DEPARTMENT OF THE INTERIOR, CANADA

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REPORT

OF THE

DIRECTOR OF FORESTRY

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FORESTRY

REPORT OF THE DIRECTOR OF FORESTRY, E. H. FINLAYSON

Canada's natural resources are the foundation of her economic development. Of these resources, land is by far the most important. The efficient use of the land resource is therefore a matter of the utmost importance in planning for the future.

Over three-quarters of the land area of the Dominion is unsuitable for successful agriculture, but of this immense area, upwards of a million square miles are capable of growing forests if protected and managed to that end. The accessible and productive forest area approximates 792,000 square miles, of which 379,000 square miles carry timber of merchantable size, and 413,000 square miles bear young growth of various ages. Nearly three-quarters of the productive area carries coniferous species of trees predominantly, these constituting the softwoods of commerce, which are most useful and valuable for general industrial purposes.

The proper utilization and conservation of this immense resource is one of the primary problems in Canadian economics. Despite the immense area of forest land, unfortunately the situation with regard to timber supplies is unfavourable owing to two causes: first, the prevalence of forest fires in the past, and, second, the exploitation by industry without adequate care for the future productive possibilities of the land. It is, in fact, estimated that the next thirty or forty years will see the end of the present merchantable timber supplies and that, subsequent to that time, timber used by industry will have to be produced by cultural methods.

The growing of timber is a long-term proposition; obviously, it will not suffice to wait until present supplies are practically exhausted before undertaking the building up of a new forest estate. Plans for the future use of the forest resource must therefore be laid in the present, and methods of management evolved, correlated on the one hand to the best economic development of industry, and, on the other hand, to the production of the most valuable kinds of timber with the minimum expenditure of time, energy, and funds.

The investigation of problems thus arising must start with the biological characteristics of the tree species to be used and a thorough study of their reaction to specified methods and intensities of treatment. In the natural forest, loss and replacement is constantly going on. As mature timber dies, it is replaced by hundreds of seedlings which enter into an intensive competition for light and food, which comparatively few individuals can ultimately survive. Nature produces and maintains forests without regard for the production of the kinds of timber most valuable to man. The problem is, therefore, to favour certain species at the expense of others, and at the same time not overstep those limits set by nature, which would result in losses through insects or fungus diseases, wind damage, and other agencies, thus nullifying the result desired.

The forests of Canada are divisible into four or five main forest regions, the limits of which have no relation to provincial boundaries. The study of the silvicultural problems arising in these regions is therefore a matter with which no one province can deal satisfactorily. By its very nature the situation

is one which only the federal authority can adequately handle. In consequence, the responsibility for forestry research devolves very largely on the Dominion.

FOREST EXPERIMENT STATIONS

The great majority of problems arising in connection with the proper handling of forest lands cannot be solved through single short-term investigations, but must be carried on over periods of time comparable to the life cycles of the species under investigation. This fundamental characteristic of the work requires that the areas wherein the investigations are to be made shall be definitely set aside and dedicated to the work, under conditions wherein the organization conducting the investigation has complete control of the lands so utilized. There are, however, certain phases of the work which can be satisfactorily carried out over comparatively short periods of time; and in such cases permanent and exclusive control is not so necessary, provided the areas are safeguarded properly for the life of the investigation.

To meet the general need for forestry research, the Forest Service of the Department of the Interior, some sixteen years ago, set up a Division of Silvicultural Research to pay particular attention to these national and regional problems whose solution must precede the inauguration of proper management of Canada's forests. This organization has operated in all the provinces, concentrating in the initial stages on the national forests in the West, which were then under the control of this service, and also on the Petawawa Military Reserve, a large section of which was set aside as a forestry experimental area under a co-operative agreement with the Department of National Defence. In addition, an important series of investigations has been conducted on holdings of pulp and paper companies situated in the provinces of Ontario, Quebec, and New Brunswick.

With the development of this work, the necessity was early foreseen (as indeed, it had been anticipated by reason of the experience of other countries) for the selection of definite areas in each of the main forest regions of Canada, to be set aside under control of the Forest Service as forestry experimental areas. It was realized that these areas must in each case be typical of the timber conditions in the region and contain as great a variety of stands of timber and age-classes as possible. In addition, it was necessary that the areas should be so situated that there would be available a good market for all timber to be disposed of; that the areas would be accessible to the general public, so that the fullest publicity and understanding of the problems investigated might be secured; and, finally, that the areas should be so located that complete fire protection could be provided, thereby safeguarding the results of long-term investigations from loss through sudden destruction. Work on such areas must, however, be supplemented by other experiments conducted in co-operation with industry on lands containing stands and conditions of growth not occurring on the experimental areas proper.

Possession of definite areas of timber lands provides opportunity not only for study of the fundamental biological and silvicultural problems, but also affords a means of conducting demonstrations of the results of researches and experiments, the practical application of which can be made available to lumber operators and to the public as a whole. In such demonstrations particular care must, of course, be taken to dispose of the slash and débris which is ordinarily so great a hazard after logging, as well as to make available complete costs of every phase of extraction operations.

The objective of the research organization above explained is to centralize the work in each main forest region in what is known as a forest experiment station, the term "station" embracing not only the forestry experimental area proper, but also supplementary projects carried out in co-operation with provincial authorities or industrial concerns. The purpose is to supply the basic

knowledge necessary to the best management of forests existing in the region and the best utilization of the products thereof. From the national standpoint, the result should be to stabilize and perpetuate forest industry; from the local standpoint, solutions are provided for the immediate problems encountered by the provincial authorities within the boundaries of the region and indirectly by the operators themselves. The fundamental objective of forest experiment station work may be stated as being the problem of managing and developing forests so that the demands for different species, sorts, and sizes of timber, of the highest quality possible, may be met, and adequate provision made for regeneration of a new crop without deterioration of the productive capacity of the soil and with fullest possible use of all natural factors of forest growth.

Research procedure in forest experiment station work is based largely on the establishment of carefully selected sample plots, each plot being characteristic of the average condition which it is proposed to study and having as a counterpart an untreated control plot for comparative purposes left undisturbed to grow under natural forest conditions.

Sample plots are of two general kinds: permanent sample plots, and temporary, or single-examination, plots.

On permanent sample plots every tree is carefully measured and mapped and a written description is recorded. Remeasurements are made at five-year intervals, the difference in size and volume, less losses due to decay and mortality, representing the growth of the stand during the period. Certain series of plots are subject to various cultural treatments such as thinning and logging under different methods. The results both with respect to increased growth-rate and presence of seedlings to form the new crop are carefully noted and the proper deductions made therefrom.

Single-examination plots are set aside for the purpose of securing accurate data with respect to conditions on the ground in any particular locality at a given time. In this case growth-rate may be ascertained by means of increment borings made into the trees on the plot, the width of the annual rings in the cores being measured and recorded.

The information secured from sample-plot investigations is combined with data from intensive forest surveys, and compiled into a forest working plan prescribing the treatment and regulation of the cut for specific forest areas. The object of the working plan is, of course, to provide a "sustained yield" approaching as near as possible to the full productive capacity of the forest soils under treatment.

Incidental to problems relating to the proper management of woodlands as detailed above, there are other associated problems of a technical nature. These include:—

1. The measurement of trees, stands, and forest products. This involves the development of standard volume and yield tables for use in timber estimating in various parts of Canada; the study of converting factors between different units of measurement of timber; analysis of log scales and investigations with a view to standardization thereof.

2. Slash-disposal investigations with a view to arriving at the methods best adapted to the types of timber concerned, not only with respect to reduction in fire-hazard, but also with regard to their effect upon the provision of proper seed-bed conditions for regeneration.

3. Owing to the wide variation in topographic and climatic conditions, the watershed-protection functions of forests are of outstanding importance in Canada where hydro-electric energy plays such an important part in industrial development. Forests regulate stream flow, stabilize the water table, and prevent erosion. Very little scientific research into these phenomena has as yet been made in this country. It is a branch of forest conservation which must be investigated much more actively if the potentialities of our water-power resources are to be realized and preserved.

4. Notwithstanding the relatively short period during which Canada has been settled, extensive areas of sand dunes and barrens have developed as a result of forest denudation. In most cases artificial reforestation is the only feasible method of rehabilitation, owing to the infertility of the soil, and a special technique must be built up to induce forest regrowth.

Other important problems concern protection of forests from fire, insects, and disease. Advances in fire protection are possible to the greatest degree in the field of fire prevention. In this connection an adequate warning of the onset of fire weather and a knowledge of the behaviour of fires under given climatic conditions is of the utmost importance. Studies in the inflammability of materials making up the forest floor and relative fire hazards in different timber stands are the best means of obtaining the information required for forecasts of the probability of fires. The relative susceptiblity of pure stands and mixtures of various species to insects and disease, particularly in the earlier growth-stages, is information prerequisite to the selection of a proper system of management.

As indicated above, so far as forestry experimental areas were concerned, the Forest Service was, for a number of years, restricted to one locality, namely, the Petawawa Forest Experiment Station. This was the only area definitely under the control and authority of the service, although co-operative arrangements had been made with pulp and paper companies in Quebec and New Brunswick for the setting aside of restricted areas for a term of years pending the completion of certain investigations thereon.

However, within the past year or two the work has been consolidated by the establishment of additional stations. In Quebec an experimental area of some 7½ square miles has been secured at Valcartier, the lands there, as at Petawawa, being made available by the Department of National Defence. In the Maritime Provinces an area of 38 square miles, designated the Acadian Forest Experiment Station, has been obtained, situated some 15 miles northeast of Fredericton. This tract was transferred to the Dominion by the Provincial Government free of all encumbrances, certain deeded areas being in fact revested in the Crown by purchase to round up the area. In Manitoba the Provincial Government, by Order in Council, set aside some 37 square miles in the Duck Mountain provincial forest reserve to be used by the Dominion for forestry experimental purposes. In Alberta the provincial government has deeded to the Dominion some 62 square miles in the Kananaskis valley on condition that it be used as a forestry experimental area. Finally, in British Columbia, negotiations are in progress for the acquisition by the Dominion of an area representative of timber conditions of the West Coast region.

The development of the experimental areas now secured has been greatly expedited through the splendid co-operation extended by the Department of National Defence, whereby unemployment relief projects for the care of single homeless men have been established thereon. These projects have resulted in the installation of many of the primary improvements required for the development and administration of the areas, including the construction of roads, trails, telephone lines, buildings, nursery stations, planting of denuded areas, logging of mature timber, and thinning operations in growing stands. By these means very substantial progress has been made, the foundations laid, and facilities provided for a broad program of scientific field-work in forestry research.

The general policy and basis of the work on forest experiment stations having been described, the details with respect to operations during the year under review on individual stations follow.

Petawawa Forest Experiment Station

The primary purpose of the working plan prepared for the Petawawa Forest Experiment Station is to assure continuous and systematic conduct of forest research. It provides, as a secondary activity, for the management of the area on a sustained-yield basis. Consequently, each logging operation is conducted so as to form the basis of some research project.

During the year a number of studies have been conducted on this basis. In certain mixed red, white, and jack pine stands, of which 75-year-old jack pine formed the overstory, a proportion of the overstory jack pine was removed. In three silvicultural experiments the stands were marked to leave 20 per cent, 40 per cent, and 60 per cent, respectively, of the upper-story crown-cover as a protection for the second-growth stand. The amount removed from the respective areas was approximately 6,000, 3,000, and 2,000 feet, board measure, per acre. Permanent sample plots are to be established on each area to permit the study of the relative effect of the cutting methods upon the remaining stands.

Poplar is not only a valuable fire-type nurse-crop species for pine, but the present demand exceeds the supply available. Although poplar may be found on various sites, probably no species reflects quality of site as affecting the growth and the quality of wood so pronouncedly as does poplar. In two stands of poplar, 80 years of age, less than a mile apart, the one was found to range from 50 to 70 feet in height, and to be 70 per cent defective, because of heart rot; the other was 80 to 100 feet in height with a cull factor of less than 30 per cent. From various stands of poplar—many with understories of pine, balsam fir or spruce—3,500 cords of match stock were cut this year. On each site and type represented permanent sample plots are being established to enable the examination of the soils, and the study of the relationship between soil, ground vegetation, and tree growth. Similar plots have been established in poplar of younger age-classes so that all stages of its development may be considered.

The cutting of spruce pulpwood was restricted to 360 cords from small swamp areas. Cutting was done to 3-inch top diameter, the slash being piled and burned. The effect of this clear cutting of the stand upon the soil moisture, the advance growth, and reproduction will be investigated.

From a mixedwood stand all merchantable timber, both hardwood and conifers, was removed except conifer seed-trees selected by the officer in charge. The amount cut was 142,000 feet board measure, much of which was boxwood stock. Softwood slash was piled and burned; the hardwood tops were lopped. The forestry objective is to secure a greater proportion of softwoods in the new crop.

There were no fuel-wood sales; but for the requirements of the relief project and the stations 750 cords were cut. About one-half of this was taken from the tops and other waste material from the logging operations. Fuel-wood cutting included also 100 cords tolerant hardwoods from the demonstration woodlot, the last of the overmature material. This stand now consists of healthy, second-growth hardwoods, and future cuttings will be restricted to the annual increment. Since it is in a healthy and unsuppressed condition, there should be no mortality during the next few years, and hence net and gross increment will be synonymous.

The total amount of material for all purposes removed during the year is the equivalent of 6,400 cords.

Under the planting program, a project largely conducted by unemployment relief labour, 675,000 transplants, red and white pine and white spruce, were set out on waste lands. The planting stock and equipment were supplied from the nurseries of the Forestry Branch of the Department of Lands and Forests of the province of Ontario. Except on one dry area where 100,000 plants, mostly white pine, were set out and where the loss was heavy, the fall recount showed a survival of about 85 per cent.

In nursery operations a good deal of attention was given to the development of hybrid poplars in an endeavour to find a rapid-growing, rot-resistant species, with fibre suitable for match stock. As a basis for selection of suitable inherent qualities, or of suitable qualities developed by hybridization, some forty species were obtained from the Dominion Experimental Farm at Ottawa, and from the research nurseries at Rumford, Maine. From Riga, Latvia, a supply of selected root cuttings of *Populus tremula*, the European aspen, was obtained. At the end of one growing season some species had failed completely, others had grown indifferently well. A few varieties gave promise of success. Altogether, four species from the Ottawa Experimental Farm and four from the Rumford nurseries had shown low mortality and rapid growth-rate. The roots from Riga were not received until late autumn.

Marked progress has been made in the development of a site classification based on vegetation, which reflects the quality of the soil and its effect upon tree growth. This is a classification similar to the Cajander classification used in Finland.

