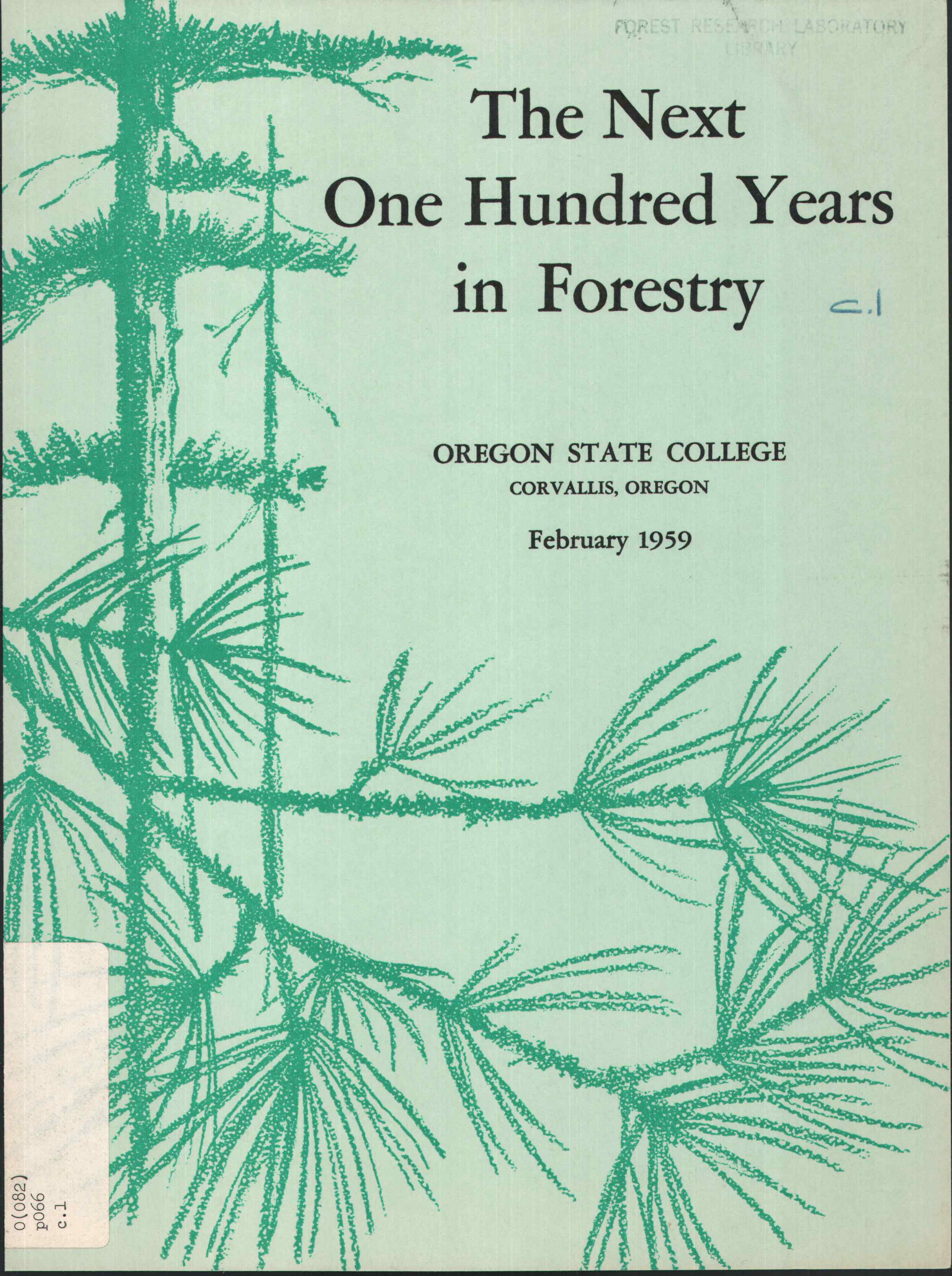
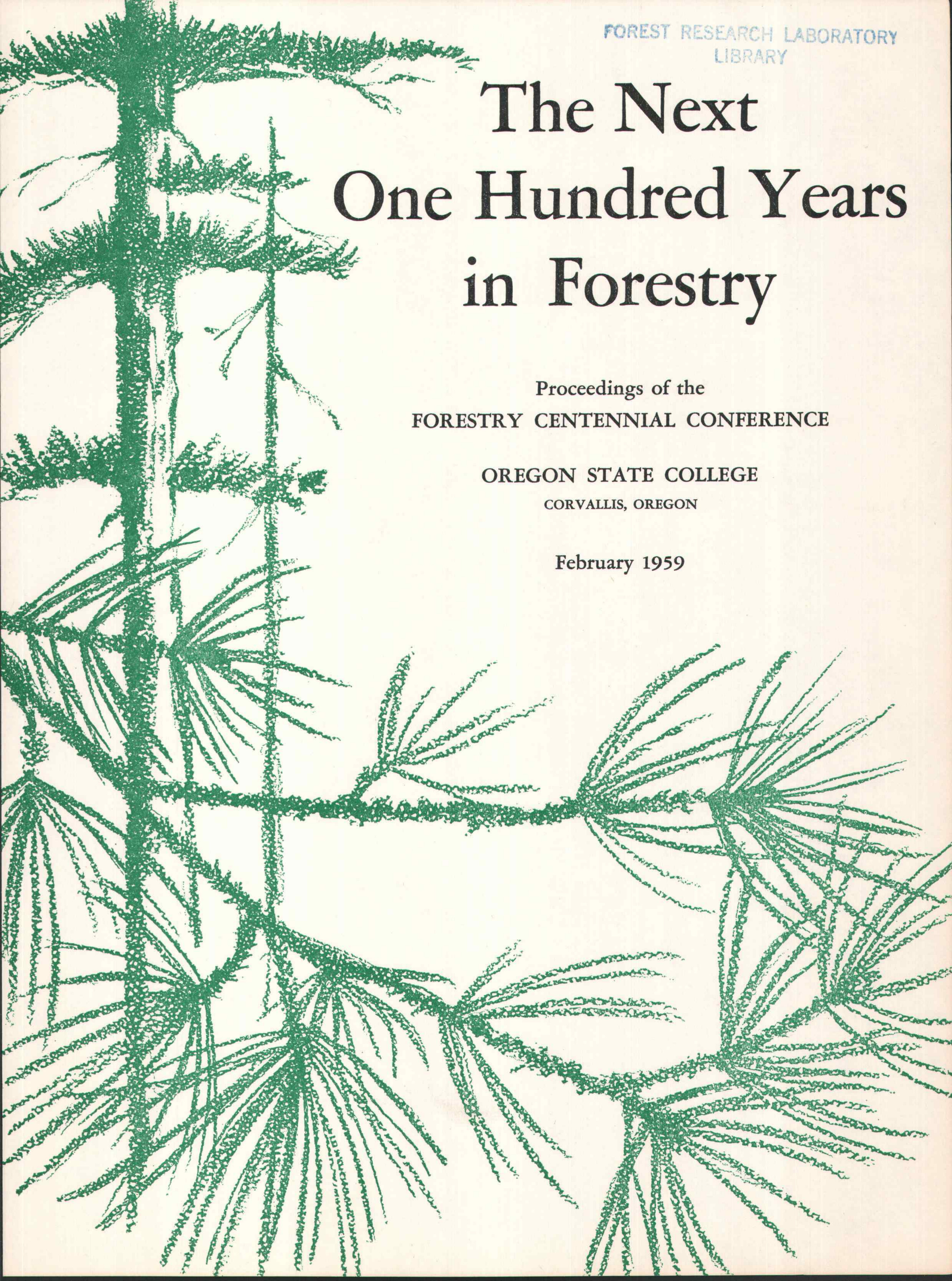


The Next One Hundred Years in Forestry

OREGON STATE COLLEGE

CORVALLIS, OREGON

February 1959



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Proceedings of the
FORESTRY CENTENNIAL CONFERENCE

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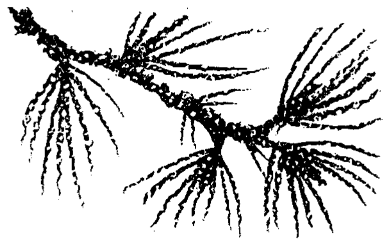

Foreword

NOTHING could be more appropriate to the celebration of Oregon's Centennial than a prudent consideration of the second century of forestry on which we are now embarking. The full and hearty cooperation of all the various governmental agencies, state and federal, together with the wide interest shown in the conference by neighboring states and Canada, combined to give the future of forestry in Oregon the attention it properly deserves.

The most important duty of the administrators of any enterprise is to examine the objectives of their undertaking. Such appraisals need a careful study of all the factors that may contribute to the success of the enterprise on the one hand, and on the other, of those things which must be corrected in order to achieve the goals which have been established.

The papers included here were given at the Forestry Centennial Conference held at Oregon State College February 20 and 21, 1959. They should prove valuable in reference to the second century of Oregon's major industry.

—A. L. Strand, President
Oregon State College

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The Next Hundred Years in Forestry

Planning for the Future

H. J. Vaux
Dean, School of Forestry,
University of California, Berkeley, California.

A 100th anniversary, whether of an individual or of a sovereign state, is a significant event and one which merits distinctive celebration. In the case of mere mortals the luster of the occasion may be somewhat dimmed by the fact that the object of the celebration has little future. Fortunately for us, on this Centenary of the State of Oregon, no such restraints need be imposed.

Indeed, such an anniversary is a most appropriate occasion for a stock-taking and a long look at what may lie ahead—a look ahead not in the spirit of idle speculation but with the serious purpose of trying to identify, through the mists of the future, the major landmarks that must guide the second century of the Oregon adventure. For Oregon with its highly productive forests and with the tradition of forest conservation which it has so firmly established during the first century, it is entirely fitting to focus attention during this Centennial on "The Next 100 Years in Forestry."

With these things in mind President Strand and Dean McCulloch have laid out the plan for this Conference. They have brought together 16 eminent men from across the United States and Canada—men with special qualifications to take the long view and to discern the trends most likely to influence the forestry of the future. Collectively, these papers will bring viewpoints based on long experience in research, forest industry, education, public administration, and high government office. I am sure that none of these men has access to either a crystal ball or some sort of magic spectacles which enable him to view the next century with 20/20 vision. But I am confident that each has that combination of long experience in his field, responsible concern for where we are headed, and seasoned judgment of both scientific and human affairs so that his ideas will provide us with truly significant guides to "The Next 100 Years in Forestry."

The papers included here fall into four groups. Our first one devotes attention to some broad foundations: the history of forestry and forest industry in Oregon which has laid the base on which the next 100 years must be built; the prospective future needs for research in order to expand both the scientific knowledge and the technical knowledge available to the forestry of the future; and the strategic responsibility which Oregon State College and agencies cooperating with it here in Corvallis must assume for the effective conduct of that research.

We have two groups of papers concerned with the future of forestry science and technology. One will deal with prospects for the biological research needed to enable Oregon to realize from its nearly 26 million acres of commercial forest land their full productive potential. The other will consider the companion problems of making full use for human purposes of the total forest crop and of insuring that wood retains acceptance in the markets of the world.

Research in forest biology and utilization must give us the tools to solve the problems of the future, but population pressures will do much to determine what those problems are. And so our concluding papers will discuss the problems and the opportunities which explosive growth in numbers of people is creating for forestry.

Forestry and Forest Industries in Oregon

THOMAS VAUGHAN
Director, Oregon Historical Society, Portland, Oregon.

IN THIS BRIEF PAPER I wish to survey an explosive century in forestry, with particular reference to Oregon and the Pacific Northwest.

I use the word explosive to embrace the idea that one of the greatest developments of this memorable century has been the understanding and development of power. The application of these new power forms to every phase of man's work has brought phenomenal advances in every field. One of the great examples is the application of power machinery to the forests, to their greatest produce—trees.

It took some 300 years for Europe's greatest mariners to find and map the tree-lined Oregon coast. An American captain, the redoubtable Robert Gray out of Boston, then found and penetrated the elusive mouth of the great River of the West. This feat accomplished, it was foreordained that sailors in wooden, tall-masted ships from every harbor along the wide Atlantic frontier would comment upon the great, straight trees covering every slope of the green Oregon Country. How appropriate it was that weary Hudson's Bay mariners rolling in from the long London voyage would use two tall trees to line up and sight upon the safe channel into the turbulent Columbia River's mouth.

Early log books frequently note the rich chandler supplies and mastage for which Great Britain, in particular, had been dependent upon the sometimes blockaded Scandinavian countries, she having recently lost her once reliable sources in the now independent colonies. American settlers later coming into the Oregon valleys from the Mississippi bypassed the hills for familiar valleys and water courses. In this way settlers passed over some of America's finest farm land, looking for recognizable areas that were neither too grassy nor tree covered. On the prairies one often found a shortage of water and wood, and in the forest far too much time was spent in girdling trees and burning and grubbing stumps to let sun into the forest. Most landseekers wanted open land with adequate water plus a nearby abundant woodlot for building, fencing, and fuel.

For the Oregon Country, too, we may be fairly certain there was no true understanding of what the land and climate would demand of early settlers or what pursuits would best secure the livelihood the pioneers sought. The settlers' first philosophy was to try the land and then see what it would do. As one pioneer said, "Every wild and unsettled country has peculiarities both of soil and climate, and these cannot be fully ascertained until tested by the experience of at least several years permanent residence; when these are satisfactorily understood, its settlement takes place in proportion generally to its agricultural resources."

When one walks through the museum of the Oregon Historical Society and views the shaft of the first Hudson's Bay water driven mill or the planing mill brought out from England to Fort Vancouver by Factor John McLoughlin, it is difficult to conceive that these are remainders of the beginning of forest industry in this, the greatest timber region of the continent.

In the 1820's traders and trappers from the East and ships from England converged to build a British post on the north shore of the Columbia River near the Willamette River mouth. As men have for a millennium, the fur merchants built for protection, shelter, and comfort and they turned naturally to the surrounding forests.

Three years after the establishment of Fort Vancouver, leader John McLoughlin located a small sawmill on the Columbia River bank a few miles east of the Fort. In the fall of the year the bark *Cadboro* was sent to California and returned with good news that a lumber market existed there for planks at $40 to $50 per thousand feet. In 1829 John McLoughlin shipped another cargo of lumber to the Sandwich Islands made up of surplus lumber from the winter's cut. From that year on a regular trade developed with California, with Spanish America, and to some degree with the Pacific Islands. While the Hudson's Bay Company sash sawmill operated many years, it was always understood by McLoughlin and Governor George Simpson that the falls of the Willamette would have been a far preferable location for their sawmill had not hostile Indians forbade the hazard of such expensive construction. Of special note is the fact that lumber was being powersawed on the estuary of the Columbia at that time equal with any lumber developments in the Lake States to the east.

Perhaps most important to the development of any lumber industry was the establishment of the first provisional government of Oregon in 1843 by a few determined pioneers and engagés who came together to form a government compact. From that first organization, and with the consequent influx of settlers, a market was created for docks, ships, shelter, lumber for wagons, wheels, barns, out-buildings, corn cribs, and all other necessities of agricultural life.

By the time of the great California gold strikes, 30 mills were operating in Oregon. Prior to California gold reports, lumber sold at $30 per thousand in Oregon mills. By November, 1849, increasing demands for lumber drove prices to $80 per thousand and in 1850 to $100 per thousand.

It has been suggested by writers in this field that here is a strong indication of the peaks and valleys of prices which have been troublesome in every decade of the Pacific Northwest lumber operations. Perhaps one of the best stimuli to the mills operating and responding so rapidly to market conditions to the south was the flow back into the Oregon Country of until then scarce gold being made available as capital for investment in new sawmills and other logging and lumber enterprises—sufficiently that the number of mills was doubled and tripled, increasing the export market and turning men's minds towards the biggest resource of the Pacific Northwest—the forest.

As the California market declined and the Russia-Alaska market languished for lack of proper development, the valleys of Oregon were rapidly settled by a continued influx of prosperous farmers and sometimes successful miners who improved their lot by building houses of sawed lumber. The demand for improved construction grew so rapidly that a sawmill could be found in any ambitious Oregon community. It is estimated by McCulloch and Rogers that 1869 saw 75 million board feet of lumber produced in this state.

It is recognized that from the period of 1850, the most rapid development of mills in the region was on the Puget Sound, including the first steam mill constructed by Henry Yesler in Seattle in 1853. His mill could cut up to 10,000 feet per day, much of which was exported to San Francisco in small schooners. In Oregon it is known that the first mills were established in the lower Columbia River region, beginning with Hunt's on the original site of Fort Clatsop. They had faults beyond cure as one settler wrote home, for "they turned out boards thicker at one end than the other and sometimes thicker in the middle than at either end." This would include the first steam saw in Oregon built at the foot of Jefferson Street in Portland by Cyrus Reed and General Stephan Coffin in 1850. The approximate annual cut of this mill was 500,000 feet.

At the Falls in Oregon City sawmills received a setback in January of 1853 when a bad flood washed away McLoughlin's sawmill and other operations at that power site. Jacksonville, Oregon, bursting at the seams with a new gold strike in 1852 used lumber whipsawed in a hundred gulches around the town and sold at $250 per thousand.

The mid-nineteenth century saw little demand for Pacific Coast lumber in the east or midwest, for in this period the great pine forests of Michigan and Wisconsin approached their zenith in lumber output. The treeless prairie states were gorged on the production of hundreds of lumber camps and mills in the upper Mississippi Valley. Not until later were the Dakotas and middle western states competitive territory for the Pacific coast, for though the railroad arrived here in the seventies and eighties the problem of freight rates and the proximity of Lake States competition long remained. Idaho, Montana, and adjacent areas early recognized the Pacific woods, but for years they particularly sought shingles and other cedar woods.

The Federal census of 1880 revealed 265 lumber manufacturing plants of every character in the states of Oregon and Washington with a combined capacity of approximately ½ billion feet annually. The same census a decade later credits Oregon and Washington with a billion and one-half annual output. Certainly among the most important decades were the 1890's. Up until this period, the woods had to some degree resisted hand logging, logging with dirty, slow, expensive oxen, too much block and tackle, and manpower. Logging techniques developed in the less hilly country of the Lake States. The beneficent Oregon climate negated such techniques as skidding logs along the frozen ice roads; large wheels were impractical on the steep hillsides of the tidewater and interior valley operations.

Necessity mothering invention in this period, lumberman John Dolbeer of Eureka developed a spool donkey, the first steam donkey engine used by western loggers. Horses, oxen, and prize bull teams were still valued in the nineties, however. W. E. Crosby notes one record of five yoke of oxen hauling a 32-foot log 89 inches in diameter to the Snoqualmie River from a hillside camp. But expensive draft animals could not survive when the November, 1891 issue of the *Puget Sound Lumberman* advertised the Dolbeer engine as "doing the work of 60 oxen."

The 1893 northern rail extension into the Pacific Coast opened a new epoch in the lumber industry which was as important as Mr. Hill's later establishment of the 40 cent freight rate from the Pacific Northwest to St. Paul. While the national rail and freight pattern was being established, it became apparent locally that legendary driving streams such as the Wisconsin, the Eau Claire, the St. Croix and Black rivers of Wisconsin did not exist in the Pacific Northwest. With few driving streams available, loggers determined that railroads must be laid down as timber along the bays and rivers disappeared. Since neither oxen nor donkey engines could efficiently operate at distances over a mile, the first locomotives arrived in the woods in the nineties, including such heavy equipment as the geared Climax used in Washington and introduced in Astoria, Oregon in 1898.

During this period the southern pineries came into their own as lumber producers with 40% of the nation's production. In the same period some of the most important leaders of the industry began to log the Pacific Northwest. The Polson Brothers incorporated in 1895 with $40,000; Simpson and Anderson incorporated the Simpson Logging Company with capital stock of $50,000; E. G. English, McCaffery and Million incorporated in January, 1896.

In this era the faller and the crosscut saw remained supreme in the woods, and the familiar skidroads, chutes, and flumes were still used despite the introduction of steam power. By 1906 one may say that animal power in the woods was almost entirely replaced by machine power; and machine power was greatly accelerated with the opening of the Panama Canal in 1914, a great influence on lumber production in the West.

Logging was again revolutionized by the engineering geniuses of the woods. In this period the high lead was developed. This system carried logs by cable above stumps, gulches, and other obstacles of woods operations. R. W. Vinnedge of the North Bend Timber Company, commenting on this development during the 1913 Pacific Logging Congress modestly said, "I am not so sure that logging methods have kept pace with the demands made upon them with the different epochs. It is true we have substituted in turn the horse and donkey engine for the bull, the railroad for the skidroad and many other accomplishments, all representing progress, but the fact remains that in spite of our high powered donkeys, our mammoth locomotives and miles of railroads, we are still zig-zagging around the stumps just as the bull puncher did a generation ago. The stumps were his problem and so they are ours today." Besides obviating the need for expensive roads, high leads produced greater quantities of logs in ratio to the number of men employed, but did not materially lower the cost per 1,000 board feet. This heavy equipment often ran to an investment of $50,000 for one skidder engine and complementary equipment. Such heavy equipment followed the railroads, and was discarded as trucks gradually superseded locomotives, an important change for all foresters interested in reforestation and conservation. The gradual elimination of this massive equipment assisted a more productive program of reforesting cutover land. From this time on there was even more significant development of oil fuel for forest machinery, and the introduction of electricity which would become the prevailing motive power after World War I. Introduction of gasoline donkey engines in the early 1920's included a four speed gas donkey developed by Skagit Steel and Iron Works and improved by the Willamette Iron Works.

During this same period phenomenal developments were apparent in the mills handling enormous spruce and fir logs—a far cry from the whipsawed lumber used by John Meares to build the first ship at Nootka Sound in 1788—or the 1827 power-driven mills of the Hudson's Bay Company. The bandsaw with smaller kerf and less waste, the double-cut bandsaw and the head rig were developed in surprisingly short time. With more efficient production of lumber and timber, better power tools, kilns, better transportation, and shortened routes such as the Panama Canal, came improved grading and distribution techniques.

Among the most commendable developments were the organization of the U. S. Forest Service, the State Board of Forestry in 1911, the Western Forestry and Conservation Association, the Pacific Logging Congress, the West Coast Lumbermen's Association, and other organizations devoted to the soundest principles of logging, lumbering, distribution, and conservation.

In an earlier time when a settler acquired land title, the way he used the land was his business. Schoepf, the German traveler, observed in 1784 that "in America there is no sovereign right over forests and game, no forest service. Whoever holds new land, in whatever way, controls it as his exclusive possession, with everything on it, above it, under it. It will not easily come about therefore that as a strict statutory matter, farmers and landowners will be taught how to manage their forests so as to leave for their grandchildren a bit of wood over which to hang a teakettle. Experience and necessity must here take the place of magisterial provision." But now it would seem we have come of age and are gaining wisdom in forest practices.

Such organizations as mentioned have educated the public and other lumbermen to the effect that forests, commercial and noncommercial, have values other than the logs they produce. Watershed coverage, water for homes, industries, irrigated farms, and hydroelectric generators come from our rainfilled forests. Trees protect the soil in which they grow from erosion, eliminating lower level silt problems. The forests also maintain plant cover to retain runoff from heavy snowfalls and are put to double use not only in sustaining tree farms but also in providing grazing areas for both sheep and cattle. We have achieved greatest value in the permanent creation of a philosophy that timber is a crop, which wise management may gather for generations to come. Of special interest to me in the records of earlier management is an observation made by a distinguished forester in 1923 that by 1933 the Pacific Northwest would have reached its zenith in lumber production and started downhill, and that in two decades we would undoubtedly be producing far below the volume of 1923. He indicated that 1943 would see the annual consumption of lumber fall under 25 billion feet.[1] For though the Pacific Coast region, through fav-

[1] In 1943 the figure actually was above 34 billion feet.

ored natural reproduction, is ideal for growing trees he saw no possibility of reforestation reversing this situation.

Since that time however, long strides have been made in forest fire prevention and replanting. Along with public conservation "Keep Green" movements, such things as tree farms, and the partnership of industry and agriculture have become progressively constructive and popular in the Pacific Northwest. Coupled with better care of the forest a much finer understanding of the full use of the tree has come about. The burners that once marked the site of every sawmill, large or small, have given way before the superb advances of the laboratory as manufacturers and technicians have found new and better uses for the whole tree. Oregon's greatest industry has come forward a century.

Today, we have in Oregon and the Pacific Northwest some 65,262,000 acres of commercial forest land. A little more than half of it is owned and managed by the federal government. Perhaps half is commercial sawtimber reserves under federal ownership. The privately owned and managed wood-using industries, the region's largest single source of income, provide an increasingly important market for thousands of small woodlot owners. The forests of Oregon under sound, long-range forest management will produce more wood than has ever yet been harvested in a single year.

Today, Oregon's timber lands are of greatest importance. Despite a busy century of "progress" we possess the greatest forest resources in the United States, and equally important, the opportunity to continue as national leaders in the sustained wise harvesting of forest crops. In this centennial year, we have millions of acres of land best suited to the growing forest crops, and a climate that encourages their rapid growth. All we need is public understanding, continued education, and the cooperation of forest owners and forest users in a wise, persevering management program. If we devote ourselves to this end, we shall have exceeded John McLoughlin's greatest expectations, and we shall have used our gift well.

Research Needs in Years Ahead

R. W. COWLIN
Director, Pacific Northwest Forest and Range Experiment Station, U. S. Forest Service, Portland, Oregon.

FOREST RESEARCH needs in the years ahead can be appraised best by anticipating and projecting future demands upon the forest resource. I judge that a quantitative as well as a qualitative appraisal of future forest research needs is wanted. Since forest research is less than 50 years old in the Pacific Northwest and since my foresight probably cannot be better than my hindsight I will limit my observations to the twentieth century. In other words, I will deal with the period between now and the year 2000.

Perhaps I could sum up my appraisal of research needs by using a popular expression—"it is later than you think." Current forestry research programs are obviously inadequate in both scope and intensity of effort to provide reliable information needed now in planning public and private forest land policies and in meeting everyday problems in actual management of our forest resources not to speak of providing for the future. In developing estimates of research needs in the years ahead we should logically commence with an appraisal of the status of current research programs and their strengths and weaknesses.

First, to establish a frame of reference, I shall describe briefly the present and future forest resource situation. Since Oregon is the heart of the Pacific Northwest forest economy, I believe we should discuss this subject from the regional rather than the state level. Finally, I believe we should consider the overall national situation as a background since the Pacific Northwest forest economy is not self-contained. Regardless if it be timber, forage, recreation, or water, the end products of Pacific Northwest forest land are sold in national markets and this region is a major supplier of those markets. Furthermore, I expect this situation to continue throughout the period we are considering.

Most of you are probably familiar with the figures I am about to quote but they bear repeating. Starting with the basic resource, forest land: The United States has nearly 650 million acres of forest land or one-third of its total land area. Of this, 485 million acres is commercial forest land, and 163 million is noncommercial forest. Thus, one-fourth of the nation's land is commercial forest.

Three-fourths of the commercial forest land is in the East compared to one-fourth in the West. Of this land, 183 million acres is sawtimber, 170 million acres is poletimber, and 136 million acres is seedling and sapling or nonstocked forest land. One-fourth of the commercial forest land area is poorly stocked or nonstocked, a significant fact in appraising research needs. Proceeding with defining the background, there is slightly more than 2,000 billion board-feet of sawtimber in the United States—four-fifths of which is softwood. More than two-thirds of the national total sawtimber and five-sixths of the softwood sawtimber is in the West. A few more figures on species distribution of sawtimber volume will sharpen the description. Douglas-fir comprises a little over a fourth; ponderosa and Jeffrey pine a little over a tenth; western hemlock and Sitka spruce a tenth; the western true firs a little less than a tenth and southern pine about one-twelfth of the total volume. These five species groups in the aggregate comprise two-thirds of the nation's sawtimber volume, and the four leading groups are found principally in the Pacific Northwest.

The dynamics of the resource situation are not disclosed by the inventory figures. About three-fourths of the sawtimber growth is in the East compared to one-fourth in the West. On the other hand, nearly half of the sawtimber cut occurs in the West. In terms of sawtimber volume, growth and cut are nearly in balance—47.4 billion board feet of growth compared to 48.8 billion board feet of cut. However, among other shortcomings this comparison of growth and cut does not include loss of timber volume through mortality—that is, loss from the destructive agents—fire, insects, disease, weather, and animals. In sawtimber volume this amounts to nearly 13 billion board feet annually. This comparison also does not consider geographical distribution of growth and cut, species, or timber quality. Nor does it include impact of these destructive agents upon growth; it is estimated this loss of growth potential is 37 billion board feet of sawtimber annually. These few bare figures and comparisons alone offer a challenging and rewarding goal for increased research attention.

Before discussing research needed to answer these current problems we should also consider the future demands on the forest resource. Fortunately, again I can draw upon recent analyses for a measure of the future demand for timber products and this may well also be a yardstick for the demand for other forest land products such as water, forage, and recreation.

Estimates of future demand for timber products were made in the Timber Resource Review using these basic assumptions: Peace, but continued defense preparations; rapid increase in the national population; a much greater gross national product resulting from higher living standards and prosperity; continued importance of timber products as a basic raw material; and continuation of present forestry trends.

