

WOOD RESEARCH PAYS HIGH DIVIDENDS

January 1945



No. R1492

(Report)



UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin

In Cooperation with the University of Wisconsin

WOOD RESEARCH PAYS HIGH DIVIDENDS¹

By CARLILE P. WINSLOW, Director

The high dividends obtained from wood research in the past and during the war can be equaled or excelled in the future provided a research program adequately directed and financed is undertaken by federal, state, and private agencies. --- The Editor.

The imprint of the times is clearly registered upon the Nation's wood research activities --- war has tremendously accelerated the process of making wood available in improved forms. Some of the new wood derivatives and modified wood products are so altered as not to be recognized as wood; others look like wood but magnify wood's major virtues and add to its usefulness.

This country is dependent during this war upon the forest resources of the Pacific Northwest. Right here are our last great stands of virgin timber, still among the finest the country ever had. You lumbermen have done a grand job of getting what we need to fight this war -- Sitka spruce and noble fir and Port Orford white-cedar for aircraft, Douglas-fir for ships and pontoons and plywood for general construction, Western hemlock for our stupendous boxing and crating needs and for pulp. Your lumber has not only fulfilled the vast wartime needs of the West, it has gone to all parts of the country as well as to the battle fronts. I am happy to say that we at the Forest Products Laboratory have devoted much of our greatly expanded wartime program to ways and means of utilizing these western species more efficiently and effectively. For research purposes, we have used giant Douglas-fir and Sitka spruce logs literally by the carload.

The Honorable Claude R. Wickard, Secretary of the United States Department of Agriculture, published an article entitled "That Wonderful Stuff Called Wood" in the November 24, 1944, issue of Saturday Evening Post.

¹Presented before the Thirty-fifth Pacific Logging Congress, Seaside, Oregon, January 10-12, 1945; published in The Timberman, February 1945, and in the West Coast Lumberman, February 1945.

60 Million Tons of Waste

The Secretary described a wide variety of new and improved wood products mostly developed by the Forest Products Laboratory in its expanded war work since Pearl Harbor; he also pointed out the enormous wastes -- from one-half to two-thirds of the total volume cut, aggregating 60 million tons of wood annually -- which are incident to current harvesting and manufacturing processes. If we pause to recall that this so-called "waste" costs as much to grow per ton as the remaining material going into useful products and that approximately 80 percent of all employment from our forests is secured through the harvesting, conversion, manufacture, and distribution of the material, it becomes obvious that it is potentially possible to at least double or treble the present employment in forest industries if research can blaze the trail for the utilization of these current wastes.

In the 34 years since the establishment of the Forest Products Laboratory there have been vast changes in the development and production of forest products throughout the country and particularly here in the Northwest. During this period the Laboratory has varied in magnitude from a total personnel of about 50 up to about 450 at the termination of the last war and back to only 180 prior to the start of the present war. While many new and improved developments during this period were the result of private rather than governmental research, I am proud to say that the successful developments pioneered by the Forest Products Laboratory, in spite of its grossly inadequate magnitude for the issues at stake, have brought economic results that transcend manifold the total costs of maintaining the Laboratory during these many prewar years. Let me cite a few examples:

Dry kilns: The development of the internal fan system of controlling drying with more than 5,000 kilns of this type now in operation throughout the United States, together with the development of kiln-drying schedules for the various species and thicknesses of lumber to prevent losses in strength and quality, have saved hundreds of thousands of dollars annually over many years and have also, during this war, been the basis upon which the Laboratory was able to quickly develop modified schedules particularly for aircraft stock which had to be supplied rapidly and dried without strength injury. More recently, chemical seasoning methods have been developed at the Forest Products Laboratory which have been a demonstrable success right here in the Pacific Northwest for the rapid drying of thick Douglas-fir pontoon stock for the Army. Twenty-five sawmills in this region are using urea for the chemical seasoning of Douglas-fir timbers, and seasoning degrade losses that formerly ran as high as 60 percent for this class of stock have dropped to less than 2 percent.