In a plantation of fifteen-year-old Norway spruce, many trees became infested with *Chermes*, commonly known as the spruce gall aphis; others were injured by the severe winter conditions of 1933-34. A few, however, appear to be particularly hardy, resistant to the *Chermes* and also rapid growers. These few specimens have been selected in the hope of developing a strain of spruce adapted to the new habitat. The remaining trees of the stand will be removed before seed-bearing age is reached.

It is a known fact that spruce seedlings often germinate better on decayed logs than on the undisturbed forest floor. In an attempt to simulate the decayed log conditions, an extensive nursery experiment has been started by supplying sawdust in various quantities to the seed-beds. The purpose of the study is to determine the rate of decomposition and its effect upon the contents of organic matter, supply of nitrogen, and the moisture-holding capacity.

A series of three permanent sample plots established in 1921 on an abandoned field to study the progress of its conversion to forest lands has been repeatedly examined, and the data have now been analysed. The plots represent three conditions:—

Conifers (white pine, white spruce and balsam fir) in serious competition with intolerant-hardwood second-growth,

Conifers after sudden release from such competition,

Conifers free from such competition.

The conclusions of the investigation show that:—

1. White birch prepares a suitable seed-bed for conifers, but the dense shade completely suppresses growth;

2. Removal of the white birch overstory after the sod has been disintegrated is likely to be followed by ample regeneration;

3. Rabbits are a more serious menace to seedlings under dense white birch than in the open;

4. White pine seedlings under dense birch are free from weevil, but in the open are seriously injured by that insect;

5. Grass sod prevents coniferous regeneration, but where other agencies, as trees, underbrush, or shrubs, destroy the sod formation, conditions for establishment of conifers become favourable;

6. Considering the suppression and damage from rodents under heavy shade, and from sod and weevil in the open, it is evident that a light shade condition is most suitable for the conifers studied.

The conclusions now deduced from four permanent sample plots established in 1921 are that satisfactory reproduction of conifers can be obtained on abandoned fields by ploughing furrows at regular intervals, provided that seed-trees are available in sufficient number, and site and moisture conditions are suitable. The experiment is being extended to determine the distance to which seed of different species is disseminated, and the minimum site and moisture requirements for satisfactory reproduction.

There are many areas, the result of severe fires, that remain blank although they are surrounded by seed-trees. A study of these areas formed the basis of five permanent sample plots established in 1918 and 1922. The difficulty was found to lie in severe competition of sod and dense growth of dry-site shrubs. Five such areas were selected to investigate the value of disturbing the ground-cover. On each plot, patches, some five feet square and some ten feet square, spaced at regular intervals, were hacked to the mineral soil with grub-hoes. From one-half of these patches the sod and litter were removed with rakes. With one exception ample coniferous regeneration resulted on these patches, but owing to suppression of weeds and hardwoods the pine seedlings disappeared within ten years. Balsam fir did not regenerate so prolifically, but, except on the driest sites, sufficient for a new crop persisted for ten years. Success was greater and more prolonged on those patches from which sod had been removed. The number of seedlings was increased over 50 per cent by the use of larger patches through reducing the proportion of border competition.

On other impoverished blank areas—some covered by dense vegetation, some lacking seed-trees—reproduction cannot be secured by natural methods. Two plots on a severely burned area, covered by grass, sweet fern, and blackberry, were twice seeded by the seed-spot method, and failed completely. Planting with 2-2 red pine (that is, trees which have been two years in a seed-bed and two years in a transplant bed) resulted in 61 per cent success, and white pine 2-1 stock in 24 per cent success. Height growth was slow. It is questionable whether it is profitable to plant such impoverished sites until nature reconditions them.

A series of four permanent sample plots in white and red pine were thinned fifteen years ago, at 35 to 40 years of age, to densities ranging from 21 to 40 cords per acre. Since then, three of them have received a second thinning. The control plot was unthinned. The results of remeasurements made during the year indicate that pine stands 40 to 60 years of age should not have more than 600 stems, nor a volume of more than 30 to 35 cords per acre; otherwise increment decreases and mortality increases. It should be noted that the thinnings from these plots utilized for lumber and fuel-wood provided returns sufficient to cover the cost of thinning operations.

With the conclusions from several series of thinning experiments as a basis, a stand of five acres of white pine 35 to 40 years of age was marked for a light thinning, and an area of thirty acres of red pine 45 to 50 years old was marked for a severe thinning. On the latter area the selected trees were pruned of dead limbs for a height of twenty feet to provide clear pine in the butt log.

In 1931 reproduction plots were established on a severely cut mixed wood stand on which pine and spruce were favoured; these were examined during the year, and show disappointing results. The coniferous regeneration after three years is very light and hardwood sprouts and suckers are dense.

Apart from nursery work and remeasurement of permanent sample plots, the major research activity was centred on poplar-pine sites and stands. In co-operation with the Division of Botany and Plant Pathology, Central Experimental Farm, Department of Agriculture, a detailed study of the relationship of site, heart-rot, and growth was conducted. Data were collected in conjunction with logging operations for the preparation of total and merchantable poplar volume tables, and for conversion factors (cubic feet to board measure).

The new road from headquarters at Corry Lake to Racehorse Camp on the Petawawa river, a distance of eight miles, commenced last year was completed. A start has been made on the section between Racehorse Camp across the peninsula to Barron river. The Highview road, five miles in length, also

commenced last year, was completed except for gravelling. The main road to headquarters camp, one mile long, was widened and gravelled. A wooden bridge, 120 feet long, over Chalk river, at the foot of Corry lake, was completed.

Valcartier Forest Experiment Station

During the planting season 229,000 transplants of red pine, white pine, and white spruce, supplied through the courtesy of the Ontario Department of Lands and Forests, were set out in the "plains" block, and 48,000 seedlings furnished through the courtesy of the Quebec Department of Lands and Forests were placed in transplant beds. In addition, a series consisting of five half-acre, and four one-acre plantation plots was planted out to investigate the relative value of spacings 3 feet by 3 feet, 4 feet by 4 feet, 5 feet by 5 feet, and 6 feet by 6 feet, respectively.

Ten permanent sample plots were established as follows: Four thinning experiments in pure stands of balsam fir; two release cuttings in a mixed wood stand; three regeneration studies after cutting; one treated seed-bed for natural and artificial regeneration of spruce. There was also one trenching experiment to study the effect of root competition. For experimental purposes two nursery seed-beds were prepared, and sown with larch and beech seed collected on the reserve.

An experimental cutting area of fifty acres in a hardwood stand was surveyed. The trees to be removed for fuel-wood for the relief camps were marked by the research officer, and these have been removed. All permanent sample plots have been designated by suitable signs, posts, and pickets, and trails have been cut to the sample plots.

Relief projects carried on were mainly planting, building of roads, cutting of reserve bounda y, cutting of fuel-wood, brush-burning, and camp-improvement construction work.

Acadian Forest Experiment Station

Work on this station started in May, and although administration problems pertaining to organizing of the station, fire-protection improvements, and projects for the three unemployment relief camps prohibited the carrying out of research activities on a large scale, nevertheless considerable progress has been made.

Under the planting program 50,000 white pine, 18,000 red pine, and 32,000 white spruce supplied through the courtesy of the Forestry Branch of the Ontario Department of Lands and Forests were underplanted in open birch and poplar stands. In these plantations four permanent sample plots, representing four densities of overcover, were established in co-operation with the Entomological Branch of the Dominion Department of Agriculture to study control of white pine weevil. A permanent sample plot was made for each species on each area planted to record detailed information concerning the success of the planting.

An investigation concerned with methods of eradication of sprout and sucker growth in wire birch and white birch cut-over areas is the basis of four permanent sample plots. In the spring, saplings were cut at one, two, and three feet from the ground on plots 1, 2, and 3 respectively; on plot 4 they were girdled. Other series will be made in the future at different seasons to check the seasonal influence.

The survey of the experimental area as a basis for a working plan was completed, as was also that of the military training area adjoining. The type map and the stand tables for the experimental area are also available. The right of way for a telephone system for fire-protection purposes was surveyed and marked.

In addition to work on the experimental area, an extensive investigation concerning conditions on areas of different age-classes, cut over at various dates,

was commenced in co-operation with the New Brunswick Provincial Government. Information pertaining to material cut, growth before cutting, growth since cutting. loss through windfall, insect, or fungus since the cutting, progress of reproduction, and the present stand per acre was recorded for 100 single-examination sample plots established in a balsam-spruce stand which had been cut over ten years ago.

Throughout the year three relief camps were maintained at the station. After establishing the necessary camp buildings and improvements, and providing fuel-wood, the principal employment was the rebuilding of the Richibucto road and other improvements pertaining to the management and protection of the area. These included:—

Construction of 15 miles of telephone line, with six stations, connecting all relief camps.

Construction of an administration building, and installation of septic-tank sewerage system.

Construction of two bridges across the Burpee river.

Clearing of 40 acres of second-growth wire birch. The wood was used for fuel, and the brush was burned. The area will be planted with conifers.

Building of three miles of winter road to connect two relief camps.

Cutting of 2½ miles of fireguard along the station boundary.

Cutting of three miles of trail, making the southeast section of the station accessible.

Duck Mountain Forest Experiment Station

A commencement was made on the forest survey of the Duck Mountain Forestry Experimental Area. As preliminary work, the aerial photographs were examined under the stereoscope, and tentative boundaries of types drawn. From some of these photographs, tracings were made of certain sections in townships 29 and 30, ranges 23 and 24. Investigation of these sections in the field was commenced towards the end of June and consisted of an examination of the types as outlined and the investigation of representative types by means of sample plots.

The work of defining the boundaries of the experimental area, which was started during the previous year, was completed in the month of May. The surveyor in charge of this work was loaned by the Topographical and Air Survey Bureau, and had an assistant who was loaned by the National Parks Branch, both of this department. During 1933-34 this party cut a total of 25½ miles of boundary and control lines. During 1934-35 this work was completed by cutting an additional 24½ miles and retracing 2 miles of lines established years ago.

A detail contour map was prepared of approximately ten acres of the administrative site on Singoosh Lake, which site is reserved for permanent buildings being erected at the headquarters for the experimental area. This map shows contour lines with five-foot intervals.

Improvement work required for the administration and development of the area was effected through the use of unemployment relief labour provided by the Department of National Defence. The main projects are outlined hereunder. Portions of the boundary lines as established by the survey party were widened during the winter. These lines have been cut to a width of 20 feet. Trees were cut close to the ground so that where the boundary is on high dry ground, it will be possible to travel along it with wagons or, in some cases, motor vehicles. All wood cut which could be utilized for fuel was hauled to the camps, and the remainder was burned. The total length of boundary line cut 20 feet wide by the end of March, 1935, was approximately 15½ miles.

Twelve miles of telephone line were constructed from Singoosh Lake along the main road now under construction through the experimental area. This line

now terminates at Unemployment Relief Camp No. 2, which is one mile west of the eastern boundary of the area. It will be continued easterly to Ethelbert, Manitoba.

An 80-foot steel lookout tower was erected in section 18, township 30, range 23, west of the principal meridian. This unit, together with existing provincial towers, will provide adequate fire detection facilities for the area.

Buildings constructed during the year included an administration building, a two-car garage, and a boathouse. Work on the main road across the area, commenced during the previous year, was continued, and satisfactory progress made. Work was much expedited through the securing of heavy road-building equipment lent by the departments of Public Works and of Mines and Natural Resources of the Province of Manitoba. This road should be completed during the summer of 1935. In addition, some miles of trail were opened up to give access to isolated parts of the area for fire-protection purposes.

Kananaskis Forest Experiment Station

Arrangements for turning over this area to the Dominion were not completed until October, 1934. Work was concentrated on the establishment of four unemployment relief camps designed primarily to undertake road construction up the Kananaskis valley and to construct the necessary administration buildings at the experiment station headquarters.

Unfortunately the early advent of severe winter weather seriously delayed camp construction, with the result that comparatively little actual improvement work was undertaken. However, a creditable start has been made on the main road, and in addition some seven miles of right of way of secondary roads were cleared. These were required primarily for the purpose of obtaining a fuel supply for the camps, but have been so located that they will be of value in extraction of timber supplies in the future and also for fire-protection purposes.

Advantage was taken of the necessity of obtaining large supplies of fuelwood for use of the camps to undertake silvicultural treatment of selected stands. Some 150 acres were cleaned, thinned, or otherwise treated in this connection. As a result, the areas around the camps and along sections of the road have been placed in a satisfactory condition from both the silvicultural and fire-protection standpoints.

British Columbia

As in previous years, considerable time was spent on seed collection and extraction for the British Forestry Commission and for the Government of Northern Ireland. The cone crop for all species was very much better than in 1933 and might be taken as an indication that crops more nearly approaching the normal may be expected during the next two or three years. On the other hand, the yield of seed per bushel was in every case but one far below the average of previous collections. Contrary to expectations, the poor seed-yield was not accompanied by a lower germinative capacity.

Seed collections during the year totalled 1,794·12 pounds, valued at $6,553.30. Collections were made from eight species in a dozen or more localities.

During the closing months of the fiscal year some planting work was undertaken to reforest a portion of the Victoria Astrophysical Observatory site which had been burned over in August, 1934. A limited amount of planting stock made available through the courtesy of the British Columbia Forest Service was utilized in this connection.

FOREST ECONOMICS

The forest industries showed a marked improvement in both production and trade during the past year. The excess stocks of logs, lumber, and other products having been liquidated during the previous years, woods operations were conducted on a larger scale in 1934 than in any other year since 1929. Though the domestic demand for lumber has been recovering but slowly, and the exports to the United States have suffered a further decline, the exports to other countries, especially to British countries, have registered such a substantial gain that the total exports of lumber in 1934 were 88 per cent greater than in 1932 and 31 per cent more than in 1933.

The trade in forest products, though materially decreased in both volume and value during the last five years, has been of relatively greater importance than during the preceding years in maintaining Canada's balance of trade. During 1931-34 forest products comprised 26·65 per cent of the total exports, as compared with 23·6 per cent during 1926-30; the imports for the same period, on the other hand, decreased from 3·34 per cent to 2·84 per cent.

TRADE IN FOREST PRODUCTS

Calendar Years	Exports		Imports		Favourable Balance of Trade
	Value	Per cent of Total	Value	Per cent of Total	
	$		$		$
1926-30 (average)	278,500,721	23·58	37,628,283	3·34	240,872,438
1931	184,641,523	30·50	21,380,003	3·40	163,261,520
1932	133,382,212	27·01	12,989,849	2·86	120,392,363
1933	130,785,302	24·59	10,442,173	2·60	120,343,129
1934	160,039,612	24·51	12,039,911	2·34	147,999,701

Lumber

In 1934 the exports to British countries increased to 1,060 million feet board measure, valued at $19,347,404, as compared with 653 million feet, valued at $10,358,053, in 1933. Though the increase was predominantly in the exports to the United Kingdom, gains were made in the trade with practically every part of the Empire. The trade with foreign countries other than the United States increased slightly in spite of the general business depression and trade barriers erected to restrict imports in many countries.

