

CHANGING UTILIZATION OF HARDWOODS[1]

By

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I'm sure this has been a stimulating and invigorating seminar. As a products research man, I seldom have the opportunity to listen in on detailed forest management thinking such as has been expressed here. But I am familiar enough with the subject to know that there has been enough exchange of ideas to have a major impact on the management of our northern hardwoods.

Fortunately, it is Bruce Buell's job to summarize and evaluate these ideas for us. It will be my purpose for the next half hour or so to give you an idea of expected trends in the forest products industries, and how these trends may be expected to affect your objectives in the management of northern hardwoods.

Obviously, you'll not have any trouble disposing of the high-grade logs at a profit. The price of veneer logs, for instance, has about doubled in the past decade. As I see it, the basic problems of the industry will fall roughly into the following categories:

(1) Utilizing the volumes of low-grade trees and thinnings that are bound to occur in any forest to pay for their removal and make room for better growing stock;

(2) Integrating operations so that each log can be channeled to the processing operation in which it will yield products with the highest total value;

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(3) Improving efficiency and reducing degrade in primary processing operations;

(4) Improving the quality of the trees themselves;

(5) Engineering better products; and

(6) Improving the processing and protection of the finished wood products.

, as industrial foresters, must be concerned with and have some basic 'edge of all of these to serve as guidelines in performing your basic naking sure the generations of our children will have the abundance ortable, convenient, and necessary forest products we take for today. Make no mistake about it--insuring this long-term abundance objective as a profession, not merely keeping the wood room full ar to year at a particular mill. It is an objective that will become ingly difficult to achieve as other pressures for land use continue rease.

Theme: Integration

Every meeting seems to have a theme these days--this Seminar has a theme--and I believe there is a theme made to order to coordinate what I have to tell you about changing trends in wood utilization. It is integration--integration of processing operations so that each log harvested can be evaluated and directed toward the end use for which it is best fitted. A completely integrated operation will necessarily be big and complex; not all operations, however, would need or benefit from complete integration.

Essentially, what we mean by integration in the forest products industry is a horizontal grouping of processing plants. This grouping would perhaps include a sawmill, a veneer and plywood plant, a board plant, a pulp mill, and, eventually, an organic chemical complex.

The advantages of such a setup are quite obvious. Basically, it allows us to be more flexible in handling a raw material that is not one distinct substance but a variety of substances in a variety of sizes and qualities. If you as forest managers are limited to but one processing outlet for all the wood substance that grows on your domains, your efforts must necessarily be all in one general direction--not that this makes your job any easier--and profit is limited by the profitability of the one process. With several alternative processing outlets, your management plans will become more complex, because more tree quality judgments must be made. On the other

hand, some of the objectives would be simpler, because there would be no forcing of round pegs into square holes. In the natural course of forest growth, and with a little professional help, we can expect a fair percentage of above-average trees that warrant carrying for several extra years to make veneer logs. Profitability will be higher if this is done. Some trees will become diseased or culls, or should be removed for some other reason during timber stand improvement thinnings. Such trees, depending on their characteristics, may be marked for the pulp mill, the particle board plant, or, possibly, the chemical plant. Processes for the complete chemical conversion of wood have not been brought to an economic level in this country, but the possibilities are good, and I will discuss them in more detail later. Residues from the processing of solid wood--the sawmill slabs and edgings and veneer trim and cores--also become raw material for paper or particle board.

Thus all trees can be used at their highest level of profitability, and the greatest percentage of each tree can be utilized for a product. Nothing, not even bark, need go to the burner.

So far, I have talked about integration as a horizontal grouping of forest products enterprises. Actually, when an operation is large enough to span several product fields, vertical integration also becomes more economic. This fact is most obvious on the West Coast, where the trend toward integration has had the best opportunity to grow and show its potentialities. These West Coast operations, however, are based primarily on the big softwoods. Hardwood volume out there is not so significant as it is here, yet in recent years hardwoods have been included more and more in forest management plans.

In vertical integration, the objective is to carry the raw wood product, after initial log breakdown, as far as possible toward the final consumer product. For a hardwood sawmill, this might mean furniture dimension stock, lumber paneling, and a pallet operation to make use of the low-grade material. A hardwood veneer and plywood plant might carry through a few more steps to produce flush doors and prefinished plywood paneling. A preservative-treating plant should accompany a tie or post and pole operation. I hardly need cite examples in the paper industry.