Timber connectors and laminated arches: The large numbers of big structures that have risen all over the country during the present war -- aircraft and dirigible hangars, factories, shipyard buildings, and similar structures -- have been made possible by the use of metal timber connectors. Beginning in 1931, the Laboratory developed the principles of design and established strength data for the use of these connectors, which increase the strength of joints in wood structures by as much as fourfold. During the past 11 years, new buildings employing timber connectors -- many of which wouldn't have been built of

wood at all but for these metal rings -- have required approximately 7 billion board feet of lumber valued at 230 million dollars. Connector-built wood structures have been estimated to have saved 400,000 tons of critical steel in 1942.

The glued, laminated wood arch is another development that has found extensive use for commercial and industrial structures requiring large unobstructed floor areas since its introduction in this country by the Forest Products Laboratory more than a decade ago. Such laminates can be made of small sized boards, largely low grade, glued together in straight or curved form, as required; they have greater strength and efficiency and better appearance than solid wood members. Some outstanding examples of western structures are the Hughes Aircraft Company factory buildings at Culver City, California; the Wallingford Memorial Church at Seattle; and the Boeing Aircraft Company cafeteria at Seattle; in the East, a number of plants are producing laminates for farm and industrial buildings.

Structural grading: The Laboratory has steadily striven to bring order out of bewildering complexities of structural lumber grading rules and specifications. For over 30 years it has worked closely with the varied regional associations and the National Lumber Manufacturers Association and in engineering and architectural fields, to place structural lumber grades on a sound engineering basis for successful and efficient competition with other structural materials. Based on the Laboratory technical findings, this cooperative activity with industry has in the past generation brought about truly striking and significant achievements.

Glues and plywood: During the first World War the Laboratory established basic methods of testing the strength of glue joints that have since become standard in this country and are now generally employed to test the strength of every new glue that comes on the market. Its studies during the same period of the factors that influence the production of good glue joints set forth the principles of good gluing techniques that have since been the basis of great improvements in commercial gluing practice and the manufacture of plywood. Forest Products Laboratory research has contributed much to the development of new and better glues during the past 25 years, beginning with a moisture-resistant casein glue in the first World War and continuing until the present. This work has included a testing program for commercial glues of all types to establish their relative merit for various uses in plywood, laminated wood, structural gluing, and furniture.

With the development of synthetic, water-resistant glues in the thirties, the Laboratory evolved the principles of the plywood panel system of prefabricated house construction that have since resulted in a tremendous commercial evolution of this type of housing. It tested the strength of "stressed-skin" plywood panels for walls, floors, ceilings, and interior partitions and designed suitable panels for each use that can be factory produced complete with insulation and the necessary conduits and fixtures for modern homes. Many thousands of low-cost homes for the defense communities of the nation have since been built of such factory-constructed panels.

Pulp and paper: The great pulp and paper industries of the South employing Southern yellow pine, which were nonexistent 30-odd years ago, are founded on developments in pulping of these southern woods at the Forest Products Laboratory. Its original developments for unbleached pulp from southern species were followed by its developments for bleached sulfate pulp, the production of which now exceeds 800,000 tons annually. Still more recently, a Laboratory-developed process for newsprint production from Southern pine has come into commercial use by the only newsprint mill in the South.

Simultaneously with the southern pulp and paper developments there has been a very large increased production on the Pacific Coast. While it is recognized that the success of these developments has resulted from much fine technical research work by industry, it can be justly said that the work of the Forest Products Laboratory has made significant contributions. Its pioneer work in establishing the effect of cooking variables, in improvement of processes to secure yields and improved properties, and the application of these broadening and diversifying the usable species, have found significant industrial application on the West Coast as well as in other regions of the country.

Any one of the foregoing developments has brought to the nation economic values far in excess of the cost to the government of its pioneer research. Taken collectively, they constitute a contribution to the national welfare that makes the expenditures of maintaining the Laboratory microscopic by comparison.