Projection of trends to the year 2000 was based on several sets of economic assumptions. I shall select as a benchmark the lower set for no other reason than to be conservative. This assumes an estimated national population in 2000 of 275 million people and a gross national product of 1200 billion dollars. Changes in trends of these factors since these estimates were made in 1952 show they are conservative estimates. The most recent Bureau of the Census estimates the 1975 population will be from 216 to 244 million. Projection of those trends to the year 2000 would show 275 million to be less than a minimum figure. Population trends are the basis for estimates of gross national product and other major elements of economic growth. Assuming future price of timber products will parallel price trends of competing materials—the projected demand for timber products is estimated for the year 2000 at 95 billion board feet annually or about twice our present consumption of these products.

Since our present commercial forest land is now producing less than half the amount of our estimated year 2000 needs in terms of sawtimber, four things are plain:

1. We do not have any excess of commercial forest land.
2. Productivity of our forest lands must be increased greatly.
3. We must utilize forest growing stock more effectively, and
4. We need strong research programs to accomplish these three things.

Until now I have been defining the situation only in terms of timber products and national totals. What about demands upon the forest resource for products other than timber, and how do all these factors bear upon the Pacific Northwest forest resource?

Undoubtedly rising standards of living and a greatly increased population will intensify pressures upon the commercial forest land for uses other than timber. Demands for withdrawals for single purposes will become stronger and stronger in order to meet these pressing needs, pointing to the future necessity of reconciling several demanding uses of the same forest. Intensive multiple-use management will create many complex problems needing research.

Since the Pacific Northwest contains about two-fifths of the total sawtimber volume and 45 million acres of highly productive forest land, it must supply the bulk of the demands for timber products for the western states' share of the national total. At the same time its wealth of water will lead to mounting demands for hydroelectric power, and industrial, agricultural, and domestic water. Consequently, use of the watershed potential must be given important consideration in managing the forest resource. The same conclusion applies to forage for livestock and game and to recreation particularly since population of the Pacific Coast States is increasing at a much more rapid rate than the remainder of the country. It is estimated that the present population of the three states of 17.4 million people will increase to 30 million by 1975.

What is the present strength of research programs and facilities nationally and in the Pacific Northwest? The best current estimate of total national expenditures for forest research that I have found is about 60 million dollars annually. How does this compare to expenditures in other industries? Total annual expenditures for all types of research in the United States is about 1.3% of total consumer expenditures. In comparison, annual expenditures for forest research are 0.2 of one percent of consumer expenditures for forest products. If we accept the thesis that forestry deserves parity with other segments of our economy in magnitude of research effort, one forest research man is attempting to do the work of six. Is this comparison true for the Pacific Northwest? Total annual expenditures by all agencies for forest research in the Pacific Northwest is about 2 million to 2½ million dollars or not much more than 3% to 4% of the national total of forest research. Considering these few comparisons it is obvious that forest research programs in the Pacific Northwest not only are far below needs as judged by standards set by other portions of the economy, but also are considerably below the country-wide average expenditure for forest research.

I believe a reasonable estimate of the minimum 1975 goal for total annual expenditures for forest research by all agencies in the Pacific Northwest is 15 million dollars exclusive of capital investments in physical plant and related facilities. It is difficult to estimate necessary future investments in physical plant and related facilities, but between now and 1975 I believe we should invest at least 10 million dollars in new research construction. We probably shall not reach these goals immediately but considering the great lag in research and the time required to produce results we should get an expanded program underway at once. I arrived at these estimates through considering the analyses by Kaufert and Cummings in 1953, other evaluations of forest research needs made during the past several years, recent trends in research expenditures, and changes in the basic economic situation including diminishing dollar values in the past 5 years.

What are the short-range and the long-range needs in the years ahead? The panels of experts scheduled for this afternoon and tomorrow will appraise future research needs in detail for you. I want to make only a few general points. First, I believe future research programs in both the biological and physical forest sciences must be directed more and more toward solution of basic problems. Lack of basic research on natural principles and processes in forest plants and animals and in their living environment has handicapped applied research programs because we don't have "how" and "why" answers. I shall give a few simple examples of what I mean. Why does an adequate crop of Douglas-fir seed occur only about once in 6 or 7 years? Why do insects attack some forest trees and not others? Why do some Douglas-fir trees escape *Fomes pini* infection under the same environmental condition as infected trees? I am sure you can think of many similar questions. At the same time I should like to point out that the almost total emphasis in the past on applied research in the Pacific Northwest was a logical and necessary approach in view of the relative immaturity of its forest economy. We shall continue to need a strong program of applied forest research as we continue converting old-growth forests to new managed forests. We should give increased attention to species other than Douglas-fir and ponderosa pine although we have by no means answered all the immediate questions of applied management of these two species. The program should be directed toward learning more thoroughly how to harvest, protect, utilize, and regenerate these species and the types they compose. Applied research programs in the Pacific Northwest are barely started in the fields of watershed management and game habitat. We have not even started research in forest recreation. A great deal of immediately useful information could be obtained by strengthening research in these important forest uses.

Looking ahead to immediate broad objectives we must learn how to increase the productive capacity of our forest lands if the Pacific Northwest is to grow its share of the country's timber needs in 1975 and in 2000. This requires better use of what we now have in forest land and growing stock. More effective protection against loss from insects, disease, and fire through developing effective and economical control methods is needed. More complete utilization of the wood material is needed so we don't leave as residue in the woods and mill such a large part of the wood volume. We must learn how to use as thinnings the material lost from death before harvest cuts. Probably of highest priority is learning how to obtain prompt and effective regeneration following cutting. Looking further ahead we must better the quality and growth of our forest stands through tree improvement, tree breeding, and cultural methods such as pruning and fertilization. Since it is evident we must practice intensive multiple-use forest land management we must learn more about the forest community; the complexities of the interrelationships of soil, water, flora, and fauna through study of the basic behavior and life processes of these four community members under conditions which may be carefully controlled and precisely measured. This research cannot be done by costly trial and error methods in forest and field. It requires personnel well trained in a number of scientific disciplines, modern scientific laboratories and equipment. Money will build the laboratories and buy the equipment. We must look to institutions such as Oregon State College to furnish the trained manpower. A goal of 15 million dollars annually means a staff of 400 to 500 research scientists. I anticipate that within a few years forest research organizations will be recruiting most of their personnel from the graduate schools probably at the doctorate level. I also expect that in the near future the numbers of our current research workers returning to the educational institutions to obtain additional graduate training in research methods and the forest sciences will accelerate.

In closing I cannot resist commenting briefly on the advantages of integrated forest research-educational centers although I know it will be covered thoroughly later. At Corvallis we have the nucleus of an outstanding forest research center located near a fine forest school. This offers reciprocal advantages. The research institution profits from the availability of college faculty experienced in many scientific specialties, graduate students, and specialized laboratories and equipment. On the other hand the neighboring research institutions help raise and maintain instructional levels through providing guest lecturers and consultants, through giving academic faculties ready access to the most recent scientific information, through offering part-time employment to graduate students and faculty, and by providing career opportunities to graduating students. I do not need a crystal ball to see a completely integrated forest science community at Corvallis several times the size of the present group long before the year 2000.

Corvallis: Center of Forest Research

A. L. STRAND
President, Oregon State College.

The Forests of America, however slighted by man, must have been a great delight to God, for they were the best He ever planted.
—JOHN MUIR

Where there is no vision, the people perish.

RECENTLY, in a $35,000 study of Oregon taxes by a Princeton professor, one important conclusion was drawn, namely, that the state's tax resources can be improved only by enlarging our economic base. The author of the report must have felt very secure in making that statement for it falls in the category of self-evident truths. Because our productive economy now is about two parts forestry and one part agriculture, there is no gainsaying that great importance attaches to the future development and use of our forest resources.

In the first 100 years, our forests have changed from that "continuous woods where rolls the Oregon," more or less of a hindering nuisance, to standing out as our greatest source of income. Accordingly, I suppose that this conference, were it to adopt a single resolution about the second century of forestry in Oregon, would say something like this: (after various whereas's) BE IT THEREFORE RESOLVED that our forests and our forest industries be the subject of our greatest material concern and that we devote to their welfare and development all the science, all the technology, and all the genius at our command.

A brief look at the historical development of forest research in Oregon will show that we have moved in the direction of such concern about our forests very slowly, very slowly indeed.

1903 Earliest efforts of the U. S. Forest Service in preliminary studies of hemlock and fir were made.

1910 The first sample plots to study growth were established by Thornton T. Munger.

1913 The first Forest Experiment Station in the Northwest founded by the Forest Service at Wind River, Washington.

1927 Extra-curricular research was conducted by the OSC forestry staff in silviculture and products. The 1927 pioneers who took this step were Professors Starker and Voorhies.

1941 The first formal program in forest products research was begun by the School of Forestry with a small grant from the state general fund, through the State Board of Forestry; Oregon Forest Products Laboratory was established on the campus.

1947 The severance tax to support work on forest products and forest management was passed by the State Legislature. The School of Forestry program was merged with the new undertaking in a greatly expanded forest products laboratory.

1950 Requests were received from industry to initiate programs in fundamental research (on the campus) in forest soils, pathology, and entomology; beginnings were made in these areas during the years immediately following.

1954 The OSC Forest Experiment Station was established.

1957 Forest research was consolidated into the Forest Research Division of the Agricultural Experiment Station.

Some of the dates above require more explanation. The small appropriation obtained by the School of Forestry in 1941 was such that it could allow members of the school to engage in only part-time research during the regular school year and full-time during the summer.

When the severance tax became available to the State Board of Forestry, the dean of the School of Forestry was made director of the program and was paid in part from severance-tax receipts. In view of that fact, the general fund appropriation through the State Board of Forestry to the School of Forestry was discontinued, and applied instead to the new, expanded program under the Board of Forestry. Members of the School of Forestry were still employed on but a part-time basis on research projects.

Then in 1953 the administration of the research program passed from the dean of the School of Forestry to a newly-created Forest Protection and Conservation Committee. The dean was retained as one of the five members of the Committee. Because Committee funds were basically derived from the timber harvest, any decline in the annual cut was reflected in reductions in the research program. To maintain its own staff, the Committee has had to cut off cooperative funds formerly used to employ research people, such as members of the staff of the School of Forestry.

Before the State Legislature at the moment, as part of the budget request of the Agricultural Experiment Station, are requests for a modest increase in forest research funds. These would be used (1) to develop information on basic problems vital to forestry, (2) to develop staff specialists who will become progressively better teachers through their research, and (3) to develop graduate students as competent forest scientists now so much in demand by industry and public agencies.

Recently T. J. Starker, mentioned above as one of the professors who, in 1927, initiated some research in the School of Forestry, but now one of the leaders in private industry, in his very effective way, poured a bit of salt on this research sore of which we have become very conscious. Very properly, he pointed out that the proportion of research funds made available for forest research—in comparison with agriculture—is a mere pittance, whereas the income from Oregon forestry is twice as great as from agriculture. One needs merely to scan the dates that were given above to see that recognition of the necessity for research on forest problems is some 30 or 40 years behind agricultural research in Oregon. This is a most peculiar situation for the leading forestry state in the nation to be in. If nothing more comes out of this centennial inventory of forestry than a wide appreciation of this fact, the present conference will be a success.

Now from that dull picture, let us turn to what our opportunities are. They are very bright.

Here in Corvallis there has developed an appropriate center for the study of forest problems. First I should list one of the very best Schools of Forestry in the country with a firm and honored background in the teaching and promotion of forest-management principles. As indicated above, its forte in the past has been teaching and the preparation of young foresters of high morale and excellent discipline. The School of Forestry is the nucleus of the center for it has long produced and attracted the manpower essential to the whole enterprise.

Next I would name the Oregon Forest Research Center (Forest Products Division and Forest Lands Division) excellently quartered adjacent to the campus on land sold to the State Board of Forestry by Oregon State College. It is the outgrowth and enlargement of an arrangement entered into some 10 years ago under which the college constructed an "industrial-research building" and provided more than half of it to the Board of Forestry for its Forest Products Laboratory. This building was the first structure erected on the campus following World War II. The Board of Forestry research outgrew these quarters and the significant result was the erection of its "Center" on Philomath Highway.

We hope a third leg on this triumvirate of agencies will be an extensive laboratory of the U. S. Forest Service. Such a laboratory, devoted to a wide variety of basic investigations, would be of tremendous importance to the state and to the region. We have a place for it contiguous to the site which has been chosen for the college's new forestry building.

I need not recite the advantages of associating various agencies of teaching and research, except to say that ideas are generated usually not by isolation but by day to day contacts between teachers, researchers, and students. Manpower in scientific research is the great problem of our day and for forestry this is the way to produce it.

Also very pertinent to the Center is the Agricultural Experiment Station through whose forest research division the School of Forestry carries on its own research program. Emphasis is being placed on insects and diseases; tree seeds; physiological studies to explain germination and to develop reliable methods of testing; sampling procedures for quality control; forest soils, including soil-vegetation relationships; soil characteristics as related to site quality; genetics, including racial variations within Douglas-fir and ponderosa pine; and variable characteristics for the improvement of seed stock. Other research has to do with a wide variety of forest-management problems carried out in cooperation with the Forest Service and the Lands Division of the Oregon Forest Research Center.

The union of our endeavors in agriculture and forestry brings into full play the extensive facilities of our School of Science, and in addition tends to suppress personal empire building.

Located also on the campus or in the city are other ancillary factors of importance to the growth of this center for the study of forestry. Among them I would name the seed laboratory, the Evans Products Corporation, the Mater Machine Works, the OSC Engineering Experiment Station, and such engineering consulting firms as Cornell, Howland, Hayes, and Merryfield.

Corvallis and Oregon State College provide an excellent environment for forest research. It is easy to overlook some very helpful contributors to this situation, and we know that still others will seek location here in the future. I should also note the further collaboration of the U. S. Forest Service through the establishment of the Willamette Research Center. Another is the U. S. Public Health Service which is using the McDonald Forest watershed as a laboratory to conduct pollution research. In other words, we have an excellent climate of cooperation prevailing between forest scientists and scientists representing very diverse fields, but still having impact on all the many complicated situations arising in the social-economic environment in which forests are grown, and of which, in this state, they play such an important part.

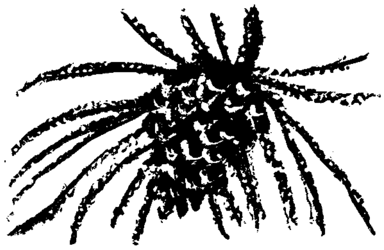
And we have dreams to which I have not alluded. Refinements in scientific research know no end and some of them are very costly. When research consisted mostly of observation and simple experiments laid out to detect cause and effect, they could be done with little or no outlay of money. But things have progressed far beyond that stage. I'd like to cite an example from agriculture. Here in Oregon we are proud of our strawberries which have a superior flavor. What we need most to protect and develop the great freezing industry built up around them is to produce more of them to the acre and at less cost. We were making progress in that direction, but still we did not know just why we have an advantage in the important matter of flavor until a year ago when we invited to the campus Dr. F. W. Went of the California Institute of Technology. That is a great institution in Pasadena for scientific research. They have there, as a result of Dr. Went's efforts, what is known as a phytotron. This is a large building where every last factor affecting the growth of plants (or animals too for that matter)—temperature, light, humidity, moisture, nutrition, parasites, gaseous composition of the atmosphere, etc.—can be absolutely controlled. This is not a simple thing to accomplish and requires great ingenuity along with all the niceties which engineers and other scientists have been able to devise in the way of regulatory apparatus. Cal Tech has no connection whatever with agricultural research, yet Dr. Went was able to tell us here in Oregon the real reason why our strawberries are superior in flavor to the same varieties grown in California. It's just a matter of three-or-four-degrees lower temperature during the morning hours, which develop additional sugars found in the berries.

Our dreams included a phytotron long before Dr. Went was invited here. We have been aware that learning about the interaction of certain factors in the development of organisms, whether they be minute parasites, plants, or forest seeds, requires controlled conditions far beyond anything we are able to produce with our facilities. Accordingly, we know this institution cannot long forego the addition of a phytotron to the campus. It will be of inestimable value to all of our biological investigation. It would add a resource to the Center I have been talking about that would pay great dividends in the future. We hope to have one.

Finally, let me say again that our opportunities are great to build here, on top of the valuable start which has already been made, a great Center for Forest Research commensurate with the importance of Forestry to Oregon and the Pacific Northwest.

I told you in my informal remarks at the start about the kindly pioneer woman who offered to improve my speeches by furnishing me with appropriate quotations from Shakespeare, Wordsworth, and other poets, which accounts for the quotes at the start of this paper. Allow me to add another which I hope is appropriate to my remarks and to the artistic background in front of which I stand. It was known to the earliest settlers on the eastern shores of our country.

"The eastern nations sink, their glory ends
And empires rise where the sun descends."



Biological Research in Years Ahead

Remarks of Moderator, George S. Allen
Dean of the Faculty of Forestry,
University of British Columbia,
Vancouver, Canada.

Our panel is going to take a long look ahead into the future of biological research. The five panel members have put on their forecasting bifocals with the knowledge that the short-range picture will come into fairly sharp focus whereas the long-range images will be pretty fuzzy. Being experts, however, they will interpret for the rest of us who have neither the eyes nor the ability to do it for ourselves.

First of all I would like to do a little backward looking into the past 100 years of progress in the broad field of biology and bring to mind some of the important milestones. A great deal has been accomplished during this time. Perhaps these remarks will help to put the panel's forecasts into better perspective.

Exactly 100 years ago, coincidental with the entry of the State of Oregon into the Union, Charles Darwin published his revolutionary "Origin of Species." That same year occurred the death of the first ecologist of modern times, Alexander von Humboldt. The year before had seen the death of the plant geographer Robert Brown and two years previously Schimper was born, the man who pioneered the field which was to become known as "physiological plant geography," the beginning of modern ecology.

About this same time the sciences of pathology and bacteriology had been conceived and were being nursed along by their father-mother, Ferdinand Cohn of Breslau.

It is worthwhile recalling that only 120 years ago the cell was first recognized for what it is—the essential unit of living organisms and apparently leading a double life as an individual and as an integral part of the whole organism.

During the second half of the last century tremendous strides were taken in all of the sciences and, out of the great mass of biological observations and data were distilled three useful generalizations: Virchow's "every cell from a cell;" Siebold's "every living thing from an egg;" and Pasteur's "every living thing from a living thing." Descriptive biology had come a long way in a short time. Samuel Butler took a unique view declaring: "a hen is only an egg's way of producing another egg."

It was not until 1875 that Edouard Strasburger discovered that cells divide in a manner other than by budding. He and Flemming, the pioneer cytologist, contributed such terms as "cytoplasm," "prophase," "metaphase," "anaphase," "mitosis," and "chromatin," considerably less than 100 years ago. Another step was Sach's discovery of the vital nature of chloroplasts and the role played by stomata in photosynthesis.

One hundred years ago, Jean Baptiste Boussingault proved that plants absorb nitrogen from the soil and need no organic matter as such; hence, that they get their carbon from the air. Also 100 years ago Thomas Graham began the first studies in the new field of colloidal chemistry.

Even a thumbnail sketch cannot neglect to mention Emil Fischer's work in protein chemistry; Sach's on plant respiration; Pasteur's breakdown of the spontaneous generation theory; Hofmeister's monumental work on the embryology of flowering plants and the alternation of generations which set the stage for modern taxonomy and a more adequate concept of evolution; Ouetelet's theory of probability and Francis Galton and Karl Pearson's invention of statistical method.

Galton, one of the fathers of biometry, went so far as to draw up statistical tables of mutual ill-temper in married couples; also the distribution of female beauty in Great Britain. He actually attempted to estimate statistically the efficacy of prayer. And yet, because Pearson and Galton dealt with masses of data, they missed the significance of the Mendelian phenomena even as they experimented with inheritance in peas and with eye color in humans.

Neither can we forget Mendel, the father of modern genetics, who published his classical works in 1866 and 1869. Unfortunately Darwin did not hear of them and Negeli, who did, chose to ignore them. It was left for de Vries to rediscover them in 1900 and go on to develop his mutation theory.

As far back as 1894 Driesch suggested that hereditary factors may act as enzymes, a remarkable forerunner of today's viewpoint that relates inheritance to physiology and biochemistry.

Weismann was the one who actually fastened on chromosomes the responsibility for carrying the hereditary elements; his "id" theory foreshadowed that of the gene developed in 1926 by T. H. Morgan and others. As you know, in certain parts of the world the names of Mendel, Weismann, and Morgan are grouped and their contribution is called the "Mendelian-Morganistic-Weismanian reactionary genetics;" at least the three great names are linked together, if in an uncomplimentary way.

Another famous name in biology is that of *Drosophila melanogaster,* the lowly fruit fly, discovered in 1906 by W. E. Castle which, in the hands of T. H. Morgan, C. B. Bridges, H. J. Muller, and A. H. Sturtevant, led to the gene theory, believed by many to be the most important development since Darwin's "Origin."

Reduction division of cells was discovered in 1887; now, 70 years later, the chemical nature of the substance of heredity is being explored; the dual nature of the virus particle with its protein and nucleic acid is bringing us closer to a knowledge of the basic nature of life itself.

During the past 20 years many new tools have accelerated progress: the electron microscope in 1938, the phase microscope in 1934, and more recently, radioactive tracers and their attendant instruments and techniques. Exciting advances have been made in enzyme and protein chemistry, and the vital role of mitochondria in the chemistry and physiology of the cell is becoming recognized and better understood. As a result of Beadle's and Tatum's work on biochemical genetics and their use of made-to-order mutants that lack the ability to produce required substances, knowledge regarding the synthesis of amino acids and other complex compounds is increasing rapidly. Even the centers of enzyme activity in the cell are becoming located specifically and life processes are being translated into terms of physics and chemistry. And yet it is only 60 years since Buchner settled the old Liebig-Pasteur dispute regarding the nature of enzyme activity. Today the gap between biochemistry and heredity is being bridged; almost certainly the two are related through the enzymes and their relatives.

And now, having swallowed a somewhat undigestible capsule of concentrated history, I am going to call upon our prognosticators to tell us what they see ahead for biological research.

Trees for the Future

LEO A. ISAAC
U. S. Forest Service (retired), Portland.

IN THE PAST CENTURY, our state of Oregon has offered to the world a great volume of the finest forest products ever grown. Today, Oregon is the leading lumber-producing state in the Union. In the next century she may well retain that leadership, because much of the land is chiefly valuable for forest purposes, but if we are to maintain this lead private and public agencies alike will have to cooperate in planting more and better trees.

Throughout the world, and especially in the United States, the area of virgin forest is dwindling and in settled countries will soon disappear. When original forests are gone, timber will be raised as a long-time crop, and the growth rate and quality of trees will be as important as quantity or number of trees, if not more so.

Up to the present time forest trees throughout most of the world have been used in the natural wild state in which they grew, but there is no logical reason why they should not be improved when grown as a crop just as fruit trees, grain crops, vegetables, and other growing things have been improved under management. There is also a financial reason for tree improvement. Improved planting stock may greatly increase the net profit from a plantation, while poor stock is likely to result in a financial loss or failure; yet it costs as much to produce a poor forest as it does to produce a good one.

Forest tree improvement is underway in many parts of the country but forest trees are a long-time crop and cannot be improved overnight. Once a superior coniferous tree is developed, it takes 15 to 20 years to produce and to contribute to the growth of a better forest. Therefore, the job ahead is twofold in nature: (1) we must find and develop the best possible seed sources for immediate use during the next 15 to 20 years, and (2) we must start now to develop superior trees for future use through all forms of selection and cross-breeding. As time passes and new and better trees are developed they will provide the planting stock for the forests of the future. In Oregon the big seeding and planting job underway must be continued if our state is to retain its leadership in forestry. Our forest lands must be kept productive.

Better Trees for Immediate Use

The first and most urgent problem is to provide better seed or better planting stock for the reforestation job immediately confronting us. Since a superior tree cannot be developed overnight, our only recourse is to learn how to select the best strains and best individual trees in our natural stands, and then to improve them for seed production.

The order of procedure in developing a natural seed source for immediate use should be something like this: The forester should first decide which species will do well in the locality, and will answer the purpose for which it is being planted. You would not want to plant oak for pulpwood, or poplar for flooring. Once the species is decided upon the second thing to look for is a climatic strain that is suitable to the proposed planting area.

Tests of both ponderosa pine and Douglas-fir in this region and tests of loblolly pine in Louisiana and tests elsewhere have demonstrated that seed from a matching climatic belt produces a good forest while seed from a different climate is likely to result in a poor forest or a complete failure.

Once the right species and a suitable climatic strain is selected the more detailed groundwork of selecting superior trees and superior strains for seed collection purposes is ready.

That superior strains and superior trees exist in our natural stands is a well known fact; there are also strains and individual trees which are definitely inferior. Just how they developed in the natural succession is not yet well understood but for the moment this is not important.

Here in the Northwest there is no precise yardstick by which to select the superior tree or stand, except that the trees and stands must be measurably superior to their neighbors—something better than one would expect in a given locality. The qualities to look for first are the external or visible characteristics of growth rate, form, and branch arrangement. The next step is to determine wood quality from increment cores.

A high quality young or a mature stand may be selected for seed collection. Both stands in their natural condition will produce good seed for reforestation. But if the natural stand is to be improved for seed collection it should be young, preferably near the beginning age of seed production, and large enough to permit an estimate of growth rate, form, branching habit, and wood quality. The first step is to cut out the slow growing, poorly formed, and diseased trees (bad pollen parents). The thinning plus the mulch of the finer branches and the application of fertilizers should stimulate cone production.

How much tree or forest improvement may be expected from such seed source development? The answer is difficult to give in dollars and cents or board feet per acre. However, it is safe to say that you may expect a better forest than the original stand, or better than would develop from unaided natural regeneration. It would no doubt be comparable to the gain expected by a cattleman who purchased a good strain of stock, then proceeded to take out the poor bulls and the poorest of the cows.

Throughout Europe there are countless examples of excellent tree seed sources that have been developed (often unintentionally) through the continuous removal of poor stems for many tree generations in the ordinary process of thinning. In a somewhat similar but inverse manner practically worthless forests have been developed by cutting out the best stems for several tree generations and allowing the scrubs to reproduce the stand. This is particularly true of European beech.

Another outstanding example of the value of selection, or rather the loss resulting from the lack of proper selection, exists in the *Pinus brutia* forests of south and east Turkey. For perhaps 2,000 years the best stems have been cut from the forest on a tree selection basis, and the scrubs left to restock the stand, until today a vast area is covered with crooked, poorly-formed, slow-growing, scrubby trees. Here and there in remote areas beyond the reach of existing transportation facilities there are naturally reproduced remnants of the original forest with tall, well-formed trees making reasonably fast growth. These are now being reserved by the Turkish government as seed collection areas.

At any rate the above examples illustrate the need and value of selected and improved seed collection areas for immediate use, to bridge the gap between now and the time when still better trees will be developed through selection and forest tree breeding.

Genetics in Tree Improvement

Tree breeding is the more technical and time consuming method of tree improvement but it also promises the greatest rewards. Because of the time required it should be carried on simultaneously with the selection and use of natural seed collection areas mentioned in the previous paragraphs.

The aim of the forest geneticist is to capture and develop in a single stem the superior qualities of two parent trees. This he seeks to accomplish by artificial cross pollination of superior specimens of different strains and different species and by natural cross pollination of superior trees in seed orchards.

The logical starting point for both artificial and natural cross pollination is to locate the superior or "plus" individual trees in our natural stands. The superior tree may be superior in one or more of the desired characteristics. From these trees are taken pollen for artificial pollination and cuttings for the grafted stock of seed orchards. "Plus" tree registers have been set up and a superior tree can now be registered in the same manner as a purebred animal.

The Tree Seed Orchard

While artificial cross pollination offers great promise, tree improvement by the natural cross pollination of superior individuals that takes place in seed orchards is most frequently recommended by forest geneticists and forest owners at the present time. This is probably true because, next to the improved natural seed area, it offers the quickest and most certain improvement and can be developed on a large scale.

The conventional method of establishing a seed orchard is to take cuttings from a dozen or more superior (or "plus") trees in a given locality. The cuttings are grafted on to sturdy seedlings two or more years old, and when the graft is well enough established the stock is outplanted in a seed orchard. Sometimes the seedlings are outplanted first and the cuttings grafted onto them after they are established in the seed orchard; in other instances cuttings from superior trees are grafted to the trees in an established plantation. In any event the seed orchard must be isolated and reasonably free from outside sources of pollen.

The selection of plus trees varies with species and purpose. In addition to the standard characteristics of growth rate, form, branch habit, and wood quality, they may also be selected for resistance to drought, insects, and disease. Instructions for the selection of "plus" trees for this region have been prepared by John Duffield, by the author, and others, and are available upon request. Once established, a seed orchard can be stimulated to earlier and more prolific seed production by cultivation, thinning, and fertilization; some additional stimulants are still in the experimental stage. Once the seed bearing age is reached, the seed orchard should produce seed, not only from the best strains in a locality, but from the very finest individual trees in the best strains. The next step is to progeny-test seedling stock from the selected trees to determine if they are genetically superior or if their superiority in the stand was the result of some unknown factor in early life. In other words, will the seedlings be as good as the parent tree? Once a tree has been progeny-tested and found genetically good it becomes a certified (or "elite") tree and can be used indefinitely for propagation purposes. On the other hand, if a tree is found not to be good genetically all trees grown from that clone can be eliminated from the seed orchard.

