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How Research in Forest Products Affects the Practice of Forestry

By Arthur Koehler

In Charge of Office of Wood Technology, Forest Products Laboratory, Madison.

Address delivered at the meeting of the Intercollegiate Association of Forestry Clubs, Ames, Iowa, March 8, 1924.

A prominent professor in one of our large universities told his class that his ambition had been to become a philosopher for he loved to speculate on the abstract realities of life; but he soon found out that the philosopher has to go where the scientist pushes him, and so he decided to become a scientist and do some of the pushing.

Similarly, practical matters have to yield to the onslaught of scientific research. Often the yielding is slow, the old wagon doesn’t quite fit the gauge of the new road, but eventually the gauge of the wagon is changed and the new order is better than the old.

Research in forest products still is in its teens and hasn’t forced many issues on a reluctant public, but already the youngster is beginning to have influence on his environment. His efforts are felt from the value of the standing forest to the value of waste paper; from the mill where steel is made for saws to the factory where the glue is made for gluing up the final product, aye, from the type of furniture in our homes and offices to the golf shaft used on Saturday afternoon to relieve the nervous strain of a cosmopolitan week.

The effect of research on the utilization of forest products is in itself no small story, but this paper will be confined to how more knowledge of the possibilities and limitations of forest products may affect the growing of trees, or the practice of forestry.

The aim of a forester is chiefly to grow timber of the most valuable kinds in the shortest possible time, on a permanent basis. There are side issues which under certain conditions become the predominating issues but these will not be considered here.

The value of timber is determined by its usefulness which in turn depends on its properties and completeness of utilization. Timber may be valued for its stiffness, toughness, hardness, durability, ability to take preservatives or finishes, easy workability, resistance to splitting in nailing, appearance, and a number of other properties or combination of properties. A forester should be well acquainted not only with present demands for timber but with the intrinsic value of the var-
ious species of wood which may govern future demands and determine the kinds of timber most profitable to own 50 years hence.

The amount of the timber on a forest which finally finds its way into commodities of various kinds varies between wide limits but averages about 25 per cent. That it is possible to increase the percentage under present conditions has been demonstrated in a number of practical ways. The greater the returns from each acre of timberland, the greater is the incentive to grow timber.

The time required to grow timber of sizes which are profitable to harvest depends on its value in different stages of growth. Scientific research may develop uses which will increase the value of young timber and thereby shorten its financial rotation.

Research of forest products, therefore, affects the kind of timber that should be grown, the length of rotation, the profits derived from growing timber, and, as will be shown later, to some extent the silvicultural methods pursued. These subjects will be taken up in this order.

Choice of Species

How does research in forest products affect the choice that a forester has to make between the many native and numerous exotic species of trees that are adapted to his conditions? The choice of species depends on the following factors:

1. Market value
   a. Intrinsic value as wood for by-products, as naval stores
   b. Market conditions—future markets should be considered,
   c. Cost of getting material to market—ease of logging, weight (cost of handling and whether it will float or not).
2. Adaptability of species to site.
3. Rapidity of growth. Rapidly growing species may be preferred to more valuable but slower growing species.
4. Cost of establishing stand. When natural reproduction is used, some of the species on the ground must be selected. Under artificial reproduction some other species may be cheaper to propagate.
5. Resistance to injury by fungi, insects, wind, and fire.
6. Silvicultural value: Some species help to improve the site or the quality of other species in admixture with them.
7. Aesthetic value, especially on private estates and on public grounds used for recreational purposes.
Research in forest products affects the first of these only, that is, the market value. It may do this by finding more valuable uses for the timber and its by-products or by reducing present waste in harvesting and manufacturing. Examples are numerous.

As a result of research which showed that good paper could be made from aspen and jack pine, a firm in northern Minnesota selected these species to be grown on a sustained yield basis. Shades of Jehoshaphat! What timberland owner would have thought of encouraging the growth of "popple" and a scrubby pine 10 years ago?

Now the chemists at the Forest Products Laboratory have discovered a new process of making strong paper from hardwoods which yields pulp from 80 to 85 per cent of the original dry weight of the wood, as compared with 40 to 50 per cent for other chemical processes or about as good as for ground wood and at the same cost but with less power. The meaning of this can hardly be fathomed. It will give an added value to aspen and other northern hardwoods, and will open up the possibility of using southern hardwoods such as gums, sycamore, hackberry, magnolias, etc., for paper, thereby not only making the quick-growing second-growth southern hardwoods more valuable and more profitable to grow but, together with the comparatively recent adaptation of the sulphate process to southern pines, development of the paper industry in the South which has to import nearly all of its paper from the North. Already, research on the use of southern pines has made possible the use of 323,000 cords in 1920. Of this about one-half has been converted by the sulphate process. The development of these two paper-making processes will have a tremendous influence on southern forestry.

