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Abstract
Continued consumer demands, particularly for construction lumber and plywood, coupled with a reduced commercial forest land base, make it imperative that consideration be given to more Intensive forest management and wood utilization. Utilization efforts to extend the timber supply Include improved efficiency in manufacturing, closer utilization of each harvested tree, new products and processing systems, and utilization of forest residues. Forest residues accumulating at the rate of 9.6 billion ft^3/yr represent an untapped wood resource that is a timely bonanza.

Forest residues—the timely bonanza!

Harold E. Wahlgren

In this era of pending energy shortages and environmental concern, it is appropriate to take a closer look at our timber resource—one of our most abundant, most versatile, and yes, most valuable material resources. The demands for wood products have been increasing steadily during the past three decades. For example, the consumption of wood products has increased by 65% between 1942 and 1972 to an annual total of 125 million tons. During this same period, lumber consumption rose 27%; round pulpwood, 157%; and veneer and plywood, 438%. Recent Forest Service projections indicate that further substantial increases can be expected in the future.

Wood provides a combination of properties which make it attractive for the huge construction market. Since early 1970, for example, housing starts have risen from a rate of 1.5 million per year to a high of 2.5 million in 197‘ , Add to this a rising national and international demand for paper and fiber products, and one can appreciate the timber supply problem we face.

The conclusion to be drawn is inescapable. Timber will be in short supply. At the same time, people are acquiring an increasing appreciation for the aesthetic and other values of the forest, with the result that we can look for the land base for timber production to decrease. The end result is the present price–supply squeeze, which is serious and likely to continue.

Unless the supply situation is materially improved by more intensive forest management and utilization, it is likely that we will see more competition for the available timber supply, rising prices, and increased substitution of competing materials. The general timber resource and environment situation is such that timber, like all resources, must be used more efficiently.

The challenge before all of us is what can be done to extend the timber supply to satisfy the needs of our people. This paper explores how we can accomplish this by improved efficiency in manufacturing, by closer utilization of each harvested tree, by developing improved products and processing systems, by utilization of forest residues, and by protection of products in use. The improved utilization should not be considered an alternative to increased timber production. The two supplement each other. An increased production of consumer goods, per unit of timber grown, adds to the justification for the investment of public funds in intensified forest management.

Great potential for improvement in the wood industry exists, even though some significant progress in recent years has been made in the better utilization of our timber resources. For example, relatively small logs, in qualities formerly not used, are now used in the production of structural lumber. Plywood is now made for structural applications from logs of small size and low quality, many of which were previously used only for pulpwood. Manufacturing residues from sawmills and plywood mills, formerly burned, now supply 22% of the pulpwood demands of this country. Another 22% of the total wood fiber consumption in the U.S. is supplied by reuse of 11.8 million tons of wastepaper that is now annually recycled. Further improvement in this area is expected. The paper industry has set a recycle goal of 35% by 1985. It is safe to conclude that there are alternatives available. Regardless of these improvements, wood as a material is not being used to the limit of its capacity. Let us see how we can improve the utilization potential of our timber resource.

IMPROVING EFFICIENCY IN THE SAWMILL

While much obsolete equipment and processes exist in this industry, there is improvement underway through the use of better machinery and improved quality control. Since nearly one half of our nation’s timber is being, and will continue to be, processed in sawmills, we must consider steps which can be taken to improve their efficiency. The efficiency of the industry becomes apparent when we realize that lumber recovery factors (LRF) average less than 6.5 bf/ft^3 of log. Increasing this average to 8.7 bf/ft^3 would be the practical equivalent of a one-third increase in the log supply.

We are faced with a very disturbing paradox: this 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, usually about 40%. The remainder of each log is used for lower-value products or is wasted, with attendant pollution.

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One answer to this is a program developed in our laboratory called Project STRETCH—a coordinated program that will develop and adapt modern technological concepts to each step of the process of breaking down a log into products; the further manufacture of these products; and finally, the most efficient use of these products. The events included in STRETCH are: automated quality assessment; computerized decision making; improved processing alternatives; product quality assurance; and high-yield, high-performance products.

We begin with quality assessment of the raw material, which includes automated procedures for sensing and locating defects in lumber and logs. Quantifying this information makes possible the application of computer software to processing decisions. This is needed because man is incapable of integrating defect information, processing alternatives, and end-product criteria to make processing decisions correctly and quickly.

To increase efficiency, one development in Project STRETCH is a new sawing breakthrough known as best opening face (BOF) sawing. Here is how it works. Sawing involves the removal of rectangular lumber, of specified sizes, from cylindrical logs—fitting rectangles into a circle. The opening cut is the key and fixes the position of all other saw cuts made in the same plane. To maximize yield, the BOF system uses a computer to analyze all possible combinations of face-opening widths, for all diameters, to determine the saw setting giving the maximum yield.