Now that we have established what we mean by integration, I would like to spend some time discussing our research at the Forest Products Laboratory that I believe will fit into this scheme, and affect changes in the utilization of hardwoods.

A few minutes ago, I mentioned a half dozen general problem areas faced by the wood products industries. Integration may be considered a general

theme to tie them all together. The specific area that will present the greatest challenge to you foresters is in the improvement of the quality of trees themselves.

Wood quality in general is going down, especially among the hardwoods. This is true because we have "high-graded" our hardwood forests for years, taking the best trees and leaving only the misshapen culls for breeding stock--not a very good idea if we have any confidence at all in the theories and principles of genetics. We are also forced to use smaller, second-growth trees that have not had the time to lay down a large proportion of clear wood over a good length of stem. In managed forests, this trend should be reversed. But in our haste to grow big trees rapidly, we must not lose sight of what wood quality really is. Of one thing you may be sure--it is not a constant thing--not merely a matter of size, shape, and soundness. We must recognize the concept that wood quality is a function of the end-use requirement and apply that concept constantly in management plans. This factor becomes critical in multiproduct utilization.

Let's take an example. It is an extreme one, but it makes my point nicely. On the West Coast of our country are some vigorous, fast-growing stands of second-growth ponderosa pine. The foresters who managed them were quite proud of the exceptional growth rates they had achieved. The pride faded away quickly, however, when their regular customers began to refuse the material. The beautiful, wide-ringed wood was so poor in machining properties that it was totally unsuitable for its intended, high-value use as millwork.

What, then, is wood quality? We believe that quality is the resultant of physical and chemical characteristics possessed by a tree or a part of a tree that enable it to meet the property requirements for different end products. In other words, the intrinsic quality of wood is evaluated solely in terms of its suitability for various products or end uses. In this concept, we are not considering accessibility, operability, markets, harvesting costs, aesthetic values, and so forth. They are important considerations in making utilization and management decisions, but are not concerned with quality.

Now, what are the wood characteristics that we should be concerned with in our attempts to improve wood quality? One is density, the amount of wood substance in a unit volume. There is a direct relationship between density and pulp yields, and there is a strong correlation between density and strength properties of solid wood. Not only do we want high density, but, especially for strength considerations, we want uniform density. Stress grades for softwood structural lumber must presently be conservative to accommodate the fair proportion of lighter, weaker pieces that occur in any species. Uniform density would allow us to design with wood more efficiently and make it a more competitive engineering material.

One request for low-density hardwood comes from the particle board industry, which gets the best combination of properties from wood flakes of 0.3 specific gravity, for example, aspen.

The ratio of springwood to summerwood may be important, especially for pulp and paper. Thin-walled springwood fibers tend to felt better and collapse to form a denser sheet, while the thick-walled summerwood fibers are stiffer and impart higher tearing strength.

Fibril orientation--the angle formed with respect to the long axis of the fiber by the cellulosic fibrils, which make up the bulk of the cell wall--has significant effects on wood quality. A large angle means lower strength and high lengthwise shrinkage in solid wood, low yields, low tearing strength, and high bleach requirements in pulp.

Rate of growth affects the quality of wood laid down. With most of our hardwoods, density increases with growth rate. Thus rapidly grown hickory and ash are fine for athletic equipment and tool handles, products with high strength requirements. Material of slower growth, on the other hand, is favored by the furniture industry because of its superior machining and finishing properties. A nonuniform rate of growth means undesirable stresses in the wood produced. Differences in density and shrinkage between slow growth and fast growth will cause serious warp if both are present in a board.

Chemical composition--percent cellulose to the paper industry--is an indicator of pulp yield, and therefore of pulpwood quality. We are now beginning to think there may be almost as much variation within a species as there is in structural features.

Tension wood, the abnormal material commonly found on the upper side of leaning hardwood trees, and somewhat akin to compression wood in softwoods, causes much more woodworking trouble than it is given credit for. Fuzzy surfaces, torn grain, buckled veneer, twisted lumber, all are often the result of this abnormal wood produced as the hardwood tree reacts to stress and tries to right itself.

I could go on here for some time describing factors that affect or determine wood quality, but the point should be clear: quality depends on what is required of the end product.

Nowhere in the Lake States is the changing utilization of hardwoods more evident than in the pulp and paper industry. The changes are already highly significant, and the trends are but a few years old. Prior to 1950, aspen was a minor species, so far as pulpmill receipts were concerned, and heavy hardwoods were negligible. Aspen is now the leading species at Lake States

mills, and the other hardwoods are in a steep rise. Together they are making possible increases in capacity.