Cross Breeding in Forest Tree Improvement

The forest geneticist may make considerable progress by selection alone, but the greatest and most permanent gain will probably be made by cross breeding, either by hand pollination or by natural cross pollination. Seldom, if ever, would a "plus" tree be found in natural stands that was superior in all of the most desirable tree characteristics. One tree may be outstanding in growth rate and form, another average in growth and form but outstanding in wood quality. The geneticist then crosses the fast-growing tree with the tree of superior wood quality, hoping that a limited number of the progeny will develop the good qualities of both parent trees. These in turn will be recrossed until the gain becomes a fixed characteristic. The tree may then be crossed with a more disease-resistant tree to develop a strain that is not only disease resistant but is superior in growth rate, form, and wood quality as well. So the forest geneticist moves on, his work more time consuming and technical, his results less certain, but his promise of ultimate gain greater than in other forms of tree improvement.

Because of the long-time nature of tree improvement by seed orchards and cross breeding it has been recommended that both be carried on simultaneously with the selection and improvement of seed collection areas in natural stands. Natural stands will provide better seed for the immediate future and as time passes the genetics program should provide still greater improvement for the trees of the future.

Improving Trees for the Future

Fortunately, a great deal is being done to provide better trees for the future, not only here in Oregon but throughout the country.

The Forest Genetics Research Foundation made a survey and issued a report in November 1958, reporting 22 agencies doing forest genetics research, carrying a total of 156 research projects in the western United

States and Canada. Federal and state government agencies, schools, colleges, universities, lumber companies and associations, are taking part in the program. Scientists in the different organizations are working on all phases of the tree improvement program.

The Western Forest Genetics Association is an organization of forest genetics workers from all agencies. They hold a general meeting once each year to exchange ideas and discuss problems, and hold subsection meetings at more frequent intervals. Each year the Oregon or Washington forestry schools have sponsored a forest genetics short course for the benefit of those interested in forest tree improvement.

Some recent accomplishments: blister rust-resistant white pine have been discovered and developed in seed orchards; ponderosa pine growth rate, form, and resistance to animals and disease have been found to be hereditary characteristics. Douglas-fir has been found to grow better than 150 other conifers tested. There are many other findings of less significance.

With all agencies working together toward tree improvement it is my feeling that Oregon can celebrate her 100th anniversary with the firm conviction that, as her remaining virgin forests are gradually cut, they can be replaced promptly by younger and better trees for the forests of the future.

We must not be lulled into false complacency by this favorable start. Forests are vital to the prosperity of this State. Everyone concerned must continue to work for more and better trees if Oregon is to retain her leadership in the field of forestry during her second hundred years of statehood.

Forest Insect Research in Years Ahead

PHILIP C. JOHNSON
Entomologist, Intermountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Missoula, Montana.

FOREST ENTOMOLOGY is a distinct branch of economic entomology and is scarcely more than 50 years old in the United States. Knowledge afforded by this branch of biological science has become so increasingly important to foresters that today it is a well established part of professional forestry practice. Insects are generally recognized as a major cause of tree mortality, reduced growth, stem deformity, and seed destruction. Successful management of forests in certain localities, in fact, depends primarily upon achievement and maintenance of adequate control of specific forest insect pests. We are all too familiar with the frustrations brought about by persistent forest insect problems.

The destructive impact of insects upon the forest resource is not new. True, man's increasingly intensive use of some forests has accelerated insect depredations so that they are greater today than they used to be. However, awareness of this impact is fairly recent in the minds of the general public and even of some foresters. Constant publicizing of forest insect damage over the years is finally paying off, as have similar efforts directed toward forest fire prevention and control. Certain persistent forms of insect damage in extensive virgin forests of the West are now more readily apparent and thus are cause for greater alarm as these once-vast forests diminish in area through steadfast harvesting. Conversion of old-growth forests to plantations and natural stands of reproduction and second-growth have posed a whole new set of insect problems to the forester.

This awareness of the importance of forest insect pests has resulted in unprecedented demand by foresters and timberland owners everywhere for aggressive programs of insect control. The key to successful control is research. Unfortunately, ability to control many major forest insect pests is being delayed pending establishment or completion of vital studies. Only by research can we hope to solve the complex problems leading to satisfactory prevention and control of economically important forest insect pests.

Past Research

Before discussing the future of forest insect research, I shall briefly review the scope and significance of some past insect investigations in the United States.

First provision for organized research in forest entomology was made in May, 1902 by establishment of the Office of Forest Insect Investigations in the U. S. Department of Agriculture. The Department has maintained a dominant position in entomological research ever since. Present investigations are centered in the Division of Forest Insect Research as part of the overall research program of the Forest Service. In recent years, however, the Department's research effort has been augmented by that from a growing number of colleges, universities, state governments, and of forest products, chemical, and allied industries.

Forest insect research in Oregon has always been an important part of the overall national effort. Dr.

W. J. Chamberlin of Oregon State College—"Joe" to many of us—was a pioneer teacher and an ardent taxonomist in forest entomology. The Department of Agriculture has maintained forest insect laboratories at Ashland from 1913 to 1924 and at Portland from 1929 to the present. The Weyerhaeuser Timber Company has cooperated with the Department in investigative work as far back as the 1920's in the Klamath Basin. The State of Oregon began forest insect research in April 1948, first by the Oregon State Board of Forestry at Salem and, since 1957, by the Oregon Forest Lands Research Center in Corvallis. Further research was done at Corvallis by the Oregon State College Forest Experiment Station from 1954 to 1957, since then by the Forest Research Division of the Oregon Agricultural Experiment Station under the aggressive leadership of Dr. Julius A. Rudinsky.

Contributions of forest insect research in the United States during this pioneering period might be divided into the following five categories:

1. **Insect taxonomy**—the phylogeny, classification, nomenclature, and identification of forest insects.
2. **Biology**—the morphology, life history, mode of injury, and the environment of economically important insect pests of forest trees and wood products; also those of many beneficial insect parasites and predators that normally aid in holding the pests in check.
3. **Epidemiology**—the term taken from medical terminology by entomologists to describe study of the occurrence, frequency, and duration of epidemic infestations of specific insect pests and of the associated biological and ecological factors.
4. **Surveys**—detection and appraisal of individual pest outbreaks by observational or systematic methods from the air or on the ground.
5. **Applied, or direct control**—suppression of epidemic infestations by application of various mechanical, chemical, or biotic treatments; also indirect control, or prevention of outbreak by the use of silvicultural practices.

Summarizing the significant research contributions of past years, we know the identity of several thousand insects that inhabit American forests; we know those that cause, or have the potential to cause, serious economic damage and those that are beneficial to man's purposes; we know the life histories and habits of the more important of these insects; we know something of the natural factors that "trigger" epidemic infestations and that sustain or curtail them; we know how to determine by surveys whether infestations of certain species need to be controlled; and, finally, we know what treatments can be applied to control infestations of a comparatively large number of forest insect pests.

This does not mean that most of the insect problems have been solved; but applied research has brought us to the point where basic research on a broad front is urgent.

Past research contributions were made under programming that resulted in many empirical studies. These were undertaken by forest entomologists—technicians trained in general aspects of forestry and entomology—who had only a minimum of assistance from specialists in these and allied sciences. Many studies were devoted to the task of finding what insects lived in the forest and which of these required describing and naming. Laboratory facilities usually were simple, often only the forests themselves, the natural environment of the insects under study. Environmental controls and instrumentation, when employed, were often elementary, but decreasingly so in recent years. Past forest insect research represents a transition from the keen observations of the naturalist to the precise experimenting of the highly skilled specialist.

I would be remiss if I were to close the subject of past research in forest entomology in America without mention of the excellent contributions made by Canadian forest entomologists. Many forest insect problems in the United States also occur in neighboring Canadian provinces. Research by our Canadian colleagues has been of an exceedingly high quality. The willingness of these technicians and the agencies they represent to exchange research information has been valuable in solving important forest insect problems on this side of the International Boundary.

Future Research

Forest entomologists best realize the need for continuing research effort in forest insects. Others concerned include foresters, timberland owners or managers, forest pest action committees, and the forest products industry. The Forest Research Advisory Committee, lay adviser to the U. S. Department of Agriculture, also recognized this need. In its October 1958 meeting in Asheville, North Carolina, and Valdosta, Georgia, it advised that research on epidemic insect infestations capable of lowering or destroying forest productivity merited high priority by the Department.

The general public probably will support increased forest insect research as it becomes better informed through the dissemination of information dealing with the severity of forest insect problems. The Forest Service's recent Timber Resource Review performs a distinct service in this direction. The Review presents for the first time comprehensive statistics showing the full impact of tree mortality and growth loss caused by insect pests in American forests.

We should not assume that either the volume or nature of past investigations has lessened the need for research, or that opportunities for additional study have diminished. New tools have opened up new approaches to research. Some perennial problems are yet unsolved even while new ones demand attention. This situation probably will always exist, because solving some problems of the moment often directs attention to new avenues of study or to other problems of equal or greater importance.

Future research programs in forest entomology may include continuation of present investigations with little or no modification, the pursuit of leads derived from past endeavors, and the starting of entirely new kinds of investigations. Thus, future research in forest entomology might well:

1. Expand in volume.
2. Increase in complexity, requiring greater effort in studies of a more fundamental nature.
3. Require a corresponding increase in applied research effort to translate findings of fundamental research into practical use.
4. Employ the coordinated effort of scientific teams composed of technicians skilled in the physical and other biological sciences as well as those in forest entomology.
5. Use more and better-equipped facilities, perhaps with a separation of those for basic and applied studies.
6. Rely upon closer cooperation between the public, privately endowed agencies, and educational institutions engaged in research.
7. Strive for greater effectiveness of applied control programs by a greater use of insect biological and ecological information.
8. Improve its public relations to better acquaint the general public, as well as foresters and other direct beneficiaries, with the progress being made in the research itself and how it can be used to stop insect-caused damage to forests.

The continuing objective of forest insect research is to gain the knowledge needed to prevent, or efficiently control, outbreaks of insects that cause intolerable damage to forest resources. Outbreak prevention or control must rely more than ever on the biology of the insects involved. Research entomologists and their collaborators must make this possible.

We might consider a hypothetical insect problem that is certain to arise in the years ahead and see what research is expected to do. The problem may start with a report of some strange symptoms of tree damage that have been ultimately determined by an entomologist to be caused by a little-known species of insect. This determination might also include the insect's identity, whether it is native or introduced, feeding or other habits of the insect that cause specific damage to the host tree, and infestations that may appear periodically to cause damage that the resource manager says cannot be tolerated. Perhaps nothing more is known about this particular insect. The resource manager might claim that he must be able to control epidemic outbreaks when they occur by methods at his disposal and at a cost commensurate with the forest values at stake. The manager expects research to provide a control method he can use. Eventually he might be given a method, complete with instructions and a guarantee of success. When this happens, the method will be the product of a great many technicians working on numerous study phases.

Let us look briefly at the chain of investigations and at some of the scientists who will be involved in developing this control method. First, insect biologists may conclude from studies of natural control factors that populations of the pest insect in question may occasionally rise to epidemic, tree-damaging levels. Entomologists and research foresters may collaborate in finding that these occasional epidemic population buildups cannot be prevented by cultural manipulations of the timber stand, such as regulation of stand composition, age classes, density, individual tree vigor, or site improvement. The only hope of controlling the pest, then, appears to be by the occasional application of an insecticide. The entomologists may select a chemical insecticide for testing because of the wide range of materials of proved toxic value. For the sake of discussion let us assume that the insecticide is to be dispersed from aircraft.

The selected chemical's insecticidal properties probably were determined by industrial research technicians. Exhaustive tests by insect biologists, the medical profession, and public health officials will necessarily precede establishment of its toxicity rating, commonly referred to as the median lethal dosage, or LD_{50}, and of its mandatory tolerance rating given by the Food and Drug Administration. Further testing by fish and game biologists will indicate the dosage level that will prevent excessive mortality or sickness to fish, birds, and mammals. Plant physiologists will join in studies to learn whether the chemical has any phytotoxic, or plant damaging, effects. Insect toxicologists will prove the mode of action of the toxic element in the insecticide, and show exactly what effects will occur to specific insect tissues and organs or to the insect's metabolism. They may show, in some instances, that these effects might occur only in this specific insect and not in other species of insects, including beneficial parasitic and predaceous forms. All of these things would indicate that the insecticide might be a good one for forest use, because it would kill the pest insect without harming beneficial insects, vegetation, drinking water, game fish, birds, or mammals, including man.

The toxicologist might then determine a recommended dosage. Chemists and entomologists must work together to recommend an economical but effective formulation for the insecticide. Mechanical engineers and physicists will team up to design equipment to obtain the required droplet size and swath pattern and to deliver the recommended dosage per acre from various aircraft designs. Meteorologists will determine the atmospheric conditions needed to assure that the insecticide will reach the target trees in the desired amount and form. Methods will undoubtedly be developed to provide means of quickly measuring these conditions in each air stratum between the spray planes and the forest canopy.

Timing and location of the application will have to be established by insect biologists who will determine what part of the insect's metamorphosis is most vulnerable to the poison and where the insect will be at that time. Field tests by economic entomologists will finally show what percentage of mortality could be assured by normal application.

The method of control apparently is now available and ready to use. It should not be used, however, until certain infestation conditions have been reached. Research again will determine this by providing means of obtaining adequate biological evaluations of specific outbreaks. These evaluations will show the degree of damage caused by the current insect population, the amount of increase or decrease in the population expected during the next generation, and the current status of the infestation with respect to its full anticipated cycle. This information will be helpful in deciding whether the insecticide treatment need be applied, when it should be applied, or when application should be stopped if it is already underway.

This, in brief, is the cycle of events leading to development of a method for controlling a forest insect pest. Keep in mind that this same cycle must be conducted for each of the many forest insect species we may someday have to control. This indicates the magnitude and nature of much of the forest insect research that lies ahead.

The chain of research I have just outlined points to the need for a forest research community where most of the needed specialists and facilities would be available for immediate concerted action. A start toward such a community has been made here at Oregon State College.

Considerable research applicable to forest insect problems necessarily will be undertaken in laboratories and by technicians not primarily concerned with forest insect problems. Among them will be the facilities and staffs of many governmental, industrial, and educational institution laboratories working on insect pests of fruits, vegetables, field crops, man and animals, and on insect identification, pesticide development, and parasite introduction. Forest entomologists will continue to draw upon the results of experimenting by these outside laboratories. At the same time, however, they must start substantial research directly relating to forest insect problems.

I have already mentioned that future experimenting in forest entomology will need to emphasize fundamental studies. How this will be done may be indicated from plans being considered by the Department of Agriculture. Forest insect research is now conducted at each of the nine forest experiment stations and the Alaska Research Center of the Forest Service. The stations will probably also shift to more fundamental problems in the future while maintaining a place for those that show promise of early application.

Besides these programs, the Department is considering the need for several biology laboratories for basic studies of forest insects and diseases. These new laboratories would be equipped and staffed to conduct technical investigations beyond the present capabilities of the forest experiment stations. Probable subjects of investigation should include the anatomy, physiology, and metamorphosis of specific forest insects. The complexities of insect behavior and population dynamics would also be likely fields of study, as would toxicology, the study of the chemistry of insecticides, their uses and modes of action. The basic biology laboratories certainly should have facilities to study the response of various forest insects to the exposure of controlled environments or of certain subjected treatments, such as those by radioactive substances.

Such laboratories will have to be staffed by technicians highly skilled in the physical and biological sciences, including entomologists with specially developed proficiencies.

Similar basic studies undoubtedly may be made by other public agencies, research foundations, private industry, and educational institutions interested in forest insects. The coordination of studies exhibited by similar laboratories already in operation probably will continue and will be a major feature of future entomological investigations.

Such a research program will create a pressing need for research technicians representing several scientific disciplines. Probably this need can be met by the present curriculums of many of our colleges and universities. The need for forest entomologists will be greater than it is now. Encouragement can be gained from the prospects of increased employment opportunities for students who hope to be forest entomologists.

A few employment opportunities may always exist in the basic research laboratories, but the great majority probably will be found in applied research laboratories similar to those operated by the Forest Service experiment stations. The experiment station program in detecting and evaluating the seriousness of forest insect infestations will become more complex, but more significant, as it absorbs more of the products of biological research. The need for technicians trained to make these insect surveys seems certain to increase, for such surveys are prerequisite to the more intensive forest protection practices now being undertaken in this country.

As research results multiply the possibilities for controlling insect outbreaks, forest resource managing agencies are almost certain to take advantage of them. To do the job right, these agencies will probably add more forest entomologists to their pest control staffs. Entomologists already employed have demonstrated their worth by helping to plan, train personnel, supervise, inspect, and assess the technical aspects of many large insect control projects. Staff entomologists should be even more helpful to management agencies in the future by reviewing the pertinent findings of forest insect research and converting them into more effective insect control practices.

Up to this point the discussion of future forest insect research has been largely the viewpoint of the entomologist. He can devise necessary experiments to solve specific problems, and he can even suggest some of the problems. But the entomologist is not in a position to suggest many of the problems, or to say which is most important or how much overall research is needed. The forester will have to decide these things, for he is one who needs and can use the products of this effort.

How much research is done, and what kind, will depend largely on how important the forester considers the job of insect control is, how convinced his employer is of its importance—whether that employer be the taxpayers or a corporation—and how energetically the employer and his forester set out to do the job. Forest insect research will ride only a short way on the coattails of the push given to scientific research in general by Sputnik. The real push will come from demands by public and industrial forestry agencies for more and better ways of controlling insect outbreaks.

I think these demands will be made, and made with increasing urgency. Others have shown, or will show, what pressures will be upon the Nation's foresters to maintain maximum forest productivity in the years to come. Entomologists, too, appreciate the importance of such compelling factors as population trends, timber growth rates and yields, per capita wood consumption, forest ownership, and sustained yield. I am sure you will find entomologists sympathetic to the foresters' problems and eager to work side by side with foresters to overcome them.

Forest Disease Research in Foreseeable Future

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The purpose of this paper is to discuss a few of the many important problems in forest pathology that I feel will require attention in the foreseeable future. Frequent reference will be made to conditions in Canada. These conditions are broadly relevant to the forest disease situation in both the United States and Canada because of similarities in forest stand composition and climate.

The history of forest pathology in our countries shows that much of the activity in this field has been concerned with the very important decay problems of mature and overmature forests and with destructive diseases such as chestnut blight, white-pine blister rust, the Dutch elm disease, and birch dieback. Some attention has been given as well to noninfectious disorders, nursery and plantation diseases, dwarf mistletoes, cankers, and the deterioration of windthrown, fire-injured, and insect-killed timber.

A number of complex diseases have occurred in the past few years including pole blight of western white pine, birch dieback, needle blight of eastern white pine, sweetgum blight, and, more recently, sugar maple blight. These maladies have not been associated with specific pathogens and have proved most difficult to study. They have emphasized, however, how little we know about the ecology of trees and their biological flora. When a catastrophic dying occurs such as birch dieback in the New England States and the Maritime Provinces, research become necessary at every turn of the investigative road because many features such as rooting, water and temperature relations, and growth habits are unknown or require further understanding.

With the ever increasing awareness that a disease is a complex phenomenon, the demand for many specialists to cooperate on specific disease research becomes increasingly important. Birch dieback and pole-blight are excellent examples of diseases that may involve many specialists such as climatologists, tree physiologists, chemists, entomologists, pathologists, and silviculturists. In recognizing the advantages of cooperative "team" effort I would like to make a special plea for individual scholarship. I would urge that we place in proper perspective statements such as the following that you will find frequently in the current literature:

> "Only by co-ordinating and concentrating the skills of research scientists in the fields of silviculture, soils, genetics, and physiology will this goal be achieved."

Unquestionably the "team" approach will do much to advance certain knowledge, but in forest pathology as in other related sciences, it is important that we do not lose individual creative effort within this "team" environment. We greatly need the significant fundamental discoveries, achievements, and new ideas that will come from the individual who is given the latitude to exploit original efforts according to his intuition in an atmosphere reasonably free of conflicting responsibilities.

In forest pathology as in many other sciences, research begins invariably as the result of compulsion. Seldom do we seem to get ahead of the game and practical application of control may precede the acquisition of fundamental research information essential to successful control. Research according to need is unavoidable but would it not be refreshing to reverse this process whenever we can take advantage of the opportunity?

I do not wish to leave an impression that all basic research leads readily to control application or that empiricism is undesirable. On the contrary, empirical research will continue to make valuable contributions to successful control leaving basic research at times to explain why controls were effective. What I do imply, however, is that in many cases, the time and effort to achieve disease control might be markedly reduced if we knew more about the biology and physiology of the parasite and the host, and their interrelationships. For example, a lack of this basic information might well explain why "ad hoc" experimentation in western North America (3, 19) has failed to provide a chemical compound or compounds with all the essential characteristics to control dwarf mistletoe of lodgepole pine.

The most urgent need in forest pathology, therefore, is for a greatly broadened program of basic research on the ecology, biology, and physiology of disease pathogens and tree hosts and their interrelationships in the forest as a guide for disease control. New data of this nature are required and many gaps in our present knowledge need to be bridged for diseases such as oak wilt, Dutch elm disease, the beech-bark disease, various cankers including *Hypoxylon* canker, decay and root organisms, dwarf mistletoes, and many others.

To elaborate on this premise of the need for a greatly broadened program of research in forest pathology, I propose to expand this subject under the following headings: Forest Disease Survey; Damage Appraisal; Viruses; and Control of Forest Diseases.

Forest Disease Survey

Before we can begin to manage a forest we must have an accurate and comprehensive forest inventory. Similarly, before we can work effectively with forest disease control and forest planning we must have an appreciation of the identity and seriousness of these diseases and know how they are progressing from year to year.

While our knowledge of tree diseases on this continent has advanced considerably over the past few years, we need to improve our data on the identity, distribution, and severity of known diseases.

One answer to this need, which was started in Canada in 1952, is a permanent forest disease survey organization with a definite and continuing commitment of research officers and subprofessional personnel to this function. In the Canadian Federal Government forest biology rangers, operating under the Forest Insect and Disease Survey of the Forest Biology Division, have prescribed districts within a region for the sampling and appraisal of insects and diseases. The unique feature here is that the progress of diseases in all regions of Canada is methodically surveyed each year. At each of the regional laboratories across Canada, research officers direct a program of survey with the salient results published annually in the Forest Insect and Disease Survey Report. Periodic research contributions arising from the survey are published in various journals. The primary objectives of this continuing disease survey are to detect, identify, record, and interpret the significance of tree diseases in Canada.

I believe this survey structure is a sound approach to the need for a methodical and purposeful watch and appraisal of known diseases so necessary to control procedures, to prevent the establishment and spread of new diseases, and to provide a foundation for disease research program planning and development.

In the United States, the Forest Pest Control Act of 1947 provides for the detection, appraisal, and control of insects and diseases. It is apparent, however, that much greater attention is needed in this aspect of forest pathology (11, 12). Forest disease surveys of a continuing nature, therefore, require establishment and expansion to provide the data so necessary for effective forest management now and in the future.

Damage Appraisal

The precise appraisal of damage caused by various types of disease is one of the most neglected aspects of forest pathology. How can disease control proceed, presuming we have the required control perfected, unless we have an accurate idea of the seriousness of damage and can say that control is necessary, or when it should be effected? Stand values in relation to control costs must be weighed carefully to determine the feasibility and type of control warranted.

Some of the best information on the development and seriousness of diseases concerns decays of conifers and hardwoods. But even here, considerable fundamental research on decays is needed and work on the standardization of analysis by various research groups is necessary before such data are to become meaningful beyond local interest (7, 15). In the United States, Hepting's (10) appraisal of cull in Appalachian oaks is particularly commendable. Unfortunately, similar publications are rare.

Generally, we know very little of the best methods to assess the damage caused by dwarf mistletoes, foliage diseases, cankers, or root rots caused by *Poria weirii,* Murr., *Armillaria mellea,* (Vahlex Fr.) Quél. and *Fomes annosus* (Fr.) Cke.

Depending upon the disease to be evaluated, what sampling technique is most appropriate? Should it be a sequential scheme or a form of random sampling? And when this refinement is achieved what then? Will a 20% sample for dwarf mistletoe be sufficient to evaluate the disease situation for a particular area or would a 10% or smaller sample, with its savings in time and funds, accomplish the same results?

In Canada, a great deal of work is needed before we can answer these questions that are considered intrinsic parts of the forest disease survey program. At our Victoria Laboratory, studies have been started (8) to examine the relative merits and precision of various sampling methods for assessing diseases in Douglas-fir plantations.

Damage appraisals should not overlook the beneficial role of diseases in over-stocked stands. For example, mortality of yellow pine caused by rust canker (*Cronartium comandrae* Peck) has resulted in useful thinnings (13) and various disease organisms appear to perform salutary functions especially in dense stands of lodgepole pine (14).

Obviously, accurate appraisals of diseases in relation to crop potential are extremely important in forest management and information of this nature is scarce. Research is therefore required to develop the techniques of sampling most appropriate for specific types of diseases and to determine the minimum amount of such sampling that will give the precision necessary for meaningful assessment.

Viruses

The scarcity of studies concerning viruses of forest trees has been a noticeable gap in forest pathology. In Canada, preliminary work has suggested the occurence of viruses in birch (1). In 1958, systematic investigations in this field were begun at our Fredericton Laboratory with the assignment of two research officers specifically to study tree viruses and potential insect vectors, with the initial activity concerned with viruses on birch. In the United States, viruses are known to cause the phloem necrosis of elm (18), the brooming disease of black locust (9), and zonate canker of elm (17).

A greatly expanded interest is needed on this continent, however, for a methodical research program on viruses of forest trees. Until this is achieved to a degree where we have some idea of the role played by tree viruses in disease development in forest stands, the accuracy of our observations on complex diseases will remain questionable.

Control of Forest Diseases

Much has been said about the control of diseases through adjustment in forest management procedures, through direct control by applying chemicals, sanitation, and pruning, through the development of resistant hosts, and through biological control. The type of control will be influenced first by the nature of disease, whether it is infectious or noninfectious, and, if infectious, whether it is caused by a native disease organism or a virulent introduced pathogen that may require drastic direct control.

New vistas in direct control may develop through biological and technological advances that cannot be predicted. Who can foretell, for example, the miracles that may develop to affect forestry practices in the future as the result of research for new products in cellulose chemistry and other research endeavors? I believe, however, that the significance particularly of native forest diseases in the future can best be reduced to an acceptable level by adjusting forest management procedures according to the results of competent research. This adjustment of management procedure based on forest disease research has occurred frequently in the past. For example, many studies indicating the incidence and distribution of decay in mature and overmature forests have proved valuable for developing priority cutting schedules and for preparing accurate inventories essential to effective forest management. Investigations of decay have also been helpful in making possible the utilization of valuable timber inaccurately considered to be defective beyond economic salvage.

Beyond the nursery and special conditions involving high unit values, and the direct procedures necessary to combat virulent introduced pathogens, direct control will rarely be economically feasible or justified.

I mentioned in the "Introduction" that research is usually complementary to need and we seldom have the data essential to the timely design and application of control measures. Yet there is an opportunity here that we in the United States and Canada have largely failed to exploit to the benefit of forest practice in our countries, despite the previous expression of this idea (5).

This opportunity lies in the fact that many species of our forest trees have been planted abroad in several countries. Pathologists from this continent could be assigned to survey the diseases of these plantings and those of the exotic trees closely allied to our species. They could undertake research on virulent pathogens to give the information necessary to prevent or control new disease introductions. Further, critical examinations (surveys and ecology) of plantations in other countries might identify native pathogens that could prove troublesome under certain conditions in future plantations on our continent.

It is known also that we are moving from an era of forestry in mature and overmature forests to an era of managed second growth forests. In this conversion, growing seedlings and establishing plantations will increase with remarkable swiftness. We are already aware of some of the disease problems in nurseries, plantations, and second growth forests and that many of these problems have not been studied sufficiently to provide the research information essential to the formulation of operative controls. Of the many problems in second growth stands, the root rots such as *Poria weirii* of Douglas-fir are extremely important. Also noteworthy are various cankers and diebacks of conifers and hardwoods and complex diseases such as the pole blight of western white pine. In coniferous plantations *Fomes annosus, Armillaria mellea,* and other pathogens need intensive research to reduce their significance in future plantations.

A very useful compilation on the diseases of North American forest trees planted abroad was published recently by Spaulding (16). It would be helpful as well if appraisal listings of this nature were annotated to define influencing environmental conditions such as soil and climate; diseases occurring as the result of unfavorable environmental factors may not develop when these factors are not limiting. In forest nurseries, research is particularly needed in the fields of mycorrhizal symbiosis; on soil fertilization in relation to the development of mycorrhizae and damping-off pathogens; on soil management methods involving investigations of the soil properties; and on the effects of photoperiodism, moisture, and temperature. Further, an improved knowledge of the biology and etiology of the major damping-off fungi is needed.

