# BRITISH COLUMBIA REGION

## PROGRAM REVIEW 1967 & 1968

DEPARTMENT OF FISHERIES AND FORESTRY

forestry branch

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## PROGRAM REVIEW 1967 and 1968

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# FOREWORD

Federal forestry agencies have been active in the Province of British Columbia as far back as 1899. Since then, forest research in resource management and protection has steadily increased in direct cooperation with the British Columbia Forest Service and the forest industry.

This expansion, particularly in the late 1950's, necessitated a major reorganization of Canada's forestry facilities, especially in British Columbia. The new Victoria Research Laboratory, which opened on February 15, 1965, demonstrated the Department's determination to improve research services in this region.

This publication is the first of a series of biennial reports covering the major aspects of the Laboratory's program in British Columbia. Information on other projects is contained in reports and publications (page 34), copies of which are available from the Forest Research Laboratory, 506 West Burnside Road, Victoria, B.C.

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*Research development technician demonstrating prototype container-planting equipment. (Photo courtesy British Columbia Forest Service).*

## PROGRAM COORDINATION

In accordance with departmental policy, the British Columbia Region Advisory Committee was formed in the fall of 1966 to advise the regional establishment on development of its research program and related activities. The committee consists of senior members of the British Columbia Forest Service, forest industry and the University of British Columbia. It has recommended a broad 15-point program to be developed by the British Columbia regional establishment. Some parts of this program have been in existence for a number of years, i.e., entomology, pathology, forest insect and disease survey, and some recent work in tree physiology and fire. New major approved areas of work are concerned with mechanical tree planting systems, forest fertilization, land classification, forest genetics, more fire research, growth and yield studies, the balsam woolly aphid, Sitka spruce weevil and forest economics research. Because work in some fields of forest research was established only recently in B.C., accomplishments during the past five-year period may be limited by the time available to obtain positive results.

In addition to the Advisory Committee, other committees, agencies, companies, and individuals may bring their problems to the Department at any time for appraisal. The main "organizations" include the British Columbia Forest Service, Tree Farm Forestry Committee, Reforestation Board, Tree Improvement Board, Forest Fertilization Board, Pest Control Committee, the Council of Forest Industries of British Columbia, and three interior forestry associations, i.e., Northern, Cariboo and Southern Interior.

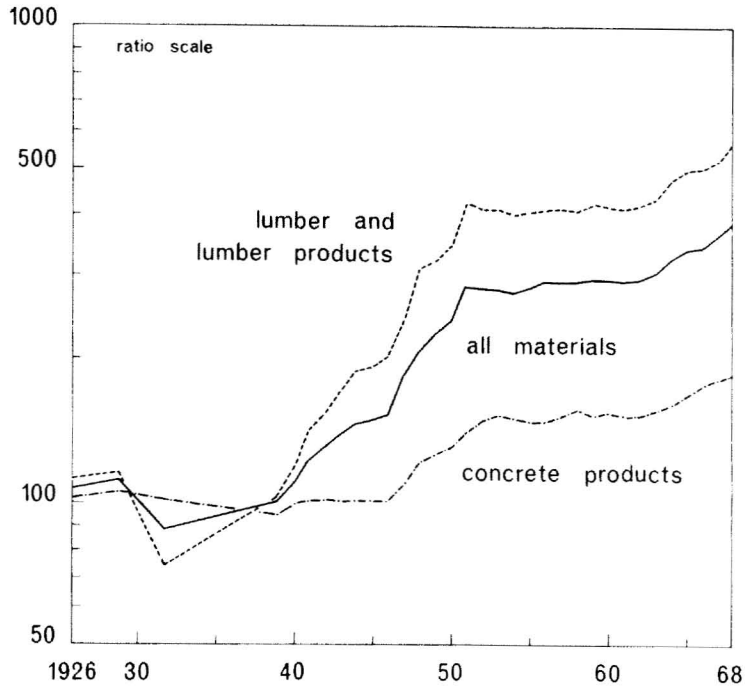
Problems are evaluated by us in terms of priority and availability of staff and financial resources, and a decision is reached as to if and when studies should be initiated on them. These proposals are subjected to scrutiny by our economics unit.