It is gratifying to note that the United Kingdom is securing a larger proportion of her lumber requirements from Canada, as the following table shows:—

PERCENTAGE OF UNITED KINGDOM LUMBER IMPORTS FROM CANADA

Sawn Lumber	Av. 1926-30	1934
Softwood, rough	4·9	17·2
Planed and dressed	0·1	18·1
Hardwood	13·0	19·9
Total	5·2	17·5

The exports of lumber to the United States established a low record of 234 million feet in 1934; this decline was due largely to the import taxes imposed by the United States, but also to the decreased consumption.

The consumption of lumber has been decreasing steadily in both Canada and the United States since the beginning of this century, not only in the amount used per capita, but in total volume as well. The visible consumption is com-

puted by adding imports to production and subtracting exports. This includes, therefore, an unknown quantity of stock on hand; in individual years this may be a source of considerable error, but during periods of five years or more surpluses are usually liquidated. The abnormally large stocks in 1930 to 1932, however, undoubtedly account for the larger apparent consumption in Canada during the last period, 1928-32.

AVERAGE ANNUAL CONSUMPTION OF SAWN LUMBER

Period	Canada		United States	
	Total	Per Capita	Total	Per Capita
	Million Ft. B.M.	Ft. B.M.	Million Ft. B.M.	Ft. B.M.
1908-12	2,750	395	42,212	460
1913-17	2,352	300	38,805	390
1918-22	2,157	250	32,764	305
1923-27	1,837	195	38,521	335
1928-32	2,146	210	25,624	210

The displacement of lumber by other materials such as iron, cement, and cellulose products is probably the principal, but not the only cause for this falling off in the use of lumber. The reduction in size of the average house, the concentration of families in apartment houses in which little wood is used, the lengthening of the life of wooden structures through preservative treatment, and the development of more economical methods of construction, all have contributed to the reduced per capita consumption.

Though it is possible by informing the public as to the technical qualities of wood to curb the substitution of other materials for certain purposes for which wood is not only cheaper but more serviceable, the trend is undoubtedly towards a still further reduction of the use of lumber on this continent. In the United Kingdom, which has to depend on imports, the per capita consumption of sawn material is less than 100 feet board measure per annum, and even in countries such as Sweden and Finland, which produce a large exportable surplus of lumber, per capita consumption is apparently very much below that of the United States and Canada.

Pulp and Paper

In common with most other industries, the pulp and paper industry has experienced during the past four years the most critical period in its history. Production in 1932 was reduced in volume to less than 80 per cent of the average of 1926-30. In each of the two following years, there were substantial gains which have enabled the industry almost to regain the status of those years as far as quantity is concerned. The most serious phase of the situation has been the drastic and sustained reduction in the prices received for both pulp and paper. As compared with the average during 1926-30, the price realized per ton of newsprint has declined about 44 per cent, chemical pulp 34 per cent, and mechanical pulp 37 per cent.

PRODUCTION OF PULP AND PAPER

Period	Newsprint		Total Paper	Wood Pulp		Total Pulp and Paper
	Quantity	Value	Value	Quantity	Value	Value
	Tons	$	$	Tons	$	$
1926-30 (average)	2,314,671	136,341,249	175,600,877	3,551,478	118,433,998	294,034,875
1931	2,221,551	111,050,704	143,957,264	3,167,960	84,780,819	222,738,083
1932	1,915,479	85,304,536	114,115,570	2,663,248	64,412,453	178,528,023
1933	2,016,612	66,714,677	97,030,429	2,979,562	64,114,074	161,144,503
1934	*2,597,641					

*From Newsprint Service Bureau.

Exports of Pulp and Paper.—In spite of the decrease in value, pulp and paper rank among the principal exports of the Dominion.

VALUE OF EXPORTS OF PULP AND PAPER

Period	Exports to United States	Exports to United Kingdom	All Countries
1926-30 (average)	$156,921,807	$9,637,058	$183,754,861
1931	118,808,762	7,863,278	141,170,685
1932	87,656,019	6,373,199	105,253,603
1933	77,689,200	6,206,741	95,750,769
1934	88,684,933	7,071,600	112,653,565

Employment in the Woods

Although logging operations are conducted throughout the year in the coastal belt of British Columbia, in the rest of the Dominion they are for the most part confined to the winter months. The camps usually open in October, so that the cutting can be completed before the snow gets too deep; after this the logs are hauled out to the streams or railways on sleighs. During 1926 to 1930 the number on the monthly pay-rolls varied from about 54,500 in August to 139,000 in February, averaging 63,000 for the six months April to September, 119,000 for October to March, and 91,000 for the year. The employment of from 50,000 to 75,000 additional men during the winter is of the greatest importance, for during that season in many occupations such as agriculture, construction, and navigation, there is either a partial or a complete cessation of work, and the lumber camps not only absorb much of the floating labour but provide work for many thousands of farmers and their horses, especially in the newer settlements where such additional source of revenue is most needed.

The index of employment in the woods based on the year 1926 as 100 dropped to 42·5 in 1932, but in 1933 it rose to 66·5 and in 1934 to 124·7, which almost equalled the peak of 125·8 in 1929.

The indices for the six winter months of 1934-35 indicate that on the average about 124,000 men were employed, as compared with 100,000 during the previous winter; the average throughout 1934 was about 95,000 as compared with 50,000 in 1933.

New Brunswick Forest Inventory

The inventory of the forest resources of New Brunswick conducted by the Dominion Forest Service reveals that more than three-quarters of the land area of the province is productive forest land, of which two-thirds carries timber of merchantable size and one-third young growth of various ages.

The total stand of timber of merchantable size is estimated at 11,196 million cubic feet. The amount which is classified as accessible under the existing conditions of transportation and operation is 9,222 million cubic feet (82 per cent).

This accessible timber consists of 9,601 million feet board measure of sawtimber size and 63,807,000 standard cords of smaller material which might be used for pulpwood, fuel-wood, and other similar purposes.

The softwoods comprise about three-quarters of the stand, chiefly of the two pulpwood species, spruce and balsam fir, of which there is estimated to be about 50,000,000 cords, including the saw material.

The hardwoods are about equally divided between intolerant or light-demanding species (poplar and white birch) and the tolerant or shade-enduring species (yellow birch, maple, beech, ash, etc.). The accessible saw material is composed of 5,675 million feet board measure of softwoods, 1,130 million feet of

intolerant hardwoods, and 2,814 million feet of tolerant hardwoods, of which yellow birch comprises 1,696 million feet, maple 631 million feet, and beech 339 million feet.

The young growth, which covers 7,189 square miles, is predominantly softwood on 2,416 square miles, hardwood on 890 square miles, and mixed softwood and hardwood on 3,883 square miles.

In the distribution of age-classes New Brunswick is fortunate in having over half in the older class nearing merchantable size, there being 3,736 square miles from 41 to 60 years old, 2,116 square miles 21 to 40 years, and 1,338 square miles 1 to 20 years old.

Much of the timber classified as merchantable consists of young growing stands which have not as yet attained their maximum volume, so that it is possible to arrange a felling budget by which there will be no period of shortage, and the yield can be progressively increased.

Lumber Industry Survey in the Prairie Provinces

The study of the lumber industry in the Prairie Provinces, commenced in the autumn of 1933, was continued during the present year. An analysis of lists of sawmills provided by the provincial authorities was completed, and formed the basis for selection of a number of representative mills, which were visited and described during the summer.

As the number of mills listed exceeded 600, it was necessary to select a relatively small proportion to be visited. In this selection an attempt was made to pick out a group of plants which would include due proportions of the different size-classes, and also include fair representation of the different areas in the region. Field inspections were made with this grouping as a basis.

The mills visited during the summer included 24 small mills, 13 medium-sized mills, and 9 large mills, a total of 46. From the completion of field work till the end of the year, the time was spent in collecting and sorting the wide range of material acquired, and in drafting portions of the proposed bulletin.

Air-Photographic Forest Mapping

During the year air-photographic forest maps have been prepared covering approximately 650 square miles in the Pasquia Provincial Forest, Saskatchewan, and 40 square miles in the Acadian Forest Experiment Station in New Brunswick.

The Pasquia map was prepared under a co-operative arrangement which included the Saskatchewan Forestry Branch. The aerial survey revealed an important body of timber, for which estimates in board feet and cords were made. The securing of this volumetric data was greatly facilitated by the fact that winter photographs were available. The absence of foliage on the deciduous trees and undergrowth provides a better view of the trees, enhanced by the illuminating effect of the snow, and permits of greater accuracy in the measurement of trees and tree shadows.

The air-photographic research was mainly in connection with the development of steep oblique photography. Experience has shown that views intermediate between the vertical and the ordinary comparatively flat horizon obliques are superior to either for forest interpretation. A new type of adjustable stereoscope was designed and constructed which is particularly adapted to steep obliques, though it is useful for other photographs as well. This instrument permits the stereoscopy of photographs of divergent scales and angles to a degree not possible with the fixed stereoscope.

Tests were made of the suitability of infra-red film for use in aerial photography. It was found that in the present stage, the emulsion is not sufficiently fast to give clear definitions of the tree images. However, efforts are being made to produce speedier films. These photographs differentiate the greens of the foliage, especially that of deciduous and coniferous species.

FOREST PROTECTION

The forest-fire situation in Canada during 1934 can be described as slightly better than the average for the past five years. Fewer fires were reported than in 1933; but these burned over an area exceeding the 1933 figures by about one-third, with a corresponding loss and damage.

Precipitation throughout Canada during the months from November to April inclusive was generally normal or slightly in excess of the normal. However, while this situation was helpful, it was offset to a great extent by the extreme drought which followed during the whole of May from coast to coast. This condition was relieved somewhat in Ontario and the four western provinces, but in the eastern portions of Quebec and to an even greater degree in New Brunswick and Nova Scotia it continued throughout the summer months to produce a situation of extreme gravity which lasted from May until September in the latter two provinces.

British Columbia.—Except for a dangerous situation which developed in the Nelson district and remained acute from late July to September, a comparatively favourable season was experienced in British Columbia. Conditions were slightly better than the average for the past five years, although twice as severe as the two years immediately preceding.

In all, 1,590 fires were reported, which burned over an area of 638,690 acres, comprising 124,314 acres of merchantable timber, 137,926 acres of young growth, 365,626 acres of cut-over area, and 10,824 acres of non-forested lands. The total loss and damage amounted to $1,138,142, which sum included $104,877 damage to other property and $144,658 for fire-fighting costs.

Prairie Provinces.—In Manitoba there was heavy winter precipitation in the forested areas, a generous proportion of which was absorbed in the soil. This condition, together with timely and well-distributed rains, did much to produce the most favourable fire season for the past five years in this province.

The total number of fires reported was 237; these burned over 27,863 acres, comprising 4,678 acres of merchantable timber, 9,140 acres of young growth, 13,563 acres of non-forested land, and 482 acres of cut-over area. The total damage and loss amounted to $46,049, of which $12,699 was spent in fighting fires and $5,465 represented damage to other property.

In Saskatchewan all previous records for a favourable forest-fire season were eclipsed; this result was due in part to satisfactory weather conditions in the forest areas. In all, 142 fires were reported; these burned over 8,457 acres, comprising 936 acres of merchantable timber, 3,757 acres of young growth, 344 acres of cut-over lands, and 3,420 acres of non-forested lands. The total loss and damage was only $9,718, of which $4,620 covered fire-fighting costs and $557 represented damage to other property.

In Alberta the first fires of the season were reported in March, and in every month, up to and including December, further fires were reported, a total of 240 fires occurring in the province during 1934. Precipitation was more general in the northern and central parts of the province, where an early hazard existed during May. In the southern portion, where precipitation was least, the hazard was more severe, especially during August. The number of fires reported was somewhat smaller, and a decided improvement was shown over the previous year. The total area burned over was 58,870 acres, comprising 19,346 acres of merchantable timber, 15,208 acres of young growth, 2,659 acres of cut-over area, and 21,657 acres of non-forested land. The total loss and damage incurred was $166,849, including $38,169 for fire-fighting, and $1,720 for damage to other property.

Ontario and Quebec.—Barring 1931, the fire season of 1934 proved the least severe of any in the past five years in the Province of Ontario. An outstanding feature of the fire situation in this province was the fact that 31·6 per cent of

all fires reported were due to lightning, which was the major cause and accounted for 36·1 per cent of the total area burned over. A further 29·8 per cent of the total area burned was attributed to logging operations, although fires from that cause represented only 2·2 per cent of the total number reported.

In all, 1,568 fires were reported, which burned over an area of 198,633 acres, comprising 100,817 acres of merchantable timber, 31,785 acres of young growth, and 66,031 acres of non-forested land. The total loss and damage amounted to $1,145,342, of which $295,578 was spent for fire-fighting.

In the province of Quebec the fire situation was most acute during the month of May and the early part of June, which period accounted for 69·4 per cent of the total of 1,101 fires reported for that province. The total loss and damage amounted to $662,335 (double that of the previous year) and included an item of $161,261 for fire-fighting costs. The total area burned over was 255,379 acres, which comprised 37,092 acres of merchantable timber, 22,250 acres of young growth, 178,384 acres of cut-over lands, and 17,653 acres of non-forested land.

Maritime Provinces.—New Brunswick passed through a fire season of unusual severity in 1934; it began in May and extended into September. This period was one of high winds and continuous drought. The number of fires during 1934 was 235 (half of the number reported in the previous year), but weather conditions were such as to cause fires to spread rapidly and to make their control both difficult and costly. A total area of 221,673 acres was burned over, comprising 26,726 acres of merchantable timber, 1,052 acres of young growth, 10,348 acres of cut-over land, and 183,547 acres of non-forested land. The total loss and damage amounted to $219,347, of which $23,002 represented value of other property destroyed, and $81,527, fire-fighting costs.

Nova Scotia, like New Brunswick, experienced one of the worst fire seasons in its history, owing to drought. Small, and even moderate-sized, streams dried up, which added to the difficulty of fire suppression. Normally June and July are comparatively free from fires in this province, but because of continuous drought almost as many fires broke out as in May and August, the months of major fire occurrence.

In all, 690 fires were reported; these burned over 61,984 acres, comprising 5,495 acres of merchantable timber, 20,380 acres of young growth, 4,288 acres of cut-over, and 31,821 acres of non-forested land. The total loss and damage amounted to $144,247, which included $76,063 for fire-fighting operations and $14,279 for the other property destroyed.

General.—In addition to the foregoing remarks on the general fire situation throughout Canada during the calendar year 1934, the following summaries indicate the fire situation on lands directly controlled by the Dominion Government where organized forest protection exists.