Although the evidence to date is inconclusive there is some indication that biological control is a field of research deserving greater emphasis. In the Prairie Provinces, effective natural control of dwarf mistletoe of lodgepole and jack pines by fungus parasites has been reported (4) and the antagonism of *Trichoderma* to *Fomes annosus* and to other organisms in nursery soils and in forest products is intriguing. It is conceivable that intensive research in this field may reveal techniques of biological control useful under certain conditions for specific pathogens.

Tree breeding for resistance as a method of disease control is beset with many difficulties (6), chief of which is the long time required for this work. For example, breeding for chestnuts resistant to blight has been underway for 50 years and another 25 years of field testing may be necessary before resistant strains have been effectively evaluated. Even then, there is no assurance that the new hybrids will not be susceptible to other diseases. Meanwhile, chestnut has lost its place in the forest economy. Despite its limitations, however, tree breeding remains very important in the long range planning of disease control.

The history of aberrant results in breeding resistant hosts for Dutch elm disease, chestnut blight, and *Dothiciza* canker suggests that the development of suitable hosts that will resist diseases under all environmental conditions may be an unrealistic goal.

The Christine Buisman elm is disease resistant in Italy (although we do not fully understand the reasons for this resistance) but it is very prone to disease in the Netherlands. In northwestern Connecticut trees resistant to white-pine blister rust under dry soil conditions became susceptible to white-pine blister rust when planted in a new locality with normal soil moisture (6). In British Columbia the differential resistance to *Cytospora* canker (*Cytospora chrysosperma Fr.*) in three species of poplar has been correlated with differences in water economies as reflected by anatomical differences in the wood and bark tissues of the three hosts (2).

Concomitant with tree breeding, therefore, I believe there must be an intensification of fundamental research to find out why certain host strains or even the same strain is disease resistant in some locations and not in others. Some very useful information along these lines might also be gained by studying the basic mechanisms of resistance in trees that are closely related to the susceptible host.

With a knowledge of the reasons for resistance of host trees to various diseases, it should then be possible to define the conditions under which resistance is maintained and to plan accordingly the program of plantings with resistant hosts.

Along with the tree breeding program there is a definite need for research on fungus succession particularly in the processes of infection. Research to define host condition and infection technique necessary for successful inoculation will be important to any international program of testing for disease resistance. Testing hybrids for resistance to specific diseases will be of questionable validity unless these conditions are defined.

The scope of this symposium will not permit my mentioning or elaborating on the many problems in forest pathology requiring research. Little has been said, for example, about the needs of research with decays except in a very general way; nothing has been said of the need for research on the behavior of endemic pathogens in relation to the problems precipitated by man in his manipulation of the forest by various silvicultural treatments; nothing has been said of the influence of density and stand composition on disease susceptibility; nothing has been said of the need for research on the physiology and morphology of trees in relation to disease; nothing has been said about nematode and environmentally induced diseases; nothing has been said of the application of chemistry to the study and control of diseases; and nothing has been said about needed research to determine pathogenic races and their significance in disease development.

This partial list is indeed a formidable one. I believe, however, that some of the most urgent requirements in forest pathology in the foreseeable future have been mentioned in this discussion and are summarized as follows:

1. The most important need in forest pathology is for a greatly broadened program of basic research on the ecology, biology, and physiology of disease pathogens and tree hosts and their interrelationships in forest stand developments as a sound guide for disease control. Empirical research is recognized as a continuing valuable requirement in disease control development.

2. Forest disease surveys of a permanent nature, with a definite commitment of research officers and technician personnel, need to be established and expanded.

3. Disease damage appraisal research is required to develop the techniques of sampling most appropriate for specific types of diseases and to find out the minimum amount of such sampling that will give the precision necessary for meaningful assessment.

4. Unless methodical research programs are undertaken on viruses of forest trees we can have little confidence in the accuracy of our observations on diseases of questionable origin.

5. Disease control in the forest, particularly of native diseases, can best be reduced to an acceptable level through management procedures adjusted to the results of competent research. In the knowledge of the gradual conversion from virgin forests to managed second growth forests, with the attendant increasing demand for growing stock and the establishment of plantations, this research should concentrate on the known and anticipated disease problems affecting second growth forests, plantations, and nurseries.

6. Disease prevention through prior research undertaken on diseases of native trees planted in foreign countries is an old, relatively unexploited idea. It is advocated as a good approach to combating potential introduced diseases or native disease situations that may arise as a result of increased activity in plantations.

7. In biological control intensive selected research may reveal techniques useful under certain conditions for specific pathogens.

8. Research is needed to understand the basic mechanisms of resistance to permit a definition of conditions under which resistance is maintained and to design programs of plantings with resistant hosts accordingly. In addition, research to define host condition and infection technique necessary for successful inoculation will be important in testing for disease resistance.

In conclusion, I look forward to the future in forest pathology and in forestry generally with optimism and confidence because, distributed in our countries in government, industry, and in our many fine schools of forestry (typified by the excellent School of Forestry at Oregon State College), we have many individuals, both administrators and research men, with the vision, scientific skills, and the energy necessary to bring about what I would like to label as quiet miracles. But miracles nevertheless in effective forest development that will be based on sound principles of research and economics.

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The Role of Chemicals in Forest Management

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FORESTRY appears to be standing on the threshold of a new era—the chemical era. To the chemist, the forest is a big open air chemical factory. This plant has neither roof nor sides.

Man contributes very little to the manufacturing process but merely benefits through the finished products of recreation, soil and water conservation, and timber products. The quantity of any one of these products is determined by either factors of environment or the genetic makeup of the plant. If we examine closely, we can see that these factors ultimately express themselves through a chemical effect. For example, the amount of moisture available to a plant determines whether the moisture content of that plant will be sufficient for optimum growth of the tree. This growth is directly dependent on the enzymes, those versatile chemical substances that bring about the reactions necessary for the production of cellulose, of chlorophyll, and all the other multitudinous products that form a tree. So, also, may we examine the influence of light, of temperature, of soil fertility, and find that they too may finally be shown to influence the chemical activity in a plant and thus determine the yield of the desired products.

The genetic composition of the plants has been mentioned as having a chemical effect. Perhaps one wonders how genetics can possibly be construed to have a chemical basis. To illustrate this point, we may cite the present genetic concept that the gene, that is, the unit of inheritance, that carries the traits of the ancestors on through many generations, is actually a mold for the enzymes of the plant. The gene determines the kinds and amounts of enzymes formed and the enzyme content and balance with other enzymes results in an expression of growth that is characteristic of that genetic composition. We will attempt to ascertain just how we can change the course of these chemical processes in order to secure more of the three essential products of the forests and to improve the quality of the products received.

We cannot look to a past century for the use of chemicals in forests. Even though the use of paints and natural products for preservation of wood may have been used for this long, it has only been in very recent years that the foresters have looked specifically for chemicals to aid them. The events leading up to our present interest in forest chemicals started around 1940, which quite unexpectedly saw the discovery and development of such exciting new chemicals as DDT for control of insects and 2,4-D for the control of plants. The discovery of these powerful new pesticides had awaited the proper development of the field of organic chemistry and interest on the part of agriculture for such tools as these to aid production. Although these chemicals were developed for agriculture, it soon became apparent that they would have invaluable applications in forest management. Since 1947, some 15,000,000 pounds of DDT have been used to control the ravages of insects attacking our forest with a saving of fourteen billion board feet of lumber. In this time also, several million pounds of the weed killing chemicals, 2,4-D and 2,4,5-T have been used to control Ribes and other intermediate hosts for the white pine blister rust organism, with savings of untold millions of board feet of lumber.

It might be well to ask whether we are making full use of the potentials of chemicals in forest management today. The answer, unfortunately, is "no." The reason for this lies partly in our lack of knowledge of where to best utilize these chemicals, and partly to a lack of close cooperation between chemists and foresters. The relationship between chemists and foresters is rather like the initial stages of the romance of a middle aged couple, where each recognizes the attraction of the other but is uncertain about giving up a comfortable rut for the more rocky but exciting road of romance. This situation will change, however, as research expands the vistas of application of chemicals to forest management.

What use could be made of presently available chemicals in forest management? We have to not only draw from our knowledge of forestry but also illustrate some of the points by what is now being done in the field of agriculture. It should be remembered that 25 years ago, agriculture was just entering into its present chemical age. Forestry now stands where agriculture was 25 years ago. Today, agriculture is, in a large measure, dependent on chemicals to maintain the high standard of production of quality that it now enjoys. Without these chemicals, agriculture would have a hard time supplying the needs of our people, let alone producing a surplus.

Present day chemicals are varied enough to provide us an armamentarium to ward off attack by the enemies of trees starting from the seed right to the ripe timber. There are chemicals available that can protect the seed from disease, insects, and rodents. The various seed disinfectants afford protection against disease. Others, such as the insecticide Endrin, not only can give the seed short term protection against insects but also discourages rodents from eating the seed by giving them a monstrous "tummyache." After the seed has germinated, chemicals such as Stoddard Solvent and other herbicides can be used to control the weeds that would otherwise compete with and perhaps choke out the little seedling. Later, after the seedling has been moved into the forest area, chemicals such as 2,4-D and 2,4,5-T can be used to kill brushy species that threaten to overrun the planting. Indeed, in some cases, these chemicals may be employed to clear sites for planting. In many instances, these chemicals are more effective than slashing or burning because of the longer-term reduction in competition that may be obtained with them.

As the seedling tree goes along in life, it is subject to insect attack. Potent materials such as DDT can give it the protection it needs. Deer or rodents may be making a lunch counter of the young tree, but again chemicals come to the rescue. Materials are available that serve as repellents to these animals to discourage their destruction of our future forests. To be sure, our present repellents are far from satisfactory. However, when the foresters put the chemist to work on this problem, it will be but a short time until effective long-term animal repellents will be produced.

Finally, in connection with the use of chemicals in forestry, we have witnessed the use of chemicals in fire control in the past few years.

Among the very highly effective chemicals that can be used in the forest today, we have DDT and, of course, 2,4-D, and 2,4,5-T products. The chemicals 2,4-D and 2,4,5-T are members of a rather large family of growth-regulating compounds. These materials, when applied at the proper concentration, may stimulate the growth of a plant or may stimulate a particular phase of morphogenesis, but become lethal at higher concentrations. The possibility of controlling undesirable woody species with 2,4-D and 2,4,5-T became very apparent soon after their discovery. After some years of research with these materials, we now find that a number of brushy species can be satisfactorily controlled with them. A vivid picture of the value of chemicals in forestry management may be seen in the highly successful use of 2,4-D for release of conifers from an overstory of alder. The early work on this problem was carried out on the Siuslaw National Forest, where a stand of conifers was released from an overstory of alder by airplane application of chemicals. Today, we are using 2,4-D and 2,4,5-T combinations as foliage sprays, for basal spray treatments to weedy trees, and in paste formulations to be painted on the trunk. There is no doubt at all that if we knew how to use these chemicals more effectively, their application in forest, management would be more extensive than it is today. One has to recognize the limitations of these chemicals and the fact that not all species are equally well controlled. This, however, does not detract from the fact that they could be effectively used on a still larger scale. What we need, however, to foster a systematic use of these chemicals in the forest, is more information on the absorption and translocation of the materials. After all, it is the amount of chemical getting into the plant and moving to the right place that determines whether or not the tree will be killed. We also need to know more about how plants metabolize or break down the chemical. If we knew this, we might also know when to apply the chemical so that its destruction by the plant would be at a minimum, and thereby get better results. Time of application is important to results. We need to know more about the timing of application to get most effective control on different species. We have also seen in the past few years that the formulation of the chemical is tremendously important in determining results. Further study on this problem might show us how to formulate the chemical to obtain much more effective and economical control of weedy species.

A number of other herbicides could be used more extensively in the forest. For example, the soil sterilants might be used for establishing permanent fire breaks and trails in the forest. They may also be used to develop guard areas to prevent the encroachment of some of the slower moving brushy plants.

Let us look at the use of chemicals in agriculture in order to get an idea of the potential of chemicals in forest management. One of the more dramatic jobs that chemicals are doing for agriculture is changing the growth habits of plants. An interesting development along this line is the control of blossoming and fruiting of the pineapple plant. Pineapple is very erratic in blossoming and fruit set under normal conditions. So much so, indeed, that if allowed to grow unaided by man, it is not at all amenable to large-scale production. Plant physiologists and chemists, in studying the problem, discovered that the application of a chemical called naphthalene acetic acid or NAA for short, would cause pineapple to blossom in a regular and orderly manner and produce its fruit on schedule. This treatment now is being used on a large scale in pineapple production. In like manner, chemicals have been found that stimulate the development and quality of the strawberry, prevent blossom drop in beans, thus assuring a bumper crop, and that prevent the drop of fruit, such as apples and oranges, as they ripen. In forestry, particularly dealing with Douglas-fir, much concern is felt over the erratic seed crop. I think it not only probable but quite likely that in the very near future we will be using chemicals to assure a good seed crop from the desirable seed trees.

The discovery of the plant growth regulating substance produced by a fungus, gibberellic acid, which gives remarkable growth stimulation to plants, has opened up an entirely new area in agricultural thought. We are now not only looking at gibberellic acid but a number of other plant growth regulating substances as a means of stimulating greater growth of our crop plants. The stimulation of growth by chemicals is a phenomenon that has been known for years. However, the more common materials gave erratic results when applied in the field. Gibberellic acid, however, seems to give rather consistent stimulation to the growth at least of certain plants. Agricultural scientists are now re-examining the possibility of markedly accelerating plant growth by this means. It is only reasonable to expect that something similar could be done in the field of forestry, particularly in the establishment of seedlings. We might note the difficulty encountered in the establishment of slash pine. Here it has been found that an amino acid, arginine, which is a normal constituent of the plant, accumulates in abundance in the young seedling and prevents the normal growth and development of the plant. There is some indication that plant growth regulating substances may possibly help to overcome this problem and accelerate the development of this plant by some three to five years. We can even draw on experience from the animal field to illustrate the use of synthetic substances to accelerate growth. Diethylstilbestrol, a synthetic hormone-like material, is being used to promote growth of farm animals.

Agriculture has also discovered that while the root is the natural portal of entry of the inorganic nutrients, properly formulated chemical nutrients can be absorbed by the leaves. This has proved to be a particularly valuable discovery for fruit bearing trees. Here we find that we can take an element such as iron which is an essential nutrient, mix it with a chelating or sequestering agent and supply the plants' needs for iron by a foliage application. This should excite the interest of foresters in considering the possibility of stimulating tree growth by extensive aerial application of nutrients to the foliage of forest trees.

The chemist has also produced some rather novel chemicals to protect both plants and animals from insect attack. The plant growth regulators, such as 2,4-D or naphthalene acetic acid, are known to be absorbed by the foliage of the plant and translocated or moved from one portion of the plant to another. It had long been the dream of entomologists to have available to them a chemical which the plant would absorb and translocate, to kill any insect eating the plant. Such systemic insecticides have been developed and an intensive search is on for others. Recently a systemic insecticide was discovered for animals. This substance, dimethyl 2,4,5-trichlorophenyl phosphothioate, somewhat related to 2,4,5-T, is highly effective in control of the cattle grub when added in small amounts to the animals' diet. The success of the chemists and entomologists in discovering systemic insecticides in addition to the systemic plant growth regulators has spurred the chemist and plant pathologist to look for systemic agents for disease control. We can be assured that such developments will soon be forthcoming.

Seeing the tremendous possibilities with our present day chemicals, should we not look to the future to see what a well supported research program might discover? It would be well to emphasize the critical need for research in forestry, not only in terms of chemical application but in all phases. A comparison of the amount of money spent by the State of Oregon on research in forestry in contrast to that spent on agricultural research reveals the inadequacy of the research effort in forestry. Certainly we do not mean to suggest that agricultural research is over-financed but rather that research in forestry is dangerously under-financed.

Before attempting prognostication as to the chemicals of the future, we should offer some evidence for the optimism we feel for the future. In order to make any advance in the solution of a problem, it takes trained manpower working toward this end. It is encouraging to note that several of our large chemical companies have evinced a real interest in the problems of forestry and have set teams of chemists, entomologists, and plant pathologists to work to develop products that will aid the forester in his task. One company has already gone so far as to establish a Forest Chemicals Department that will devote attention exclusively to this area of work. Similarly, there is a stirring of interest on the part of schools of forestry and the Federal Forest Service in this area. We may look to the future then, with some confidence that new and powerful implements will be given into the hand of the forester for the management of our vital forest resources.

We stated earlier that forestry stands on the threshold of the chemical era, much as did agriculture some 25 years ago. It is reasonable, then, to ask what the future may hold in store in the way of chemicals for forestry. What follows in the way of predictions may be sadly in error, but certainly the future has a way of bringing discoveries far more dramatic than we imagined.

On the basis of our present knowledge it seems reasonable to expect tremendous developments in the field of chemicals for use in the forest. We will probably live to see the discovery of chemicals that will stimulate the germination and growth of young seedlings. Undoubtedly, there will be discovered systemic materials that protect the young seedling from both disease and insects in its early stages of growth. We already have such a chemical in Thimet that may be applied to seeds to protect the seedlings from the ravages of insects. I think too, that we will see the development of chemicals that accelerate the growth of seedlings perhaps two or three fold. Such chemicals would be a great boon in establishing new plantings. We are not far now from chemicals that will reduce mortality among seedlings during the first year by reducing the water requirement and thus conserving moisture for the maintenance of life rather than losing it by transpiration.

Research should develop more effective herbicides for use in forestry. It is quite possible to develop chemicals that would reduce the competition from grass, broad-leafed plants, and brush, during the early seedling stages of the forest tree. Undoubtedly there will be intensive efforts in the future to discover more effective brush control chemicals and I think we have no reason to doubt that they will be discovered and developed. These chemicals would make possible the reclaiming of large areas of land now covered with brush for reforestation. In addition, such chemicals could be used to protect our forests from the weed trees that threaten to engulf them.

The systemic insecticides available today encourage us to believe that even more effective ones will be available for use in the forest shortly. Perhaps equally important will be the development of systemic fungicides and other disease controlling agents. We may hope that these chemicals will be of such nature that they may be applied to the foliage of a tree, translocated to all parts of the plant, and protect it from disease. Certainly as our knowledge of the nature of the chemical required for absorption and translocation increases, the possibilities of discovering such an agent become ever more likely.

Most assuredly as we intensify our cultural efforts in the forest, the role of plant nutrition will be of greater importance. In this field I think we can expect to see the development of foliar applied fertilizers to stimulate the growth of trees. One can almost envision at the present moment the use of a nutrient concentrate applied as a spray from an airplane, particularly for young plantings. Finally, when we consider the fact that the day is coming when all of our timber will come from second growth, we can see the need for some means of modifying growth in order to assure quality as well as quantity production. In light of the possibilities of modifying plant growth by chemicals, it seems only reasonable to believe that we will see the development of powerful new growth-regulating compounds for this purpose. It is conceivable that in the future we shall have chemicals that will accelerate growth to give relatively clear lumber. Other chemicals that will change the pattern of growth and modify the wood density or other characteristics to meet our needs in timber products are also in the future. Such chemicals are not far from being realities at the present, lacking only the necessary research for their development. One can only imagine what a few effective chemical agents for regulation of growth and quality of product can mean in the forestry of the future.

In closing, let me adjure you to face forestry's chemical future with equanimity and confidence. The transition to this era will be fraught with pitfalls but will be none the less exciting. We must recognize the tremendous value of these chemical adjuncts to forest management. I urge you, therefore, to make the effort to add the chemist and chemical industry to the team of forester, entomologist, and plant pathologist, for the sake of maintaining and expanding our timber resources for our own needs and those of generations to come.

Ecological Research in Forestry

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SILVICULTURE is essential to any forest management that extends beyond the orderly liquidation of existing forest capital; the biological basis of silviculture is forest ecology. The relationship between silviculture and forest ecology is, by analogy, that between a structure and its foundation. The degree to which foresters will be able to improve and intensify silviculture in the years ahead will depend, to a very great extent, on their basic knowledge of the physical environments (the sites) and of the ecology of the species and communities with which they deal. We have made a fair start, and it is only a start, toward acquiring this knowledge but many gaps exist; it will be the business of research in the years ahead to broaden and deepen our comprehension of how trees and forests grow. In this connection I would like to express my conviction that field foresters should never delegate all inquiry to professional investigators. Any forester who works in the woods can make useful contributions to knowledge if he has an inquiring mind and is a close observer. The long list of things we do not know about trees and forests includes many simple, but important, questions that can be answered without the benefit of either elaborate research equipment or highly specialized training.

Before considering some of the specific contributions that research in forest ecology may make to silviculture, I wish to advance, in briefest possible fashion, certain concepts that I regard as guiding principles. They are not new concepts, but I feel that they, and their implications, often are not sufficiently kept in view.

First, I would direct attention to the concept of the forest as an ecological universe, or better, an *ecosystem*, involving the total physical environment and the whole of the living organisms (the *biocenose*). This is the antithesis of a mechanistic view of the forest as a mere sawlog or pulpwood factory. The concept of the forest as an ecosystem carries with it the implication of interrelations between the elements of the system, both the physical environment and the organisms. The physical environment affects the organisms and they, in turn, affect the physical environment. Interrelations between the organisms themselves may range from commensalism, through all degrees of competition, to parasitism, and to symbiosis. In our investigations we usually find it necessary to fractionate the environment into its aerial and subaerial components, and parts thereof, and we fractionate the biocenose into its plant component and animal component, and parts of these. As a consequence of this approach, the unity of the forest ecosystem is seen but dimly, if at all. This is unfortunate, for it would seem, as T. S. Eliot said of Shakespeare's work, that we must know all of it in order to know any of it.

Second, I suggest that it is useful to view the physical environment of the forest as the source of influences or stimuli that call forth in the living organisms responses in structure and function. It is well to understand that in some instances the plants and animals themselves *are* the environment; and that they, as well as heat, light, moisture, etc., may provide stimuli that evoke responses. Many silvicultural operations have as their objective manipulation of the environment to provide the stimuli needed to trigger desired responses in the trees or other members of the biocenose. As our knowledge increases we will be able more intelligently to manipulate the environment to our ends, or, where such manipulation is not feasible, to match environments as they exist in nature with adapted organisms.

Ecology of Individuals

The importance of knowledge concerning the relations of trees to their environment has long been recognized by foresters. From observations and experiments there has been built up an assortment of knowledge that we designate as silvics or silvical characteristics. We know quite a lot about some of our species, such as Douglas-fir, ponderosa pine, longleaf pine, eastern white pine, and eastern hemlock, but for many others our ignorance is fairly complete. In the years ahead we must greatly extend our understanding of the relations of trees to their environments, replacing, as rapidly as possible, proximate knowledge by more definitive knowledge. It is understandable, and perhaps right, that the commercial trees themselves should enjoy a prejudiced position in the interest of foresters. However, it is my conviction that we must also press forward with study of the ecology of other members of the forest biocenose —for example, the shrubs, the lesser vegetation, and the animals. This view may seem too idealistic, too impractical. I would merely point out that the label of impracticality often fails to stick; what is deemed completely impractical today has been known to turn out to be highly practical tomorrow. In the world of living things there are many illustrations of the truth of John Dewey's remark that it does not pay to tether one's thoughts to the post of usefulness with too short a rope.

Turning to areas of research that do have obvious practical application, I would mention, first of all, tree seed production. As we learn more about the external and internal influences governing flower production and seed development we shall be able to exercise a greater measure of control over these important functions. The advantage of this knowledge will be apparent to the manager of seed orchards and to the silviculturist who wishes to obtain natural regeneration although operating on a short rotation. Knowledge of how to inhibit or depress seed production of unwanted trees and shrubs may be just as valuable as knowledge of how to increase fruiting of wanted species. With increased understanding of the complex reproductive function in our trees we should be in a better position to anticipate years of heavy and light fruiting.

The juvenile stage of seedling development represents a most critical period in the life of a tree. During this stage the seedling ceases to live on nutrients stored in the seed and becomes self-supporting, elaborating its own organic compounds from the raw materials supplied by the environment. Transition takes place while the seedling is in a delicate, succulent condition with very modest equipment for absorption of water and nutrient salts and for assimilation of carbon dioxide. Further, the microhabitat of the seedling starting its life in the open is one in which there are very pronounced gradients in temperature, moisture, and other physical influences; the little world at the soil-air interface is a harsh one. Research on seedling ecology will supply the forester of the future with knowledge of the requirements or tolerances of the seedlings of our forest trees. In some situations he will be able to manipulate the seed-bed conditions to favor desired species, or, failing that, he will be able to concentrate attention on those species whose tolerances are known to match existing conditions. As knowledge of seedling ecology increases, we will not only be able better to control the establishment of wanted species but will also extend our control over species that are unwanted.

In spite of the fact that there is an intimate relation between the subaerial and aerial portions of trees, research on roots has lagged far behind that dealing with bole and crown. Virgil's reference to oak as a tree,

> "Whose roots descend
> As low towards Pluto's realms, as high in air
> Its massive branches rise"

may not apply generally but we do know that the root system often represents between 10% and 50% of the total volume or weight of the tree. We also know, or have good reasons to suspect that troubles above ground often have their origin in troubles below ground. Root, grafting, once regarded as unusual and a sort of oddity of nature, is coming to be regarded as general in some species and on some sites. It appears that in certain stands the root system may better be viewed as communal rather than as individual. This may have important implications in spread of disease (for example, oak wilt) and in nutrition.

In the years to come foresters will be increasingly concerned with the maximum quantity of fiber and cellulose that can be produced per unit area of forest land. They will also pay more attention to tree quality and wood quality. Here again, ecological research at the species level will be required. We now know that epicormic branches may issue from previously clear boles of trees but we do not know why they appear. That they are not fortuitous is certain for every structure and function has its antecedent causes or stimuli. The factors that govern bole form during the course of a tree's development are only vaguely appreciated. That bole form in trees, particularly conifers, tends to conform to the requirements of a beam of uniform resistance has been known for years but the reasons are scarcely better understood than they were in the time of Schwenderer and Metzger in the latter part of the last century. We know that there is such a thing as reaction wood in trees—called compression wood or *Rotholz* in gymnosperms and tension wood in angiosperms. Something is known of the anatomy of reaction wood and in a general way we understand some of the things it does in the tree, but we do not really know why it forms. The relations of growth conditions to the structure and properties of wood is another field of research which, although holding great promise, has not received the attention it deserves. The forester in the field usually does not know very much about the structure and properties of the wood he grows and the wood technologist generally does not know very much about the ecological conditions under which his wood was grown.

Ecology of Communities

It is not enough to know our trees as individual species; we must also know them as components of communities or forest types. In other words, we need to know the forest—the soil below, the atmosphere above, and the plants and animals, both large and small. For a long time to come we will have to operate with fragmentary knowledge; full understanding lies very far in the future.

Research in the years ahead, as today, will usually be concerned with limited objectives, or problems. For example, we will want to know how soil conditions can be maintained in a condition for optimum production, how they may be improved, and how deterioration may be avoided. This will require attention to all aspects of the soil—physical, chemical, and biological. Research will also be called on to provide more reliable information on site capability in terms of species adaptation, productivity, and general crop safety.

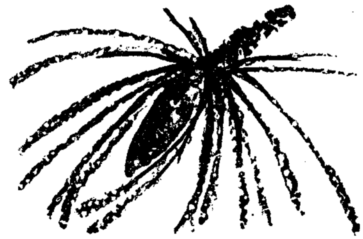
Ecological research can discover the factors responsible for the natural limits of the range of species. This information may enable the forester successfully to extend a tree's range in some cases and in others it may save him from costly ventures, the unsuccessful outcome of which might be anticipated.

The old problems relating to the merits and demerits of pure versus mixed stands and the even aged versus the uneven aged form will probably be with us for a long time to come. They will best be solved by research in the field, for specific sites, species, and other conditions, rather than by debate. In passing, I would suggest that Nature may provide evidence as to the biological acceptability of pure stands; quite a number of our tree species form natural pure stands and I take this as an indication that these species, at least, may safely be grown pure.

It seems certain that our present long list of forestry problems will be extended substantially in the years ahead. Through his ever increasing demands on the forest, and through his actions, man is a creator of problems. As forest and site conditions depart more and more from those prevailing originally, new problems will have to be faced. We will have more troubles analogous to those already experienced with chestnut blight, white pine blister rust, little-leaf disease, and the gypsy moth, to name a few. As we move tree species outside their natural range we may also anticipate difficulties such as those encountered with Norway spruce and eastern white pine in Germany, and with Scots pine and Norway pine in the eastern United States. Research, it seems to me, may be most effective, not in explaining or even solving problems after they develop, but in providing knowledge whereby the troubles can be avoided in the first place.

Research in the field of ecology, and in soils and climatology, will make possible many advances in forest production but one would be naive to anticipate early entry into an era of push-button silviculture with man in full control. Locally, the production of forest crops for special products may approach arboriculture in artificiality and intensity of cultural operations. In general, however, foresters of the future will continue to deal with native species in natural or seminatural stands on most land areas. They will have a better understanding of the interrelations between organisms and environment in natural communities and will take more advantage of the experimentation and testing that Nature has conducted throughout evolutionary time. In his quest for knowledge the forester may well be guided by the advice given over one hundred years ago by Wilhelm Pfeil:

"Ask the trees how they should be grown; they will teach you better than books."