Internally, program coordination is achieved mainly by monthly or twice-monthly meetings of section heads, the appointment of coordinators or group leaders for interdisciplinary problems, periodic (at least annual) project review, advice from Branch coordinators, and by agreement on areas of work that the region should emphasize based on Branch workshops on specific problems, i.e., container planting, forest fertilization and balsam woolly aphid.

## FOREST ECONOMICS

The regional forest economics unit was established in 1966 to conduct applied economic studies of selected aspects of the provincial forestry sector. Its purpose was to achieve improved allocation of human and material resources within the department, and in the economy at large.

Internally, economic analysis of the research program will help direct our efforts to the most serious problems, and the best means of attack. This involves all staff at the laboratory in the endeavor to define and achieve the best possible returns from federal forestry research investments in British Columbia.




*Relative prices of residential building materials 1926-68 (based on D.B.S. data). The erosion of the competitive position of B.C.'s most important product (in its largest market) is evident. Significant technological advances are imperative, from the forest to the finished house, if wood products are to hold their position in this traditional market. This will require accelerated investment in research and development.*

Special economic studies of particular problems, now in progress, provide an important extra dimension to forestry and biology projects. A current example is the container reforestation project. A "total system" framework for cost performance analysis is being developed which will help prevent waste and duplication of applied research efforts in this field. In addition, the framework will be useful in actual management of container, bare root, or mixed systems of the future.

Close cooperation with the Vancouver Forest Products Laboratory is maintained in the economics program. Forestry research investments yield their major returns through increased volume or value of forest products. Changing products, technology and markets must be monitored carefully if forestry research investments are to be effective.

The exceptions to the forest production rule lie in watershed management, recreational values, and other factors not well measured in economic terms. These factors are far too important to ignore, however, and future research projects will attempt to improve our techniques of assessing them in the forest environment.

## LIBRARY

The library, situated on the second floor of the administration wing, is expanding rapidly coincident with the widening interests of the federal forest laboratory. Primarily it serves the needs of the research staff and their assistants, but is also open to use by other libraries, industry, students and the general public. The library comprises approximately 6,000 bound volumes, 30,000 reports and reprints, and subscribes to about 275 periodicals. It has a small but growing

collection of microfilm material, is equipped with a 3M "400" reader printer, and is able to have necessary microfilming done on the premises through the courtesy of the photographic staff. The library is linked with similar services throughout Canada as it contributes a record of its holdings to the union catalogue of the National Library of Canada, and to the senior departmental library in Ottawa.

## RESOURCE AND MANAGEMENT RESEARCH

### Land classification

In cooperation with federal and provincial soil surveys and the B.C. Forest Service (Research Division), further progress was made on the Canada Land Inventory. Land was classified as to its capability for forestry, using air photos and standard air photo interpretation techniques, combined with field checks on landforms, soils and vegetation patterns. Potential productivity ratings were assigned to delineated land-units based on mean annual increment of fully-stocked stands. Field work was completed on approximately 9 million acres in the East Kootenay region, 2 million acres in the Princeton-Tulameen area, 1.5 million acres at Fort Nelson and 500,000 acres in the Kelowna area. Maps and reports on area descriptions have been completed for the Special Sales Area and for Princeton-Tulameen, and maps prepared for the East Kootenays. Completion of the inventory is anticipated by the spring of 1971.

To provide a proper basis for a large-scale cooperative fertilization project, land classification studies were undertaken on 37 forested areas on Vancouver Island. This classification is for correlating tree-growth response to fertilization to varying conditions of soil, physiographic features, geology, and climate. Data collected included soil classification to the subgroup level, total and effective soil depth, soil texture, soil drainage, and landform and soil parent material. Data were collected on each area to obtain an approximation of stand conditions. Data are being compiled for presentation to cooperating forest industries before establishing fertilization trials.

### Effects of burning on soil fertility

Opinions differ regarding the usefulness of fire for forest management, and since slash burning is mandatory in B.C., a study was undertaken to evaluate some of the effects of burning on the properties of soil and seedling growth. The soil samples collected from slash burned were in the southern interior wet belt of the province.