On Indian lands, 34 fires burned over a total of 2,180 acres, comprising 1,594 acres of merchantable timber, 271 acres of young growth, and 315 acres of cut-over land. The total loss and damage is estimated at $5,955, of which $2,333 represented fire-fighting costs, and $23 the value of other property damaged.

In National Parks, 62 fires burned over 1,369 acres, comprising 415 acres of merchantable timber, 319 acres of young growth, and 635 acres of non-forested lands. The total loss and damage amounted to $15,310, including $10,522 for fire-fighting.

On Dominion Forest Experiment stations, 12 fires burned over 19 acres, including one acre of merchantable timber, 13 acres of young growth, and 5 acres of non-forested lands. The total damage amounted to $81, including $50 for fire-fighting costs.

TABLE I.—STATEMENT OF FOREST FIRES IN CANADA DURING THE CALENDAR YEAR 1934, AND COMPARISON WITH 5-YEAR PERIOD 1930-1934

Item	Year 1934	Average for years 1930-1934
Total number of fires	5,911	6,453
Total area burned over (acres)	1,475,117	1,942,280
Merchantable timber—		
Area burned (acres)	321,414	474,970
Timber burned (M ft. b.m.)	900,002	519,784
Timber burned (cords)	863,554	1,445,096
Estimated stumpage value	$1,756,701	$2,836,112
Young growth—		
Area burned (acres)	242,101	443,414
Estimated value	$ 573,469	$ 982,170
Cut-over land—		
Area burned (acres)	562,446	525,875
Estimated value	$ 246,031	$ 308,975
Non-forested—		
Area burned (acres)	349,156	498,020
Other property burned—		
Value	$ 149,923	$ 289,412
Actual cost of fire-fighting	$ 827,451	$ 817,693
Total damage and loss	$3,553,575	$5,234,364

From Table I it will be observed that the total number of fires reported for the calendar year 1934 was 5,911, which represents a reduction of 6 per cent compared with the previous season. The total loss and damage in 1934, however, amounted to $3,553,575, as compared to the 1933 figure of $2,513,270. This increase of more than a million dollars was accounted for by losses sustained in Quebec, New Brunswick, and Nova Scotia of more than one-half million dollars, and a similar increase in British Columbia. Fortunately, other regions were able to show an improvement of approximately $200,000 over 1933, thus keeping the figure for total loss somewhat below the average for the past five years.

TABLE II.—STATEMENT OF FIRES BY CAUSES FOR 10-YEAR PERIOD 1925-1934, IN CANADA

Cause	Year										Total	Per cent	Average annual number of fires by causes, 1925-34
	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934			
Camp-fires	944	999	669	814	1332	1,256	1,540	1,302	1,202	1,111	11,169	19	1,117
Smokers	531	513	369	500	856	762	937	809	893	971	7,141	12	714
Settlers	692	763	532	728	769	966	1,095	1,385	1,265	946	9,141	16	914
Railways	711	1,129	574	752	1,011	731	624	354	312	255	6,453	12	645
Lightning	978	823	716	485	1,167	1,482	880	651	940	957	9,079	15	908
Industrial operations	257	247	129	170	206	160	134	91	139	198	1,731	3	173
Incendiary	204	167	95	230	387	521	673	746	511	349	3,883	7	388
Public works	28	60	54	35	80	98	97	73	11	104	640	1	64
Miscellaneous:—													
Known	431	260	130	227	240	276	367	243	300	365	2,839	5	284
Unknown	714	729	337	320	637	553	607	641	725	655	5,918	10	592
Total	5,490	5,690	3,605	4,261	6,685	6,805	6,954	6,295	6,298	5,911	57,994	100	5,799

Table II shows the agencies responsible for more than 57,000 fires which have occurred in Canada during the past ten years and which on the average have caused an annual loss of five million dollars. This amount does not include the cost of operating the various forest-protection services, nor the loss to industries dependent on the forests directly or indirectly. Table II is a simple statement of fact, indicating that 85 per cent of all forest fires started in Canada are attributed to human carelessness. The situation is serious. The remedy would seem to lie in two main directions, first, joint action to carry on a nation-wide

campaign of forest-fire prevention designed to reach all who use the forests and, second, to provide adequate financial support to the services now charged with the protection of forest resources.

Fire-Hazard Research

The past year marked the sixth season of forest-fire hazard studies at the Petawawa Forest Experiment Station. These studies were started with the object of establishing a unit of measurement for forest inflammability, based upon those weather factors which cause the inflammability to vary from day to day. This object has now been achieved for certain types of pine forests and the results, available in the form of tables, enable any forest officer who has a daily record of rainfall, evaporation, and relative humidity to convert these records into terms of forest inflammability. The measure of inflammability so obtained may be shown graphically each day, and the forest officer may see at a glance the daily trend towards serious fire danger.

The fire-hazard tables developed at the Petawawa Forest Experiment Station are now in use at many places. The practical value of these tables is attested by a forest-protective organization, which has used the tables for the past two years, in the following terms:—

"During low-hazard periods, inspectors with this information may divert the activities of their men from tower or patrol duty to more productive work such as the construction and maintenance of towers and telephone lines, trails and portages, etc. On the other hand, during high-hazard periods forces may be kept in readiness for direct action in case of fire. Furthermore, when fires occur, this hazard measurement enables the inspector to judge more accurately what force is required to control the situation. It may readily be seen that this is of economical value in fire-protection operations."

During the past season investigations were continued in the mixed hardwood, white pine, and open grassy types, and a new project begun in a mixed softwood and hardwood type.

The efficiency of several types of meteorological-instrument shelters were compared, and a design was developed for a new portable shelter. An inexpensive type of rain-gauge was also designed.

A two-years' study of diurnal and seasonal fluctuations of forest-fire hazard was completed and the material analysed.

A study was made to determine the amount of volatile matter other than water given off in oven-drying leaf litter, as a check on the accuracy of moisture-content determinations by the oven-drying method.

An investigation was made of the reliability of the wood-cylinder method of measuring fire-hazard. An alternative method using untreated match splints, begun three years ago, was found to possess promising possibilities as a supplement to the fire-hazard tables at points where the continuity of the daily weather readings may be interrupted.

The data collected in previous years for the pure red pine; mixed red, white, and jack pine; and cut-over jack pine subtypes were worked up and put in readiness for the preparation of tables.

A study of the effect of forest canopy upon wind velocity, temperature, relative humidity, and rainfall compared with records in the open, which has been under way several years was completed, and articles published in periodicals.

The accuracy of the various methods of determining the moisture content of forest litter was submitted to a careful mathematical analysis.

Perhaps the most outstanding advance during the year was the development of a formula for determining the average fire-hazard in a district when the degree of hazard in each forest type is known. This formula can be used to give the proper weight to each sub-area and allow for season of the year, accessibility, visibility, prevalence of fire-starting agencies, and any other factors which contribute to fire-danger.

White-Pine Blister Rust

In the report of the Forest Service for the fiscal year 1933-34, mention was made of the serious menace of the white-pine blister rust. Experimental control operations, undertaken in 1933 in order to safeguard the existing pine stands in the Petawawa Forest Experimental Area, were continued during 1934. The work accomplished may be briefly described as follows:—

Detailed control work covering an area of five square miles of pine forest was carried out. The rust passes part of its life on the white pine and the remainder on plants of the botanical genus *Ribes*, which comprises currants and gooseberries, wild and cultivated. Primary eradication of these latter followed an approved plan of scouting and crew work and was carried out at a cost of about fifteen cents an acre. In five years' time a re-eradication treatment will be required to protect the existing young stand to maturity, at a cost not exceeding one-half of the primary work.

During the latter part of the field season a general reconnaissance of the reserve was made in order to determine the location of the white pine stands of a quality to justify rust-protection, and to acquire a knowledge of the relative abundance and occurrence of *Ribes* in each of these areas. The above data when mapped showed 22 square miles of white pine requiring immediate protection from the disease and eight square miles where protection was less urgent. The remainder of the reserve, an area of approximately one hundred square miles, was found to contain mostly other species, such as jack pine and hardwoods, which are, of course, immune from attack.

The penalty for neglect of this disease is the ultimate destruction of the white pine as a commercial species. What this means to the future of Canada will be better understood when it is stated that the average annual value at the sawmill of white pine lumber produced in Eastern Canada for the five-year period 1926-1930 amounted to approximately $14,500,000. To this must be added the transportation, re-manufacture, and distribution expenditures, which also materially aided the labour, industry and trade of the country. Even considering the sawmill price alone, the above figure is in effect the annual return of a resource which, if capitalized at three per cent, represents a value to the Dominion of over $480.000,000. Consequently in considering the justification for the expenditure involved in protecting Eastern white pine, it is essential that the future wealth-producing power be also given adequate consideration. The above figures sufficiently indicate that Canada cannot afford the loss of this valuable species of timber. There is, therefore, need for a vigorous campaign designed to awaken public sentiment to a just appreciation of the situation in order that those responsible may be enabled to set aside the funds required for control of the white-pine blister rust.

Generally it may be stated that the experience at Petawawa has demonstrated that approximately 20 per cent of the total area contains concentrations of white pine of sufficient importance to demand the undertaking of control measures against the blister-rust disease. There is good justification for believing that the situation thus revealed is typical of the white pine distribution over its commercial range in Eastern Canada.

Blister-rust control measures have been undertaken in the United States for a number of years on a very intensive scale. The United States Department of Agriculture held a hearing in Washington in December, 1934, to review the existing situation in that country and determine future policy with regard to control. A representative of the Dominion Forest Service attended this hearing in company with officers from the Dominion Department of Agriculture. The main point brought out at the hearing was that the future of white pine in the United States is absolutely dependent on protective measures being taken against the white-pine blister rust. The cost thereof must be considered as much a primary charge against the growing of white pine as is the cost of fire protection.

In the United States some nine million acres of white pine territory had been worked over by the end of 1933, the cost, exclusive of overhead, amounting to 23·2 cents per acre, and the total expenditure, also exclusive of overhead, approximately $2,100,000. It should be pointed out, however, that the average number of *Ribes* plants per acre occurring in the United States is 11·2, thus showing a much greater concentration than has been found in Canada.

The total range of white pine in Eastern Canada comprises an area of twenty million acres. Assuming that the figures for Petawawa are approximately correct and that 20 per cent of this area would have to be worked over at a cost of 15 cents per acre, the expenditure to provide initial protection for the valuable commercial stands in this country would be approximately $600,000. Preliminary survey work to determine areas requiring treatment, training of supervisory staff, and so forth, would probably require another $120,000. This expenditure, it is estimated, would extend over a period of eight years. The average annual quantity of white pine manufactured for the pre-depression years 1926-30 was 446,000,000 feet board measure. Field-work on blister-rust control would, therefore, entail a charge of approximately 20 cents per thousand feet against the normal annual cut.

The Forest Products Laboratories of Canada

Investigations of technical problems pertaining to the manufacture, marketing, and use of forest products are carried out in Canada by the Forest Products Laboratories in three centres. The main laboratories are located in Ottawa, the Pulp and Paper division in Montreal, and the Vancouver laboratory in Vancouver.

The Pulp and Paper division confines its investigations to problems pertaining to pulp and paper, and works in close co-operation with the Canadian Pulp and Paper Association and McGill University.

The Vancouver laboratory deals with certain problems pertaining to British Columbia timbers requiring local treatment.

The work of the Ottawa laboratories covers all fields of forest-products investigation excepting those for which branch laboratories are specially equipped or those which, from their nature, require attention locally.

During the year under review, increased demands on the part of industry for the services of the laboratories indicate appreciable revival in business among the wood-using industries. Most of the problems which engage the attention of the laboratories are undertaken at the specific request of different branches of the industry, particularly at the request of committees of trade associations charged with the study of technical and scientific problems in connection with the industry. Valuable assistance was given to the laboratories by such committees, and the industry generally helped materially in promoting the work of the laboratories by special grants, contributions of material and equipment, and in many other ways.

Details follow in connection with the principal problems which have engaged the attention of the laboratories.

Ottawa Laboratories

Division of Wood Preservation

Creosote treatment of green yellow birch, hard maple, and beech ties

The service life of untreated beech, birch, and maple ties is only three to four years. When treated with creosote, or with a mixture of creosote and coal tar, the service life is extended for a further period of eighteen to twenty-two years. Hardwood ties are stronger than softwood ties and may be considered to have a comparatively long mechanical life. The object of preservative treatment is to protect the ties from decay for the period of their mechanical life. At present hardwood ties are air-seasoned before treatment, and a certain amount of trouble is experienced from checking during the air-seasoning period. In 1932, six hundred hardwood ties (200 yellow birch, 200 hard maple, 200 beech) were shipped to the laboratory by the Canadian Pacific Railway for treatment in the green condition. The treatment was successfully carried out, and the ties were stacked in the yard at the laboratories for observation of checking after treatment. Last year's report stated that yellow birch showed very promising results with respect to checking after creosote treatment in the green condition. Further observations have tended to confirm this finding, and one of the Canadian railway companies is now carrying on tests on a commercial scale. If the ties can be treated in the green condition, there will be a considerable saving in carrying charges, and further, owing to the reduction in checking, the service life should be appreciably increased.

Service tests of treated and untreated timber

Heretofore in Canada it has been difficult to obtain accurate and specific data on the service life of such timber products as telephone and telegraph poles, piling, fence-posts, railway ties, and miscellaneous timber structures such as wharves, bridges, culverts, loading platforms, and mine timbers. The laboratories are co-operating with government departments, railways, and other large users of structural timber in installing certain structures for test purposes. Suitable forms have been prepared to facilitate the recording of service data. During the year over 200 service tests were started, and in course of time these records will provide useful information on the service life of timber. The material selected for study includes ties, telephone poles, piling, caps, stringers, and wharf decking.

Creosote treatment of jack pine

The object of this project was to determine whether a treating schedule could be developed for jack pine ties which would provide better penetration than the empty-cell process with initial air now in use. One hundred and fourteen ties were sawn into twelve sections each to provide material for a series of experimental treatments. Nine treating schedules were used, and of these the most effective was found to be an empty-cell treatment with initial air followed by an expansion bath at 220° F., with temperature during the pressure period reduced from the customary 190° F. to 150° F.

Analysis of creosote before and after use

Samples of creosote were obtained before and after it was used to treat four charges of timber in a commercial treating plant. The samples were examined in accordance with the standard methods of analysis to determine the effect of continued use of the creosote on the coke residue. At present it is customary to allow for an increase of one per cent in the free carbon. The results of the analysis showed that there was no appreciable increase in the coke residue.