Before the utilization of western conifers for pulp and paper could be put into effect on a commercial scale a certain amount of research was necessary. The fitness of these woods, especially western hemlock and the true firs, for paper making is going to affect the regard in which the western forester holds these so-called "weed trees."

Chemical investigations on wood may bring to light new possibilities for use of certain species and show the limitations of others. For example, the utilization of western larch butt logs and mill waste in the manufacture of mucic acid may give this species a more favorable standing among foresters. On the other hand, research has shown that the gums are not so suitable as some other species for destructive distillation and should not be propagated with that as a primary or secondary object. In general, to what extent the chemical
conversion of waste of any species is feasible can be determined only by prolonged research.

Ailanthus and the empress tree (Paulownia tomentosa), both native of the Orient, are of the most rapidly growing hardwood species either native or introduced in this country, but their propagation would be risky without first inquiring into their technical properties. Too great haste in proclaiming these as excellent species to grow might lead to grief as in the case of the eucalyptus.

It has been determined that certain acacias have a large amount of tannin in the bark but the value of the wood would have to be ascertained before the species could enter into our forestry program.

Seasoning experiments must not be ignored in the choice of species. Although southern oaks grow rapidly and produce dense wood they have the serious drawback of being difficult to season even under the best methods. Any species which shrink and swell, warp, or check to a large extent had better be given thorough consideration before it is decided to give them a place in the forest for a generation or two. On the other hand, research in seasoning may show how to get around some of the bad features of certain woods. This has been done for red gum, and investigations are now planned to cut down air-seasoning losses in white fir for which species it was found that 53 per cent of shook rejects at a box factory were rejected on account of seasoning defects, a large part of which very likely can be prevented.

The value of second-growth eastern white pine as compared with western yellow pine lumber for boxes was established more definitely when tests showed that thicker boards are necessary for the sides, tops, and bottoms when made of the eastern species because of the larger number of knots in the box grades.

It had been believed in a general way that spirally-grained trees were not so desirable for structural purposes as straight-grained trees on account of the weakening effect of spiral grain, but it remained for research to show how much of a slope in grain could be permitted before the weakening became serious. This definite information is of material advantage to the forester in appraising the value of a stand or the value of an individual species subject to more or less spiral grain as compared with other candidates for perpetuation.

Perhaps the effect of research in forest products on the choice of tree species for intensive forest management is shown best in the field of wood preservation. The use of lodgepole pine for railroad ties, a happy outlet for this small
but abundant species, is made much more practical by first giving the ties a preservative treatment. The same applies to second-growth southern yellow pines with their wide sapwood, western hemlock, and numerous non-durable woods. The forester is no longer confronted with the problem of producing ties from slow-growing white oak, cedar, cypress, and other highly durable species, on a rotation period which makes their production profitable.

The preservation treatment of timber is strictly a research problem. No reasonable amount of ordinary “experience” would give sufficient information on the effectiveness of various preservatives, and the best methods of injecting them to solve the problem of efficient wood preservation.

Even the by-products of timber may be a determining factor in the choice of species, and research on the development of those by-products may turn the balance to one species or another. Within certain areas of the South, loblolly pine, longleaf pine, and slash pine can be grown. Loblolly grows very rapidly, reproduces easily, but does not produce dense timber or the quality of naval stores to make turpentining practical. Longleaf has these two qualities lacking in loblolly but is slow in growth, and reproduces poorly. Slash pine grows rapidly, propagates itself readily, produces dense timber, and excellent and abundant naval stores as early as at 15 to 25 years of age.

It is not uncommon to hear it said, however, that slash pine is more apt to become injured from turpentining than its associate, longleaf. Research shows that slash pine is a little more sensitive than longleaf to improper chipping and must be handled in a more conservative manner in order to make turpentining profitable, but with this precaution it certainly looks like the leading species wherever it can be grown.

The development of tannin extraction from chestnut and the use of the spent chips for pulp, the usefulness of the wood in general, together with its rapid growth from sprouts would make chestnut one of the most desirable of eastern forest trees if it were not for the blight. By developing the use of western hemlock bark for tanning purposes it might also become a more useful species.