Take Wisconsin as an example. Twelve years ago, less than a fifth of the pulpwood consumed by Wisconsin mills was grown within the state. Her paper production has nearly doubled since then, yet the state's forests now contribute nearly half the total pulpwood requirement. Much of this increase can be credited to hardwoods, aspen in the recent past, and in the future the large volumes of low-grade oaks, which are still being cut at a rate con-iderably below the allowable cut in nearly all areas, and their management as not exactly been intensive. It is unquestionable that the heavy hardwoods vill form the basis for much of the expansion to come in the Lake States pulp and paper industry.

Several factors will help bring about this increased use of heavy hardwoods. It is not hard to visualize, in the not too distant future, new and simpler methods of harvesting pulpwood. Experimental barkers and chippers are now being tried in the woods, and considerable research has been done on the transport of chips in pipelines. It may be possible to use water as the transport medium to bring chips from the woods to the plant in pipelines, then use the water in the pulping and papermaking operations. Thus we could eliminate the long piles of roundwood at the mills, and the repeated mechanical handling of the bolts. This should lower cost of harvesting, therefore lower grades of material can be harvested. We have already demonstrated that both hardwoods and softwoods can be stored in chip piles with less degradation than we get with roundwood.

There will undoubtedly be improvements in existing pulping processes, such as modified sulfite, magnefite, and two-stage sulfite pulping. There are certain to be entirely new processes. There will be greater acceptance of recently proven pulping processes, such as the cold soda process developed at the Forest Products Laboratory. In addition to the usual corrugating medium and food boards, we have made good white papers--lower grades of bond, and so forth--from light-colored hardwoods pulped by the cold soda process. Oddly, there isn't yet a single cold-soda mill in Wisconsin, where the process was developed. This process, which falls in the chemimechanical category, gives high yields per ton of wood, and with the heavy hardwoods there are more tons per cord.

Improvements will also come as we learn more about how to handle hardwood pulp stocks in papermaking. We are finding, for instance, that we should keep the hardwood and softwood furnishes separate as long as possible. Thus we can develop the most desirable fiber properties of each to a fuller extent before they are blended.

Changes in paper machine design will undoubtedly make possible better utilization of hardwood pulps. Relatively minor changes will minimize drainage problems, improve handling of more tender sheets in the wet condition, and increase operating speeds.

I seriously feel, however, that there must be drastic changes in the way in which we make paper. All we have done in the past 100 years is make the basic paper machine bigger, faster, and more complex. It seems incongruous that it should require so many tons of steel and brass roaring like a freight train to pull a sheet of paper a few thousandths of an inch thick and roll it up on a spool. Paper is now feeling the pinch of competing synthetic films, and there is nothing like serious competition to stimulate changes where we complacently thought none were possible. This concept applies to the entire wood industry, of course, not just paper.

Closely related to pulp and paper is the field of chemical utilization. In fact, it is not possible to draw a distinct line between them. Dissolving pulp is strictly a chemical product. Food chemicals such as yeast and vanillin, on the other hand, are produced profitably in pulping byproduct operations from spent sulfite liquors. Further expansion into chemical utilization, especially of hardwoods, is almost guaranteed. Let me explain why.

Both hardwoods and softwoods are composed basically of cellulose, hemicellulose, and lignin. Cellulose from either is about the same, and can be utilized either as fiber or as chemical raw material. Lignins from the two have more significant differences, but will have somewhat the same uses. Volume lignin utilization for products of any real value is still a major stumbling block.

With the hemicellulose fraction, however, the story is different. Hemicellulose is the carbohydrate fraction that can be hydrolyzed, or dissolved, fairly easily, much more easily than the highly resistant cellulose. Softwood hemicellulose yields a mixture that contains mainly 6-carbon sugars. Hardwoods, however, yield primarily a single 5-carbon sugar, xylose. This xylose is unique in that it can be converted directly to sweetening agents and to furfural, the basic chemical intermediate in the production of nylon and some other synthetics. The concentration of xylose produced by mild hydrolysis of hardwood puts the hardwoods an important step ahead of the softwoods in this field.

We feel strongly that, for a chemical industry based on wood to be economic, each of the three basic fractions must be isolated and utilized at a relatively high level. Volume production of furfural would satisfy this requirement for the hemicellulose fraction. We have developed the engineering data on the

process at the Forest Products Laboratory. Similar chemical intermediates, such as hydroxymethylfurfural and levulinic acid, can be derived from the cellulose fraction. Volume production would bring the price down to a point where markets would open up.