Butt treatment of poles and fence-posts

Field tests are under way on jack pine poles treated by boring holes in the sapwood at the butt and filling the alternate holes with a salt which will combine with another salt placed in the adjacent holes, to precipitate a toxic insoluble salt at and below the ground-line. Sixteen posts were removed for examination after one year's service. A visual inspection indicated a satisfactory climb of the preservative, and quantitative analyses are being made to determine the distribution of the toxic material. These experiments are for the purpose of developing a cheap method of treating fence-posts and poles. Existing methods of timber treating generally require treating equipment and fairly expensive preservatives, which render the cost of treating small numbers of fence-posts or telephone poles in rural districts too expensive.

Suitability of cedar poles floated in sea-water for use in electrical-transmission lines

The Provincial Inspector of Electrical Energy for British Columbia requested the laboratories to determine the percentage of salt present in a pole before and after floating in sea-water. It was claimed that the pickup of salt during storage or towing of poles in sea-water caused a lowering of the electric resistance of the poles to such an extent that it would constitute a hazard to linemen. It was found that there was an appreciable absorption of salt in the sapwood of the poles, but it was considered that the decrease in electrical resistance due to the salt was comparatively unimportant, in view of the fact that the electrical resistance of wood decreases so greatly with increased moisture content such as would occur in a pole after a rain storm.

The determination of arsenic in treated wood

Work in connection with this project was completed early in the year, and a report compiled and published.

General

Some other matters which received attention as a result of inquiries made to the laboratories were: staining wood by impregnation of the standing tree, treatment of radio masts of Canadian wood for use in Java, treatment of shingles, fire-retardant treatment of lumber, protection of hardwood logs from decay, the tainting of water in creosoted pipe, the use of certain salts as a preservative, the treatment of mine timbers, the painting of creosoted wood, the vermin-proofing of sawdust, and the preparation of pine oil in Canada.

Division of Timber Mechanics

Testing of small clear specimens

Testing was completed on the air-dry specimens of a shipment of white pine from Beauchène in the Témiscamingue district of Quebec. Specific-gravity and volumetric-shrinkage determinations were made on the above shipment and also on shipments of cedar, white ash, and beech from New Brunswick. The values derived from the above tests were incorporated in Blue-print E-113, which, together with Forest Service Bulletin 82, gives data on the mechanical and physical properties of Canadian woods.

A total of 5,625 tests was made under this project.

Glues and gluing

Testing was continued to determine the relation between animal-glue solution concentration and adhesive strength as determined from shear tests on specimens of hard maple. The additional data obtained indicated an increased strength with increased concentration.

Tests were made on a series of 21 animal glues to determine their jelly and melting points. The former determination was made by decreasing the temperatures of the glue solutions, the latter by increasing the temperatures of jells. The results indicated that these points were not reached at the same temperature for the same glues.

Tests were made to determine the effect of high temperatures on the viscosity and jelly strength of animal glues. The results indicated that heating at the boiling point of water over a period of 4 hours decreased both the viscosity and jelly strengths approximately 10 per cent per hour. Comparative tests made in co-operation with the National Research Council indicated that viscosities of animal-glue solutions as determined by the standard pipette and a specially designed overflow viscosimeter were in close agreement at the standard temperature of 60 degrees Centigrade.

A total of 2,046 tests was made under this project.

Nail-holding power of wood

Standard nail-pulling tests were completed on the air-dry specimens of basswood, Eastern cedar, large-toothed aspen, red maple, white ash, beech, white and jack pine, yellow and paper birch, balsam fir, aspen poplar, and white and black spruce.

The holding power of cement-coated box and bright common nails was also determined when driven in balsam fir, aspen poplar, black and white spruce, jack pine, and paper birch; this completes the investigations commenced last year on these types of nail.

Analysis of the results was completed and confirms the preliminary finding of last year, namely, that a definite relation exists between the specific gravity of the wood, the area of the nail surface in contact with the wood, and the holding power of the nail.

Tests to determine the effect of slant driving on the holding power of nails were completed. Cement-coated box, bright box, and bright common two-inch nails were used; these were driven vertically and obliquely in several different group-arrangements. The test specimens were subjected to various conditions of seasoning before being pulled under both static and impact loads. Computations have been completed and the analysis commenced. The results of the standard tests have been incorporated in Blue-print 166. Additional data on nailing are given in Forest Service Circular 39.

A total of 5,659 tests and determinations was made under this project during the year.

Shipping containers

No project tests were undertaken during the year. A considerable number of tests was carried out, however, on many types of containers submitted by both manufacturers and consumers, including such types of containers and classes of commodities as wooden boxes for export of electric stoves; wooden crates for handling of bottled goods; Canadian-constructed orange-crates for South Africa; fibre-board boxes for export of fruit, and fruit trays for use in the West Indies.

Structural timbers

No testing was carried out under this project during the year. A considerable amount of analytical work was undertaken, however, with the data already obtained. These analyses were used in connection with the preparation of uniform grades and specifications for Canadian structural timbers. After a complete survey had been made of the existing grades, a grade specification based on strength conditions was prepared and submitted to the Canadian Engineering Standards Association to be used by that association as a basis for Canadian standard grades for structural timbers.

Assistance was given to the timber sub-committee of the Toronto Building By-law committee with respect to grades and working stresses for structural timbers. This work was considered as being particularly important, as the timber items in this code will in all probability be subsequently incorporated in the building code of other Canadian municipalities when making revisions to their codes.

Approximately 6,000 gradings of individual pieces were made in connection with the above analyses.

Efficiency of logging sleighs for pulpwood operations

This study is being carried out in co-operation with the Woodlands Section of the Canadian Pulp and Paper Association. The working plan was prepared, and preliminary surveys made of types of topography, logging methods, and sleighs employed at pulpwood operations in the Upper and Lower Gatineau.

Testing was commenced late in the season on a round-shod heavy logging sleigh. These tests were made on different types of surface such as dry and wet snow, rough and glare ice, and slush. Testing will be continued next winter.

Splitting effect of nails in orange-crate construction

Test material of white spruce, balsam fir, Western hemlock, and amabilis fir was obtained. Half of the above material was kiln-dried to a moisture content of 8 per cent; the remainder was stored until a moisture content of 14 per cent had been reached. Tests will be made during the early summer.

Minor investigations and miscellaneous testing

A considerable number of investigations of a limited character, usually originating in technical inquiries from the wood-using industries, was carried out. The following list indicates the variety and volume of testing involved:—

Tests on Douglas fir beams removed from an industrial building after 27 years' service,

Tests for a railway company to determine the effect of knots on the strength of red pine car flooring subjected to drastic heat and moisture conditions,

Tests for a mining company on spruce caps and girts used as mine timbers in northern Ontario,

Tests for a plywood manufacturing company on the resistance to puncture of different types of plywood,

Tests for the Aircraft Inspection Department of the Royal Canadian Air Force on samples of woods used in aircraft construction and repair,

A total of 1,097 tests on animal, casein, and vegetable glues and glued joints, carried out for 17 glue and furniture manufacturers,

Tests to the number of 263 on wooden, corrugated, and fibre-board containers made for 12 Canadian manufacturers,

Twenty-three tests for the Department of National Defence on woods and metals used in the construction of general-service wagons and gun limbers.

Tests to the number of 2,192 were carried out in the course of these minor investigations, and a total of 16,161 tests was made during the year in this division.

Division of Lumber Seasoning

Kiln-drying studies

During the year a new unit was built in conjunction with the kiln constructed last year, and it is now possible to experiment with material up to 12 feet in length.

Among the most interesting charges dried in the new kiln were those of 4-inch green yellow birch and 4-inch green hard maple. The charges were successfully dried down to a moisture content of 10 per cent. Test runs were made on commercial-length white pine, the schedules previously developed for short lengths in the small laboratory drier being used. The charges were reduced from approximately 60 per cent moisture content to 7½ per cent in 92 hours, with a complete absence of degrade and no indication of kiln-burn.

A study was made of three new patented drying processes from data available; opinions were given on request in connection with certain new kiln designs; and assistance was given in connection with the repair, remodelling, and new construction of a number of commercial kilns.

Features of note as disclosed by inquiries received and discussions with members of the industry were (1) the interest among white pine operators in the possible kiln-drying of deals and upper grades with a view to shortening seasoning periods and reducing shipping weights, and (2) the interest of certain spruce exporters in the possible kiln-drying of Eastern spruce to meet overseas moisture-content specifications.

Equilibrium moisture content

The work of previous years in determining the seasonal fluctuation of the moisture content of various species of lumber was continued. The varieties of lumber tested were white pine, red pine, jack pine, and white spruce. Sample boards were placed in an ordinary commercial lumber pile in an Ottawa yard and weighed monthly. The moisture contents were computed from these weights.

The results for the year showed a more or less regular variation, the moisture content of the samples dropping sharply in May, rising again in June, then falling again in July and August. During the autumn the general trend was upward, except in October, to a maximum reached in December, and more or less maintained during the winter months. The highest average moisture content recorded was 18·69 per cent for the spruce in April; in May the white pine dropped to an average of 10·65 per cent, which was the lowest figure for any species for the year.

Air-seasoning studies

It was found desirable to make yard brown-stain studies a separate project, and work on cost studies had to be temporarily suspended owing to pressure of other work. The work done on the remaining two sub-divisions was as follows:—

1. Drying-rate studies. Routine weighings and computations were made on the sample boards in test piles, and drying-rate curves plotted for the various species under observation.

2. Degrade studies. Inspections of test piles in commercial yards in Ottawa, Thurso, Calumet, and Pembroke were made. The almost general use of a sap-stain dip in white pine yards has greatly reduced the amount of degrade from blue-stain. In consequence of this reduced stain-hazard the laboratory advised the closer piling of stock in several yards, and material reduction in degrade from checking has resulted.

With the co-operation of one large white pine operator a new method of drying white pine deals was tried. The deals were dipped in a sapstain preventive and flat-piled in a shed, thin narrow crossers being used. The thickness of the crossers was progressively reduced from 1¾ inches to ⅞ inch, and degrade from checking and stain was practically eliminated. In its previous practice of yard piling on edge, this firm had experienced a down-tally of as high as 80 per cent in piles of first-quality deals.

The further co-operation of the division in the matter of a change in yard-piling practice was sought by a large hardwood operator. It was decided to segregate all lengths and completely eliminate overhang. The results have proved the economy of the extra outlay entailed in sorting. Besides reducing degrade the practice simplifies the covering of piles and greatly reduces labour of handling and re-piling during shipment.

Yard brown-stain in white pine

Under the keener competition met with in lumber selling in recent years, crosser burn and " coffee " stain are becoming increasingly important factors. It was decided that this study was of too great importance to be dealt with as a part of the general studies on air-seasoning, and it was made a separate project. A new working plan was prepared and discussed at the annual convention of the Canadian Lumbermen's Association.

Since the matter of the revision of the grading rules of the White Pine Bureau was imminent, it was thought desirable to deliver illustrated lectures at the annual conventions of the Canadian Lumbermen's Association and the Ontario Retail Lumbermen's Association, explaining the nature of these brown-stains. As a result the White Pine Bureau decided to modify their proposed revisions of rules in so far as " coffee " stain was involved.

Careful observations were made on the material in a number of test piles from Ottawa yards, as it was being dressed in a local planing mill, and plans for further study have been outlined.

Use of yellow birch and hard maple for spokes and felloes for artillery wheels

The test wheels prepared, under the supervision of the division, from material kiln-dried and treated by these Laboratories last year are still under observation in service tests. Verbal and written reports received to date indicate that the birch and maple components are comparing quite favourably with the standard oak and ash components also in test. Since no failure has occurred, it was decided to conduct a complete test under both summer and winter conditions before having the division make a detailed examination. This will not be possible until May, 1935.

The drying of maple last-blocks

Owing to kiln-construction work and the use of the kiln for other work, it was necessary to interrupt progress in the matter of developing drying schedules, but assistance was rendered to both the Commercial Intelligence Service of the Department of Trade and Commerce and to a number of last-block manufacturers.

A mimeographed, illustrated pamphlet on the detailed requirements of the United Kingdom market was prepared and both English and French copies were distributed to the trade and others interested. An examination of an overseas shipment was also made on behalf of the Commercial Intelligence Service, Department of Trade and Commerce.

Minor Investigations

Wood Taint in Butter Boxes.—This study is being conducted in co-operation with the Dairy Branch of the Dominion Department of Agriculture. The casein-formaldehyde treatment developed last year has met with general success wherever it has been experimented with commercially. The division is at present engaged in developing a somewhat modified procedure of application from that at present used experimentally in order to eliminate certain inconveniences attendant on its use. Not only has the treatment proved efficacious in preventing wood taint but also by its use the objectionable bleaching of outside surfaces of butter in paraffin-coated boxes is prevented.

A further subject of investigation at present engaging the attention of the division is the acetic-acid flavour imparted to butter by certain boxes. This is distinct from the usual wood taint previously investigated.

Study of proper moisture content for rifle stocks.—Service rifles collected by the Department of National Defence from various parts of Canada and representative of different conditions of use were dismantled, the wooden parts examined, and moisture-content determinations made in each case.

Seasoning and storage of walnut for rifle stock.—At the request of the Department of National Defence a study was made of the usual practice in this connection, and definite recommendations as regards yard lay-out and dry-kiln arrangements are in preparation for submission.

Splitting of Tonkin cane ski poles.—Tonkin canes are more favoured than bamboo for ski poles because of their flatter nodes. However, they are reported as having a greater tendency to split when subjected to cold-weather conditions. An investigation was undertaken with a view to ascertaining whether or not such splitting is due to faulty seasoning or to storage practices.

Division of Timber Physics

Wood sections

The collection of microscopic preparations of timbers of the world has been increased by the preparation and addition of 18 species.

Porosity of wood

In studying the rate of flow of water at controlled pressure through wood samples one inch thick, it was found that the rate of flow was less through wood samples of high moisture content than in those of low moisture content. This is in keeping with the general findings of commercial wood-preserving plant operators that wood properly seasoned is impregnated more easily than green wood.

Variability of wood

This investigation has for its object the determination of the variation in density of wood of the more important pulpwood species (the spruces and balsam fir) of Eastern Canada. The density is so closely related to the yield of pulp that it is proposed to obtain samples of pulpwood from representative areas for testing in order to determine the variation in density of each species in different localities. By noting the environmental conditions of the wood in the forest types to be studied, it is expected that the annual supply of pulpwood sent to the mills may be planned with greater accuracy in respect to its yield of pulp when more exact information is available regarding the density of such wood.

Samples were obtained from the Petawawa Forest Experiment Station from a stand of black spruce (*Picea mariana*) and from a stand of the white spruce (*P. glauca*) and balsam fir (*Abies balsamea*) type. This material was tested at the laboratories.