The entire system uses already available electronic and mechanical equipment. It includes, (a) most important, a computer program that takes into account lumber size, planing allowance, shrinkage, sawing variation, wane allowance, log taper, saw kerf, log diameter range, increments of opening face cuts, plus the option to maximize for volume or values; (b) an automatic device to measure log diameter to an accuracy of 0.1 in.; (c) a mini-computer; and (d) numerically controlled, high-precision set-works.

In mill operation, the ROF sawing pattern is stored in the mini-computer. The diameter scanner relays the diameter to the mini-computer which searches its memory and selects the best opening face and directs the saw to cut the log to that pattern, maximizing for either volume or value. Mills can improve their yield by at least 10% using this system. Or, in terms of LRF, from a low of 4.9 for 5-in. logs, to a high of 11.6. It is suitable for mills cutting at least 40,000 bf per shift (80% of our lumber production comes from mills of such size).

Edge-glue-and-rip (EGAR) is an alternative processing system. Logs are live-sawn into 2-in.-thick flitches with maximum width. These are kiln dried, edged to maximum width, and edge-glued into panels. After automatic defect scanning, the computer directs the sawing into desired lumber widths in such a way as to minimize the degrading defects, e.g., by avoiding edge knots in the finished lumber. Wide, thick-dimension lumber can be produced from small-diameter trees. No longer are we restricted to growing large-diameter trees with long rotations. EGAR promises an increased recovery of at least 15%, plus improvement in quality of lumber products.

Another highly promising processing system is Press-lam. It is an innovative system that avoids sawdust, planing, and edging waste and results in products made without limitation as to shape and size. The log is knife-cut into $^1/_2$-in.-thick sheets. These are instant-dried by a new press-drying process and instantly glued into a parallel laminated assembly. In this case, the defects are dispersed and the resulting product shows higher average strength properties and markedly less variability than sawn lumber. The entire processing time, from log to finished product, is 30 min; and the yield is 65%.

Product quality assurance, based on final performance requirements, applies to every phase of STRETCH. Defect sensing must be further developed and coordinated with nondestructive testing techniques to guide conversion processes. Ultimately, each wood member must be tested and evaluated on its own merits. Engineering design is also necessary, as it is the vehicle that ties together the processing system, product quality, and required performance in use to satisfy consumer needs for safety, durability, reasonable cost, and conservation of timber resources.

WOOD RESIDUES

Wood residues are the leftovers from man's cutting timber and making and using wood products. We personally feel that the term "residues" is a poor choice because it is the same type of wood we harvest and make into useful products. The only difference is the size and distribution of this material.

Where are these wood residues found? From the forests to the city dumps, all over the country, not piled quite as high in some sections as in others. We can further classify the wood residues on the basis of the processing or use operation. Starting in the forest with harvesting operations, there is logging residue. This may be lumped with other unused material not directly related to the logging job and referred to as *forest residue.* From primary processing of roundwood, such as sawing or veneer peeling, *primary mill residue* is developed. A wide range of secondary manufacturing operations such as millwork and furniture production generate *secondary plant residue.* An important difference in secondary residue is that it is nearly always dry and bark-free, as compared to logging and primary mill residue which are usually green wood and bark.

To give dimension or opportunity to the wood residue problem we need to know how much there is. We are not, however, always in possession of good data on residue amounts. Fortunately, residue types in some locations have been subjected to close attention to provide useful volume estimates.

Primary Mill Residue

Unused residue at wood processing plants still represents a significant wood resource even though considerable progress has been made in recent years in the utilization of roundwood delivered to the sawmill and other processing plants. In 1970, more than 2.8 billion ft^3 of slabs, sawdust, veneer cores, and other residues were used for pulp, particleboard, fuel, or other products. Residues used for these products represented about 75% of all residues produced in primary manufacturing plants.

Use of residue by the pulp industry was of chief importance, with almost 1.8 billion ft^3, about 22 million cords, utilized in 1970. Nearly 2 million cords of this total was exported as pulp chips. Of much significance is the fact that 7 or 8 billion bf of sawtimber is now converted to pulp, although a lower-grade raw material could be used for this purpose.

Total use of plant residues increased roughly 50% between 1952 and 1970. Trends for different by-products differed radically. Use for industrial or domestic fuel declined sharply, while use of chips and other material increased 18-fold during the period. In spite of these advances, the volume of unused residue is still sizeable. In 1970, almost 1 billion ft^3, the equivalent of more than 12 million cords of material, was left at sawmills and other primary manufacturing plants. Rapidly changing markets indicate great demand for this material.

Secondary Plant Residue

In addition to unused residue at primary wood processing plants, shavings, trimmings, and other residual material are available at secondary wood manu-

facturing plants. These include plants producing millwork, hardwood dimension and flooring, prefabricated structures, pallets, etc. Secondary plants are widely distributed, with many in eastern population centers.

While data on amounts of residue generated are not generally available, a study in the midwest disclosed a total production of close to 250 million ft^3 of residue. This limited sample suggests that total production of secondary plant residue may be about 900 million ft^3.