Utilization in Years Ahead

Remarks of Moderator, J. Alfred Hall
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HERE IN THE CENTER of the greatest developments in wood utilization in our country, we have an excellent panel to gaze into the future and forecast trends in the most important fields. I shall not trespass on their presentations, nor discuss forest products utilization and research of the last 100 years. A hundred years ago there was no forest products research—as a matter of fact, it goes back only about 50 years.

There was some research in forest products before the establishment of the Laboratory at Madison. There was a little at Yale, Purdue, Washington, and California, and a few other places, but the amount was very small in relation to the job that was to be done. A brief look at the situation before the turn of the century and an evaluation of the situation as it is now is in order.

In 1900 lumber was king. It had been harvested from the New England states and from the Lake states, and was being rapidly harvested from the South. The Northwest was not yet heavily in business. Wood was being used lavishly and extravagantly for the building of the towns and farms of a westward-flowing civilization.

The pulp and paper industry was a comparatively small affair, mostly sulfite, centered almost exclusively on the true firs, spruces, and eastern hemlock. The enormous kraft industry of today was hardly even a dream.

There was no plywood industry as such although there was a small business sticking chair bottoms together out of thin veneer with something that passed for glue. About all I can remember about those chairs is that they had an unfortunate habit of coming to pieces in the damp summer weather and kicking up splinters that were embarrassing. There were no such things as fiberboards, hardboards, particleboards, or a laminating industry. Per capita lumber consumption reached a peak about 1910 that it has never attained since.

Research in forest products was begun primarily to encourage and provide technical assistance in more efficient utilization of our virgin woods, in order to prolong their usefulness and delay the day when we should be out of the virgin harvest. There was very little information upon which to build. We did not even know the physical properties of our 200 major forest species.

Over the years a tremendous background of technical information has been accumulated and that technology has expanded and developed in a great many directions. Let me recapitulate a few of the things we are doing today.

For example, here in the Northwest we have seen Douglas-fir plywood production come to exceed more than six billion square feet a year, most of the increase having come about since the war from about one billion to six billion. We have seen the hardboards and the insulating boards come from nothing to their present very considerable magnitude, from one to two billion square feet a year.

In pulp and paper products our per capita annual consumption now exceeds 420 pounds per year. I recently made a rough calculation of what we had to build in the way of new pulp capacity in order just to keep up with the population increase. It came out about 600,000 tons a year. This does not have any provision for a steady increase in per capita consumption; in fact, our annual expansion in pulp and paper capacity in recent years has probably been more than double this basic 600,000 tons, nor is the end in sight.

We have seen very great changes in the patterns of utilization of industrial wood products. For example, per capita consumption of lumber has been steadily decreasing for years while per capita consumption of all industrial wood products, which includes about everything except fuel-wood, has been steadily increasing. I am sure you know some of the interactions that are responsible for these trends.

For example, corrugated board has very largely displaced lumber in the small packaging field and has made great inroads into the heavy packaging field. Various forms of artificial boards have had a lot to do with the shrinkage in the consumption of lumber for sheathing, subroofing, subflooring, and the like in house construction.

The so-called particleboards have made very heavy inroads into the use of lumber for furniture core stock, furniture parts, and a great many other uses in which they are still in a developmental stage.

Furthermore, we have seen paper taking over a very large part of the bag field formerly occupied by cotton, jute, and other fiber goods. The revolution in display packaging, and marketing of food products has brought a tremendous increase in consumption of paperboard and various forms of molded wood pulp products.

Briefly, all these things add up to a structure in the forest products industries radically different from that of 50 years ago. Perhaps the 50-year trends indicate some directions for the future. There are a few broad lines that appear fairly clear. In the housing field I think it is inevitable that the trend should be in the direction of goods available in a form that can be readily and economically assembled into a dwelling. This means more wood in the form of sheet products whether plywood or artificial board or small pieces joined into big ones for ready application. I do not believe we need longer tolerate the present type of house construction in which a carpenter, at $3.50 an hour, will drive 50,000 nails into 2,000 pieces of wood, many of which he has had to saw and shape for a special purpose. The cost is far too high. We shall have to center on low installment cost, and this is going to rule out use of a lot of materials that were formerly economical.

Others have indicated the necessity for a program of forestry aimed at the production of wood in which quality has a predominant role. All I can say is that in tree improvement programs of the future, the quality of wood must be given a very important role or in the long run the silviculturist is going to have trouble staying in business. We shall no longer be content to grow wood as measured by gross volume yield. We shall insist upon growing wood for the purposes to which it is designed. There is a lot of work going on in this field. For example, we have a lot of supertrees already identified and ready for propagation. I call to mind one particular tree—a longleaf that we found in Mississippi—that has a growth rate just about double that of the average for the species on this site. It has a favorable summerwood-springwood ratio, it has excellent specific gravity, and, therefore, strength properties, and the slope of the fibril angle is small. All these properties spell good wood combined with rapid growth. We can find more such stock and we shall.

In the future there are two or three urgent matters that must be solved if the utilization of wood in the form of wood is to develop. Last year we had a conference at the Forest Products Laboratory on the general problem of drying. I think a great deal of progress was made in organizing our thinking nationwide in this field.

This year we had a conference on dimensional stabilization. We know how to stabilize wood in several ways, but they are all too costly for general application. We hoped that out of such a conference ideas would come, that thinking would be stimulated, and that somewhere somebody would give us the breakthrough required to really achieve wood stabilization dimensionally in an economical manner.

The same thing holds true for fireproofing. We know how to fireproof wood but not cheaply enough for general use. I hope we can have a similar conference in that area soon. These problems will be solved because they must be.

Timber Harvesting Methods in Next Fifty Years

R. P. CONKLIN
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WE LIVE in a world of change and chance. When the computer is perfected to foretell the future accurately, a lot of fun will be lost to people of imagination.

We are fortunate indeed to have had a part in the evolution and developments during the first half of the twentieth century. These 58 years have been exciting ones for those connected with the timber industry. We are now in the age of transition. A yet nameless new era is ahead. The so-called "modern" age is gone. The new sources of power available have sped obsolescence. The passing of the virgin stands of timber introduces new opportunities. If the past portends the future, I am thrilled at the prospect of witnessing the changes about to take place in men and their methods.

It would be fun to engage this group in a brainstorming session. Think of the ideas that could be offered toward progress in the coming century of Oregon's history. Why, Dr. McCulloch will have to begin the revision of his new book, "Woods Words" right now. Picture such terms as Electro-dyno-log extractor, High-frequency tree faller, Supersonic barker unit, aerojet Transporter, the Hopnagle, a flying platform for hooktenders, a "Presumascope"—a transistorized polarized transit for logging engineers. The yarder puncher will become the Helio-lift operator. The timber faller will be replaced by the Thermosonic High-frequency Tree Detacher. Why, the pushbutton age for loggers is just beginning!

Such flights of fancy are a lot of fun but hardly productive of practical planning to meet the problems that lie ahead. Getting back to realities, my reading and inquiry seem to point to these situations that will influence loggers' future lives and thinking, and the development of our logging industry. Surely we will face:

1. Continued wars and perhaps another World War
2. A tremendous population increase in the United States
3. The lessening of the number of the unskilled labor force
4. The influence of large central government
5. An increase in the educational effort toward the full development of the brain power of all people
6. Continuation of cyclical trends in business, sun spots, stock market, and weather, etc.

These predictions are not mine. They seem to be the consensus of those whose information, training, and perception permit such prognostication. I have chosen the above six as being the more relevant to my assigned topic. Now, on this basis, permit me to apply some imagination.

The United States has engaged in four major wars in my lifetime. Each had its effect on the development of new methods and the rate of extracting logs from the forest. Most of us can recall the speed-up in the invention and refinement of many pieces of equipment as a direct result of the needs for forest products during World War II and the Korean Conflict. The jeep, the tractor, the helicopter, lightweight diesel power, hydraulic transmission, light metals and alloys, electronic controls, high pressure lubrication, radio communication, and many other devices were in a crude form or nonexistent 20 years ago. The periodic law of Mendeleeyv records the steplike processes of progress and evolution. Our progress has not been steady; its curve is not uniformly ascending. War and threats of war seem to bring the application of this law to the forest products industry. Tremendous national expansion ahead of us will repeat the cycle of speed-up in equipment, as wars did in the past.

As the accessible private timber supply became short in World War II, great pressures developed to increase sales on the federal lands and to build access roads. Similarly, continued national expansion will place a severe drain on public forests. Long-range sustained yield plans and allowable annual cutting budgets will be strained during the change over to a second-growth economy. The over mature stands now being held back until sufficient second growth becomes merchantable will be liquidated more rapidly than present plans anticipate.

A highly practical airlift may displace the slow and costly access road program. I am certain of one thing—if the past is an indicator of the future, our thinking in terms of "permanent" roads is a colossal fallacy. There is a beautiful color photograph of a concrete logging road bridge hanging in a certain forest engineer's office. When it is admired by a visitor, the engineer sheepishly admits that the bridge was used but for a short time. New standards made the road obsolete and the relocated road made this bridge a permanent monument to the thinking of those who ignore the only sure and certain part of our future—change!

At one time or another, all engineers and planners seem to entertain the idea that we have reached the ultimate in design, methods, and means to do the job at hand. My grandfather built a "permanent" water wheel to power a woolen mill. I built "permanent" logging railroads, using concrete and steel in the structures. We all tend to use words carelessly. I warn all loggers to strike the word "permanent" from their vocabularies.

Our nation is growing rapidly. A 20% increase in our population is estimated within the next decade. Our Pacific Northwest is being discovered as a good place to live and raise a family. More homes and churches and schools to build, more jobs to create, and new social and economic problems to face—all will affect our business. Surely we will be eating and drinking the products of trees (from paper plates and cups, of course) in our lifetime. Surely we can look forward to new demands on the forests which will require more rapid liquidation of the old, static, and overmature trees; prompt reforestation with fast-growing trees; and a shorter rotation of the timber crop.

I feel safe in saying that fire and forest pests will be of little concern in commercial second-growth forests. Paradoxically, however, foresters of the next century will be concerned with the spread of insects and disease from the decaying timber in the wilderness regions along the crest of the Cascades. Many of these areas will suffer from lightning fires burning uncontrolled due to the high fuel content of these overripe forests and lack of accessibility—a condition created by law. Eventually the pressure will mount for multiple use of all forested areas so protection can be extended to them.

Due to the exigency of the times, we will be unable to let nature reproduce forests erratically. Planting and effective seeding techniques are being further developed to assure full and prompt restocking. Research in forest genetics will give us fast-growing, disease-resistant trees. Fertilizers, hormones, and other stimulants are being developed. Site and aspect are being given more and more intelligent consideration in planning reforestation projects. Erosion and water conservation problems should become unimportant because logging methods and the prompt replacement of the forest cover will eliminate them. Stream flow will not be impeded by logging during the next generation. The deer population probably will decrease because of the lack of abundant food now existing on partially stocked lands.

In other words, in the second half of the twentieth century, we in Oregon will face all the problems of a second-growth economy. Logging will be affected by these things, among others:

1. Lighter, faster equipment
2. Short feeder roads to concentration landings
3. The air age of log transportation
4. Tree roots loosened by sonic waves, making possible the extraction of the whole tree
5. Electronic bucking and sonic barking
6. Complete utilization of stumps, roots, tops, and branches
7. Greater reduction to fiber and chips
8. Use of horses and light tractors in accelerated thinning
9. Fire and insect hazards reduced to the very minimum
10. A new standard for measuring volume replacing the board foot, and machines to take the human element out of log scaling and grading
11. A realistic tax system based on productivity of the soil
12. Stumpage prices tied more nearly to the cost of raising a timber crop
13. More mergers to form companies better able to finance research and supply the capital to implement the results of research
14. Merger of federal agencies charged with forest management

The applied imaginative process creates a chain reaction. I may as well continue to look into this crystal ball, which Bill Hagenstein says is made of cellulose.

Inflation will continue moderately, and the cyclical depressions will arrive on schedule in spite of politicians and those who rig credit. I think we will attain a balanced budget and a reduced national debt before the Soviets take us through the bankruptcy route. We will be able to produce the logs needed by the new era in a four-day week. Rewards for labor will be higher through the application of incentive systems for production. Social problems will increase because of the shorter work week and the lesser number of men required in the woods. Men with greater skills will produce more at lower costs and at the same time enjoy a high standard of living. This trend will downgrade muscles and upgrade brains.

Management will gain in its responsibility in the political and social fields and further contribute to good and equitable government. The development of a discipline and ethics of management is a reality. The profession of management will increase as a responsible force for good government, business stability, and maturity in labor relations.

The increased need for skilled technicians will bring about a cooperative apprenticeship training program sponsored by both unions and management. The upgrading of common labor skills and earning ability will be a major project and a most necessary one. However, such activity cannot attain complete success. It is said that "Man is a bus on which all of his ancestors are riding." People will still be born without the mental equipment to compete or to be educated beyond their hereditary capacities. There will always be the lazy who will prefer ignorance, apathy, and the soft, easy life under a welfare program.

On the negative side, I believe there will be more conflict before union and management maturity is reached. Bitter strikes, slowdowns, inflationary demands, the flexing of muscles on both sides will begin again this year after the brief respite we have enjoyed. Union leaders may price their members out of the job markets in the forest products industries for a time. This will tend to hasten the day of automation and the demise of the unskilled worker. Laws regulating both labor and management will be enacted "to protect the public interest." Government control of wages, profits, and incentive could be the result, and if this comes to pass, we can expect a retrogression instead of the imaginative and exciting advancements I have cited.

But on the positive side, the evolution toward closer management understanding of the labor movement and toward enlightened union leadership is already underway. I see great changes for good in our industry's labor relations. The age of cooperative understanding is not far off.

Now, let us consider the role of government forestry agencies during the next 50 years. Because the federal and state governments control the greater forest land acreage and the dominant volume of merchantable timber in the Pacific Northwest, the policies of these agencies will influence our progress. The knowledge of industry's problems by the officers of the State and Federal Forest Service is tending to put in practice fair and business-like policies. Greater responsibility as a landowner will be accepted by government agencies and greater equity will eventually prevail in their contractual relationships with industry. As time goes on, federal timber will all be administered under one policy and, I hope, through one agency. The change will come when big central government delegates authority and responsibility to the various forest regions. I am sure when federal timber is so administered, it will be on a business basis and not on a socio-political concept. Stumpage prices will be tied to the cost of raising and protecting the crop and not to taking all that is left after allowing the logger and mill 10% for profit and risk.

Gradually the meaning of the term "board foot" has been vitiated. The new era we are entering will surely bring agreement on a unit portraying tree and log volume (a quantitative unit carrying a new name) which will displace "board foot." It will be one permitting buying, selling, transporting, and costing the raw material of the forest (including chips) without the application of modifying factors. It will permit the reduction of human error in cruising trees and scaling logs and will bring order out of the present chaotic system. It will apply universally to every forest region. I wonder which large timber-owning agency, private or federal, will show the leadership necessary to call a national convention to work out a solution.

One of the most significant changes we loggers face in the coming years is the growing need for superior men in the woods. This need will increase as we enter further into the second-growth economy and more intensive use of forest lands.

The best answer to the problems of the last half of the 20th century lies in Corvallis. This Oregon State School of Forestry has the means to foresee situations and to provide the brains, the creativeness, and the imagination to meet them. The logger of tomorrow will have to be smarter than we are. Logging management is growing into a profession requiring highly trained and well-rounded people. The logging operation has been and always will be made up of a series of engineering problems. As new methods and equipment appear, technically trained loggers will be required. Our concepts of safety programs will undergo a change. It may take a highly intelligent and alert man to stay alive. (I am only here today because of luck and rapid reflex. I wouldn't dare count on these elements tomorrow.) Loggers will need backgrounds broader than can be obtained in the school of hard knocks.

The trade and technical high schools, along with union sponsored apprenticeship programs, will help provide technical foresters, machine operators, and foremen. The forestry colleges must recruit and develop highly intelligent personnel required for professional categories of forestry, engineering, planning, supervision and management, and research of the new era. I am thrilled to know that this school, through its faculty and Dean, has already started in the proper direction. The logging industry must give forestry colleges more interest, advice, encouragement, and summer jobs to the students if for no other reason than survival. The sons of our employees who show adaptability and interest in the industry of their fathers should not be lost to other industries, especially our competitors.

The experts seem to agree that we can expect to suffer war, economic crisis, a growing population, great social adjustments, increases in scientific and technological applications, a big dominating central government, and most certainly, the continuation of cyclical change. In accepting these predictions, I have permitted my imagination to get out of control here and there so I could apply their influence to our woods in Oregon.

I do not particularly like all that I have discovered. But how can one assess the future? Certainly not by isolating one's self and ignoring the obvious trends working around us. Certainly not by hoping with closed eyes that war, hardships, inflation, and misunderstandings will all go away. Quoting Peter F. Drucker in his book, *Landmarks of Tomorrow,*

" . . . we have to look upon the new tasks as opportunities rather than problems; have to see them as chances of success rather than as threatening risks."

The logging industry will advance with the times under periodic and cyclical influences. The second-growth age will bring with it new methods and equipment. No longer will loggers have to move 20 tons of log over rough ground to a landing and load it. Our grandsons will look at pictures of our rudimentary old growth logging practices and say, "I'm glad we don't have to contend with the 'good old days' grandpop talks about."

More intelligent and better trained loggers will do a better job than we ever accomplished. I call your attention to two words I used in developing this facet of the future. They are "well-rounded." The narrowly trained technical specialist can be turned out in the trade schools. Our forestry colleges must concentrate on preparing creative professional men who can cope with the expanding economy and the inherent political, ideological, and business situations.

Most important of all, further emphasis will be given to the spiritual basis by which men live, think, and act. Each of us is challenged to adjust to the disciplines of the new era!

Boards of Tomorrow

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THE RAW MATERIAL, the mechanics of production, and the products produced are all phases of wood utilization. Although they are completely intermeshed and dependent upon each other, our consideration here shall be directed primarily upon products with only brief consideration of the related fields.

In the field of production equipment and organization, we have the opportunity for great changes, particularly with respect to plywood manufacture. Most of the significant development in recent years has been directed toward greater volumes of production. A great deal of opportunity remains for impressive improvements in automatic handling and sorting of material, combining and integrating operations, upgrading of materials and reduction of waste. In laminating and plywood fields, completely new techniques are being investigated by a number of manufacturers, equipment designers, and adhesive producers. The pressure of production costs and demands for new types of products should bring certain processes into use. Progress towards these new methods is slower than might be expected due to the conservatism of the industry and to the attention being given to type and quality of log that will be available. The smaller, variable logs of the future will necessitate a great deal more individual selection and care. As a result of these developments, we can expect not only changes in methods of manufacture but, also, modification of old materials and introduction of completely new types of products.

From a utilization standpoint, the paramount problem in the future will be quality, not quantity. As old-growth logs disappear and knotty, fast-grown second-growth logs become predominant, our markets will increasingly demand higher quality products. In these days of proportionately high labor costs it will not be economical to have carpenters and secondary mill labor cut knots and other defects from lumber. Somewhat the same situation will exist with plywood.

Silviculturists and management foresters concentrate their efforts on growing the maximum gross volume of cellulose per acre per year. There have been few attempts to grow the greatest volume of high quality wood for specific uses. Faced as he is with enthusiastic predictions of fiber and chemical products of the future, it is only natural for the forester to assume that the biggest tree that can be grown in the rotation period will be the best.

We can, therefore, expect to have logs with wide growth rings, coarse-textured wood, and wide ranges of density. The proportionately large core of the log will show extremely rapid growth with large knots. The sapwood will be wider than in old-growth trees and will represent a large proportion of the better quality wood in many species. The wood in the outer shell of the "mature" log of the future will be rather coarse grained, fairly uniform, elastic, and reasonably free of defects. If we could hope for pruning of crop trees, some logs would have a thick outer shell of this wood.

Lumber

The problem will be how to best utilize this comparatively thin shell of light-colored, high grade wood and how to make useful products from the knotty interior. If the heart is boxed in the sawmill, high grade lumber will result but wide boards will be scarce. Large top-quality timbers will not be produced directly from these logs. The percentage of wood going into chips will increase steadily, eliminating the need to consider lowest grade material for lumber or plywood in the future. Despite careful sawing practices, use of thin gauge saws, and chipping of lowest grade material, the bulk of the lumber will be comparatively low grade. Through the pressure of price the customer will become accustomed to use grades lower than presently specified for many uses. However, to supply the demand and to obtain higher dollar returns, lamination and other gluing will become an increasingly important factor in the lumber business.

Present gluing of lumber is largely limited to laminated timbers and a comparatively small amount of end- and edge-gluing directed toward the salvage of short and narrow pieces. It is reasonable to expect a continuing increase of timber laminating until such material represents the bulk of the market, including standard sizes. Exceptions will be low grade timbers where compression across the grain is the main structural requirement and large knots are of less consequence.

The edge- and end-gluing of plank and boards probably will continue its present development as a competitor of large-size, clear-lumber stock, as a source of extra large material, and as architectural specialties. As competitive high grade lumber becomes increasingly scarce and higher in price, techniques and designs will be developed for the production of larger quantities of both plank and boards edge-glued to width and end-glued to length. When acceptance of such material is general and techniques are further developed, high grade faces of re-sawed lumber or veneer will be applied. It is technically practical at the present time to assemble a wide board on a continuous basis, to be cut off in lengths as desired, which will have as specified: One or two clear faces, one or two clear edges, and an interior or back of low grade knotty wood.

Our present glued-up lumber products face a number of problems which must be surmounted before general acceptance can be obtained.

1. The end joints are too crudely made for good results in many uses.

2. Adhesive limitations materially increase production costs.

3. Some uses require matching of wood of similar grain and density in the piece.

4. Wide color differences must be eliminated from better grades, through matching or staining, as a standard practice.

5. Standards and test methods and working stresses for engineering design data must be developed.

6. Uses must be specified for various grades and species.

7. Improved nomenclature must be developed for promotional purposes.

The laminated, edge- and end-glued board developed to a first class product can be the lumberman's answer to competition from aluminum, hardboard, plywood, and particleboard. If plastics are demanded, this type of board can be made to take a plastic overlay at the time it is assembled, even on a continuous basis.

Plywood

Judging from experience in other parts of the country, abroad, and at a few operations in this region, high grade plywood can be produced economically from second-growth timber. Many operators will be surprised to find that clear, elastic wood from the outer parts of these small logs will give exceptionally high yields of defect-free faces. As some small compensation, the very knotty wood of the young logs holds together better in veneer than similar wood from old-growth logs. Unfortunately, the volume of clear wood will be insufficient to supply faces on plywood for all the low grade veneer produced. Also, the low-grade wood will frequently contain too many large knots to permit economical patching.

While higher values will insure direction of large logs to veneer and plywood mills and quantities of such material will be available for years to come, the increasing demand for plywood, veneer-faced particle board, lumber-core plywood, and other structural panels will bring an acute shortage of wood suitable for high and medium grade face veneer. As prices increase, customers will use more lower grade material for construction purposes. Increasing attention will be given by manufacturers to chemical and mechanical means of maintaining or improving veneer grades. Practical means will be developed to keep knots in veneer and also to replace those which have fallen out. Narrow strips, now used for fuel or chips, will be salvaged.

Despite all these efforts, we doubtless face an ever-increasing shortage of faces for fir plywood and other laminated products. One source of veneer faces is tropical hardwoods, imported in the form of veneer or veneer logs. Our own native hardwoods offer a very considerable backlog of useable material. In addition to rotary cutting of larger logs, high speed flat slicing could be made to yield large quantities of medium grade stock from smaller hardwood timber.

Probably the most significant development of the future in the plywood industry will be new types of facing material to replace or to cover veneer. Doubtless plastics will be the leader but metal and other materials will also be used. These materials will differ from presently used plastic overlays in that most will be applicable to low grade, knotty veneers. Some will be colored, often with designs or patterns, for interior or exterior applications. Plywood will become increasingly a structural filler substance for other protective and decorative surface materials.

Composite Panels

As a result of designers' efforts to develop new structural members for better or simpler design there has been an increasing demand for engineered non-standard plywood and composite panels. Among those being tried are various combinations of veneer, plywood, lumber, aluminum, plastic laminates, and low density cores of plastic foam or honeycomb. Such panels may be comparatively thin surface coverings or may be complex structural elements several inches thick. They will bring to the plywood manufacturer new problems of engineering, production, sales promotion, and marketing.

Unquestionably large structural elements and components will become significant parts of our future construction methods. During the present early development stages it is difficult to determine the point at which manufacture of raw material ends and assembly of these structures begins. The large bulk and low overall density of components increases unit freight rates and often severely limits the economic shipping radius of such products. At the present time component design is largely limited to a particular structure for which it was developed, limiting its production to comparatively small numbers of units. We can expect considerable effort towards standardization which will make it possible to manufacture and even assemble these structural panels at the lumber or plywood mill, farther from the point of ultimate use.

Along with the development of combination panels and structural components will come increasing demands for materials cut or made to size, ready to use. Narrow, long, and very long plywood will be required. Odd lengths, such as 8′4″ and 9′2″, may be required in quantities. Gradually new structural standards will be developed and specialties will be a major concern of many mills in the future.

Finishing and Packaging

Better finishing of the product will become increasingly important. For some products this will be nothing more than improved sanding or polishing. Other products will be presealed, partially finished, or completely finished for final use. Better and more attractive packaging will become the rule. Wherever possible the product will be cut, fitted, pre-drilled, and finished in ready-to-use form to reduce as much as possible on-the-job labor and skill requirements.

Conclusion

A developing demand for larger, better, and more complex products from both lumber and veneer during a period in which the second-growth log will become predominant poses a number of critical problems for the wood-using industry. As product types are developed, the usual American ingenuity will find ways and materials to supply the demand. A larger problem is the maintaining of demand against the ever increasing competition from plastics, metals, and other materials. The greatly increased promotional work now being carried on is not a complete answer. A new approach, a new basic philosophy is required.

It is time now for both the lumber industry and the plywood manufacturers to build better products, tailored accurately for final uses. Built-up assemblies of lumber must become the best product, not a substitute made from waste pieces. Plywood must become a laminate of many colors, many materials, and more uses. Standard components must be made at manufacturing plants, not assembled on the job. Lumber and plywood must be prefinished and ready to assemble or use without cutting or fitting. These ready-to-use products must be attractively packaged for protection and promotion of acceptance and use.

The period of the air-dry rough, random width, and random length board is passing. The complete dominance of the stock 4 x 8 fir panel must be reduced. In the face of vigorously expanding competition, the lumber and plywood industry must cooperate with architects and designers of vision to supply wood products in new forms that will use the properties of wood to advantage and thereby maintain its dominance as the prime construction material of the future.

Chemical Utilization of the Tree

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LOOKING BACK over the last 100 years in wood chemistry makes the wood chemist feel rather humble, because in spite of considerable efforts made during that time and the great strides made in the utilization of its major component, cellulose, we still know relatively little about the second largest constituent of wood, lignin. The commercial chemical utilization of lignin is still in what might be called a beginning phase.

Perhaps the wood chemists' topic for the next 100 years should be "Know and use your lignin!" With our accumulated experience, our modern tools, and, above all, our brains, I entertain no doubt that we can achieve a breakthrough in a shorter time.

The occasion of this centennial is a good point at which to stop and ask ourselves some searching questions about the problem of chemical utilization of wood and why it has not yet been solved satisfactorily. I invite you to follow me in an attempt to answer these questions and come up with an idea indicating in which direction a solution to the problem might be found.

Definition of Chemicals

For our discussion, I should like to define the term "chemicals" rather broadly. Instead of limiting it to well defined chemical compounds such as sulfuric acid, carbon bisulfide, or acetone, I like to include in the term "chemicals" such items as tannins, resins, sugars, plastics, synthetic fibers, or synthetic rubber.

The Chemical Industry in Forestry

The chemical industry has a good reputation because it is profitable, stable, and flexible. The latter characteristic stems from its ability to produce, from a few basic compounds in relatively simple equipment, a number of diversified products which can be selected to fit the changing demands. You have all seen such product families often pictured as trees of chemicals based on compounds such as ethylene, acetylene, butadiene, sulfuric acid, or carbon monoxide/hydrogen.

It is desirable for the forest industry to develop such basic or key chemicals and become a partner in the chemical industry because this offers increased versatility for forest products and overall stable profits.

Participation in the development of chemicals has a deep significance because chemistry has become a tool which satisfies man's needs and shapes man's environment. By joining it, the wood industry will become increasingly involved in man's welfare, i.e., beyond providing materials for construction and packaging.

The forest industry contributes as a major asset a large and renewable source of raw materials which are complex but nevertheless can supply valuable basic compounds. To recall the order of magnitude, the State of Oregon in 1952 cut 9.8 billion feet of lumber, i.e., 20% of the national total of 48.8 billion feet. (1)

The Chemical Compounds in Trees

Taking stock of our raw material, we recognize that we have in our trees, chemically speaking, quite a mixture of compounds. There are aliphatic chemicals, aromatic chemicals, crystalline and noncrystalline compounds, some in large percentages, some in traces. Conveniently, we can divide them into four groups: wood or extractive-free lignocellulose, bark, foliage, and extractives.