As a result of this the methods of sampling were revised, and a working plan for this section of the project was prepared. This plan involves collection of test material from the black spruce type, the softwood type, and the mixed type where hardwoods form a considerable portion of the stand. Suitable localities, from Manitoba eastward to Nova Scotia, were selected in which to collect material.

In conformity with this plan, test material from the three kinds of site were obtained from the Lower Gatineau River area and material from the softwood type and the black spruce type were obtained from the Upper Gatineau River area, through co-operation with pulp and paper companies operating in these districts. A preliminary report on material from these three areas was made at the annual meeting of the Woodlands Section of the Canadian Pulp and Paper Association.

The oldest two stands of black spruce tested—with mean age at stump of 108 years (Chalk River stand) and 117 years (Upper Gatineau stand)—showed somewhat similar average density (about 0·43), although the trees of the 108-year-old stand were about 25 per cent taller in corresponding diameter-classes than those of the other stands. Two other stands of black spruce (one from the Lower Gatineau and the other from the Upper Gatineau about 60 miles distant) were also quite similar in density, though lighter than wood of the older stands (averaging about 0·40).

The data on balsam fir in the following table indicate that local growth conditions may affect the quality of wood:—

Location	Type of stand	Mean age	Mean sp. gr.
(1) Balsam fir from northern Quebec	Balsam fir and spruce	98 yrs.	·31
(2) Balsam fir from Petawawa, Ont.	Balsam fir and spruce	47 yrs.	·33
(3) Balsam fir from Quebec (about 160 miles from No. 1)	Balsam fir and spruce	50 yrs.	·31
(4) Balsam fir stand 2 miles from No. 3	Mixed hardwood	72 yrs.	·33

This brief mention of tests made so far in the investigation suggests its scope and purposes, and indicates a desirable method of presenting its findings in a

form that may be applied by the woods management of paper companies to their stand tables. If the density of wood from trees of each diameter-class is known, the figures may be applied directly to the records showing the proportion of each diameter-class represented in the stand.

It is planned to obtain material from a sufficient number of stands in different localities so that the factors which affect the density of wood may be adequately appraised. The co-operation of the Pulp and Paper Association was obtained in pursuing the work of this project. Some of the pulp and paper mills have already obtained a certain amount of information on the density of pulpwood. Plans are now under way to make collections of material for tests during the coming year in co-operation with the woodlands divisions of the mills in the neighbourhood of the regions from which samples are to be taken.

General

Identification of lumber and wood products was carried out on request from a variety of sources, including lumber producers, inspectors, and buyers, dealers in wooden products, the Department of Customs, paper mills, and others. Other requests for information on the fuel value of wood, the weight and solid volume of various woods per cord, the general properties of wood, wood-bending processes, methods of wood identification by anatomical examination and detection of fluorescence, suitability of woods for specific purposes, tests of pulpwood, cause of specific degrade, ignition temperatures of wood, and other items, received attention. A considerable amount of work was done by this division in making microscopic examination of material submitted. The samples included specimens of dowels, box boards, handles, and veneer. The examination of the structure of chemically treated ties and of white pine affected by brown-stain was also carried out.

Division of Timber Pathology

Reference collection of pathological material

In September a member of the laboratory staff spent several days at Chalk River, Ontario, collecting specimens of fungal fruit bodies and decayed wood for the laboratory collection. From these specimens cultures were set up. Of the specimens, 24 have been added to the permanent collection; and cultures made from them have been added to stock culture series. The remaining specimens and cultures await final examination.

The collection now contains 915 specimens; and the stock cultures number 173.

Red stain in jack pine: its development in creosoted and untreated railway ties under service conditions

Untreated ties to the number of 30 were removed from an experimental track near Ottawa, and subjected to complete analysis. Cultures were made from the heartwood. The following table gives the results of cultural analysis of the heartwood of untreated ties removed from track during the course of the experiment:—

DISTRIBUTION OF CULTURES FROM HEARTWOOD ON PERCENTAGE BASIS

Condition of ties	No. of ties	Date of removal from track	No. of cultures	Per cent				
				Trametes Pini	Fungus No. 2	Mould and staining fungi	Secondary wood-destroying fungi	Blank
Untreated	40	1931	3746	10·8	24·5	47·1	9·3	8·3
Untreated	40	1933	3610	5·8	14·9	51·4	29·2	3·3
Untreated	30	1934	3788	7·3	10·9	45·4	32·8	3·8

The results of analysis indicate that *Trametes Pini* and Fungus No. 2 are still alive in the ties, but that their distribution is not extensive. Secondary wood-destroying fungi have, on the other hand, become increasingly active during the years. Of these, 23 were isolated during the analysis. The sapwood of the 30 ties removed in 1934 showed advanced decay; and in some, rot was sufficiently advanced to have caused their complete destruction. The heartwood also of all the ties contained decay caused by the attack of secondary wood-destroying fungi; and in many cases this decay was advanced and extensive. The investigation is still in progress, and will be carried on until all the ties still in track have been removed. Of the untreated ties, 86 are still in service. These will be analysed during 1935, 1936, and 1937. The creosoted ties. which now number 157, will be removed in groups of 20 at two-year intervals.

Blue stain in white pine

During September, 1934, complaints were made to the laboratories by pine lumber manufacturers that lumber treated with a sapstain preventive had shown very profuse development of mould during the humid weather of late August and early September, A questionnaire was, therefore, sent out to members of the White Pine Bureau, in order to obtain full information as to the extent and nature of the trouble. A visit was also made by the timber pathologist to several pine-seasoning yards. It was decided that laboratory tests should be carried out in order to obtain further information regarding the efficiency under varying conditions of the chemicals now in use, and also to test other chemicals.

Decay of pulpwood in block piles

Analysis of 60 pulpwood sticks submitted by one of the paper companies was completed. To date, three lots of samples have been examined from block piles with the results recorded in the following table:—

DECAY IN STORED PULPWOOD

—	Lot No. 1	Lot No. 2	Lot No. 3
Age from time of cutting, years	4	2	4
Years in storage	3½	1½	3½
Number of logs	25	25	60
Condition of bark when piled	Barked	Mostly unbarked	Unbarked
Percentage of wood volume affected by:—			
Stain	30·45	6·33	0·23
Incipient rot	28·80	22·79	49·72
Advanced rot	2·15	1·05	44·34

These figures indicate that great losses due to decay may occur in pulpwood during prolonged storage, especially in unbarked logs. The small amount of stain recorded for Lot No. 3 is to be accounted for by the fact that decay has invaded the sapwood and has masked the stain which probably developed during the first year of storage. In addition to completion of the study of the sample lot discussed above, analysis is in progress of 50 sticks (mixed spruce, balsam fir, and jack pine) received from another paper company. This wood was piled in 1930, and samples were obtained when the pile was opened up in the autumn of 1934. Two additional sample lots of pulpwood are on hand awaiting study.

Inquiries

During the year many requests for technical information were received by the Division of Pathology. Of these, some related to stain or mould on sapwood of spruce or pine, with special reference in several cases to chemical treatments recommended for prevention of discolouration; others had reference to red stain in jack pine; a number came from manufacturers of pulp and paper

and had reference to stain or decay in pulpwood, moulding of pulp, analysis of slime or water samples, and other technical questions. Other miscellaneous requests for information related to brashness in ash; decay in Douglas fir, oak, and maple; luminescence of decaying wood; decay in cedar shingles; discolouration in box boards shipped for orange crates; relative durability of spruce and balsam fir, and red discolouration in spruce.

Division of Markets and Exhibits

Wood Specimens

During the year there were distributed on request 170 sets of wood samples, 128 in Canada, thirty in the United Kingdom, three in the United States, three in the Argentine, three in South Africa, one in New Zealand, one in Finland, and one in Holland. These samples were prepared in sets of thirty small specimens, principally for schools; in sets of fifteen panels, 8 inches by 15 inches, labelled with the principal characteristics and uses of each wood for museums and dealers abroad; and in sets of twelve pieces, 3 inches by 6 inches, in wooden boxes, with concise descriptive labels of the properties and uses of each wood, for architects and architectural schools in the United Kingdom. In connection with wood samples, the quantity distributed is limited by the facilities of the laboratories for their production. Advice has been sought during the year by two provincial governments and the Department of Trade and Commerce, through their Trade Commissioner service, on the wider distribution of such samples.

Exhibitions

The laboratories prepared and set up an exhibit of Canadian lumber grades at the Produced-in-Canada Exhibition held at Montreal in November, 1934. This exhibit was intended to promote a better knowledge of lumber grades, and to encourage the practice of purchasing lumber by grade rather than by specification. An exhibit of diversified forest products was also shown at the Central Canada Exhibition held in Ottawa in August, 1934.

Co-operation was given the Department of Trade and Commerce in exhibits in South Africa during the British Empire Shopping Week, the Eastern Canadian Timber Commissioner in the United Kingdom for an exhibit in the British Industries Fair, and the Canadian Exhibition Commission in the preparation of a permanent exhibit in the Imperial Institute, London, England. In several instances the laboratories supplied material to, and in other ways assisted, the Canadian Government Exhibition Commission in London, the Quebec Forest Products Commission, the Canadian Hardwood Bureau, and similar bodies in their general exhibition work.

Wood Chemistry

No investigations involving the use of laboratory equipment were carried out, but considerable attention was devoted to the assembly of existing data for inquiries regarding the following subjects: the manufacture and briquetting of charcoal; the utilization of sawdust, shavings, and mill waste; the products of softwood and hardwood distillation; producer gas from charcoal and wood waste; essential oils, oleoresins, and tannins from Canadian woods.

General

Publications

During the year 14,021 publications were distributed from the Ottawa laboratories; 8,864 of these were sent out through their mailing lists, and 5,157 were sent on special requests. In addition to these, numerous publications were

sent out by branch laboratories in answering requests for information made direct to them.

In addition to printed publications, mentioned elsewhere, the following reports were mimeographed and distributed:—

Last-block Manufacture for United Kingdom, by W. J. LeClair. (In English and French.)

Review of the literature on the Fire-retardant Treatment of Cedar Shingles, by J. C. L. Charlebois.

Twenty-one lectures for a Lumbermen's Class, prepared by members of the staff of the Ottawa laboratories.

A number of articles were written for technical and trade papers and addresses delivered before trade associations. Among the subjects dealt with were: End-coatings for Lumber; Red Stain in Jack Pine—Its Development in Creosoted and Untreated Ties under Service Conditions; Douglas Fir; Canadian Spruce; Pathological Enlargement of Resin Canals in *Picea;* Cross-ties for Canadian Railways; Industrial and Economic Problems in Connection with Forest Products; The Variation of Pulpwood as an Indication of Pulp Yield; Logging Sleighs; Brown Stain in White Pine; Forest Products Research.

Co-operation with National Research Council

Representatives of the Forest Products Laboratories participated in the work of sub-committees of the National Research Council dealing with the following subjects: Minor Forest Products of Canada; Paint Specifications; Pulp and Paper Purchasing Standards. The laboratories also assisted the National Research Council in the preparation of standard specifications for red cedar shingles and reviewed, at the request of the council, the manuscript of certain articles dealing with wood which had been submitted for publication in the " Canadian Journal of Research."

Lumber Courses

On request of the Commercial Intelligence Service, the Ottawa laboratory gave a course of lectures to junior commissioners in training. In March, 1935, a series of lectures and demonstrations extending over five days was given to representatives of lumber firms and other wood-using industries in Eastern Canada, in order to familiarize them with the work being carried out at the laboratories.

Canadian Engineering Standards Association

This association received a request to set up standard grades for structural-size timbers, applicable to all species used for such purpose in Canada. The laboratories, through its representative, prepared the draft specifications for the committee empanelled to prepare the grades.

Miscellaneous

In the three laboratories about 3,000 inquiries for technical information received attention, and 640 negatives, 3,628 prints, 149 lantern slides, and 4 enlargements were prepared in the photographic division.

PULP AND PAPER DIVISION (MONTREAL)

During the year the Pulp and Paper Division has maintained close co-operation with the pulp and paper industry. Among the principal activities of the division were the study and development of methods for analysis and testing of pulp and paper; fundamental researches in the properties of lignin, cellulose, pulp fibres, and wood; semi-commercial studies in pulping wood both by chemical and mechanical processes, and fundamental researches in the same fields; the standardization and calibration of instruments for testing pulp and paper; testing and analysis of samples of various woods; pulps and papers submitted

by commercial firms and individuals for examination; delivery of a series of lectures dealing with the research activities of the division, and response to inquiries for information. A detailed description of the activities of the division follows.

Methods of Testing and Analysis

Work on the classification of pulps by selective screening was completed, and the pulp-fibre classifier devised at the division was adopted as a tentative standard instrument by the pulp and paper industry. Arrangements have been made with the industry for making this device available in Canada as soon as the necessary legal arrangements have been concluded with respect to the patent for the instrument. A method has been developed for making microphotographs of fractions of pulps classified in this manner, and the influence of fibre length on the properties of hand sheets made from selected fractions has been studied briefly.

Experiments have been commenced which will, it is hoped, enable larger samples to be classified in the same manner, partly because of the value of various experiments performed upon such fractions, and partly because of the possibility of direct commercial application of the principle to the processing of pulps. If these experiments are successful, an exhaustive study of the influence of fibre length upon pulp properties will be undertaken.

In this connection preliminary studies have been made on the rates of drainage of pulp fractions with a narrow range of fibre length. It has been found that the paper-making properties of pulps are affected both by the relative proportions of fibres of different lengths and also by the degree to which such fibres have been fibrillated. Such properties as freeness, rate of drainage, and physical strength have been found to be influenced by both these factors, to evaluate which two separate measurements are at present necessary. By limiting the fibre length of the fraction of pulp tested within a narrow range, it may be possible to evaluate a pulp approximately by means of a single test.

In collaboration with the Department of Physical Chemistry at McGill University preliminary investigations have been made into the relation between the external area of pulps in suspension and the other properties of such pulps, including the influence of fibre length upon external area.

A modification of the sheet-forming apparatus employed in the British method of pulp evaluation has been developed which permits the forming of hand sheets at consistencies such as are employed commercially on Fourdrinier machines. This method is so constituted that no loss of substance takes place, and sheets may be prepared containing size, loading, and colour in the same proportions as those used in commercial furnishes. The combined use of heat and tension in drying the sheets is possible in this method.

A comparison of different laboratory methods for fibrillating pulps has been made, including the use of a laboratory pebble-mill, a single ball-mill, a single rod-mill and a small laboratory beater. The work will be extended to include the use of a new type of laboratory kollergang and to determine the influence of storage of sample before testing.

By arrangement with the Department of Physical Chemistry at McGill University, the method for determining the external area of pulps referred to above, and a method for determining the absolute opacity, reflecting power, and capacity for light absorption of paper have been made available at the division. The necessary apparatus was constructed in the divisional workshops.