Lignin remains the stumbling block. Large volumes are used as road binder, but the value is too low. Oil well drilling mud additives are a good usage; similarly, desugared lignin sulfonic acids are used as emulsifying additives in concrete. Vanillin has high product value, but low volume. Lignin appears in the pulping liquors of Lake States mills now in such quantities that, if it were all processed for vanillin, we could impart the characteristic vanilla flavor to the entire world food supply. In other words, the few current uses cannot provide outlets for the expanding amounts of lignin available. Someday, lignin will inevitably be able to carry its fair share of the burden in a wood chemical plant. When that day comes, we will have another important change in the pattern of hardwood utilization. Wood in sizes, shapes, and mixtures not now considered usable will become satisfactory raw material. We will have another tool in hardwood management.

I have spent a lot of time this morning discussing the use of wood in forms not immediately recognizable as wood. Solid wood products will also continue to play an important part in the overall picture. Changes may not be so dramatic, but they may have a drastic effect on the operator who is not watching for them.

As I said at the beginning, you'll not have any trouble finding good markets for high-grade hardwood logs. The demand for yellow birch veneer logs is going to continue strong as long as we continue to build houses with doors and kitchen cabinets. Housewives tried steel kitchens, and have turned away from them. Walnut and cherry will always continue to be sought for furniture, so far as we can tell, because their richness and beauty result in a product unsurpassable in quality, <u>if</u> we manufacture it properly.

Because of the great interest in bowling, which certainly isn't a passing fad, clear sap hard maple brings a higher price than any other native wood. It is light-colored, hard, fine-grained, and not likely to be replaced for either alleys or pins.

Aspen is an ideal species for particle board, the market potential is good and increasing, and we are producing great quantities of the wood without too much effort. We can reasonably assume that the Lake States can and will support a much more potent particle board industry than it does now. This industry is so new that the product has not yet found its proper spot in the market place.

Opportunities for other species and lower grades will depend on a variety of factors: alertness and aggressiveness in marketing, likes and needs of the customer, and manufacturing and engineering techniques of the producer.

Paneling, both of plywood and solid lumber, is one of the few current bright spots for wood in housing. Although slab construction will not become so prominent in the Lake States because of our climate, the trend is still toward smaller houses with more substitute materials, thus considerably less wood. Most of the decline is in softwood construction lumber and siding, and hardwood flooring. Paneling, on the other hand, especially of hardwood plywood, combines the character and warmth of wood with ease of installation, and is thus well suited for even relatively low-cost housing. It has a look of luxury, and is a valuable sales tool. We don't need to go to Africa for exotic woods--I'm sure our local name-coiners can come up with equally imaginative adjectives to characterize and sell our native elm, ash, oaks, and so forth. I would also suggest that you foresters who have some connection with genetic programs keep your eyes open for wood with unusual grain or texture. Appearance is definitely one of the quality criteria by which we may judge improvements in hardwoods.

The market for conventional hardwood strip flooring is depressed and likely to remain so. There is nothing wrong with the product, the cost of installation is simply too high. Block and veneer types of flooring have a good chance to hold or regain much of the market now being taken by synthetic tiles, over both concrete and conventional subfloors. Some companies are now developing a combination finish and subfloor that can be put down as a unit.

Methods of log breakdown may significantly affect patterns of hardwood utilization. In the South, many softwood sawmills have adopted the so-called pulp-chip saw in an effort to cut down waste. The principle of this saw is not to reduce the amount of sawdust, but to produce it in particles large enough to be acceptable as raw material by the pulp mills. The economics of making a wider kerf to get pulp chips is still questionable, but the basic idea is good. We have done only very preliminary work with this type of saw on hardwoods so far, but it looks as though some of the surface-roughness and tear-out problems experienced with softwoods may not be so pronounced.

The increased use of barkers at hardwood mills would tie in with pulp-chip saws. On the basis of our studies on fiber-length requirements, coupled with the experience of western mills, we can expect slabs, edgings, and kerf chips from barked hardwood logs to become an increasingly important source of raw material for Lake States pulp mills. Again, the advantages of an integrated operation are obvious.