The effects of burning on soil may be classified as those which are direct and immediate and those which are indirect and delayed. Immediate effects are usually confined to $\frac{1}{2}$ to 1 inch of the surface and are the direct result of burning; delayed effects may occur anywhere within the entire subsurface soil mass and result from subsequent weathering and leaching. There is a slow but steady trend for modified soil properties to revert to a status characteristic of the soil before burning, but the time required for completion of the process depends largely on the nature of the soil and other environmental factors.

Burning had little effect on such physical properties as physical composition, bulk density and hydraulic conductivity. It is possible that the coarse texture of the soil masked slight effects.

Both immediate and delayed effects are evident in the chemical characteristics of the soil. Immediate effects included increased pH values, soluble salts, exchangeable cations, cation exchange capacities and moisture fluctuations. Nitrogen concentration levels are little influenced, except under intense burning, but total nitrogen content may be greatly reduced by the loss of surface litter. Burning normally reduces the C/N ratio.

On some types of terrain, the removal of the vegetative ground cover by burning subjects the soil to excessive erosion, with the loss of both nutrients and soil material.

For the duration of the greenhouse study (2 years), Douglas-fir seedlings grew best on unburned soil. A relatively high negative correlation occurred between soil pH and stem height and diameter. Tissue analysis revealed that seedlings grown on burned soils had increased levels of phosphorus sulfur and potassium; nitrogen levels were little influenced by burning. Mixing the soil surface material with underlying mineral soil improved seedling growth and reduced growth variability of seedlings.

Environmental influences

To improve the quality and quantity of tree growth, we should know how growth is affected by environmental conditions and how these conditions can be changed by cultural treatments. The influence of light intensity and temperature on growth, photosynthesis, and respiration of seedlings of Douglas-fir, western hemlock, Sitka spruce and white spruce is under study. The results should aid in evaluating cultural means of improving growing conditions in the field and in the nursery, and in appraising the site quality for these trees.

Most work to date has been with Douglas-fir and hemlock. Marked differences between these species, in response to light and temperature, have shown up, as well as interesting similar features. For instance, day temperature generally has more effect on growth than night temperature, and growth does not benefit from a differential day-night temperature regime. The most favorable temperature for growth is 65 F, and it is considerably slower at 55 F for both plants. Increasing the temperature from 65 to 75 has little effect on Douglas-fir, but it decreased growth of hemlock. Growth is affected less by temperature when bud dormancy sets in than during the leaf production stages, because much of the temperature effect is associated with its influence on leaf production. Increasing the light intensity up to 1,000 ft-c increases growth, but high light is detrimental to hemlock.

Extensive studies of light and temperature effect on the rates of photosynthesis and respiration have been especially useful for evaluating the influence of short-term changes in environment for growth.

Effects of balsam woolly aphid on grand fir

Physiological and biochemical processes of balsam woolly aphid infested grand fir are being studied to learn why they die from the aphid attack, and to provide possible means of overcoming the harmful effects. Stem infestation leads to formation of abnormal wood, "redwood", which may encircle the stem and interrupt the normal water translocation. The route of water conduction and the permeability of redwood of infested trees are under study. In addition, effects of aphid attack on water stress of the trees and on the content and distribution of carbohydrates is being investigated. The permeability of redwood to water is

considerably lower than for normal wood. This is, in part, caused by an effect of the aphid on the ultrastructure of the tracheid pits.

Rooting of cuttings from mature trees

In recent years, incompatibility between rootstock and scion of grafted Douglas-fir trees has become apparent in seed orchards and clone banks. This has shown up several years after grafting, and has resulted in reduced vigor and eventually death of a high percentage of grafted trees. Consequently, the Douglas-fir tree improvement program has been adversely affected. To avoid this problem, a study of rooting of Douglas-fir cuttings was initiated. Many chemical and physical treatments have been tested but few have shown promise for cuttings from mature trees. Some success (20 to 30%) was attained with cuttings set in mid-November and early December, in a greenhouse with no air heating but with the soil medium heated to 70 F. Before setting in the greenhouse, the basal end of the cuttings were soaked for 24 hours in 100 ppm I.B.A. Cuttings taken later in the winter and in the spring did not root nor did cuttings taken in November when the greenhouse air was 70 F. Therefore, setting cuttings in the fall and early winter seems to be beneficial to rooting provided the tops are kept at low temperature. A low air temperature has also promoted rooting of western hemlock cuttings, but no soil heating was necessary.