Wood. Wood constitutes by far the largest part of the tree. It is at present practically the only part which is completely used commercially. Wood is a fabulous structural polymer in which cellulose fibers are ingeniously cemented together by lignin and probably hemicellulose, in a way similar in principle to modern glass-fiber reinforced plastics.

Bark. Approximately 10% of the tree substance is the protective sheathing known as bark. The barks of most of our tree species have been analyzed chemically, many of them here in Corvallis at the Forest Products Research Center (2, 3, 4, 5). From this work, we can draw the following conclusions:

a. As a general pattern, bark consists of lignocellulosic fibers, water-soluble phenolic compounds (tannins), phenolic acids, and extractives, such as wax, thujaplicin or dihydroquercetin. The larger part of these components seems to be chemically combined.

b. Composition of bark varies for different species.

c. Percentage of constituents varies from tree to tree.

We have a fair idea of the chemistry of these constituents excepting the phenolic acids, which are the second largest component of bark. Our knowledge of this constituent, as that of wood-lignin, is rather limited. Without having to go into the details of lignin chemistry, we must confess that we don't know yet whether in its natural state it is a low or high molecular weight compound, whether it is a polymer with a recurring building block, and if so, what the building block is.

Foliage. Foliage seems to have attracted research efforts only to a small extent so far. We have a general idea of the chemicals present in foliage: chlorophyll, starch, cellulose, aromatic oils. Others might be found. Problems of collection and transportation will have to be solved if utilization of foliage is considered.

Extractives. Although extractives are not physically separate component parts of trees, it is useful to list them separately because they form a large group of specialty chemicals which can usually be separated from the tree components by simple physico-chemical means, usually extraction. Some of these specialties are now being made synthetically, such as camphor and some grades of wax; others are recovered from wood or bark of trees, such as rosins, tall oil, cascara, and, more recently, quercetin. (6)

Taking stock of what we have, we can summarize in terms of the log (excluding foliage):

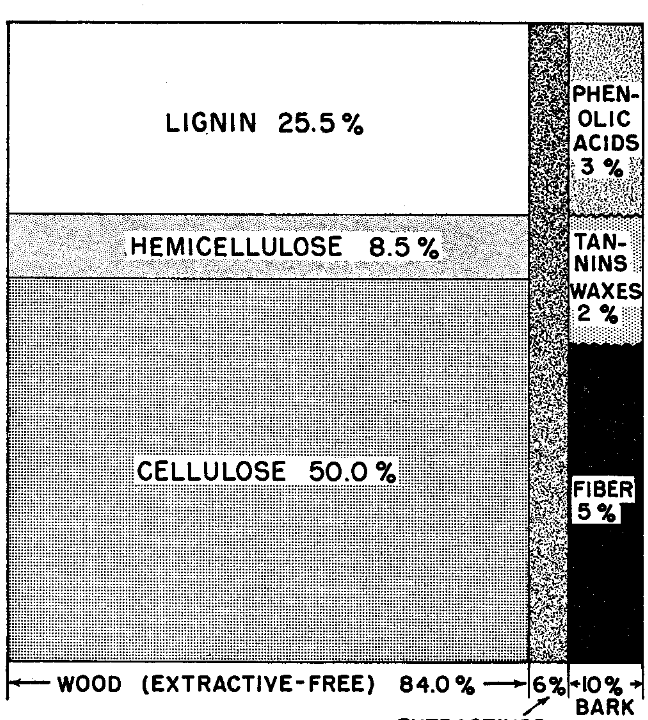


Figure 1. Approximate composition of a softwood log.

What Has Been Accomplished

Against this background, to which must be added: hazards of nature, difficulties of logging, and the ever-present fight against cost, the accomplishments are impressive. We can summarize the status briefly as follows:

1. The chemical utilization of the tree has developed in the U. S. into an industry producing at an annual rate in excess of $111 million. (7) If we include the manufacture of chemical pulp from wood, we arrive at a figure of over $2 billion in 1957. (7, 14). Oregon's share of the national total had grown to 5.1% in 1954. (1)
2. We know a great deal about the carbohydrates in wood: cellulose and hemicellulose, enough to tackle their utilization intelligently.
3. We know very little about wood lignin; a major breakthrough is required in our knowledge of wood lignin and related bark products for comprehensive chemical utilization.

A review of advances made during the last two years has just been published in the Forest Products Journal. (7) It shows that steady progress is being made in improving existing processes and products, but also that continued efforts and new processes are required for commercial utilization of larger portions of residuals which amount to over 100 million tons annually. (8)

Breakdown of wood to chemical pulp is by far the largest wood chemical industry. Progress is evident in the wider use of continuous pulping, in the introduction of new processes: the cold soda process, two neutral sulfite processes, i.e., the Arbiso and the Magnifite processes, and a semi-neutral process, the Sivola process.

Wood distillation or pyrolysis seems to be holding its own primarily because of widespread public use of charcoal for outdoor cooking.

Wood hydrolysis yielding sugars and lignin, continues to be investigated but no plants seem to be operating except possibly in Soviet Russia.

Breakdown of wood through hydrogenation or biological means is still confined to the laboratory stage.

An excellent review of the chemical utilization of bark (9) lists two plants extracting chemicals from bark.

Obstacles to Progress

These accomplishments are fairly impressive, both from the point of view of dollar value and product diversification. There are also available a number of suggested processes for the integrated manufacture of forest chemicals (10) and quite an array of products.

Table 1. TYPES OF PROCESSES USED IN CHEMICAL UTILIZATION OF WOOD

Process type	Unit process	Products
Extraction	1. Solvent extraction	Tannins Rosins; terpenes Wax Dyes Aromatic compounds: camphor, pine oil*, eucalyptus oil* Medicinals: quinine, cascara, quercetin
Fractionation	2. Prehydrolysis	Wood sugars Modified lignocellulose
	3. Treatment with Alkali	Alkali lignins Carbohydrates Oxy acids
Cleavage	4. Delignification	Chemical cellulose Sugars Soluble lignins
	Oxidation	Vanillin
	5. Hydrolysis	Hydrolysis lignin Levulinic acid Reducing sugars
	Fermentation	Alcohol
	6. Hydrogenolysis	Propylbenzene
	7. Pyrolysis	Char Wood tar Gases Volatile acids (acetic)
	8. Oxidation	Oxalic acid Protocatechuic acid Gases

* Some of these products are obtained by steam distillation.

We must confess that the chemical utilization of the forest is not moving ahead at the pace characteristic of the chemical industry in general. Why?

The main problem is, of course, to take apart an ingeniously designed structural plastic. In addition to this, there are five factors or obstacles which make it difficult for any primary or natural product of the tree, i.e., compounds as they exist in the tree, to compete in the chemicals field. Two of the factors are economic, two are technical, and one is developmental. The factors shown in Table 2 are:

Table 2. OBSTACLES TO THE USE OF PRIMARY WOOD CHEMICALS.

Uses	Obstacles
Economic	General availability of the main building block of lignocellulose: glucose
	Low concentration of extractives
Technical	Unknown composition of wood lignin, bark phenolic acids
	Instability of some protective products such as tannins (temporary protection)
Developmental	Obsolescence in a progressive technology

Obsolescence is demonstrated by the fact that primary natural products are continuously being replaced by modified or synthetic products. Concrete, dyes, nitrates, wood alcohol, detergents, fibers, elastomers, are examples which quickly come to mind. It seems as if nature teaches us to use its raw materials and invites us, then, to improve them, or tailor better products for specific uses.

These obstacles are valid, but, like any obstacles, they exist to be overcome.

Long-Range Trends

Because the theme of this conference is "The Next 100 Years in Forestry," we should also apply a long-range outlook to the chemical utilization of the forest. Such crystal ball gazing over extended periods of time is never safe, especially in the chemical industry which is vigorous and dynamic.

Yet, we have to tackle the subject as we are partners in the great evolutionary and developmental process of nature. So I invite you to obtain an answer to the question by analysis of the past performance of the chemical industry in order to see whether there are some general, heuristic principles.

Development of the Chemical Industry

I believe you will agree that there are three such general principles:

1. Nothing should be excluded as impossible.

We are all waking up to this when we look at the spectacular achievements of the missile men. Less spectacular achievements, such as the applicability of chemotherapy, are equally impressive. The basis for this principle is probably that in our whirling universe "possible" and "impossible" are relative terms.

2. The success of a new product is determined mainly by its performance and usefulness, not by its price. This seems strange at first sight, but becomes less so when we reflect that we are willing to improve products and pay a price for improvement. In doing so, our living becomes more expensive instead of less expensive.

3. In order to survive in the competitive struggle, it is desirable for a branch of the chemical industry to produce a few basic building blocks or key chemicals which permit diversified processing to diverse uses. For instance, ethylene is such a building block which can be processed into a host of solvents, polymers, or detergents. Aluminum provides an example of highly diversified uses, including structural elements (planes, houses, bridges), packaging, and articles of use. In the same fields wood has led the way, but is forced now to seek new outlets and improve its performance.

Application of Principles

It becomes evident that in order to develop a vigorous, stable, and lasting chemical industry based on the forest raw material, we must find such key chemicals. So far, a number of attempts have been made to produce chemicals from the tree, such as sugar or alcohol from wood, tannins from spent liquor or bark, wax from bark, or phenolic chemicals from bark by extraction. Excepting alcohol, none of these products can be called a key chemical. Although a few of the products are fairly successful, it seems that, by and large, this approach results in a rather precarious situation. The reason for this is, as we see it, the rigid line from raw material to end use without the benefit of a key chemical intermediate. Such a key chemical acts as a fulcrum, lending flexibility to the set-up, equalizing not only the ups and downs of current products but also leaving the door open for future products.

I admit that some of these statements sound rather harsh and that we have, in many instances, cases which are not all black or white. Nevertheless, this should not change the validity of our conclusions.

If we agree that, ultimately, it will be necessary to produce one or more key chemicals from the forest, the question arises: What are these key chemicals?

I believe we should leave the quest for key chemicals to the many excellent research men in the numerous laboratories.

Nevertheless, we might end our analysis with a rather broad sketch outlining where such key chemicals might be found and what they might look like.

Qualification of a Key Chemical

We shall define a key chemical in the forest products industry as a fairly simple chemical product, derived from a major component of the tree and capable of diversified modification and use.

Going back to our four groups of constituents of the tree: wood, bark, foliage, and extractives, we will agree that the latter two can be excluded as raw materials for key chemicals because of their relatively small percentage of the tree. Extractives are excluded also because they are rather complex specialty chemicals.

There remains, then, wood and bark. Since bark represents only 10% of the tree substance, one might be inclined to exclude bark as a source for key chemicals. This is correct if the whole tree were available for production of chemicals. At present, this is not the case. In integrated lumber and pulp mills, approximately 25% of the wood is unusable residuals, sawdust, and shavings. This is comparable to the amount of bark available. Therefore, both wood and bark must be considered for the manufacture of key chemicals.

Key Chemicals from Wood Cellulose

Taking a look first at wood, it seems as if we would wind up with two key chemicals, based on the two main constituents of wood: carbohydrates (cellulose) and aromatic chemicals (lignin).

Probably, we must exclude the cellulose part of wood as a source of chemicals, at least for the time being, because cellulose is composed of a relatively low-priced building block, glucose. Glucose or dextrose is abundantly available through hydrolysis of starch, and has to compete with cane or beet sugar which are also abundantly available. It would seem desirable, therefore, to preserve the unique structural element of wood residuals as much as possible. This is one of the reasons why the wood pulp industry is so outstandingly successful.

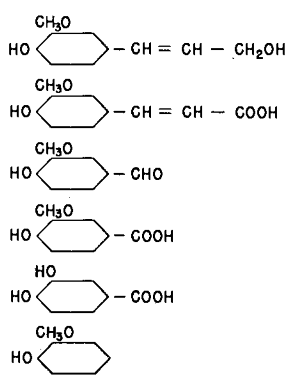
Wood cellulose itself may be called a key product because its end uses are numerous and diversified, such as paper, board, or derivatives. If in the distant future, greater demand for food increases demand for glucose, cellulose can be called upon to furnish glucose. In the form of trees, cellulose is grown on unarable land and can be processed to glucose and glucose derivatives.

There are several derivatives of glucose which have been made from wood and might qualify as potential key chemicals. I am thinking of levulinic acid (11), hydroxy-methyl furfural (12), levoglucosan (13), or ethyl-alcohol.

Ethyl-alcohol can be considered a key chemical. Besides being potable, it is a good solvent, and can be processed into numerous products, such as acetic acid, solvents, plastics, or elastomers. Approximately 12% of the present alcohol consumption of 1,400,000 tons (excluding beverages) can be recovered by processing the available spent sulfite liquor. By and large, recovery of alcohol from wood is unattractive and hinges on a breakthrough in the utilization of lignins.

Key Chemicals from Wood Lignin and Bark

In the utilization of the other component of wood, lignin, lies the challenge. It constitutes approximately 30% of the wood of conifers, or 25% of the log, to which might be added a few percent of related compounds in bark. (Refer again to Figure 1.) Its exact composition is unknown, but periodic reviews, especially recent ones (14, 15), indicate that it is largely composed of, or converted to, aromatic organic compounds, such as the examples in Figure 2.



CONIFERYL ALCOHOL

FERULIC ACID

VANILLIN

VANILLIC ACID

PROTOCATECHUIC ACID

GUAIACOL

Figure 2. Some basic units recoverable from conifer lignin.

Such substituted phenols open up considerable prospects for the manufacture of versatile chemicals. For instance, a product like ferulic acid is an extremely versatile chemical. It can react as an acid or a phenol, its double bond can be modified, or it might be polymerized to form a polyester or a polyvinyl derivative. It contains a methoxyl group which is rather uncommon in petrochemicals, the chief competition in volume organic chemicals. It can be sulfonated at the double bond. A sulfonated polymer may be present in spent liquors from the pulp manufacture and the monomer might be recoverable as such.

Two beginnings have been made along such lines. One is the commercial production of vanillin, perhaps a cleavage product of ferulic acid. (16) Vanillin might well develop into a key chemical; its chemistry is being studied intensively.

The second is the conversion of lignin to a useful fiber through a series of steps, the key products being vanillic acid (17, 18) and protocatechuic acid. (19)

This is a very brief sketch of potential key chemicals from wood cellulose and lignin.

Summing up this speculative analysis and looking ahead into the next century, I believe we can be confident that the organic raw materials of the forest will become the basis of a chemical industry much as petroleum has become the basis for the petrochemicals industry. A prerequisite is that the forest chemicals industry develop key chemicals which will enable it to meet the continuous challenge of change and progress.

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Wood Engineering and Construction

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THE FABRICATION of wood for engineered timber construction is not merely the cutting and boring of some formerly unrelated pieces of wood to make some sort of assembly. Many things have come before and after this process; the choice of material as to species and grades, and the determination of availability, the choice and application of design, the actual application to the problem at hand, the preparation of shop drawings, checking by code authorities, insurance rates, quality control, erection supervision, and final inspection—all these are functions of engineered timber construction. This area can rightfully be extended to include the engineers and inventors of the machinery and tools that do the work, and the engineers and technologists and laboratory people who carry on the research by which progess and improvement are achieved.

When a person is given the opportunity to speak about the future of an industry, you think he would be so eager to enter into that realm that he would not want to waste much time with the past. As I think about this subject "Engineering in Timber," I find almost as much interest and drama in the past 100 years as I do in any predictions that I might make for the next 100 years. So, permit me to dwell for just a little while on some of the milestones of the past.

In this year's celebration of the Oregon Centennial, much has been said about the pioneers, and when we mention the Oregon pioneer, I think most of us think in terms of our great-grandfather or at least our grandfather. Do you realize that in the field of timber engineering, many of the pioneers in this industry are still alive today? I should give you the names of some of these men to whom we are indebted but I am not going to because there are so many who are deserving of mention and credit that I am afraid I would overlook some.

The selection of structural timbers to insure higher strength is no doubt centuries old, but do you know that no less than 125 years ago about all we had for a guide was something like Thomas Tredgold's "Elementary Principles of Carpentry?" A centennial of engineering was celebrated in 1952 in Chicago commemorating the founding 100 years before of the First International Society of Engineers in the United States, the date when engineering of all materials emerged as a profession in the United States. The American Institute of Architects observed its centennial only last year. The United States Forest Service was founded only 60 years ago and the Forest Products Laboratory was established just 50 years ago. The USDA Circular 295 for Basic Grading Rules and Working Stresses for Structural Timbers was published as late as 1923. While the Civil War was being fought, the first wood preservative pressure-treating plant was built in the United States.

Let me list just a few more milestones in the growth of engineered timber construction. The American Society of Testing Materials published its first standard specifications for structural timber as late as 1907, and the American Lumber Standards for Soft Wood Lumber has been available only since 1924.

One of the outstanding developments, of course, was the timber connectors promoted by the Timber Engineering Company in the early 1930's, commonly referred to now as TECO Rings.

In 1934, a firm which is still very much in business today built some glued laminated arches for a building for the Forest Products Laboratory at Madison, and it was about that time that the laboratory started research on glulam.

One of the most significant milestones of our industry was the development of adhesives, particularly the synthetic resins in the mid 1930's, which triggered the rapid growth of the plywood and glued laminated industries. The year 1938 saw the establishment of commercial standards for fir plywood, the development of the DFPA Inspection system, and the start of extensive trade promotion.

In 1940 the War Production Board gave financial support to a large testing program. Two firms still prominent in the industry today cooperated in producing the test members and the Forest Products Laboratory made the strength tests and analyzed the data. The program covered three years and finally, in August 1943, we got War Production Board Directive 29, a mandatory directive for a 20% increase in wood stresses over values formerly used.

Technical Bulletin 691 was prepared in 1939 by the Forest Products Laboratory, and was revised and republished in 1954 as Bulletin 1069, the Bible of today's laminating industry. The West Coast Lumbermen's Association published its first glulam specs in 1946; Southern Pine Association followed in 1951; Hardwood Standards in 1952; Western Larch Specifications in 1957; and Hemlock in 1958. The National Design Specifications, an outgrowth of War Production Board

29, sponsored by the National Lumber Manufacturers Association, was finally adopted in 1948 after the first edition was published as recently at 1944. Finally, what will probably turn out to be the most significant milestone in the history of the industry, was the formation in 1952 of the American Institute of Timber Construction, which is the national trade association for the timber fabricating industry. Let us close our milestones of the past appropriately with the one we are so rightfully proud of right here at home, the opening of the new Oregon Forest Products Laboratory in 1958. Now to mention a few of the high spots in the accomplishments of the industry. I think that probably the earliest structures of spectacular dimensions built of engineered timber, were the wooden blimp hangars of World War II. Each of these structures covers 7 acres, has a span of 296 feet, is 170 feet from the floor to the roof, and the building is 1,000 feet long. I have heard it reported that these buildings are so big that clouds have formed and it has rained inside the building.

A structure that probably has been one of the most photogenic was built at West Palm Beach, Florida. No article written today, which includes pictures, is considered complete without a picture of this building. This is a sports arena, made up of 12 great arches of glued laminated Southern Pine. These arches span 242 feet with a rise of 74 feet. Each arch weighs over 15 tons and contains about 17,000 board feet of lumber. These arches, at 242 feet, did not hold the record long because only a year later, some 254 foot arches were built in Schenectady, N. Y. Another glamour girl, right in there for honors of an outstanding timber structure, is a 300-foot clear span dome at Montana State College. Glulam bowstring trusses have been built in spans up to 250 feet. A school building here in Oregon has some straight beams that are 7 feet deep and 134 feet long. In our neighboring State of California, there are two wooden radar towers that are built triangular in plan with the sides of the triangle at the base being 80 feet, and each tower 357 feet high.

Another very unusual building that we can almost call an old-timer by now, since it was built in 1929, was of lamella type construction, with a clear span of 164 feet and a length of 450 feet. The individual lamella members were made of Douglas-fir 4 inches thick and 20 inches wide.

Fir plywood's development of the 2.4.1 system, and the diaphragm roofs, contributed greatly to the use of wood as an engineered material. The wood-treating industry has played a prominent role in engineered timber construction. Where use conditions require it, pressure preservatives can now add 50 years to the service life of our wood structures, submitted to the most severe conditions of insect and decay attacks. The treaters also give us today a fire-retardant treatment which satisfies the fussy insurance rating bureaus' definition of "non-combustible." Combined preservative-fire-retardant pressure treatments are already an accomplished fact.

I could go on for quite some time citing outstanding and spectacular uses and dimensions, but I will draw this phase to a close by telling you that the largest timber structure ever built, that I know of, is a warehouse, completed only two or three years ago. This warehouse has 773 bowstring trusses and 545 glued laminated timber girders. This entire building covers 28 acres under one roof.

I have admittedly been doing a little boasting for my industry and I am going to do a little more before I finish. I have so far mentioned only spectacular dimensions. What about shapes? You name it and we'll make it. Flat, or pitched, all kinds of curves, tapering sections, domes, and what about uses? We haven't been stumped yet. I challenge any construction material to exceed what can be done with wood for esthetic beauty in a church chapel. What about buildings to be used for products where that product is a hardship on the building material, such as corrosive atmospheres? They used, for example, glued laminated beams and columns for a chlorine plant. And, wood structures are performing excellent service for the humid atmosphere of covered swimming pools. Probably the most severe test of all, where glulam is performing an outstanding service, is in marine construction, such as mine sweepers. Let's at least mention the millions of little barn rafters that have been built in glulam, and mark you well the increasing use year by year of small size glulam beams in residential home construction.

I had to go through this sort of a preamble to give you some idea of how difficult my assignment is. I am not sure whether I have enough of a Jules Verne type imagination to cope with it. These spectacular achievements have been made, not in our past century, but in our past quarter century. If this curve continues upward on the chart of progress as it has in these most recent years, what mortal man can pretend such conceit as to predict what a speaker might be boasting of in timber construction when Oregon celebrates its bicentennial. I should like to outline what I think will be done or at least should be done in the years ahead in the field of timber engineering.

Starting first with the source of our construction material, the tree, I expect very spectacular progress in the field of forest products for chemical products. In fact, I fear that some day the tree will be so valuable that we won't be able to afford to use it for construction material.

Please permit me here a little admonishment to you who are going to be growing these trees of the future. Do not let your goal be nothing more than just seeing how fast you can grow the maximum cubic feet of wood. Let us first use the stumps, the roots, the limbs, the mill waste, and such materials for our chemical products, and I challenge you that you must, at the same time, give us a tree that will produce a structural building material that is not only as good as we get now from our old-growth stands, but even better.

Now, let us move on into the area of manufacture. In this classification, I am naturally going to talk about manufacturing in timber fabrication and lamination, but let us not overlook the fact that the old sawmill plays a role in this scene too. It is only prudent to presume that the sawmill will further improve and refine its products. We can expect more accurate sawing tolerances, advanced grading techniques, improved seasoning, and many more incidental refinements. This old workhorse will contribute its proper share for the increasing use of engineered timber.

In the manufacturing phases of fabricating and laminating, the lumber comes to the plant. It may be dried at the mill, or the laminator may dry it. One place or the other, it has to be dried to 10 to 12% moisture content. It may have to go through a regrading process. There is not presently a glulam grade, as such, in the grading rules. It goes through a scarfing machine. Then the lumber goes through the glue spreader. It is laid up in racks, one piece on top of the other, clamps are attached and pressure applied. Then it comes out and goes through the big planer. They may be sanded and wrapped for shipment.

All of these operations will be improved. Present scarfing to slopes of 1 in 10 wastes about 10% of the lumber. This cannot be tolerated. The answer may be finger jointing, or more likely some method we haven't yet imagined. Several people are at work now on a glulam grade that will give a considerably higher degree of utilization.

I have been doing a lot of talking about wood and lumber; now we come to the point where we must say something about adhesives. We presently have what we in the business call water-resistant adhesives and waterproof adhesives. Using a very general average now, the waterproof glues cost about three times as much as the water resistant glues. This is a lot less than it used to be and the differential is going to continue to narrow. I predict that the time is not very far off when the timber laminating industry will be using almost 100% waterproof glues. This will answer many of our problems. The present manner of applying the glue is messy. It may be that our glue will come to us like a roll of wrapping paper on a spool, and I can see some 2 x 6's come spewing out of a machine where the ends have been preglued and then this roll of glue goes 'zip' down the length of the piece and another 2 x 6 flops down on top of that and the roll comes back again, and so on. Then, when enough pieces have been made so that the desired depth of the beam is realized, some clamps, arms, or frames of some kind will pop up out of the wall or out of the floor and bind this assembly together in the flash of an eye. Then there will be an automatic application of heat, radio frequency, or a bolt of lighting, or something that will cause a chemical reaction to act on those strips of glue and they will immediately bond, and the whole process will take about five minutes instead of several hours. If Jules Verne can do any better than that, I would like to see him do it.

Now, as far as fabricating tools are concerned, like sawing and drilling and dadoing and dapping, ripping and shaping, etc., let me illustrate that by a story. When I first got into this business about 17 years ago, another firm decided to get into the business and they sent some men to look at our plant. They took measurements and drew sketches, and we didn't mind at all that they were copying what we were using because what we didn't tell them was that we had some new tools and equipment being made, and if this new outfit made theirs according to what we were using now, by the time they got them going we would have our new ones going and be two years ahead of them. The guy that worries me is the one who starts out from scratch because he is apt to think up something better than what we have.

This story may seem a little far-fetched, but it does illustrate just how quickly we improve. At the same time, it also illustrates another point quite well. One of the biggest burdens that any new fast-moving industry carries is obsolescence. Good management is always after research and development to cut down the costs and improve the product, but it takes your breath away when they come in with a new way of doing it after you have just invested x-thousands of dollars in installing the machines or the methods you use right now. This business requires a lot of good judgment and a lot of experience. "Good judgment comes from experience and experience comes from poor judgment."

So far, in this subject of Wood Engineering, I have been talking mostly about the wood part of it. Now, for a look at the engineering part. A question that is very often thrown at us in this business is "What is the factor of safety?"

I am going to crib a little bit now from a speech made by Lyman W. Wood at a meeting of the American Society of Civil Engineers last year in Portland. I like his definition: "The factor of safety is the provision for something beyond the foreseeable conditions of structural use. The factor of safety is almost the factor of ignorance." He lists 13 factors affecting safety in timbers used as beams or joists, as follows:

1. Variability of the clear wood samples
2. The indeterminancy of the stress analysis
3. Standard sizes
4. Depth factor
5. The efficiency of the grading rules
6. The efficiency of inspection
7. The range of defects within a given grade

8. Variation in size
9. Imperfection of fabrication
10. Temperature
11. Duration of load
12. Expected load versus the actual load
13. The conditions of service

If each of these factors affecting timber engineering is improved just a little bit, and all are added together, there can only be one conclusion—startling progress for the years ahead. We shall have solid sawed lumber of 2,000 pounds fiber stress as easily as we today have 1,500 pounds, and 3,000 pounds fiber stress for glulam as easily as we now have 2,600 pounds.

Now perhaps you see why I first had to mention the tree, the sawmill, the fabricator, the laminator, the glue manufacturer, and the engineer. We do not just simply dump this in the lap of the laboratory.

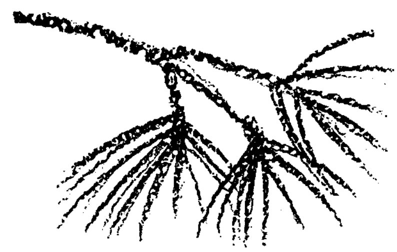
I made reference earlier to a big boost that timber engineering got during World War II with the large program that was sponsored by the War Production Board. I wonder now, if we have to wait to have another war? The logical question arises, that if, as a result of that program of testing, we were able to use a 20% increase in wood stresses over values formerly used, could we do it again? Let us presume that this challenge will be recognized and that all of these people will cooperate and each share their proportionate share of the burden. If this is done, I will predict for the future, with complete confidence, progress in timber engineering that will deserve the complete complement of Hollywood adjectives.

In the crystal ball act, we must include the enthusiastic predictions of the plywood people for the use of fir plywood as an engineered construction material for structures such as stressed skin panels, vaulted roofs, box beams, folded plates, and component construction.

As I name these people who will participate in the progress of timber engineering, I have not said anything about the educator. The roles of the forestry schools and the schools of engineering are so obvious that it almost seems needless to point them out. The schools are the very bedrock and the foundation upon which must rest all of these other things I am talking about. If we expect these people to contribute their share in the progress of tomorrow, we take it for granted that our schools will continue to give us the men of tomorrow to accomplish these objectives.

Fire safety in timber construction must be mentioned, because it does have a very proper and important role as another of the several factors that have been outlined for the future of timber engineering. It will play a major role in that increased education and publicizing of the fact that timber, as we now have it, with proper design and protective appliances, is fire safe construction. More research and publicizing to combat unrealistic insurance ratings and restrictive building codes will probably make this the largest factor of all to open up new markets and increase the present markets for timber construction.