The war has forced the use of wood as never before. Wood has quartered, transported, and gone into munitions for our troops throughout the world. We are all aware of the vast quantities of lumber going into the construction of military buildings, and for packaging of war materiel and products requiring this year over 16 billion board feet. However, few comprehend fully the list of wood items demanded by war's insatiable appetite -- wood for hangars, scaffolding, boats, wharves, bridges, pontoons, railway ties, telephone poles, mine props, antitank barriers, shoring, shipping containers, and air-raid shelters; plywood for airplanes, blackout shutters, prefabricated housing, concrete forms, ship patterns, assault boats, ship interiors, truck bodies, and Army lockers; fuel for gasogenes, for truck and tractors; pulp and paper for surgical dressings, boxes, cartridge wrappers, building papers, military maps, paste-boards, laminated plastics, gasmask filters, printing, and propaganda distribution; synthetic wood fibers, such as in rayon, artificial wool and cotton, for clothing, parachutes, and other textiles; wood cellulose for explosives; wood charcoal for gas masks and steel production; rosin for shrapnel and varnishes; turpentine for flame throwers, paint, and varnishes; cellulose acetate for photographic films, shatterproof glass, airplane dopes, lacquer, cement, and molded articles; wood flour for dynamite; wood bark for insulation, tannin, and dyestuffs; and sugar from wood for cattle feed and alcohol for explosives and rubber.

Wood Becomes Highly Critical

While at the inception of the war steel was a critical material, it was not long before wood itself became the great critical material. It was fortunate, therefore, that the Laboratory had the facilities, the experienced personnel, and the basic knowledge and experience accumulated over 30 years to undertake the necessary expanded services for the war agencies. This required the rapid expansion of its organization to nearly 700 people, with an annual gross expenditure now aggregating 2-1/2 million dollars.

Aside from meeting the necessities of the war crisis, here again the economic results alone have far exceeded the necessary expenditures and in some cases have been so great as to stagger the imagination. Illustrative of some of these, let me cite the following:

New materials: Papreg of high strength was not even in commercial production three years ago. As the result of the Laboratory's pioneer war work, today there are 12 companies making this product in full commercial production according to definite specifications. One of them is at present doing a business aggregating 1-1/2 million dollars annually with the expectation that this will be increased, with its present equipment, to 5 million dollars. The product is being used for a wide range of war purposes, such as cargo plane flooring, nose fairings, gun turret mounts, ammunition boxes, and secret ordnance parts.

A wood waste plastic has been developed in both powder and sheet form as a substitute for hard rubber for use in battery boxes because of its excellent acid resistance. This plastic material requires only half as much critical resin in its manufacture as do the common commercial plastics.

Other Moldable Products

Other kinds of moldable wood products that have been developed for war use by the Laboratory are "compreg" and "staypak." Compreg, a form of compressed, resin-treated wood of great strength, surface hardness, and resistance to shrinking and swelling, is now being commercially manufactured by seven firms, of which four are producing for airplane propellers. One company has done a 5 million dollar business in molding motor testing propellers and antennae masts. The Navy is testing compreg-faced wood for the flight decks of aircraft carriers.

Staypak is a tough form of compressed wood which retains its compressed dimensions exceptionally well despite extremely adverse conditions. In many properties it is comparable to compreg, but its manufacture does not require the use of resins; it is not yet in commercial production.

Glued laminated keels and ribs: A recent development in timber structures directly resulting from the Laboratory's work in glues and gluing techniques is the laminated ship keels and frames -- seagoing counterparts of the glued

wood arch -- now going into hundreds of small naval craft to take the place of solid white oak timbers of large cross section, which are increasingly difficult to obtain. The properties of laminated ship timbers are essentially the same as those of solid wood, but of particular significance to the timber grower is the fact that laminated members permit the use of up to 60 percent of low-grade and short-length material in the interior laminations. These timbers are going into the famed PT boats, motor launches, whaleboats, and other types of fast craft used in amphibious warfare.