In general, it may be said that research on forest products has two diametrically opposite effects on the choice of species. By ascertaining the properties and peculiarities of a species of wood its most efficient uses can be determined. This tends to make its utilization more and more specialized, and therefore the timber more valuable. That is what is happening to redwood now. On the other hand, a study of a species of wood shows how its handicaps can be avoided or
overcome by proper manipulation thus making it a more versatile species. Douglas fir, maple, and some other species, have a strong tendency to check when suddenly subjected to low humidities, as when brought into a heated factory, with the result that the manufacturer is likely to turn to other woods when at all feasible. Common sense would almost suggest the remedy, but curves on the relation of the moisture content of wood to the relative humidity of the atmosphere worked out in the laboratory are far more convincing and more definite in their application. The ease with which redwood, cypress, and eastern red cedar split in nailing has prejudiced many a carpenter against these woods, but data on the relation of the size of the nail to its splitting effect and holding power show that it often is possible to modify the dimensions of the nail so as to get equally strong nailed joints without serious splitting and so overcome the prejudice against such woods.

**Rotation Period**

The forester calculates the length of time required for a forest to bring the greatest mean net annual financial return from the anticipated value of the forest each decade or other suitable period and the cost of raising the crop. If the forest can be made to bring in earlier the greatest average return the length of rotation will be shortened accordingly. This can be done especially by an increase in the value of the younger trees. Here again preservation furnishes a good example of the effect of research. Second-growth loblolly pine trees large enough for round posts, ties, and poles are nearly all sapwood and have too little heart-wood to be of practical value for such uses in their natural condition. To continue their growth until enough heart-wood is formed would take many decades longer than is required to produce suitable material if given a preservative treatment.

An example of the rapid production of yellow pine posts is that of a tract in Louisiana on which two cuttings were made six years apart, each cutting furnishing 500 to 600 posts per acre. These posts were merchantable only when treated.

By developing the processes of gluing up stock, especially with water-resistant glue, the use of smaller material will be encouraged, thereby giving the younger trees a higher value. That glued up stock gives satisfactory service for certain purposes is an established fact. It remains to develop it to a larger degree.

One of the men who attended the gluing course at the Forest Products Laboratory gave a cost figure of 4.5 cents per square foot for edge-jointed 5-16 inch thick yellow pine
panels (not veneered) made up of scrap lumber valued at $50 per M; while three-ply birch panels 5-16 inch thick cost them 9.1 cents per square foot. A direct comparison cannot be made between these two products since one is veneered and the other is not, but it shows that it is possible to glue up waste stock economically even if the waste is credited with its full original cost.

More information on the properties of some of the faster growing species such as catalpa, redwood, empress tree, etc., may cause them to be substituted for slower growing kinds with a corresponding shortening of the rotation period. However, before the most efficient use can be made of many species grown under environmental conditions differing materially from those which are obtained in the original forests, additional tests will have to be conducted to determine the influence of changed growth conditions on the properties of the wood, such as strength, shrinkage, freedom from warping, pulping qualities, and possibly durability. The properties of young rapidly growing trees may be appreciably different from those exhibited by trees of the original forest.

Any increase in the yields from young trees, for example, turpentine and rosin, storax, thinnings, will tend to shorten the rotation by making the period of maximum mean annual return come sooner.

**Increased Profits from Forests**

A long story could be written as to how research tends to increase the profits from the forests. Any paying method of reducing waste or making better use of what is now put to use will increase the returns from forest growth and make the practice more profitable. One of the common contentions of lumbermen is that it does not pay for private concerns to grow trees on a sustained yield basis and the best answer is that some of the more progressive lumbermen are doing it. There is a firm in Arkansas which practices forestry just as intensively as the Government does on nearby National Forests. The producers of redwood are intensely interested in reforesting their cut-over lands and making them yield a permanent income. The Great Southern Lumber Company is going into forestry “with all fours.” None of these concerns, however, is content with the old methods of logging and milling. To make it pay they must practice intensive utilization, and this is possible only after considerable research is carried on either by scientists in the laboratory, or foresters and accountants on their holdings.