Another promising method is to graft cuttings from mature trees to cuttings from young trees which root fairly easily. Sixty pairs of Douglas-fir cuttings were set in 55 ppm I.B.A. for 24 hours and then placed in the rooting medium under intermittent misting. After 6 months, 40% of the cuttings from mature trees and 80% from the young trees had rooted.

*Studies in rooting of cuttings of Douglas-fir and western hemlock are carried out in support of tree improvement work. Here, cuttings from hemlock trees, ten from each of twelve superior stands, are set for rooting.*

Physiology and biochemistry of Douglas-fir seed production

Extensive fertilizer experiments on 13- and 20-year-old Douglas-fir for cone and seed production have shown that optimum responses are obtained with 200 to 400 lb. per acre of nitrate nitrogen, applied during the period of vegetative bud break. Earlier or later treatment, or ammonium nitrogen treatment, resulted only in minor increases in cone production. A retreatment schedules experiment, now in its fourth year, has demonstrated that initial overfertilization, or annual re-fertilization will reduce the long-term yield of seed orchards, whereas biennial retreatment should assure cone production every second year.

Girdling treatments on 24-year-old Douglas-fir, at weekly intervals from April 17 to July 4, have shown cone induction responses comparable to those from nitrate nitrogen, provided trees were girdled prior to one week after vegetative bud break. Later treatment reduced cone production to below that of untreated trees. Bud development studies have suggested that reproductively mature Douglas-fir initiate flower buds every year. Natural seed crop periodicity, or cone induction responses to girdling and nitrogen fertilization, correlated with an increased proportion of these buds which developed normally, or did not go into a latent bud state, during elongation of the new shoot. Cone production itself reduced carbohydrate levels, bud survival, and size and number of new shoots, explaining the normal absence of consecutive cone crops on Douglas-fir. Nitrate nitrogen and ammonium nitrogen produced similar twig-growth responses and rates of foliar nitrogen increase. This suggested that cone production responses are not primarily related to improved mineral nutrition but to qualitative differences in nitrogenous assimilates and their influence on reproductive bud development.

*Sampling upper crown twigs for studies of biochemical differences between cone inducing and non-cone inducing nitrogen fertilizer treatment. The 50-foot height capacity, truck mounted aerial platform facilitates sampling of 10 to 15 trees per hour. The integral mobile laboratory shelters a crew for field study, dissection and refrigeration of samples.*

Recent work has shown large increases in basic amino acids, notably arginine, in the foliage of nitrate treated trees, whereas the amino acid pool following ammonium treatment varied only quantitatively from that of untreated trees. In addition, a yet unidentified component comprises the major part of the nitrogenous substances in disk electrophoresis separations from the foliage of nitrate treated trees. This component has not been detected from ammonium treated or unfertilized trees.

## Forest fertilization

There has been interest in forest fertilization in British Columbia for some time and various agencies have undertaken many investigations. In 1967, a Fertilization Board was formed with membership comprising representatives from federal and provincial research organizations, coastal industries and fertilizer manufacturing companies. The Board wants to evaluate fertilization as a forestry practice, determine priority of problems relative to local needs and promote research and pilot studies for the assessment of fertilization as a sound forest management practice.

Three major projects were initiated on Vancouver Island, two being co-operative studies with coastal forest industries. In 1967, sample plots were established in dense young stands of western hemlock and fertilized to simulate and encourage thinning by increasing the dominance of the larger trees. In April, 1968, urea was applied to the plots at rates that ranged from 50 to 400 lb.N/acre and foliage collected for analysis. The objective of the other cooperative project, started in 1968, was to increase mean annual increment or reduce the rotation age of 40-60-year-old Douglas-fir by fertilization with urea. Thirty-seven stands of medium quality were selected for treatment in 1969, and detailed information collected on stand, soil, topographic and climatic conditions of each of them.