Wood sugar and alcohol production: The Laboratory, through the operation of a pilot plant for the War Production Board, has developed and greatly improved the German wood-sugar process for the production of ethyl alcohol, extensively required in the war emergency for munitions and synthetic rubber. The first large-scale plant to utilize this process is now under construction at Springfield, Oregon, near large sources of sawdust and other mill waste.

Since for every pound of wood used, approximately one-fourth pound of lignin remains as a residue, it is of critical importance that research develop more valuable uses than fuel for this lignin to insure optimum postwar success of the process. The Forest Products Laboratory has already developed, on a laboratory scale, new and interesting products by the hydrogenation of lignin, and such work should be expanded and attacked with vigor.

Wood for aircraft: For the Army and Navy the Laboratory has obtained and is continuing to obtain comprehensive data and formulas on the strength of wood and plywood aircraft elements, methods of structural analysis, detailed structural design data, and authoritative information on plastics, adhesives, gluing methods, molding and fabricating operations, and wood identification and inspection. This information is issued by the Army and Navy as official guidebooks and specifications for designers and manufacturers of wood aircraft. In addition, a steady flow of reports is issued giving the latest results of the extensive work.

Fireproofing of Wood

Fireproofing: Still another Forest Products Laboratory activity of particular significance to the Northwest is the fireproofing of wood. In 1936, the Laboratory developed a fire-retarding chemical formula that was used in the commercial fire-retarding impregnation treatment of more than 33,000,000 board feet of lumber in 1943. This is approximately one-half the total volume of lumber impregnated with fire-retarding salts during that year, much of it going into essential war uses, the full story of which cannot be told until after the war.

Recent reports from the Navy are that had it not been for the use of this fireproofed wood on aircraft carriers (and possibly other naval craft) some of these vessels which it has been possible to repair would have been totally lost.

Packaging and loading commodities for overseas shipment: As a final example, the Laboratory's packaging work with the war agencies has brought about almost unbelievable savings and improvements. By improving methods to give the needed protection against hazardous conditions, by reducing package volume to save shipping space, and by reducing the quantity of packaging and loading materials required, the combined work has resulted in:

A tremendous improvement in the delivery of material in usable condition at the battlefronts, with its resulting savings in production required at the factories. For one ordnance item alone, unusable quantity at the front was reduced from 53 percent to 2 percent.

Great savings in cargo space so that on an average four ships can now carry the materiel which formerly required five, and in some instances space savings as high as 60 percent. As one of hundreds of examples, the redesign of the crate and packing method of the 40-mm. antiaircraft gun and accessories effected a saving of 400 cubic feet of space per crate, or 200,000 cubic feet per month on shipments from just one of the ordnance depots packing this item.

Great savings in requirements for lumber production aggregating for the first year of the war for ordnance alone 58,000,000 board feet and estimated for 1943 at approximately 1 billion board feet, with attendant labor savings.

Competition Will Return

Following the temporary period of world readjustment, wood as a material of industry and commerce will, of course, again be in competition with other materials. In order to expand our forest industries and to have our vast areas of forest land and timber stands so managed and developed as to contribute the maximum to the national economy, will require much planning and many changes in current practices. Prewar techniques and economics broadly permitted conversion to useful commodities of only about one-third to one-half of the total volume of the timber cut. Also vast stands of lower quality species which ought to be harvested were entirely neglected.

If all such material could be put to economic use, the normal forest contributions to support of labor, employment of capital, and satisfaction of human needs could be enormously increased. As guides to the future attainment of these benefits, a number of significant factors must be recognized:

Available forest resources can be made to sustain an annual growth in volume that can well exceed the predepression cut.

Since 80 percent of the labor supported through forests is through the manufacture, conversion, and distribution of forest products, we must have an expanding, diversified, and stabilized wood industry.

Utilization practices must be modernized and improved -- in the past they have been largely opportunistic, unbalanced, and poorly integrated.

In the future, small-sized trees will predominate.

With the trend to shorter hours and higher wages, labor costs per unit of product will tend to increase, which means greater mechanization to keep cost of final products down.