Let us consider briefly some of the research work that has been done and is being done to reduce waste in the lumber industry.
The success of many forms of possible closer utilization will come only after timber gets much scarcer and higher priced. Enough research on the cutting and use of small dimension stock has been done, however, to show that it is only a matter of overcoming the inertia of an old industry in order to turn some of the wastes into dollars and cents at the present time. With the increase in percentages of low-grade lumber at mills, high freight rates, high labor costs at consuming plants, it has been shown that it is profitable to manufacture small dimension stock at the mill from slabs, edgings, crooked and defective logs, and low-grade lumber. A preliminary study of the use of small dimension stock in 1910 showed that out of a total lumber consumption of 40 billion board feet 97/4 billion were further reduced to smaller sizes at the factories of the secondary wood-using industries. That here is an opportunity to effect material reduction in waste and increase profits is no longer questionable.

How standardization of grades, sizes, and names reduces waste is not so obvious. We all can see how it would be more convenient for the consumer, dealer and millmen, but where does the increased profit come from? A few examples may make it clear. A lumber manufacturer in Michigan cuts hemlock heavy dimension of which dressed 2 by 4s measure 3¾ by 3¾ inches. He has a customer who also uses Douglas fir dimension, which for a 2 by 4 measures 3½ by 1¾, and wants the hemlock the same size so as to make the two interchangeable. The Michigan man promptly dresses his rough hemlock to finished Douglas fir size and so wastes an eighth of an inch on one side and one edge of each 2 by 4.

A mill in the South has export trade for about 1-6 of its one-inch lumber. Export trade demands that the lumber be 1½ inches thick in the rough, domestic trade requires only 1 1-32 inches thickness. The mill cuts all of its inch lumber as for export trade and then dresses 5-6 of it down to same thickness and the 1 1-32 inches material is dressed to, or wastes 3-32 of an inch in thickness on each board which goes to the domestic trade.

Drum tests on packing boxes have shown that by the use of metal strapping (which requires only a very little metal) thinner sides, tops, and bottoms can be used in packing boxes without reducing their serviceability. In that way not only lumber is saved but the freight on the lumber in the box. If we used boxes like we did ten years ago considerably more lumber would be used for boxes and the extra freight charges on them would be no small item.

Since a great deal of the box shook material is made at the sawmills, any saving in lumber means an increase in
profits or returns from the timber land, for you may be sure the mill man does not let his customers get all the benefit of the saving.

What made this reduction in the amount of lumber in containers possible and safe? Answer, Research, and nearly all of it was carried on at the Forest Products Laboratory.

Tests on structural timbers show that knots do not seriously affect the stiffness of timbers, joists, etc. For small dwelling construction and other requirements in which stiffness rather than strength is the controlling factor it is entirely safe to use knotty timbers and joists. This information, if properly made use of, will increase the outlet of low-grade stock, which the lumbermen always find difficult to move, thereby increasing the returns from the forest.

It has been estimated that better seasoning methods could approximate a saving of $50,000,000 annually through reduction in stain, decay, checking, crook, warping, etc. This divided over our 50,000,000 M board feet of annual cut in all forms except firewood would increase the average value $1 per thousand. Although not all of this loss occurs at the mill, most of it does. A mill cutting 250,000 feet a day could—well, figure it out, how many foresters they could hire and how much fire protection they could institute on the proceeds of this one item alone. And don't forget that by improving seasoning methods there would be less low-grade stock, and hence a better sale of intrinsically defective lumber which now goes to waste, but is not considered in the $50,000,000 above.

The preservation of timber makes possible the closer utilization of small trees of non-durable species and the use of tops of species like birch, beech, maple, and hemlock for ties and posts. Studies in the habits and requirements of fungi and bacteria have shown that it is practical to prevent the destruction of considerable pulp in storage. With an application of this knowledge a pulp mill can get larger net returns per acre from its forest land. Studies on the pulp yields of partly decayed woods shows that the yields were higher than is commonly believed. This should increase the value of rot-infected timber, as hitherto the practice has been to omit all rot entirely from the scale.

Studies of losses in the pulp and paper industry also have shown that the use of more refined methods might effect a saving of 10 per cent. This can be done by keeping all processes under control, and includes such factors as preventing pulpwood decay, more efficient barking, better chipping, regulating cooking conditions, and screening wash water (which in some instances alone causes a loss of 10 per
cent of the fiber). The recovery of valuable ingredients in spent digestor liquors offers a fertile field for investigation.

It has been demonstrated that a high grade insulating material can be manufactured by shredding up waste coniferous wood. If the market for this material were developed to the extent that waste makes it possible to market it, the net income from stumpage would be doubled, and the gross income more than doubled.