Methods for the determination of lignin in pulps and chips and for the analysis of sulphite cooking liquors have been investigated at the division, the investigation resulting in the selection of methods giving greater accuracy in determinations.

At the instance of the pulp and paper industry physical tests on pulp and paper are now computed on a metric basis, customary values being furnished for comparison in the case of tests for commercial firms and individuals.

Bonding of Fibres

The factors governing the bonding of fibres both in paper and in wood have continued to receive attention. The study of the sorption of liquids other than water has been discontinued, and a final report on this investigation in its present stage has been filed. Evidence has been secured indicating that the first portion of water adsorbed by dry cellulose is held in a different manner from subsequent portions of water, as indicated by the apparent high density exhibited by the first layer of water thus taken up. Attention has been directed to the phenomena which occur during the formation of a sheet of paper on a Fourdrinier wire, with particular reference to the rates of drainage of different furnishes and the possibility of studying the formation of a sheet of paper by photographic methods.

Pulping by chemical and mechanical processes

Semi-commercial investigations in pulping by kraft liquors, both at constant low concentration and under normal conditions, including the use of solutions of sodium sulphide without the addition of sodium hydroxide, were conducted with gratifying results. The semi-commercial equipment constructed for the purpose at the division was thoroughly tested and found to be reliable and satisfactory.

The technique of small-scale sulphite cooking was studied carefully, and as a result a very satisfactory method for conducting small autoclave cooks at high liquor ratio was developed. This method has been used successfully for studying yields from different woods and the influence of particle size upon rates of lignin removal. Studies in the influence of decay upon yields were made during the year, but owing to the difficulty of correlating the extent of the decay with the quantity of wood in storage an extensive investigation was not deemed advisable.

The rates of removal of lignin have been studied with some care, and the work is still in progress. Evidence has been secured which indicates that, contrary to the opinion of some workers elsewhere, the rate of sulphonation is of the same order of magnitude as the rate of solubilization of the sulphonated material. In collaboration with the Department of Physical Chemistry at McGill University, the effect of pre-treatment of wood is being investigated, as it was found that heating wood in water prior to sulphonation retards solubilization of the sulphonated lignin but does not affect greatly the rate of sulphonation. Heating in a non-aqueous solvent, on the other hand, has no effect over the same temperature range. The possible influence of woods which cook rapidly upon woods which are more resistant is now being studied, in view of the prevalent opinion that such mixtures produce pulps which are inferior to mixtures of pulps obtained by cooking the woods separately.

In the field of mechanical pulping, the experiments in grinding wood-pulp at high peripheral speeds were brought to completion. The results obtained may be summarized by the statement that it appears probable that any desired type of mechanical pulp can be ground at any peripheral speed attainable with existing types of artificial pulp-stone, and that if pulp-stones capable of operating safely at higher speeds are developed there is no reason why pulps should not be produced satisfactorily under such conditions. It would appear that, other things being equal, the rate of production of a given type of mechanical pulp is directly proportional to the peripheral speed of the pulp-stone, while the

energy required to produce unit quantity of such a pulp is independent of the grinding speed. Since the power which can be transmitted by a rotating shaft is directly proportional to its speed of rotation, the production of pulp from a given grinder should increase nearly in direct proportion to the peripheral speed of the pulp-stone. The commercial significance of this relationship lies in the possibility of increasing the productive capacity of existing grinders by the use of faster motors or frequency-changing devices as well as in the possibility of designing new grinder equipment with a greatly increased capacity for pulp production without a corresponding increase in capital cost. Except to the extent to which such changes increase the individual productivity of labour, little change in operating costs is to be expected in the production of a given type of pulp. It is too soon to predict to what extent the operation of pulp grinders at higher speeds will become a commercial operation, but one commercial grinder has, as a result of the experiments just described, been operated successfully at peripheral speeds over 6,000 feet per minute and the resultant pulp converted into newsprint paper of high grade on a paper machine running at a thousand feet per minute, while several mills have under serious consideration plans to increase their production of ground-wood by marked increases in grinding speeds.

As a consequence of the interest shown by the pulp and paper industry, the division has undertaken a study of the fundamental factors governing the production of ground-wood pulp, with particular reference to the consumption of power in grinding. A study of the efficiency of the present process indicates that all but a fraction of one per cent of the energy supplied to a grinder re-appears as sensible heat, and that this heat, being almost all liberated at the zone of contact between the grindstone and the wood which is pressed against it, probably raises the wood fibres to surprisingly high temperatures. This sudden rise in temperature may play a part in the grinding process by softening fibres or even assisting in their removal and fibrillation. A miniature grinder, in which wood of highly uniform character can be ground under very precisely regulated conditions, will be used to attempt to ascertain the actual conditions of temperature and pressure which obtain at the seat of grinding.

Standardization and calibration of instruments

During the year there were calibrated nine Canadian standard freeness testers, and fifty-seven parts of the Canadian standard freeness tester.

Two sets of British pulp evaluation apparatus were calibrated. A standard model of the new pulp-fibre classifier was prepared, but so far no instruments have been marketed and therefore no calibrations have been required. A set of specimen papers were tested for opacity according to the Maass method and distributed to a number of mills to enable the working of various commercial opacimeters to be compared.

General

Testing.—Testing of pulps and papers was carried out throughout the year. The total number of samples tested amounted to 610.

Most of the requests for testing were received from members of the Canadian Pulp and Paper Association; a few other requests were received, among which were several from concerns in the United States and elsewhere outside Canada.

Inquiries.—Technical inquiries relating to forest products and pulp and paper manufacture were received and answered to the number of 497. Many of the inquiries were concerned with the manufacture of mechanical pulp, and of these a number dealt with slime troubles in storage and manufacture. A considerable proportion of the inquiries received were from organizations which had previously made use of the services of the division.

Publications.—Reports and publications were issued on all projects active during the year in the form of departmental reports and scientific publications and in the Quarterly Review, the special medium through which progress at the laboratories is reported to technicians in the pulp and paper industry.

Special Lectures

At a special meeting on November 3, 4, and 5, senior members of the staff of the division delivered a series of lectures before a group of technicians sent for the purpose by different organizations to attend a course arranged by the Committee on Education of the Technical Section of the Canadian Pulp and Paper Association. These lectures were in addition to papers delivered at the summer meeting and the annual meeting of the Technical Section, and, judging from the reception accorded the speakers, the course will probably be repeated annually.

VANCOUVER LABORATORY

The fiscal year ending March 31, 1935, has been another period of progress for the Vancouver laboratory. The same close relationship has been maintained as in the past, with the forest-products industry of British Columbia. A slight improvement throughout the industry resulting from the building up of the export market, particularly in the United Kingdom, has brought increased demands for the technical service offered by the laboratory, but has at the same time changed the character of the service considerably. Over nine hundred direct requests for technical information were dealt with, many coming from foreign countries. There has also been a wide distribution of publications in both printed and mimeographed forms. Assistance has also been given to many firms in improving their production or utilization methods, either by studies at the laboratory or in the company plant, and in a number of cases a marked saving has been attained. Material for such studies and for several routine projects has been supplied without cost to the laboratory. The following will give a brief outline of the work carried out:—

Division of Timber Mechanics

This division has completed a total of 16,884 mechanical and physical tests on routine projects during the year.

Standard tests for mechanical and physical properties

Tests were completed on all air-dried test-pieces from Shipment 78, second-growth Douglas fir. Considerable attention was given throughout the year, as material was made available, to a study of the relationship between the rate of growth, the specific gravity, and the strength of aeroplane-quality Sitka spruce. It has been found that many pieces of material, which pass all specifications for visual inspection, fail to meet the strength specifications. These tests were undertaken in order to indicate a means for more closely co-ordinating the two sets of specifications. At the same time they are intended to indicate the relationship between the crushing strength at maximum load in compression parallel to the grain and modulus of rupture in static bending and the effect of size of test-specimen—whether 1 inch by 1 inch by 2 inches or 2 inches by 2 inches by 8 inches—upon the test result. The tests are made in accordance with aeroplane-material specification standards on test-pieces when in the green condition and when air-dried to 15 per cent moisture content.

A summary of the test results for one shipment of red alder in the green condition was completed. Complete test data for Douglas fir were analysed to determine the effect of rate of growth upon the strength, and a report was prepared for publication as a circular.

The retention of nails and screws by wood

A progress report was prepared summarizing the results of all tests made during the previous year. Testing has been continued on air-dried Western white pine to determine the relative holding power in this wood of 1½-inch, 1⅝-inch, 1¾-inch, 2-inch, and 2½-inch bright and cement-coated box nails.

The strength of glued joints

During the year studies were made to determine the effect upon the joint strength of varying the pressure; the relative strength of different shipments of casein glue; the ability of certain glued joints to meet the specifications for aeroplane-quality material, and the suitability of cassava flour from Empire sources as a glue base for use in furniture manufacture. A formula was developed for a high-strength, highly water-resistant casein glue made from local raw materials. This has been in use by a plywood manufacturer and has given a uniformly improved quality of finished products.

Tests of structural timbers

The remainder of the air-dried compression sections cut from the Douglas fir timber 6 inches by 12 inches by 16 feet and a few air-dried Western hemlock joists measuring 2 inches by 10 inches by 16 feet were tested. An analysis of the test results will provide information as to the effect of air-seasoning upon the strength of Douglas fir and Western hemlock timbers and joists. The information already made available as a result of these tests has proved of great value to the British Columbia Lumber and Shingle Manufacturers Association, in the prosecution of their trade-extension campaign, and was used by them in the final preparation of the Astexo Grades UKAY, "A" List, for use in the British market. Considerable time has also been spent on grading all structural test material under four standard grading rules.

Forty-nine timbers were selected from Christ Church Cathedral, Victoria, after sixty-two years of service, and tested to provide data to add to that already assembled on the effect of long service upon the strength of timbers.

Pole investigations

A final report has been prepared, for publication as a circular, giving the results of all tests made on Douglas fir poles, both untreated and pressure-treated with creosote. This will provide valuable information as to the effect of pressure treatment upon the species, and will give strength values which may be used for comparison with those for other species now used in pole lines.

The retention of railway spikes by untreated and treated Western hemlock ties

The final report on this project gives fully the results of the tests carried out and enables a comparison to be made with values already determined for Douglas fir. There has been quite an extensive use of Western hemlock ties by some railways in the United States, and the extension of this market would provide a use for a large volume of low-grade material for which there is at present very little sale. A brief summary of the test results was supplied to an officer of one creosoting company who took it with him to China, where he hopes to interest the Chinese National Railways in the use of treated Western hemlock.

The retention of drift bolts by wood

Testing was begun during the year on the holding power of ¾-inch and 1-inch drift bolts in green Douglas fir. These two sizes were selected after consultation with railway and public works engineers. When completed, the investigation will provide average figures for the holding power of these two sizes of bolt, per inch of length, and will give some information as to the best size of hole to be bored in order to develop maximum holding power for each bolt.

Miscellaneous tests on wood

Many problems of a special nature are brought to the laboratory for solution, and tests are carried out on various manufactured wood products and associated products. Of recent years a pronounced pink or slightly purplish stain has been apparent in increasing amount on the quality of Douglas fir ordinarily used for door stock. Recently objection has been taken to the inclusion of such material, and the British Columbia Lumber and Shingle Manufacturers Assn. requested that special mechanical tests be made to determine the suitability of this material for door stock. As a result of these preliminary tests, plans have been made to study the cause of the staining and to make a more intensive study of the effect of this stain upon the mechanical properties of Douglas fir.

Tests were made on eight Douglas fir doors of both dowel and mortise-and-tenon construction, in order to provide comparative information to the manufacturers of the two types in connection with their export to Great Britain.

One shipment of aeroplane-quality Sitka spruce was inspected for the Australian Air Board, and the necessary mechanical tests carried out. Many tests were also carried out for the Department of National Defence and the Civil Aviation Inspection Department, both on spruce and wing fabric for aeroplane construction and repairs.

Tests were made on a special type of double-tongue butt joint for wood-stave pipe, as a result of which 10,000 feet of pipe line for the Greater Vancouver Water District will be built of this construction.

Tests were made on various types of plywood ski construction; on Western birch plywood with a Douglas fir core; on linen life-belt cover fabric; on the bending properties of various wall-boards, and on other problems of less importance.

Customs tests

Building construction has continued at a very low level during the past year, so that demands for customs testing of materials of construction besides wood by the laboratory, which has the only equipment available in Western Canada for this class of work, have not been so numerous as in past years. Tests were made upon such different materials as reinforcing steel, boiler plate, wire rope, manila rope, shafting, shingle-bands, joint-welds, fabric, salmon nets, and rock-salt blocks.

Division of Timber Products

Lumber Seasoning

Studies on lumber seasoning are divided under three main heads: absorption, air-seasoning, and kiln-drying.

Absorption.—A test shipment of seasoned lumber was made to Port-of-Spain, Trinidad, British West Indies, being the final shipment in connection with the study of the change in moisture content of seasoned lumber when shipped from British Columbia to Empire ports. A summary was prepared and mimeographed, showing the results of all studies made during the past ten years in connection with the change in moisture content of seasoned lumber in storage and in transit by rail and by boat.

In general, the results of these studies indicate:—

1. That the absorption of moisture and the consequent change in size and weight of kiln-dried lumber in open, unheated storage sheds is a serious problem, often affecting the satisfactory utilization of the material;

2. That the fluctuation in moisture content due to absorption can be largely eliminated, and the lumber maintained at a moisture content below 12 per cent, by storage in tight sheds heated to about 60° Fahrenheit during the winter months;

3. That seasoned lumber, shipped either by rail or by boat from British Columbia at a satisfactory moisture content, and properly loaded, will reach its destination in a condition satisfactory for use.

The study of the equilibrium moisture content of lumber in various lumber-producing districts in the Interior and Northern Coast forest regions of British Columbia was continued, weekly determinations of moisture content being made in the different districts. During this year the study was extended to include Dome Creek, Vanderhoof, and Terrace, in the Northern Interior forest region. The records of these equilibrium-moisture-content studies to date indicate a somewhat lower equilibrium moisture content, both in summer and winter, in the Southern Interior region than in the Southern Coast district.

Air-seasoning.—The study initiated last year to determine the influence of thickness of crossers on the drying of 2-inch Douglas fir was continued, two test-piles of 2-inch by 12-inch Clears being erected at a mill in New Westminster.

The study of the rate of air-seasoning of Douglas fir structural timbers and Western red cedar poles was also continued and that of the relative rate of drying and shrinkage of 1- and 2-inch Douglas fir and of 1-inch Western hemlock when rough and when surfaced was completed.