Greater economic values result from the production of refined rather than crude products -- there are many more jobs in creating rayon from a cord of wood than in using a cord for firewood.

Improved Transportation

Our supplies of big timber are becoming increasingly distant from the great centers of population, a fact which accentuates the need for improved transportation methods.

If the 30 million tons of wood waste left annually in the woods (and much of this is in the Pacific Northwest) are to be converted into useful products, ways and means will have to be found to get it to conversion points at low cost and new products and processes must be developed.

Finally, as with all other raw materials, the competitive factors of quality and costs will always be with us, hence, we must have steady improvement of properties and production methods for the finished product.

In the light of the foregoing, can anyone doubt that problems of great magnitude and complexity exist? Can it be doubted that their solution will add greatly to the national wealth? Can it be doubted that research, far more extensive than anything yet done, and the application of its findings, is necessary for the progressive solutions of these complex problems in any reasonable time? Can it be doubted, in view of the lessons we have learned in the war, that it is possible to successfully conduct expanded and accelerated research that brings economic results which transcend manyfold the costs of the work?

If you concur in the foregoing, it takes us to the question as to who should conduct the required research and its affiliated problem of getting the results disseminated and applied, and on what magnitude it should be tackled at present and developed in the future. I personally feel that it is not by any means entirely a federal government responsibility. There is a definite place for states with timber supplies to perform their part; for trade associations to perform theirs; and for industry and private companies to perform theirs. Activities by all such agencies are under way. Here on the West Coast, for example, forest products research is actively under way and under expanding development by such agencies as the University of Washington, the Oregon Forest Products Laboratory, the Western Pine Association, the Douglas Fir Plywood Association, the West Coast Lumbermen's Association, the Weyerhaeuser Timber Company, Crown Zellerbach Corporation, the Harbor Plywood Corporation, the Rayonier Company, and Puget Sound Pulp & Timber Company. It is hoped that such activities, together with those of the Forest Products

Laboratory, may increasingly be developed to avoid unnecessary competition and to achieve the maximum effective integration.

This takes us to the question of what should be the scope and magnitude of such collective activities throughout the country? Well, if only 1 percent of the annual sales value of forest products were applied to research and its application (many progressive companies' research expenditures aggregate 3 to 5 percent of their sales) on the prewar basis, this would amount to 30 million dollars annually. Let us play safe, and set the starting figure at only 15 million.

Research Program Outlined

Since the federal government owns about 40 percent of the sawtimber stands of the country, and farm woodlots, in small scattered areas, constitute 30 percent of the total commercial forest land area, is it not reasonable that the federal government should plan for a program of research and application of at least 5 million dollars annually? A diagnosis of the problem involved has shown plenty of specific projects for attack to effectively require such an expenditure. The program would include not only the technical research work at the Forest Products Laboratory, but the development of necessary pilot plants, regional and otherwise, and of Forest Products Regional Units to function as the liaison representatives of the Laboratory in their respective field. Two such units, one headquartered in New Orleans and one in Philadelphia, have already been started in a small way; there is need for others here on the West Coast. It should be remembered, however, that such liaison units can develop specific problems for Laboratory attack far greater than the Forest Products Laboratory can handle on its present federal appropriations.

How soon or to what degree the policy of the federal government will permit the development of forest products research on the scale suggested is not known. At present the Forest Products Laboratory is effectively operating on a basis that is costing about 2-1/2 million dollars annually, of which only about \$330,000 is from the regular \$1,000,000 forest products appropriation. The remainder is from the various cooperating war agencies and, of course, may be expected to be curtailed or abandoned with the termination of the war. On the other hand the Laboratory has now the facilities, equipment, and personnel to carry forward effectively on its present magnitude on postwar problems when funds are provided to do so.

In conclusion, how rapidly we shall achieve the potential possibilities of bigger and better utilization through expanded research depends upon public understanding of the values at stake, which can come only from the leadership of men in the industry who are on the front lines and daily confronted with the realities.