The greater use of glued up construction would effect a better utilization of waste, of undesirable species (for cores), and reduction in drying losses, since thin stock suffers less degrade than heavy stock in drying.

Numerous other examples could be cited of how research has improved methods in the lumber-manufacturing and wood-using industries and thereby made the practice of forestry more profitable.

Silvicultural Practices

Utilization of thinnings by cutting dimension stock from them, applying preservatives to small stock of non-durable species, converting small pines into pulp by the sulphate process which does not require that the material be barked, make more profitable the cutting of thinnings. This is a desirable silvicultural practice since it removes a fire hazard, gives the other trees in the stand a better chance to grow and makes conditions more favorable for reproduction.

Research on the relation of growth conditions to the specific gravity of ash show that slow growth at the beginning, followed by a normal or gradually accelerated rate of diameter growth will produce material of high quality and having uniform properties; if, on the other hand, the tree grows rapidly for a number of years and then slows down, the slower growth is not of as good quality as that which has grown slowly from the beginning. If further research shows that this relation holds in general it will have an important bearing on silvicultural methods which aim to produce timber of the best quality, since the forester can to a certain extent regulate the rate of growth by the closeness of the stand.

Fixing the requirements of dense yellow pine and Douglas fir gives the forester a standard to work to when attempting to produce the best structural timbers possible from these species.

In conclusion, it can be said that there is a more direct relationship between forest utilization and the practice of growing trees than seems to be taken into consideration in forest administration. Research in forest products has done considerable and likely is destined to do a great deal more
to make this relation more definite and comprehensive. By obtaining accurate information on the properties of a species in comparison with other species its most valuable field of usefulness can be determined and its value increased. This applies to both the common, well-known species, and the less common little-used kinds. By learning how best to manipulate the less desirable species of timber, and the lower grades of lumber, and overcoming the prejudices against such material its value can also be increased. The effect, however, will be a gradual sorting out of species leaving only those kinds for perpetuation which show the greatest usefulness.

Let me cite one more example to show how prejudices which affect the practice of forestry may be based on wrong assumptions and overthrown by accurate data. The lumberman is very apt to say that it is not practical to raise timber because the second-growth is of such poor quality as compared to virgin growth that it is not profitable to grow it. Mill scale studies show that there is much less difference in the percentages of grades than is usually supposed. The following table gives figures for the Southern Pine Association compiled in 1923 whose mills cut mostly virgin timber, and North Carolina pine which consists largely of second growth:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Southern Pine Association Per cent of total lumber</th>
<th>North Carolina Pine Association Per cent of total lumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>B &amp; Better</td>
<td>17.3</td>
<td>18.9</td>
</tr>
<tr>
<td>No. 1 Common</td>
<td>27.4</td>
<td>13.0</td>
</tr>
<tr>
<td>No. 2 Common</td>
<td>42.6</td>
<td>46.4</td>
</tr>
<tr>
<td>No. 3 Common</td>
<td>12.6</td>
<td>15.9</td>
</tr>
<tr>
<td>No. 4 Common</td>
<td>(insignificant)</td>
<td>Red heart and bark string</td>
</tr>
</tbody>
</table>

a This covers a narrower range than No. 1 Common.
b This covers a wider range than No. 2 Common.

It is true that the boards of second-growth pine average narrower, but wide boards are going out of style anyhow. The more extensive use of glues has materially affected the size of lumber used.

More efficient utilization of timber and by-products will materially increase the financial returns which is one of the most needed inducements for the practice of forestry.

Accurate information on various phases of wood utilization will have a tendency to stabilize the market, because the timber grower will know better what his timber is worth and the buyer will know better what he can afford to pay for it. This will go a long way in putting the practice of forestry on a sound basis and eliminating some of its risks.

I wish it were possible to say that more efficient utiliza-
tion of forest products would affect the practice of forestry by making it possible to get along with less timberlands, but Mr. Winslow has shown in an address delivered at the meeting of the Society of American Foresters in Baltimore (1923) that even if all of our available 470 million acres of potential forest land were put to growing timber under highly intensive forest management we could not keep up the present per capita consumption (assuming a normal increase in population). And all that research can hope to do is to keep the per capita consumption of standing timber from being forced to an unwholesomely low level.

Finally, since the business of the forester is to grow valuable timber, he, like the would-be philosopher, will have to go where the scientists push him, particularly those whose researches influence the value of the crop.