We, who sell timber, like all the others, have our contribution to make to the progress of the future. We are going to have to stand there on the front firing line, face to face with the architect, contractor, the builder, the owner, and convince him that he should use wood construction. We need make no apologies for timber. As a structural material, timber has stood the test of time for ages. Assume for a moment that wood had never existed—plenty of stone and clay products, metal, and glass—but no wood. Suddenly, out of the research laboratories comes this amazing new product. This new material is available in vast quantities. The supply renews itself so that the product will always be available. It is strongly competitive in cost. It will not shatter when struck. Its resilience permits it to absorb shocks that would rupture or break other materials. It has fine natural insulating qualities. It can be produced in large sizes and in any shape. It can readily be worked up into items of exceptional delicacy. It stands up ruggedly under abuse. When properly used, it will last indefinitely. Left in its natural state, it offers an infinite variety of beautiful patterns. Painted, it presents a smooth, attractive, enduring service. It is electrically nonconductive. It will not rust. It will not corrode. It has the highest strength for its weight of any construction material yet made. Yes, if discovered today, wood would be hailed as the perfect building material of today and tomorrow.



Population Pressures in Years Ahead

Forestry Legislation in Next Hundred Years

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TO FORECAST legislation on forestry in the next 100 years with any degree of confidence calls for far greater ability in reading the crystal ball than I possess. We have only to look back at the changes in the last 50 years in laws, technology, and uses of forest products to realize how risky it is to try to predict laws for the span of a century.

I begin by expressing this hope: that we in our generation do a better job of writing laws for forests than did our forebears a century ago. They failed to comprehend the nation's forest problem, to legislate wisely to solve it, until very late in the nineteenth century. This failure is most conspicuous in the pattern laid out for dispersal of the government-owned forest and other lands in the Far West. The pattern was that of parcelling out tracts to settlers in blocks of 160 acres to provide them with a home where they might make a living. This pattern might work in the well-watered, level, or rolling lands in the Middle West, but it was not suited to the deserts or the forested mountains in the 11 western states. The concept was that of an agrarian democracy. The forests were to be cleared to provide homes for farmers. Thus the grant of lands to the Oregon and California railroad provided they should be sold in tracts to settlers at $2.50 per acre.

So the major portion of the western forest lands were distributed under the Homestead Act of 1862 and the Timber and Stone Act of 1878, or else dispensed in the great railroad and wagonroad grants on a checkerboard pattern. This resulted in a fragmentation of ownership quite unrelated to the facts of economic geography. Not only were the forest lands of the Pacific Northwest ill-adapted to agriculture, but the fractionated ownership by rectangular surveys destroyed the chance for an orderly and economical harvesting of their timber.

We all know the sordid story of the land frauds; but they were induced by the legislation enacted for dispersal of the public lands. Individuals simply could not hold onto their forest claims until there was a market for the timber, unless their lands were fortunately situated. Many were the financial tragedies of those who tried to hold on. Fortunes have been made in recent years by those who purchased timberlands from holders financially exhausted or from counties land-poor through tax foreclosures.

The wide dispersal of forest lands did prevent or retard monopoly ownership and doubtless accelerated regional development. But economics has forced consolidation of ownership into what we call "strong hands" either before cutting or after, a process which has been going forward rapidly in this postwar period.

Unfortunately for the forest lands of Oregon and Washington, there was not someone like John Wesley Powell whose Report on the Arid Lands in 1878 stands as a benchmark in planning the management of lands in the intermountain region. He saw that 160 acres or even 320 acres offered under the Desert Land Act of 1877 would not sustain a family. He recommended grants of 2,560 acres laid out according to the natural terrain and not by the checkerboard of surveyed sections, each grant to include 20 acres of irrigable land with a vested water right. He urged too the policy later adopted in the creation of irrigation districts, with water rights based on the riparian doctrine but on impoundment of waters and distribution through canals to thirsty acres.

I know of no John Wesley Powell who recommended the blocking of timber by drainage basins, which we recognize now is the practical way to manage and harvest our timber. Fortunately, before the wreckage was complete, Congress acted to create national forests from the remaining spread of public forests. These are held in large blocks to permit efficient management, protection, and harvesting of trees.

In the past 75 years both legislators and the public, and somewhat tardily the timberland owners have learned first, that there is a legitimate national interest in the forests, in which the national forests are a fit expression; and second, that private ownership of timberland is encumbered with a large measure of social obligation. This last is expressed in legislation for fire protection and suppression, and in the prescription of conservation practices; in the contrary direction, in appropriation of public funds to protect the forests from fire and pests.

From this vantage point, on a ridge between past and future, let us cast a look ahead to see what the probabilities and possibilities are in forest legislation.

As far as federal legislation is concerned I believe we have reached what the civil engineer calls an "angle of repose." Land acquisition for national forests authorized by the Weeks Act of 1911 seems to be dormant. States and local units of government resist extension of federal ownership and resulting loss of taxable property. The only considerable acquisition in sight, lands of the withdrawing Klamath Indians, is a special situation. Land and timber exchanges are being made, but in limited amount, partly because private owners want to retain cutover lands. Defeat of the D'Ewart bill covering grazing in national forests, preserves these lands primarily for forest management. Occasional talk of disposing of national forests or turning them over to the states lacks public backing. Currently there is no agitation for imposition of federal conservation practices on private lands such as alarmed private landholders 20 years ago.

The most important federal change in prospect is the consolidation of the now divided forest management into one department. This was recommended by a congressional committee. It may come by executive order, effective unless there is a veto by Congress. Some opposition to such a consolidation is heard at tree-root levels. Many timber buyers like the idea of continuing "competition" between the Forest Service and the Bureau of Land Management.

One legislative issue presently being pushed is the Wilderness bill, designed to secure selected areas as virgin wilderness, offering Americans a permanent refuge from the strains of everyday living. It will be discussed later in connection with other conservation matters.

We may expect continued pressures on Congress for changes in forest management, such as acceleration of access road contruction; for spelling out of sales methods (by scale or by cruise); and perhaps for further legislation like the 1958 amendment to the Small Business Act which is an attempt to spur offering small lots of timber for purchase by small operators.

At different times more grants-in-aid for specific purposes may be voted. The benefit provided by the Clarke-McNary Act of 1924 carrying federal funds to aid in fire protection seems to be securely established.

The arrow no longer points to the "chosen instrument" type of agreement for reservation of government timber to selected operators. Only one such unit was set up, at Shelton, Washington, which seems to be working very successfully. Opposition of the prospective "unchosen" instruments has prevented extension of this policy. The retreat from the philosophy of protecting local communities also may be seen in the abandonment of marketing areas under the O & C administration.

On the federal level we may see divorce of surface rights from subsurface rights, ending the grant under mining patents of proprietorship of the surface.

If weather control comes even partially within human hands, that would call for national legislation in which those responsible for forest growth and protection would take interest.

To sum up: No drastic changes in federal laws relating to ownership and management of forest lands are presently in view. But the period of stability may be short because of the gathering pressures of a fast-growing population to realize the values which forests have to offer.

State Legislation

Turning now to the state let us make a quick review of the landmarks in forest legislation:

- 1911 State Board of Forestry created
- 1913 Fire patrol made compulsory
- 1929 Reforestation act to encourage reforesting of private lands
- 1939, 1941 Creation of state forests, enactment of first forest conservation act, initiation of forest research
- 1948-49 Adoption of state-financed program for rehabilitation of state forest lands
- 1953 Strengthening of forest fire laws

Now what about the future?

A nearsighted person has only to glance in his crystal ball to see that the most acute legislative problem is taxing of standing timber. This has developed into a major issue in Oregon as the statewide reappraisal program came to the reevaluation of timber stands. It has been fought over in assessors' offices, before boards of equalization, by the state tax commission, in courts, and now is a subject for consideration by the present Legislative Assembly. Here again diversity of ownership and of intentions of owners is a complicating factor. Owners of other classes of property who observe the high prices realized in timber auctions and the comparatively low valuations given timber on assessment rolls think they are being robbed. But there is a growing realization that too heavy a tax burden will speed up the timber harvest and thus exhaust for a period of time the economic resource of the community.

There are, in my opinion, two problems involved. One is the formula for taxing the remaining virgin stands which still are extensive in some areas. The other is the adoption of a long-term tax formula covering regrowth, extending, we hope, into the indefinite future.

As to the first problem, it seems a sound principle to spread the tax over the expected life of the stand. The tax should be equitable with respect to other classes of property. There is danger in this situation that rivals within the industry, motivated by their self-interest, will defeat efforts for a sound method of taxing virgin timber, a method which will encourage orderly marketing of this stand needed to bridge over the period when new growth will be ready for cutting in volume.

As to the long-term method of taxing timber, if we retain the *ad valorem* system, timber should be regarded as a crop, with taxes accruing according to annual increment with due regard to sites and species. Or we might go to a combination land tax and yield tax. Some object to the latter because of irregularity of revenues received by taxing districts, and because of irregularity in cutting. However, as school districts are consolidated into large units, the possible hurt from this cause would be reduced. Or some reserve pool could be established to even out the flow.

Urgent as a decision on this vexing issue is, if a satisfactory solution can't be arrived at during this session of the Legislature the subject might well be referred to an interim commission, broadly representative, for study and report with recommendation.

The future of private forestry in Oregon depends in great degree on the reasonableness of the tax burden. No private individual or corporation has carried timber through a century as a self-sustaining operation. The Tree Farms now so popular have yet to prove themselves over the long pull. To quote one veteran in Oregon forestry:

> "It is immensely important to Oregon's economic future that the tax system be truly encouraging to the growing of timber and to the holding of timber, not merely to the time when it is barely merchantable, but to the time when it should be cut in accordance with sound plans of timber management."

Both taxing bodies and the public must realize that the prime value of the forest is not in the taxes which may be extracted from it but in its yield in materials, in employment, and in fair return on honest investment.

Oregon has one tax problem which has been little publicized. That is the excessive cost of the fire patrol tax on some marginal lands, where grazing is the chief use. The value of the forage to livestock may not equal the fire tax and the *ad valorem* tax. The state may have to assume part of this cost for general protection. That is contemplated in a pending bill, H.B. 394.

Another phase of fire loss may come in for attention, and that is some means of spreading the burden of fire losses, perhaps through some insurance system or state pool.

The second important area of state legislation is probably in conservation of trees, soil and water. The 1941 act which aimed at insuring reforestation is outmoded. In the pine belt the residual tree stand required is not sufficient to bring adequate reforestation, as was reiterated in discussions on the sale of the Klamath Indian lands. In the fir-growing section the prevailing practice now is to clear-cut and then to restock by aerial seeding and hand planting. This insures a better and quicker stand. A thorough-going revision of the 1941 act is proposed in H.B. 108, under consideration by the present Legislature. It fixes restocking standards by tree types, such as Douglas-fir, spruce-hemlock, ponderosa pine, etc.

In the future, much stronger legislation for forest rehabilitation may be written, with a requirement of reforestation on individual tracts according to standard tables of productivity. Some estimate the demand for timber by year 2000 at 105 billion board feet a year. Present growth is under 50 billion board feet. As demand grows to those dimensions there can be no idle acres of lands adapted to growing trees.

It is also possible that within the century timber cutting may be put under strict regulation, covering thinning and age of stand for harvest for specific uses.

Conservation in forested areas goes beyond trees. They are the habitat of wild life. They hold the springs of streams and lakes. Their openings furnish forage for livestock. Their canyons offer reservoir sites for power plants. Their trails invite hunter, fisherman, recreationists, miner, grazier. The variety of the resources in forest regions leads to conflicts over use; and those conflicts promise to grow sharper as more persons want to hunt, fish, build dams, cut timber, camp, hike, and drink in the glories and the beauty of nature.

Others will talk on different phases of this competition. One legislative issue pends now in the Wilderness bill in Congress. It would freeze as wilderness areas selected in a 10-year period, but permit a change in boundaries unless there is a congressional veto. The bill is strongly supported by lovers of the wilderness, and strongly opposed by their rivals. Whether the bill passes or not, the pressures for retention of wilderness will increase as the population grows and becomes more urban in character. There will have to be appropriate compromises between the commercial and the esthetic; and that will be worked out, one way or another. We are finding, for example, that it is safe to cut timber on watershed reserves, once kept sacred against trespass.

In the fairly near future, legislation probably will be proposed to regulate logging practices to reduce soil erosion and resulting stream pollution which muddies the waters and fouls spawning beds. The present style of logging, with many roads bulldozed through the woods and heavy logs dragged on arches, tears up the surface, exposing the soil to fast erosion. Sales contracts on public timberlands admonish the logger to protect the soil, but nothing is done to protect soils on private lands. The problem invites attempts to find a solution by writing laws, and that may bring up the question of compensation where, as in narrow canyons, logging costs under the restrictions might be too costly.

At the manufacturing end, laws already on the books aim at preventing the pollution of streams by mill waste and pollution of the air by discharges from mill stacks. Increasing industrialization will require more protection against air and water pollution.

As the number of professionally trained foresters grows, legislation may be sought for state licensing of foresters as is required now of engineers and other professions. It would give status to a qualified group and should result in higher standards in forestry management.

At this point my crystal ball becomes clouded. I admit I am no John Wesley Powell to lay out a blueprint for future legislation in forestry. I am sure that we shall have more legislation, and that it will be directed toward protecting the public interest in both public and private forests and in conserving forested regions for varied uses. The woodsmen with axe and saw have cut their way across the continent. Now legislators, administrators, trained foresters and scientists, leaders in public life and in industry must lay out the blueprint for perpetual forests and the proper conservation of forest land resources.

Population Pressures and Forest Recreation

THOMAS J. WILLIAMS
Superintendent, Crater Lake National Park, Crater Lake, Oregon.

THE DICTIONARY defines *recreation* as "Refreshment of body or mind by some form of play, amusement, or relaxation." I'll buy that.

I shouldn't have to define *forest* in this company, but I will because there might be someone here besides me who isn't a forester. The dictionary says "A forest is a large tract of land covered with trees and underbrush." That's an American forest. The dictionary also says that in Great Britain a forest is "a tract of woodland or wasteland, usually the property of the King" or "a tract of land formerly, but not now, covered with trees." For my purpose, I regard a forest as a tract of land with trees on it.

We used to have a lot of forest land in these United States. Over half the area of the United States was once forested, and it was said that a squirrel could travel from the Atlantic to the Mississippi without touching the ground. However, during our national lifetime, we have behaved as though our forest resources were limitless, and as a result, only a remnant is left. The reason we have as much forest as we do is that most of it was gradually brought under competent, professional management.

By combining the definitions of *recreation* and *forestry*, you might come up with a definition of *Forest Recreation,* such as "Refreshment among the trees and brush," but it is not quite that easy. The people of this country want the best—they're used to it. They want hunting, fishing, hiking, and camping in the best forests we have—and what's more, I think they'll get it. You see, most of the forests are in public ownership, and if the people want to use their forests for recreation, they will, conflicting uses notwithstanding.

Now, we come to *Population.* You don't have to mention pressure, for pressure goes with population just as ham goes with eggs, or pork with beans. Back in 1790, when the land was largely forested, we had 4 million people. At the close of 1958, we had over 175 million. There were 4 million births in this country last year, and only 1.6 million deaths. Since I've been standing here talking to you, there have been 30 babies born in the United States. They are produced at the rate of one about every 8 seconds, and the production peak is not yet in sight. Eighty-five percent of all our babies are produced by women between 18 and 34 years of age. We have 19½ million in that bracket today. Twenty years from now there will be 32 million of those lovely creatures on the production line.

To anyone concerned with western forests, there is another item to be considered, the *westward shift* of population. This movement is expected to continue until approximately 40% of the nation's population resides west of the Mississippi. To illustrate this trend, during the years from 1940 to 1950, the population of the United States increased 14½%. During this same period the people in the State of Washington increased 37%, Oregon 40%, and California 53%.

Now for some other factors that have a considerable bearing on forest recreation. Although an individual needn't spend much money on forest recreation, recreation time and money is influenced by the *National Economy.* Today the family income is $5,300 per year, and by 1975 is expected to reach $7,000. According to economists, the increase will continue.

And another little thing to consider when trying to determine how many people you will have in your campground on the 4th of July weekend in the year 2000 is *The Work Week.* One hundred years ago the average work week for all employed people, including agriculture (that's farmers, not the Department) was in excess of 70 hours. Today it is 40 hours, which leaves us about 70 hours of leisure time per week. There is reason to believe the work week will soon shrink to 37½ hours. More people get paid vacations; they are retiring earlier and living longer. Now, that's all to the good—it's progress—and I'm all for it, but consider the potentials. With every additional hour of leisure time, it adds 40 or more miles to the driving radius of more people with more money in search of recreation.

Transportation will affect recreation pressure on the forests. We have millions of miles of good roads, and we are operating some 50 million automobiles on them today. Actually, there is more land covered by streets and roads than is contained in our National Parks. Millions of those automobiles are dragging trailers behind them. It is estimated that by 1966, one out of every 10 persons in the west will be living in mobile homes or using them for vacations. Somewhere I read that an object moving at great speed possesses a greater mass than the same object at rest. I am not too concerned about the 50 million automobiles and the millions of house trailers and boat trailers so long as they are moving. But when they come to a halt at a fishing stream, a picnic area or a campground, that moving mass becomes a monumental mess, unless preparations have been made far in advance of their arrival. All roads no longer lead to Rome, but most western roads lead into a forest. No one, least of all foresters, should take false comfort in the smug feeling that a forest is safe from population pressures because it is remote. With transportation improving constantly, there will soon be no such thing as a remote forest.

Still another potent factor is the *Recreation Industry.* Back about 1908, American businessmen noted they were missing out on some 400 million dollars a year that Americans were spending in Europe for recreation. So they coined the slogan "See America First." That was the real start of the outdoor recreation business in this country. Today, recreation is a 50 billion dollar industry, and is growing at twice the rate of the national income.

Last year that industry was largely responsible for 450 million visits to forested areas such as National Parks, National Forests, Wildlife Refuges, State Parks and Reservoir Areas. In collecting statistical data it has been difficult to draw a definite line between outdoor recreation and forest recreation. I have arbitrarily ignored city and county figures (which included over a billion visits) and believe the omission will more than offset any nonforest data included in the figures I do use. To give you a rough idea of the growth of forest recreation in the National Parks, in 1916 1 out of every 300 people in the United States visited a National Park. In 1958, more than 1 out of 3 came to see us. And don't overlook the fact that during the period the population increased 75 million. Last year the National Parks had over 58½ million visitors. The National Forests had almost 61 million. State Parks had 217 million. In the past 15 years, the average annual increase of visitors to National Parks, National Forests, and State Parks has been about 10%. This growth rate can't go on indefinitely, but we are preparing for a continuing increase during the years ahead.

An interesting figure on camping is the report from Yosemite National Park. In 1946, 92,000 people used campgrounds in Yosemite Valley, and 12 years later there were 202,000. And at Crater Lake National Park (the park I love), campground use has jumped 59% in just two years. The Forest Service reports their rather recent estimate of 47,600 campsites needed for 1960 is now 50% short of what will be required. The way it stacks up today, recreational use on forested land is already far ahead of the dedicated land and the developments necessary to provide for, and insure an orderly use.

According to a recent survey, there are in the 49 states, more than 240 million acres available for recreation—available in the sense that the land is suitable for recreational use and development. There are, however, only 48 million acres, such as parks, wild areas, wilderness areas, etc., used primarily for recreation. There is that much forest land burned every 10 years. Congress has indicated an awareness and an appreciation of the situation by its favorable reaction to the National Park Service's *Mission 66* which is a conservation program designed to protect and preserve the National Parks through proper and adequate physical improvements, and adequate staffing to guide and supervise public use. In the same vein, Congress has supported the Forest Service's *Operation Outdoors,* which is designed to develop the sorely needed recreational facilities on the National forests. These programs are valiant efforts, and the results thus far encouraging, but they are not enough—not when applied to the entire outdoor recreational deficiency.

Now comes the crux of this topic—How will it be tomorrow in the forest recreation business? To forecast anything—the weather, the market, or recreation travel—we have to correlate trends and facts. Here are the facts, as I see them: We know that our population today is 175 million; that we have 50 million automobiles; that we have 70 hours of leisure time each week; that the average family income is $5,300 per year; that the recreation industry grosses 50 billion a year and is increasing at a phenomenal rate; that good highways reach into every nook and cranny of our land; that we have only 48 million acres that are more or less earmarked for outdoor recreation. We know too what the increment of growth has been for all these factors. Having laid down these cold facts and figures, I now pick up my crystal ball. If, at the close of this talk, some of you think my crystal is cloudy, I'll not be surprised. I'll respect those who see the recreation picture differently than I do, and I'll need to understand their views in order to understand my own more clearly. In any event, here's what I see for the year 2000.

1. Our population will be 300 million, and 120 million of them will be living west of the Mississippi, close to most of our forests. The other 180 million will be just two or three days away.
2. Those people will be driving nearly 100 million automobiles, on more, better, and faster highways.
3. They will have over 75 hours of leisure time per week, plus paid vacations, plus holidays, totalling about 4000 recreation hours a year—almost half the hours of the year.
4. The average annual family income will be in excess of $10,000, and the national economy will climb beyond the trillion dollar mark.
5. We will probably have more forest area than we have today. That's not wishful thinking—I believe the public appreciation of forest values is gaining and will eventually pay off.
6. Much, much more forested land will be used primarily for recreation, and it will be just as crowded as it is today.
7. Economically, recreation will surpass lumbering as a forest resource.

Let me interject a word of caution and hope here for any Simon-pure, pristine logging forester who might be present. Don't go out and commit hara-kiri on the basis of my prophecies. Your job in the year 2000 will be more exacting and more demanding than it is today. You'll have to produce more timber and better timber on less acreage, which you can do, and you'll overcome volume deficits by better utilization. Incidentally, in the year 2059, a sawmill of today's type will be something of a curiosity. Science and necessity will make it so. I believe that most forest products will be going through the chipper—it will be a pulp show. And if it will cheer anyone, that means a shorter cutting cycle—a more frequent harvest. You all probably know, but I'll remind you that forestry was the first specialization in the management of the earth's natural resources that became a profession. And I am confident that the forestry profession will cope with the problems ahead even though accompanied with headaches for which there will be no aspirin.

Now, how much recreational use will the forests get in the year 2000? The most conservative formula is the projection of today's ratio between population and forest recreation visits. That will net us over 775 million visitors. Another formula, projecting the average annual increase of forest visitations for the past 15 years, would bring just under 2 billion visitors during the year. A third formula—and all these formulas are hard to question when you examine the facts upon which they are based—forecasts an increase of from 4 to 40 times the present demand on outdoor recreation facilities, depending upon the distances involved. The type of outdoor recreation that is promised 40 times today's pressure is forest recreation. I tried applying this to the National Parks and the National Forests and I gave it up—I got scared. You can take any of these figures you wish, and discount them, and you'll still get a staggering figure.

I believe everyone here will agree that forest recreation is more than a fad. It is a resource, a business, and a big business. Hiding our heads in the sand of controversial evaluations won't make it go away, or reduce the problem. It is something that must be taken care of, provided for, and it isn't a one-man or a one-agency show. Almost anyone who owns or manages a clump of trees will be in the business, ready or not. It is my opinion, but doesn't originate with me, that the only solution is a nationwide, integrated plan to provide for the land and the developments, and thus insure orderly recreational use of our forests. This is a "do it yourself" age, and if we don't provide the necessary space and facilities, John Q. Public will, and it won't be orderly. He's doing a bit of it now, and it isn't orderly.

A most encouraging action along this line occurred last June when the Congress established the National Outdoor Recreation Resource Review Committee, which will inventory our recreation resources to determine the needs for the year 2,000, and recommend policies and practices to meet the demands. We were caught with our plans down by this sudden surge of forest recreation use, which is no particular sin. But I believe it a cardinal sin to leave them down.

Another step in the right direction, and one I also like, is the recent bill in Congress for a modified Civilian Conservation Corps—the Youth's Conservation Corps. Forestry in all its phases would be a major beneficiary of such a program. It is one plan that might insure rapid and adequate development of forest recreation facilities. Dollar for dollar, I know of no investment that should pay greater dividends to this generation and to the generations of the years ahead. All of them are entitled to the quality of recreation that can be found only in our forests—their forests.

The development of an adequate, orderly forest recreation program comfortable to all is going to depend upon the understanding and cooperation of just about everyone, and that includes the "amateur forester," the "bird-watcher," the "timber baron," the "dam builder," the "cattle king." There is keen competition among the several users of the forests, and each of them through lack of understanding of others' plans, is suspicious, and fearful that if he relaxes his own offensive for a moment, he will find himself in the unenviable position of the big game hunter in Africa who shot at and missed a lion. In his haste to get off another shot, he jammed his gun. As the lion advanced, the hunter fell to his knees and started praying. He was startled to see the lion sink to its knees, and he breathed a fervent "Thank God for a Christian lion!" The lion looked up, licked his chops, and said, "I don't know about you, brother, but I'm saying grace."

This condition of suspicion, an unhealthy one at best, can and will, I believe, be corrected by an integrated plan in which forest space will be assigned commensurate with the importance and requirements of the use. There will be too many people, and too limited forest space to endure anything less.

Theodore Roosevelt, a patron saint of foresters, said, "conservation of our natural resources and their proper use, constitute the fundamental problem which underlies almost every other problem of our national life." What is proper use? What is proper forest use? Timber production and harvest is a proper use, as is grazing. And so is recreation. There is a place for all of them and all of them will take their places. And if I were a betting man, with 100 years of life expectancy, I'd lay you odds that watershed and recreation will be the leading uses of the forests in the year 2059, for they are the only forest uses I can think of that will permit us to "eat our cake and have it too."

The Challenge to Watershed Management

REED W. BAILEY
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THE COMING CHALLENGE to watershed management is an open invitation to an old dog to worry an old bone. I have talked on the subject of watersheds and their care so many times in my career that I suspect I often sound more like a missionary than a scientist. However, it is appropriate to discuss our mission in conservation and how well we are fulfilling that mission.

Oregon State College has been a mainspring in conservation thinking as this Forestry Centennial Conference attests. Moreover, we are fortunate to have both State and National leaders in the use and management of our forest land resources in attendance at this centennial celebration. For that reason I would like not only to describe the physical challenge of watershed management in this region but the leadership challenge as well.

Anyone who looks back 100 years must certainly be impressed with how swiftly and drastically man can change the face of the earth. One hundred years ago—hardly more than a lifetime—only one-fourth as many people lived in the entire Northwest as live in Portland today. What has happened since may not be a population explosion but it has certainly been a dramatic growth. The taming of this once "unconquerable wilderness" has also been dramatic. If any Oregonian who departed from this earth in 1859 were to return today he probably would not survive the first major street intersection. But if he did, I am sure he would be unable to comprehend the other changes which have taken place since then. For instance, if he could see how the rivers have been harnessed, how the forests have been transformed, how gardens blossom where huge trees once stood, how desert lands have been made productive by waters from the mountains, it would seem more unreal and fantastic to him than the idea of flying to the moon does to you and me.

Two national phenomena have been at the root of this great transformation which has taken place in the Northwest. One is population growth, and the other is the vastly increased consumption of resources. Population has increased fivefold in 100 years. I don't have the actual figures but we know that because of our rising standard of living, consumption has increased considerably more than fivefold in the same period.

When you consider these compelling trends, together with the beauty and productiveness of the Northwest, it is easy to understand why people have surged into this area looking for both room and raw materials.

One thing which has become very clear in the past decade is that the upward spiral of population and consumption is far from finished. The extremely high population estimates for coming decades have been quoted so often that I won't repeat them. However, as you all know, the future holds "more of the same" for the growth of our whole country. Nothing less than a cataclysmic change can prevent additional expansion which will multiply the pressure both for room and for raw materials, here and elsewhere.

All students of the subject apparently agree that the national expansion now foreseen will be very significant from the standpoint of natural resources. But, from that starting point they go in several different directions. At one extreme is the "sanguine school" which heavily emphasizes our technical prowess. They point out that we are a very resourceful people and, further, that the earth we stand on is in reality a limitless reserve of usable material. They say that when resources common today become really scarce, science and technology can and will find ways to fill the gap with equally useful and abundant substitutes so that our standard of living need not suffer as population mounts ever higher.

Others, of course, take issue with this optimistic view. They point out that this numbers game will eventually catch up with us and that we cannot go on multiplying population at the present rate without eventually eating ourselves out of house and home.

I might as well admit that I am biased on this subject. I am instinctively distrustful of arguments which lay great stress on the capacity of technology to offset the physical consequence of depletion. There is much in history to support such distrust. I am well aware how clever we are but I feel such emphasis encourages complacency which in turn encourages national indifference in resource management. Then, too, I believe a land depleted of its forests, its slopes scarred by erosion, and its streams muddied by sediment suffers an aesthetic loss which must inevitably have a tremendous impact on social outlook.

Nevertheless, I suspect the truth lies somewhere between these two extreme viewpoints. The abundance we enjoy today can be prolonged far into the future by science and an improving technology. There is no question of that.

On the other hand, the upward spiral of population and consumption does raise some very sobering considerations. Not the least of these is that no matter how technically smart we may be, America is entering an era when maintenance of a productive environment not only will be more difficult but more important than ever before.

This brings me directly to my topic, "The Coming Challenge to Watershed Management in the Northwest." Water has become the limiting factor in the development of many localities, even in humid areas, and it certainly will become one of the most important political and economic challenges of the future. The Northwest with an apparent abundance of water, will not have a drop too much.