Another approach to log breakdown, currently still in the research stage but gaining momentum, involves slicing boards cleanly with a knife rather than chewing out a kerf with saw teeth. In our experimental work, we have used an ordinary face-veneer slicer with gears and bearings modified to allow a thicker bite. Thus the length of a log is brought down on an essentially stationary blade so that one board is sliced off with each stroke. We have been able to cut material, both hardwoods and softwoods, with good success, up to 1/2-inch thick. Since the product is neither strictly veneer nor lumber, we have named it Slicewood.

Our experimental Slicewood does contain rather deep checks, but they don't seem to affect strength seriously. Flat-cut oak boards were as strong as sawn controls in carefully matched bending strength tests, and quartered boards suffered less than 10 percent reduction in bending strength compared to quarter-sawn controls. Also, Slicewood can be dried quickly and uniformly at high temperature in a veneer drier.

We don't expect Slicewood to replace sawn lumber completely, but it will have many specific applications, particularly where a gluing operation is involved. The surfaces of the sliced boards are such that no further surfacing operations are required prior to gluing. In some work for the Navy, beams were made of oak Slicewood boards glued without surfacing. Their strength equalled that of laminated beams made of matched sawn lumber. Slicewood strips glued to a balanced subfloor construction in long panels might be a significant step in retaining the hardwood flooring market.

Bin pallets and decorative fencing are also among the applications where Slicewood has already demonstrated its suitability.

There is still one major drawback to its use, however. The machine to produce it on a commercial scale doesn't exist. We must have one that approaches the speed of a sawmill. Ordinary slicers for face veneer couldn't take such a pounding on a continuing basis. A few machine designers are coming up with unique engineering ideas, though, and I feel that a production-type slicer isn't too far away.

Improvements in the processing of wood so that it will serve better and last longer present another approach to the changing utilization of hardwoods. An example I think might interest you is in the production of gunstocks. The standard procedure is to cut out rough green blanks, dry them, throw away those too badly degraded during the seasoning process, and carve finished stocks from the remainder. Blanks with the most attractive and unusual grain patterns are normally degraded the most because of drying stresses caused by the grain deviations. The amount of degrade makes the overall process expensive.

A number of years ago, we did some fundamental work on stabilizing wood's dimensions by bulking the wood fibers with wax-like chemicals. More recently, a gun enthusiast on our staff took the idea and applied it to the production of gunstocks. He found that, by carving the green blanks close to final dimensions, he could then treat the green carvings with polyethylene glycol, the bulking chemical, dry them very rapidly, and still eliminate the checking and honeycombing otherwise prevalent. A stock manufacturer here in the Lake States has adopted the practice, and is now producing fancy-grained stocks from a variety of beautiful woods practically without loss, and thus at materially reduced cost. Drying time, incidentally, is reduced from the 3 or 4 months of air and kiln drying now required by conventional methods to 20 days of drastic kiln drying. This process, I feel confident, will insure the gunstock market for wood. It is also spreading to other processes and products where dimensional stabilization, prevention of seasoning degrade, or both, are critical.

Incidentally, the process does also stabilize critical rifle dimensions in the inletted area so that precision match rifles remain more accurate. This should be a definite aid to those of you who don't "zero in" properly, and thus shoot between the horns instead of between the eyes.

This whole area of research into improvements in wood processing is wide open, and is bound to influence what we do with both hardwoods and softwoods in the future. At the Forest Products Laboratory we are working on a broad spectrum of ideas, from using solar energy to dry lumber inexpensively to methods of destroying or tying up vitamins and trace minerals in wood necessary if destructive fungi are to live and do their damage.

How we use wood in the future will depend in part on how successful all of us, in federal and state government and in industry, are in our research. This success will be directly correlated with the amount of money available to do the job. The future of wood will also depend in part on how the wood industry faces its future and makes its decisions. The future of wood will also depend on how you, as foresters, do your job--how well you recognize wood quality in its various forms, take care of it, and see that it is developed and used to its maximum potential.

SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE

FOREST PRODUCTS LABORATORY

The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin:

List of publications on Box and Crate Construction and Packaging Data

List of publications on Chemistry of Wood and Derived Products

List of publications on Fungus Defects in Forest Products and Decay in Trees

List of publications on Glue, Glued Products and Veneer

List of publications on Growth, Structure, and Identification of Wood

List of publications on Mechanical Properties and Structural Uses of Wood and Wood Products

Partial list of publications for Architects, Builders, Engineers, and Retail Lumbermen

List of publications on Fire Protection

List of publications on Logging, Milling, and Utilization of Timber Products

List of publications on Pulp and Paper

List of publications on Seasoning of Wood

List of publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on Wood Finishing

List of publications on Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous six months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.