Forest Residues

Now we get to the source that has the greatest potential for extending the timber supply to meet the needs of our people—forest residues. Each year this nation consumes approximately 12 billion cubic ft^3 of wood in various forest products. Each year this nation leaves about 9.6 billion ft^3 of unused wood in various forms in the forests. In light of present and foreseeable needs for forest products, particularly in the construction of houses, this waste cannot be tolerated.

I would like to highlight a plan currently underway on forest residue research utilization at our laboratory. The research program emphasizes new technological approaches to effectively use forest residues to extend the timber supply and, at the same time, enhance the environment. A significant amount of society's needs for additional building materials can be provided by this effort, thus supplementing the structural products now being obtained from the forest crop.

What are the forest residues and how much in amount do they represent? Logging residues account for 3.6 billion ft^3. Insect, disease, and fire-damaged timber account for another 4.5 billion ft^3. Precommercial thinnings, a necessary management tool to increase stand productivity accounts for 1.5 billion ft^3 of residues. This gives a total of 9.6 billion ft^3.

Most of this material is usually piled, burned, buried, or simply left in the forest to rot. We all know these residues are aesthetically unpleasant to the public; they delay stand regeneration; they are a breeding ground for insects and disease; they are a potential fire hazard; and if deliberately burned, they pose air pollution problems.

We know that we cannot use all 9.6 billion ft^3. A conservative estimate is that approximately 6.6 billion ft^3 is usable material. This is equal to one-half the annual consumption of timber products in our country. Some research has begun on the utilization of this huge amount of forest residues. More, however, is necessary. It is necessary now if we are to effectively use this largely untouched source of raw material and if we are to extend our timber supply.

Where are these residues? Because it is difficult to pinpoint the exact location of disease- and insect-attacked stands, thinnings, and fire-damaged trees, we have data only for the logging residues. Let us first look at the softwoods. About 65% are located in the western United States and only 28% in the Southeast. The picture is reversed when hardwood residues are considered - 4% in the West and 96% in the East.

Optimum utilization may take many forms. It may consist of leaving part of the residue on the site to improve it. The objective of any residue utilization system is to utilize materials to their highest product value. We also visualize other options: sawlogs for EGAR; plywood for Press-lam; chipping for conventional particleboard or pulp chips; and fuel as a source of energy.

While such options are possible, we visualize using forest residues for structural products. Our primary emphasis will deal with utilization of these residues for existing and new products. The choice of end products depends on the nature of the raw material and on the nature of the markets that can be developed economically.

Particleboard for nonstructural uses has long been made from the factory floor (primary manufacturing residues). Research indicates that acceptable particleboard can now be made from the forest floor. What we now propose is to use these forest residues for structural material—products which meet the same needs as plywood and lumber and thus supplement the construction material which is already in short supply. Thus, from forest residues we visualize reducing the material to chips or flakes for structural particle boards.

Some preliminary results indicate that by careful alignment of flakes, ribbons, or strands, particleboard components comparable to lumber are possible. Such components, which may be formed into special shapes, lead logically to the design of new and innovative building systems which could provide more houses for Americans. A strong program in particle technology will also lead to building components that combine the characteristics of lumber and plywood in a single system, resulting in dramatic advances in building technology. The system envisions highly innovative developments such as the use of various shapes and sizes of particles and fibers, combined in various ways. Nonwood materials, such as rigid plastic foams, may be used in combination with wood to attain various levels of strength, thermal characteristics, and density.

Residue utilization research will aim to provide the practical equivalent of lumber and plywood, at a competitive cost, with 50–100% greater yield, with desirable properties, and less variability—all possible from forest residues.

While these products and processes appear economically and technically feasible, a full-scale engineering effort is needed to transform technical concepts into working systems for converting residues to marketable products. Engineering evaluations and marketing feedback must accompany development work to accurately assess product performance and quality. In addition, engineering evaluations of these new building component materials will be necessary to demonstrate the physical and structural adequacy of the new products to code and regulatory agencies. Ways must be found to expedite the acceptance of improved materials by code and building authorities.

The new building materials will lend themselves to innovative construction systems. Design procedures must be modified if the full potential of the products is to be realized. Such changes can be justified and successfully implemented only on the basis of full-scale evaluations of housing systems. Engineering design and evaluation tie together the processing system, product quality, and required in-use performance to satisfy consumer needs.

Current and new technology; production innovations; and new products, including full-size components, could supplement lumber and plywood supplies and lead to the development of house construction systems which would make possible more homes at lower cost for our citizens. Research efforts on characterizing forest residues, on the technology of using residues, and the economics of using forest residues for structural products are major areas in which our laboratory can contribute.

FINAL REMARKS

It is by the above methods that our timber resource can be extended. The proposals I have alluded to involve greater efficiency in manufacturing and use of large volumes of wood residues. They should be seen as opportunities for reduced environmental impact, more wood from each harvested tree for more products, and an improved image for the entire forestry profession. These are truly new vistas that provide unlimited opportunities, and more important, they provide them now. Yes, wood residues are the timely bonanza.

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