A study was begun on the air-seasoning of Western hemlock, particularly for 2- and 3-inch thicknesses. This study is designed to show the progress of seasoning throughout the year and to indicate the most economical method of piling to ensure satisfactory drying, since the trouble that has been experienced in the United Kingdom in the handling and use of large shipments of green Western hemlock indicates that it will be necessary to season this wood to a moisture content of 20 per cent, or lower, prior to shipment. Test piles of 1- and 2-inch export lumber have been erected.

A study of air-seasoning of several piles of 2-inch Douglas fir on swampy ground where the planked alleyways are often 3 to 8 feet above the bottom of the pile, indicated a variation in moisture content of about 4 per cent between courses above and below the roadway.

In order to determine whether a short period of air-seasoning during the winter months will dry the surface of thick lumber sufficiently to prevent surface discolouration when such lumber is bulk-piled in transit, a brief study was made on a special shipment of 6-inch Sitka spruce piled in an open shed. After one month of seasoning, the test-pieces showed a uniform moisture content of 22 per cent at the surface and from 22 to 24 per cent to a depth of 1 inch, while the interior of all pieces was still very wet. The condition of this shipment upon arrival at its destination in Australia will indicate the possibilities in this method of conditioning.

Kiln-drying.—The study of the effect of circulation on the kiln-drying of Douglas fir was continued. The final test run in the series of tests on 1-inch material was completed. A new series of runs was started to determine the effect of rate of circulation on the kiln-drying of 2-inch Douglas fir.

Two charges of 2-inch by 9-inch Western hemlock Clears were dried in the large experimental kiln in order to obtain information on the kiln-drying of this class of material to a specified moisture content of 18 to 20 per cent for export purposes. A satisfactory moisture-content range was obtained with the second charge after drying for 216 hours at a constant temperature of 150° Fahrenheit. Inspection by the Pacific Lumber Inspection Bureau showed a kiln-drying depreciation of 0·6 per cent trimmed for end checks and 0·9 per cent degrade for surface checks. The results indicated that the drying of 2-inch Western hemlock Clears (with their abnormally high green moisture content) is a much more difficult problem than the drying of Douglas fir or hemlock Commons.

Kiln-drying shingles.—The twenty-six test panels erected in September, 1929, in connection with the study of the effect of kiln-drying at different temperatures on the durability of Western red cedar shingles were examined periodically. After five years' exposure, no deterioration is apparent in any of the panels (coated and uncoated). The exposed portions of the brush-coated shingles are in fair condition as to appearance. The colour, however, has been almost entirely washed off the exposed portions of the dipped shingles.

Moisture content of shingles in service.—A new project was undertaken during the year to determine the moisture content of shingles in service. Eight test panels were erected of 3X and 5X shingles, green and kiln-dried, unstained and brush-stained. The variation in moisture-content was determined at frequent intervals under varying weather conditions, and at three points in the shingle, namely, near the butt, in the centre, and near the tip. While this study has not been conducted for a sufficiently long period to permit any definite conclusions being drawn, the results to date indicate that the dipping or staining of shingles greatly reduces the variation in moisture content after rain.

Effect of wood seasoning in regard to insect attacks.—Co-operation was continued with the Entomological Branch of the Dominion Department of Agriculture on the ambrosia-insect study, determinations of moisture content being made on the sapwood samples collected periodically by the entomologist from the test trees felled in connection with log-preference study. These logs were felled at monthly intervals and exposed to insect attack in order to determine if log acidity and moisture content had any relation to the extent of insect attack.

Minor seasoning studies.—Direct service to sawmills and wood-working plants in connection with their seasoning problems entailed many studies of a minor nature. A study of the bursting of bundles of shingles in transit showed that certain piling methods resulted in corrosion of the metal band; improved methods have eliminated this corrosion. Assistance was given to several sash and door factories in adjusting their drying time for door stock intended for export to the United Kingdom, where a moisture content of 12 to 13 per cent only is satisfactory, in place of the 8 to 10 per cent formerly used. This has reduced the average drying time by half a day and increased the output by approximately 10 per cent. Drying schedules were established for Douglas fir Clears showing a high percentage of "sappy" material, also for 2- and 3-inch Douglas fir and Western red cedar for export and for completing the drying of partly air-seasoned 2-, 3-, and 4-inch Douglas fir to a moisture content of 20 per cent to meet export requirements. The effect of different methods of piling this stock for air-seasoning was also studied. Assistance was given in the kiln-drying of partially air-seasoned Sitka spruce from a moisture content of 24 per cent to a uniform moisture content of 18 per cent, care being necessary to prevent case-hardening stresses. A study was undertaken to determine the cause and means of preventing severe discolouration found in kiln-dried shingles shipped by boat. The cause of serious degrade in kiln-dried Douglas fir Commons was determined, and suggestions made for reducing the loss. A satisfactory drying schedule was evolved for a firm manufacturing broom-handles from Douglas fir mill-waste. This firm was also aided in plans for utilizing their waste for steam generation. Studies at three mills on the seasoning of Douglas fir car lining showed faulty drying, and suggestions were made for future guidance. Studies were made to determine whether special conditioning would enable a local manufacturer to use local white birch or Sitka spruce for the upper plies of high-grade laminated skis. As a result of suggestions made for the drying of red alder, a large furniture manufacturer has been enabled to secure more uniform drying in one-half the time, enabling him to

increase the percentage of this wood used in his product. Ponderosa pine cylinders were prepared for the use of the British Columbia Forest Branch in the Kamloops district in determining the daily equilibrium moisture content in connection with forest-fire-hazard research.

Utilization

The first of a series of studies carried out to determine the effect of log size and grade on lumber manufacture was completed, and a draft report was prepared which will be used as the basis of more extensive studies in the future. Logging waste studies were limited to keeping in touch with special developments in logging practice, especially selective logging by tractors.

An examination was made of a large quantity of sawdust that had been held in covered storage for two years. Except that the colour was darker, the condition of this sawdust for fuel purposes was excellent, and corroborated the findings of the storage studies made under this project in 1930, when it was shown that the storage of green sawdust under cover for periods up to one year, at least, is entirely feasible.

Continued development in the utilization of sawdust for fuel has brought increasing demands for information on all phases of the industry. For this reason, recent developments were investigated and a general report prepared and mimeographed embodying all available information on the subject. Two new developments were examined, the first being an adaptation of the standard sawdust burner to the domestic cook-stove, and the second a furnace designed for the combustion of sawdust exclusively. The increasing use of sawdust-burning units for small-boiler installations has intensified efforts to find means of converting the lower grades of mill-waste into merchantable sawdust, to find new sources of supply, and to plan satisfactory storage.

Experiments were carried out on behalf of a group of sawdust dealers in connection with the drying of wet sawdust, since winter storage results in the sawdust absorbing a large amount of rain-water.

The calorific value of hogged fuel made from Douglas fir cordwood was determined for a firm using large quantities of this fuel. A slightly lower value than that for hogged fuel obtained from mill-waste was attributed to a certain amount of decayed wood being present in the cordwood. The calorific studies made by the laboratory on samples of various forms of Western hemlock mill-waste has resulted in at least one large hemlock mill being enabled to utilize all its waste. Selected waste is barked and converted into pulp chips at the mill, the remainder being hogged and sold as fuel; the sawdust and shavings are used for fuel at the mill. Information was assembled for a firm which is opening up a new sawmill of large capacity on Vancouver island, as to the probable volume of mill-waste and possible means of utilization. Calorific determinations made on a large accumulation of waste—supposedly ash—from underneath the boilers at a local sawmill showed this material to be fine charcoal with a heat value of over 10,000 B.T.U. per pound.

Information was assembled regarding the relative utilization of hemlock mill-waste shipped as barked cordwood and as chipped pulp material. Considerable information was assembled in connection with efforts to obtain suitable supplies of aspen (*Populus tremuloides*) and Engelmann spruce for export to China, where it is desired for the manufacture of the Chinese type of match. Studies were made as to suitable sizes of spruce mill-waste, necessary trimming and shrinkage allowances, kiln-drying requirements, and other points in connection with the possible development of a market for selected Sitka spruce mill-waste for the manufacture of refrigerator frames. Some further studies were made regarding the use in electric lines of Western red cedar poles that have been in sea-water. Data were assembled, for use in preparing a management plan for the University of British Columbia forest, on the properties and uses of red alder and the quantity at present used.

Timber Pathology.—In connection with the study of the development of stain and decay in ocean shipments, the study of sapstain preventives is being carried out in a limited way. Two shipments of Douglas fir, comprising, respectively, untreated material and material to which two proprietary sapstain preventives had been applied, were made to England for co-operative examination by the Forest Products Research Laboratory at Princes Risborough. Both preservatives were found to be effective in preventing the development of sapstains but not the growth of moulds. A memorandum on the stains and discolourations which may occur in ocean shipments, with methods by which they may be identified, was compiled for the Association of Marine Underwriters in Vancouver.

Further test runs made to study the effect of kiln-drying upon the sterilization of Douglas fir showed 1 by 4 inch material infected with *Trametes Pini* to be sterilized by a kiln-run of 6 days with a constant temperature of 120° Fahrenheit and a relative humidity of 50 per cent. It was also sterilized during a short run of 24 hours, under a constant temperature of 140° Fahrenheit and a humidity of 100 per cent for 4 hours and 80 per cent for 20 hours. A further shipment of purple-stained Douglas fir infected with *Fomes officinalis* was obtained for study.

A report was prepared on two experiments which had been carried out in connection with the studies of the durability of British Columbia woods. These experiments related to Western red cedar shingles, respectively green, kiln-dried, and kiln-dried and treated with an oil preservative. A start was made on the compilation of data on the relative durability of various woods under service conditions. Suitable forms were prepared for recording the results of annual inspections of various installations, and the active co-operation of several British Columbia firms in this study has been obtained. An examination of the test poles and piling impregnated under a well-known proprietary process showed the piling to be untouched by the teredo, but one pole, after the lapse of two years, had rotted at the ground-line to a depth of two and one-half inches.

Further additions were made to the reference collection of mycological material, and this was used to identify the cause and significance of stains, rots, or other defects, in 105 specimens submitted for examination as well as in the preparation of information on the colouration of Western birch, maple, and alder logs for the Pacific Lumber Inspection Bureau.

Many inquiries for pathological assistance received attention during the year. Data were assembled for the International Association of Wood Anatomists looking to the standardization of nomenclature of wood elements, and identification of the organisms causing decay was made in several cases. An examination was made of the partly collapsed floor of a baggage room on a steamship company pier at Vancouver, where leaky windows were found to have been responsible for decay of the timbers; the structural safety of the floor was also reported on and advice given for its reconstruction. Reports were made upon the cause of staining in several instances where claims had been placed against lumber shipments. The species of sixty-nine wood specimens and many samples of sawdust were identified; as a result of one such identification a large order was secured by a local firm for shipment to Spain. Western red cedar specimens which had been used in Australia for termite exposure tests were found to have decayed rapidly. These were examined for the cause of decay and the colour relationships. A report was prepared for a local firm shipping Western red cedar shingles to Great Britain, covering the cause and importance of various defects found in a group of defective shingles which had been returned.

Exhibits

Twelve sets of hand samples of from eighteen to twenty-two species of British Columbia woods were distributed to educational institutions or to those especially interested in forest products in many parts of the world. Through

the co-operation of local manufacturers the laboratory was enabled to assemble a special set of forty-five selected boards of six important British Columbia species in wide clear sections for the forestry department of an eastern university. Sample sections of five commercial species and selected sections of Douglas fir, black cottonwood, red alder, and Sitka spruce veneers and plywood were also assembled, and assistance was extended to the British Columbia Forest Branch in the assembly of special samples of Eastern Canadian and United States woods and of certain foreign species for their reference collection of world woods. A collection of short bolts of seven commercial species was forwarded to the Canadian Exhibition Commission in London for use in their display of Canadian products. Sets of hand samples from the United States, Great Britain, South Africa, Federated Malay States, Hawaii, Japan, and India were added to the laboratory collection of foreign woods, and an interesting display of tanning products, indicating materials and processes, was donated by a local tannery.

Assistance was given to the British Columbia Lumber and Shingle Manufacturers Assn., in the preparation of twenty sets of twenty large panels featuring in all commercial British Columbia woods of the finished products of planing mills and secondary wood-working industries. These are intended for market extension display purposes in Great Britain, South Africa, and Fiji.

Co-operation was again extended to forestry and lumbermen's associations in the preparation and set-up of a display of forest products at the Vancouver Exhibition.

General

Information was assembled at the request of the British Columbia Lumber Commissioner, in London, on many subjects offering possible extension of lumber markets, such as the marketing of maple burls for fancy furniture, the service of tanks and vats of Douglas fir and red cedar for water, acids, tanning liquors, wines, and other liquids, and the use of British Columbia woods in launch, boat, and canoe construction.

One firm has made exhaustive studies of the possibilities of entering the British market with Western red cedar pencil slats, the information supplied by the laboratory as to material selection having assisted them in producing a high-quality slat.

The following mimeographed reports were issued:—"The Air Seasoning of Lumber in the Southern Coast Region of British Columbia," by J. H. Jenkins; "The Utilization of Sawmill Waste and Sawdust for Fuel," by J. H. Jenkins and F. W. Guernsey (two issues); "Summary of Information on the Change in Moisture Content of Seasoned Lumber in Storage and in Transit," by J. H. Jenkins; "Utilization of Broad-leaved Maple in British Columbia," by J. H. Jenkins.

The following were re-mimeographed to meet heavy demands:—"The Kiln-drying of Douglas Fir Door Stock and Factory Lumber," by J. H. Jenkins; "Developments in Kiln-drying Practice on the Pacific Coast," by J. H. Jenkins; "Sizes of Hemlock Mill Waste Utilized for Pulpwood," by J. H. Jenkins; "The Prevention of Collapse in the Kiln-drying of Western Red Cedar," by J. H. Jenkins.

An article on "The Moisture Content of Wood and Its Relation to Strength," by J. B. Alexander, published in the "British Columbia Lumberman," was reprinted for distribution.

Publications

New printed publications issued by the Forest Service during the year were the following:—

Bulletin 87—The Investigation of Physico-chemical Factors which influence Sulphite Cooking.

Circular 43—The Determination of Arsenic in Wood.

Canadian Woods: their Properties and Uses.

The last-named is the most important and comprehensive publication that has been issued by the Forest Service for some time. It is a book of 345 pages, liberally illustrated, and deals at length with the structure of Canadian timbers; their mechanical and physical properties; the seasoning of timber; decay and stains in wood; the preservative treatment of wood; pulp, paper, and related products; and the chemical utilization of wood. A list of classified uses of Canadian woods is given, and kiln-drying schedules for different species and a number of tables for use in designing wooden structures are included.

Circular 25 (List of Publications) and Tree Pamphlet 3 (Douglas Fir) were reprinted.

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