Some very interesting studies are now underway which may help improve the water supply situation. For one thing, a number of countries are seeking ways for low-cost purification of brackish and salt water on a large scale. Enough progress has already been made to justify optimism that sooner or later this problem will be solved. As you know, the science of meteorology has made amazing progress since World War II. It now appears that we may someday be able to control weather sufficiently to secure more efficient distribution of rainfall.

I am in no position to pass judgment on the extent of the opportunity in either of these fields. However, both possibilities are beside the point as far as conservation is concerned. Nothing can be done in the sky or sea to make more water available making it any less necessary to husband the water that falls on the land or any less desirable to keep the soil in place.

As we take stock at this centennial it is obvious that we are not at the point of crisis insofar as land and water conditions in the Northwest are concerned. To that extent there is reason for satisfaction. I don't mean the situation is perfect. In comparison, however, with some other parts of the West, Oregon and the Northwest have much to be happy about. You have only to turn to the Southwest and central Rocky Mountain States for proof of this. When the settlers followed the trappers into that area a little more than a century ago they turned their cattle and sheep into the mountains and a large part of their livelihood came from these livestock and livestock products. These same hills provided game with which to supplement their food supply and, more important, the water for drinking and irrigation of desert lands. These people were practicing the multiple use about which we talk so much.

As the years passed the number of livestock increased and because predators were reduced and hunting was restricted the number of big game animals increased also. In terms of number of head per acre the total population of domestic animals and wildlife was never large. But, in that region where the ecologic and physiographic balance is delicate, population pressure became critical early in the development of the area and overuse resulted.

The effects have literally been devastating. Gullies formed on many of the steeper slopes, and during flash storms some of them have poured mud and rocks out onto the farms and communities below. On many areas, such as the Wasatch Plateau, virtually the whole topsoil layer has washed or blown away because nature couldn't keep up with the livestock and big game.

The price of this destruction in the hills has been farmlands washed downstream or covered with subsoil, sediment-choked waterways, and reservoirs clogged with sediment. The huge Elephant Butte reservoir on the Rio Grande, one of the most important storage facilities in the Southwest, lost one-fifth of its storage capacity in the first 30 years of its existence.

Another price the people in that area are having to pay is that grazing which triggered the problem in the first place has had to be reduced, and in some areas eliminated. The small Upper Valley drainage near Escalante, Utah, is a good example of this. At one time 10,000 cattle and 10,000 sheep grazed in that basin. So complete was the destruction of forage that by 1955 no sheep were allowed on the area and only 900 cattle. A 95% reduction in livestock numbers is certainly drastic, yet competent observers felt that further reductions would be necessary before the trend of deterioration could be reversed.

The tragedy of areas such as Upper Valley has been more than the material loss of forage values and topsoil. The hopes and aspirations of people have washed away with them. Each downward step of the livestock industry has been marked by suffering and bitterness. Moreover, the end is not in sight. More suffering and bitterness lie ahead as well as a staggering job of rehabilitation.

In a way it is not fair to compare the watersheds of these interior states with the more humid and largely forested lands of the Pacific Northwest. Here you have more soil, more moisture, more latitude, and more opportunity for use than the Intermountain States ever had. Nevertheless, you could not make a bigger mistake than to say, "It can't happen here."

The environment of the Northwest, like the virgin environment anywhere else, is the product of the geological past. Thousands upon thousands of years were required to produce the slopes, to cover the rocks with a soil and plant mantle, and to achieve a degree of environmental stability. Civilized man had no part in creating the environment he inherited, but he has shown an alarming capacity to upset it in a relatively short time.

In the arid parts of the West, where the balance was at best very precarious, he had only to turn cattle and sheep on the range without proper restrictions to do the job. In the Northwest it will take more abuse from more people to upset the balance. But that can happen and it is happening.

Topsoil blowing off the Palouse, and muddy streams that were once clear are but two of the many signs that man has not completely solved the problem of living in harmony with his environment in the Northwest either.

Let me repeat some basic hydrologic facts that we have to live with in the Northwest as we do everywhere else in the world.

Where there is a forest-covered soil mantle, most of the water yield from a drainage basin occurs as seepage flow, yielded from a soil reservoir. This water reaches springs, streams, and underground basins by sinking into the soil and percolating through the rock mantle. Because it is filtered and delayed on its way, it is generally a highly usable flow.

Rain and snowmelt can also leave the land as overland flow. This occurs whenever rain falls or snow melts faster than the water can enter the ground. Whenever there is stepped-up soil erosion and increased sedimentation, you may be sure that this damage has been done by overland flows.

Whether a watershed yields runoff as seepage flow or as overland flow hinges directly on the infiltration capacity of every square foot of surface. Numerous factors, including the amount and intensity of rain, the slope of the land, the porosity and structure of the soil profile, and the kind and amount of plants and litter, influence the capacity of the land to take in water. Each of these factors also has a bearing on soil erosion.

The importance of vegetation in this picture can hardly be over-emphasized. It is the key to soil stability and to infiltration capacity of the soil. Trees, brush, and herbaceous growth serve to keep a way open into the soil for melting snow and rainfall. This process is also aided by the obstructions put in the way by every trunk, limb, twig, and leaf which cushion the impact of raindrops, and act as the first deterrent to runoff. The temporary delay so imposed promotes infiltration; it aids in getting rainfall immediately into the ground and thus shackles its erosive energy.

Reduction of plant cover, including the litter on the ground, leads to reduced infiltration rates and increased overland flow. When plants and litter are destroyed or thinned, soil is exposed to the direct impact of rain. Detached soil particles seal the soil pores and thus inhibit the entrance of water. In effect, the hydrologic behavior of the land is greatly altered. Erosive energy is unleashed and water becomes quickly concentrated into peak discharges. Overland flow rushes off the land, and moisture so essential to production of forage and timber is lost.

These effects of the plant cover in getting water into the ground and of keeping soil in place have been the subject of much study on almost every type of farmland and on a wide variety of forest and rangelands. The results have invariably been the same: Removal of plant cover and compaction of the soil, by whatever means, steps up overland flow, accelerating stream discharges, in some instances as much as 1000-fold. Stream sediment loads likewise have been increased many times over.

I don't want to seem to minimize the progress that has been made in conservation in general and watershed conservation in particular because I do not. The last half century has seen great progress. Fifty years ago it would have been difficult to imagine an industry as enlightened conservationwise as the timber industry of the Northwest is today. More than that, we have the greatest fund of detailed knowledge about land management in the history of mankind, and the public is interested in conservation as never before. And to top it off, this enlightenment, knowledge, and interest have been expressed in real forward progress on the ground.

Nevertheless, too much of our farming, logging, road building, and other dealings with Mother Nature are done without proper regard for the water-regulating functions of the soil and the plant cover on it. So long as that is true, the probability of greater population and greater pressure on the land in the years ahead raises the real danger that the story of the watersheds in other parts of the United States and the world will be repeated in the Northwest. In simple terms, I am saying that until now we have been only sparring with some of the watershed problems. The time has arrived to really come to grips with them.

It is safe to say that what this land of abundance in the Northwest will look like in another 100 years will depend largely upon our capacity to prevent environmental deterioration as the population pressures mount. To the extent that we don't prevent it, there will be unpleasant consequences. It is impossible to say specifically what they will be, but I know you won't like them. The end result in any case will be that our land will become less productive and we will not be able to take full advantage of the productivity that remains.

It is inevitable that failure to protect watersheds in the face of rising water needs will result in de-emphasis of multiple use. If we can't graze the rangelands without impairing water yields, public pressures will demand that we cease grazing those areas. That has already happened some places in Utah and elsewhere. If we can't log without muddying the streams and otherwise causing havoc there will be a clamor to stop logging. That has already happened in many cases. Until now the conflict with logging has been largely on municipal watersheds. But, as we harness more and more of the streamflow in the Northwest and as water becomes more valuable, the stage will be set for the spread of that conflict to watersheds in general. I do not need to remind you that when we abandon multiple use we will be giving up the economic gain which could be obtained from the uses we forego.

The problem then is to demonstrate that we can succeed where others have failed in meeting critical population pressures on our environment.

As a research director, I would be remiss if I didn't point out that we still have much to learn before we can meet this challenge. There is still a lot we don't know about how to use mountain land without abusing it. Farm people are far ahead of us on that score. Long ago they saw the need for study and have a well-developed research program, which is yielding solutions to many farm problems. Forest research, in all of its ramifications, has grown more slowly and needs to be expanded if we are to provide all of the answers needed for managing our wildland watersheds as quickly as they are needed.

However, it is easy to be hypnotized by the idea that research by itself will solve every problem. That is not true. The major challenge today is to make watershed management part of every action we take on the watersheds. The responsibility for that rests on all of us.

It is as if we had sketched out the plot of a play and sold tickets to the first season's performance but had not yet gotten around to writing the script so that each character in the production would know precisely what he should do.

In general, I think we have done a far better job of selling the overall idea of conservation to the American people than has been realized. There is less understanding as to individual responsibilities and that is where our educational program needs to be strengthened.

In my opinion, the time has come to write the script for watershed management and to embark on a program geared to the need of our times. In making this suggestion, I am aware that several attempts have been made in recent years to include watershed management considerations in drainage basin programs. However, while dams and other downstream water projects get built, watershed treatment programs fail to materialize or fall short of full accomplishment. Evidently we as foresters have failed to convince the public of the necessity for looking beyond the headgate and above the dams and reservoirs to the action that is needed on the watershed slopes above. People must be made to have confidence in the wisdom of programs which call for full production and use of the wildland resources but which are also designed to produce satisfactory yields of water.

It is also obvious that there is need for more well-trained foresters with a knowledge of the hydrologic aspects of forestry. Here is a difficult problem which most of the forestry schools recognize, and some, including Oregon State, are taking steps to meet.

The first step in a geared-up program should be to accelerate the research effort because unfortunately there are still some big holes in our scientific knowledge. For example, in many cases, we do not know how to re-establish control of runoff and to slow down erosion in places where the plant cover has been greatly altered. I have in mind areas such as the extensive multiple burns and depleted and eroding high summer ranges on which revegetation attempts have largely failed.

We do not know which of the very steep slopes it is safe to log, or what intensity of grazing will start accelerated erosion and destructive floods in individual situations. Moreover, we are not sure we can go ahead with plant cover manipulation to increase water yields without stepping up flood frequencies and magnitudes.

It will take time to get all of the necessary answers from research but at the rate pressures are building up, we just can't delay starting the watershed management job. There is already a big fund of knowledge which can be used to good advantage. We must establish reasonable performance standards on the basis of what we now know so that public agencies and private individuals who log, build roads, or otherwise work on the watersheds will have a clearer picture of what they should be expected to do in each situation. With so much of the critical watershed land in public ownership a big part of the responsibility rests with public agencies. Watershed by watershed, we must determine what needs to be done to keep soils stable, prevent stepped-up sediment loads, and to maintain or improve the amount and timeliness of water yields, while at the same time allowing for maximum possible productivity and use of the wildland resources.

Next we need to determine what is the capacity of the individual landowners and operators to meet the minimum performance standards necessary for maintenance of our environment. Can they do the job by themselves or will they need help?

Then, of course, we should determine the kind and amount of public help and guidance the individuals will need to fulfill their watershed responsibilities.

The leadership required to determine the facts and to implement an adequate watershed program is in my estimation the big challenge of the coming decades.

Conference Summary

H. J. VAUX

AS THIS 100TH ANNIVERSARY CONFERENCE comes to a close, the Program suggests a summary of the proceedings. To attempt to put into some capsule form what our speakers have so ably brought to us would be both futile and presumptuous. I would, however, like to take advantage of the moment to lay additional emphasis on two or three themes which seem to me to have dominated the Conference discussions.

There was repeated stress on the idea that the second century will bring greatly increased need for *whole forest use.* Whether taking the viewpoint of increasing population pressing on the land or of forest industries striving to maintain profitable operations, all participants pointed to the urgent necessity of realizing to a far greater degree than has yet been achieved the full potentialities of the forest resource. Regardless of whether they spoke of chemicals derived from wood, efficient utilization of lumber, or of water and recreational values, the urgent need to make the most of what the forest provides was apparent.

In relation to this central theme, the papers have also emphasized two keys through which these potentialities of the second century may be realized. One is in a program of fundamental research stretching across the forestry frontier from the biology of tree improvement to the biochemistry of lignin. Repeatedly it has been emphasized that research in the future must concern itself with the fundamentals of forest science so that we may be equipped not only to answer present questions and to forestall future problems, but so that we may build the fund of knowledge needed to underwrite and exploit full use of our forest assets.

The second key is well-trained men to do the fundamental research which our speakers had in view; men with the controlled imagination to develop new plans and new methods for the solution of problems, and with the balanced judgment to make those plans effective; and men with the vision not only to anticipate and thus to avoid future problems, but also to see the opportunities for growth and human betterment which the forestry of the future has to offer us.

If better research and better men are among the principal landmarks toward which we must aim in the years ahead, then it is apparent that institutions such as Oregon State College have a highly strategic role to play in the exploration of the unknown country ahead. The colleges and universities are our principal agencies for the conduct of research in its fundamental aspects and for the training of men. These papers have defined both the challenge and the mission which Oregon State College and its related institutions must redeem if the forestry of the second century is to come into its own.

Oregon Looks to the Future

A welcome from the Governor of Oregon and an address by the Assistant Secretary of Agriculture presented at the annual Fernhopper Banquet, February 21, 1959, as a part of the Forestry Centennial Conference.

A Salute to Progress

THE HONORABLE MARK HATFIELD
Governor of the State of Oregon.

IT IS A REAL PLEASURE to extend an official welcome on behalf of my fellow citizens of the State of Oregon. Especially is it a personal privilege to welcome the distinguished educators who are here from Thailand, British Columbia, Wisconsin, Yale and other far points. It is good, also, to welcome Pete (Assistant Secretary of Agriculture Peterson) back to his native state. We have missed you, sir, and we trust you will rejoin us one day.

On the way over here, one of my staff members brought me up short with the statistic that I was but in the first grade when in 1928 the School of Forestry originated this annual Fernhopper banquet. May I say with this wonderful entertainment, tremendous food, and good company it is one of the real highlights of the first seven weeks in the office of Governor.

Through the good offices of Dean McCulloch, the opportunity was provided me to review some of the papers which have been presented at this Special Centennial Conference devoted to "The Next Hundred Years in Forestry." I note that one speaker estimates we will need 95 billion board feet of timber products annually in the year 2000. An incident occurred in my office just the other day that makes me wonder if that estimate is not too conservative. A gentleman from a related industry called at my office to describe an Easter wardrobe that his group wished to present to Oregon's first lady. It was only after he asked for some very vital statistics that I learned the wardrobe would be entirely from paper—and I mean entirely! I had not realized they could go that far. I gave them the statistics but it seemed only fair to remind them that they were in a constant state of change these days.

Now you and I know of the advances in the use of forest products but I wonder if you are conveying the wonders of wood to related professions—the architects, and the contractors. Are you involving them in your research, in your meetings? We have found outdated building codes and fire codes; we have found people who do not recognize that the advances through new processes, lamination for instance, insure greater strength and fire resistance than some materials that are generally believed superior. I recall a few months ago at a Board of Control meeting, the architect brought in plans for a chapel at one of our institutions. It was obvious he hadn't even considered wood products. I asked that he return to his drawing boards and give us an alternative using wood. Moreover, it is my hope that we may move to a major building on our Capitol Mall that will be constructed from wood to show to our many tourists what can be done.

Now one final word about a subject discussed here earlier—recreation and forests. I note that one paper tells of four million recreational visits per year to forested areas. May I remind you that just yesterday but 35 miles from here on the University campus the distinguished historian Allan Nevins was predicting a 30-hour work week by 1975. Think what this means to you who even now have those in recreational pursuits using your forested areas. The potential is gigantic. It is overwhelming to contemplate.

We here in Oregon are always concerned that we provide hospitable recreational opportunities, but especially so in this our Centennial year. I am happy to report that the Centennial planning is on schedule. We are delighted that those of you from the timber industry have participated so generously in providing the wherewithal for exhibits and buildings and promotion. This can be a great year. It can be the beginning of a new era in Oregon development. Oregonians everywhere join in saluting the progress you have made during the past century and we await with real anticipation "The Next Hundred Years in Forestry." Our best wishes to each of you.

Forestry in Transition

ERVIN L. PETERSON
Assistant Secretary of Agriculture.

I AM HONORED by the privilege of this platform. I am humble as I remember some of the great men of forestry who have stood here before—Colonel William Greeley, George Peavy, Nelson Rogers.

I am pleased to be home, to be in familiar surroundings, to greet old friends, to participate in this conference, to discuss a subject of such past, present, and future importance to our State and Nation—forestry.

Oregon this year commemorates a century of Statehood. Her history spans two eras. One saw the ending of the geographic frontier. Men had reached the far places. The new frontier of science began to beckon. A strange new world was dimly visible. Its vistas have been found both stimulating and frightening.

From the beginning of time man had learned more and more about how to use the fruits of his world. Now he has begun to make them multiply, to adapt his surroundings to his needs and wants. He has ceased his wanderings to build great cities, to link them together by networks of highways, railroads, airplanes. He has built great systems of communications so that instantly he may know what goes on at any point of the earth's surface. He has begun the exploration of his universe—a result of his preliminary exploration of the scientific frontier.

A new age has begun, an age of speed and change. This new age is fast-moving. Forecasts are more difficult. The dimensions of the future cannot be predicted upon events of the past.

All man's activities have quickened their pace. Consider our ability to move from place to place—to travel. From antiquity man traveled no faster than a horse could go. The first steam railroad came to being just a little over 100 years ago. Not until 1893 did even a train reach 100 miles per hour. An automobile reached 150 miles per hour only 21 years ago. The airplane is a product of this century. At the beginning of World War II, top speed was about 200 miles per hour. Only 12 years ago, in 1947, did man go faster than sound—768 miles per hour. Less than a year ago a military aircraft went over 1400 miles per hour.

Within the past year, jet aircraft were placed in passenger service in this country—only since 1952 anywhere, and man-made vehicles have escaped the earth's atmosphere at speeds upward from 20,000 miles per hour.

Who would have predicted 100 years ago that today man would travel from one coast to the other between breakfast and lunch?

Who would have predicted 100 years ago that explosive power could now be measured in megatons? It took 800 years to change from gunpowder to TNT; only 7 years to change from the A-bomb to the H-bomb.

Who would have dreamed 100 years ago that today we could sit in our homes and view events as they occur thousands of miles away?

Less than a year ago was the 97th Anniversary of the Pony Express which made communication between St. Joseph, Missouri, and California only 8 days, 80 riders, and 400 horses away.

Who among the Oregon pioneers could have imagined a house in which the climate is fully controlled?

What forester of 50 years ago could have foreseen fighting forest fires and forest pests with airplanes and chemicals?

The bull train, the skidroad, the saddle tanker have given way to the diesel yarder, the high lead, and the motor truck. What will be next?

Who, 100 years ago, would have imagined that today we would be a Nation of nearly 180 million people? Even a few years ago, in the preparation of the recently published Timber Resources Review, population estimates were 7% too low. They changed that much between preparation and publication and since have been further increased. Our population today is growing twice as fast as it was 50 years ago. A population of over 300 million people will be reached within the next 50 years—within the productive lifetimes of some of you.

No longer is the past prelude to the future. We cannot safely forecast tomorrow's world by the world we knew a few short years ago or even by the one we know today.

Is there both a warning and a challenge to forestry and foresters in the dramatic march of events, in the acceleration of change which now marks the end of Oregon's first century of statehood? I think there is.

Early forestry was concerned with the harvest and use of the wood nature provided. It required 150 years to deplete the eastern pines—the great forests of the Aroostook country. The Lake States were cut over in 75 years.

The last stand of the harvesters is here in the Pacific forests. The end of old growth is now visible. What kind of forests will replace the ones we use up? What kind of use will a growing population want to make of the new forests?

Will people want them as a source of wood, as outdoor playgrounds, as a home for game and fish, as vast watersheds to assure municipal and industrial water supply, as natural ecologic areas—a great scenic wilderness, as a place to summer livestock, or for all of these things?

Can multiple-use be sustained as a guiding principle in forest management when its concept is relatively new?

Unless the public understands what it is and believes it to be a means of providing what they want, its continuation will always be under pressure, as it already is in some places.

In the East and in the Lake States no provision was made for a particular kind of new forest. The result was a marked diminution in the ability of those forest areas to sustain their contribution to the Nation's need for wood and other forest values. The entire economy of those regions was affected. Jobs, payrolls, trade, commerce—all were reduced. The productive base was eroded away. No provision was made for its regeneration. The growth of these regions hasn't kept pace with that of the rest of the Nation.

Here in the Northwest the conversion of trees to usable products has constituted the principal economic base around which the economic, social, and political life of the region has revolved.

The region is growing. Its population is increasing. It seeks a broader and more stable economic base. Can forestry participate in this growth? I think it can. I think it will if foresters develop the vision, the courage, and the will to successfully apply themselves to this objective. Our sights must be raised. Our goals must be of large dimensions.

Today, each U. S. citizen has the benefit of 78 cubic feet of wood which he uses in some form as wood or derived products. If our population doubles as we expect within 50 years, we must either cut twice as much timber to give each person as much as he now uses, 78 cubic feet, or cut what we now cut and give each person 39 cubic feet, half the present use.

I do not believe wood is going to become less and less useful. Quite the contrary. It should become more useful. We can make it so. We have much of the know-how already. Our problem is the quantity and the quality of the supply.

Much is said about the growth and drain of our Nation's forests. Some people say growth and drain are now in balance; that the task ahead is to keep the two even. To my mind this kind of thinking judges the future by the past. It charts the future as a horizontal plane when even the present as measured by the past is a line approaching the vertical.

Growth and drain are in balance for the use of our present population provided all forests, all kinds of trees—good, bad, indifferent, usable, and unusable—are included in our measurements. Present use of soft-wood sawtimber exceeds growth. All indicia point up a need to double present sawtimber growth and triple the growth of soft-wood sawtimber.

The job ahead is to keep the growth of the kind of timber we use in balance with the total annual harvest.

To merely measure total forest growth against total forest drain is to close our eyes to both the present and the future.

A growth-drain balance must be achieved at progressively higher levels of production and use if forestry is to help expand the economy of this State and of all areas of the Nation where forests are located and to provide its share of jobs, payrolls, trade, and commerce for a growing population.

In some of the European countries a growth-drain balance has been long maintained—in Germany at about 70% of needs, in England at about 9% of needs. Here in America we have the lands, we have the forests. We need to perfect our knowledge of production and utilization. We need to better the products marketed. We need to raise our sights—to increase the dimensions of our objectives.

Early foresters were largely harvesters of nature's bounty. Public forestry was concerned with being the custodian of the publicly-owned forests. Only within the past 25 years have both private and public foresters begun to be managers of what nature provides.

There is now abundant evidence of need to embrace a still newer concept even though few, if any, forest properties, either public or private, are being managed on an intensive basis. The new concept might be called creative forestry, the kind which, using a progressively enlarging body of scientific and technical knowledge, generates from the forest soils of the country the kind and quality of trees needed to enable the wood-using industry to market the kind, quality, and quantity of wood products and wood derivatives which the people of the country want and need.

Creative forestry will be more than growing trees, supervising their harvest, and fabricating them into usable and needed products. It will be the kind of forestry which surveys and measures the place of wood and its products in our Nation's life, and which then proceeds to provide the kind of forests from which the economic stature of wood may be maintained in proportion to the growth of the Nation, to the growth of our entire level of living.

The professional people engaging in creative forestry will be more than foresters. They will be land managers applying the most diverse and up to the minute scientific and technological knowledge to the land. They will derive from the forested lands much more than forest products. They will practice multiple-use of the most intensive character. An exploding population presenting a pressure of people against our land space will permit no less.

Wood, water, habitat for fish and game, recreation, scenery, forage for livestock will be provided to the maximum of the land capability. Indeed, creative forestry will take control of nature. We will grow more and better wood per acre. We will manage all our forests big and little, public and private, at the maximum degree of intensity which a growing body of scientific and technological knowledge will permit.

Our first and most immediate task is to enlarge our capability to supply the needed technical abilities. Research must expand in all its areas.

Curricula in our forestry schools must be sufficiently comprehensive not only to provide instruction in technical forestry, but to relate it to the economic, social, and political climates in which forestry is to be practiced.

Last year there were planted in this country over one billion trees—just trees largely as nature has developed them—not trees scientifically tailored to a specific end use. Forest genetics responsive to fabricators and merchandisers of wood and wood products must come fully awake to its challenges.

Last year there were 61 million recreation visits on the national forest alone. This kind of use generates pressures to modify management plans and objectives. What will be the longer run impact on all forestry?

About 75% of private forest lands are in small ownerships. Most of them are making little or no contribution to the Nation's use of wood and wood products. How are they to play their full part in meeting the needs and wants of our growing population for the values they are capable of providing? Who is to be responsible for bringing them to productive status? Will the effort be public or private, or a combination of both?

Here is a challenge to private foresters and private forest industry of a first order of magnitude. Presently a vacuum exists. Government is strongly attracted to such situations.

Fire is still a great destroyer of forest values, but not as great as insects and disease. The entomologists, the pathologists, the chemists must all run faster.

Boards and papers are still the basic products of forest industry. Utilization research must be expanded to develop products tailormade to specific end uses. Moreover, all the volume of all the trees needs to be made economically usable. If millions of acres of low grade, low value forests are to be replaced by man-created forests, a feasible means must be found to use what is now growing.

Many forests are primarily watershed lands. Forest engineers must find techniques to remove forest values while avoiding damage to these watershed values.

Forests are the home of most of our game animals. We need to learn how to completely use the forests without making their home untenable.

More than anything else foresters, in teaching, in research, in management—whatever their place in the field of forestry—need to feel the urgency for applying intensive management to all forest lands and to moving from forest management to creative forestry which I am convinced will be the forestry of tomorrow.

As our State crosses the threshold into her second century of Statehood, let us equip ourselves with the knowledge, the vision, the determination that her magnificent forests shall participate as fully in the second century of her development as they have in her first one.

Let us not be afraid to accept objectives of grand dimensions. Let us determine that there will be rising, not declining, volumes of usable products coming from our forest lands.

Let us determine also that multiple-use to serve the varied desires of a growing populace is a solid character of creative forestry.

The decisions we now make will be reflected 50 to 100 years hence. Will the people of that day praise us for our foresight or damn us for lack of vision?

Our forestry future can be as bright and great as we choose to make it. We have made a good start. Let's now get on with the tasks before us with vigor and determination to use what knowledge we have effectively while increasing it to achieve the still greater effectiveness we will need as public use of wood continues to grow.

The interests of private enterprise and of public forestry are common and complementary. We have common objective in maintaining a healthy, prosperous, progressive forest products manufacturing industry.

We have common objective in broad and permanent markets upon which such an industry depends, and in maintaining public acceptability of wood as a building material and as a raw material for manufacturing processes. We have common purpose in maintaining a strongly supported program of forestry research and education from which comes the new knowledge needed to manage our forest properties most efficiently and productively, to attain broad uses for wood and its derivatives, and to develop economic use for forest growth which presently has either low economic value or none at all.

And, let us ever remember that our Nation has been brought to its present eminence by the inventiveness, the industry, the ingenuity of a free people where individual creativeness producing goods or services of value to others has been rewarded. Likewise, indifference to opportunity, slothfulness has been punished.

Reward and punishment have not been assessed by Government, by public authority, but rather by our economic system—by the tens of thousands of decisions made every day—by the people who use the goods or services offered.

This competitive system involving as it does profit and loss—and loss or the prospect of it is what keeps it competitive—has diffused widely among our people an ever-increasing flow of goods and services. We have more of everything more widely distributed than ever before in the history of this or any Nation.

We can keep and further perfect this system or we can, even unintentionally, throw it away. More and more our people are demanding of Government the assumption of all kinds of responsibilities which the people are capable of and heretofore have redeemed themselves.

As Government has responded, it has necessarily taken in taxes more of the rewards which come from the application of individual creativeness and industry.

As it has done so, people are less able to do for themselves. Thus, they again ask Government to assume still additional programs. And so, the process repeats itself.

Today, Government undertakes to do so many things it does none, or, at best, few of them well. Moreover, it is big. It is too big for effective management. Few persons can envision its involvements. Certainly the individual citizen can at best poorly understand its processes even when they concern him most intimately. Neither can he effectively contest its decisions.

Big Government seems remote from us individually. It is, in fact, as close as the next tax payment. It seems to offer us something we can get from it more easily than we can secure the service elsewhere. Yet, it can give us nothing except what it first takes from us of our wealth. For Government is not a creator of wealth; it is only a user of what has first been created by the people.

These simplicities we tend to ignore. Too many by their silence acquiesce in the perpetual growth of Government at the expense of the private economy. If we are to achieve the new frontier in forestry, if as a people we are to have an ascending level of living, if we believe in the America we know, we need to give our attention to the things necessary to preserve and encourage the application of individual creativeness, industry, and ingenuity.

We proclaim our faith in a free society. As individuals we need to demonstrate that faith more effectively.

Yes, we know how to grow trees. Let us also grow people who will measure up to the heritage that is America, that the trees we grow will grow to have meaning to future generations of individuals as they have meaning to us.

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