During 1968, permanent sample plots were established in 21-40-year-old fully-stocked and thinned stands of Douglas-fir to determine the growth response from different rates and dates of fertilizer application and the duration of response. Plots were thinned to approximately 10' x 10' spacing and fertilized in September with 100, 200 and 300 lb.N/acre.

As recent establishment of these projects precludes results at this time, response to fertilization will be assessed by re-examination of the plots during the next 2-5 years.

## Western hemlock tree improvement program

A tree improvement program for western hemlock was started during the summer of 1968. Hemlock is second only to Douglas-fir in commercial importance in the coastal area of British Columbia.

The first phase of the program was concerned with the selection of "plus" stands and the investigation of geographic variation with emphasis on volume growth. Sixteen stands have been selected, mainly from widely separated locations on Vancouver Island. Seeds were collected from several trees in each of the selected stands. Progenies will be outplanted in five locations on the Island.

The progeny test should help to answer the following important questions: Do genetically superior populations exist; are there important genotype-environment interactions; how important are hemlock seed zones on the Island; what would be the most productive course to follow in future phases of hemlock tree improvement?

Growth of even-aged white spruce

Information about the growth and development of forests is indispensible for long-term planning in forestry. Work on white spruce was completed in 1967, and studies of alpine fir were undertaken in the same year. The emphasis of growth and yield studies during 1968 was increased to include immature Douglas-fir stands because intensive management is feasible in these forests and large acreages are available for treatment.

Conventional techniques for building yield tables have not been employed because they cannot cope with the complex variables (e.g., spatial distribution of trees and the time, type and intensity of thinning) needed to forecast yield under conditions of intensive management. Furthermore, yield tables cannot be modified readily to include new variables, such as fertilizer treatment and improved strains.

The approach followed in these studies requires that factors contributing to the dynamics of even-aged stands be separated into natural units, e.g., site factors, growth, competition, suppression and death. The variables inherent in each unit are recognized and described mathematically. Individual trees are studied because they generate the internal forces which mould the development of forests.

Data were collected in even-aged stands to describe the relationship between age and height growth, height growth and crown expansion, crown expansion and bole increment, and growing space and crown expansion. Trees ranged in height from 5 to 90 feet. The relationships are being incorporated into a computer program which will provide a means whereby years of tree and stand growth can be simulated in minutes on a computer by compressing the physical dimensions of stands and the time scale on which they grow so that estimates of growth and yield may be obtained rapidly. In effect, miniature forests will be created for testing the soundness of management regimes in much the same way that aeronautical engineers build model planes and simulate flight in a wind tunnel. A similar but less sophisticated prototype model was developed for white spruce in 1966 and 1967.

Yield tables for particular thinning schedules or other management regimes will eventually be generated by the model if tests prove that it is satisfactory. Innovations such as a fast-growing strain of Douglas-fir can be simulated after making only minor changes in the parameters of the model, i.e., an increase in the rate of height growth.

## FOREST PROTECTION RESEARCH

Guides to burning logging slash

Before the mid-sixties, prescribed burning of the decadent cedar-hemlock stands of the interior wet belt was conducted on a sporadic basis according to the prerogative of the individual land manager. As the merits of using prescribed fire for hazard reduction and site preparation became apparent, an increasing number of land managers were encouraged to apply fire as a management tool.

In 1964 project 606, Guides for Burning Logging Slash, was established in the Mabel Lake area of the interior wet belt, in cooperation with the B.C. Forest Service Protection Division. The objectives of this project were to determine and define weather regimes when prescribed burning for the purpose of hazard abatement

and reduction of the organic layer could be accomplished with a minimum risk of escape. Six areas averaging approximately 15 acres were burned. On each area detailed fuel inventories of the initial and residual fire environments served to define parameters of expected fire behavior and the immediate effect (fire impact) on the ecosystem. Results of the 1964 studies showed that slash fuel loadings resulting from these stands averaged 160 tons per acre, with about 70 tons per acre available for combustion during the life of the fire. The organic layer contributed another 70 tons per acre, the amount of this fuel available for combustion being rigidly dependent on moisture content. The work also tested the use of cans of water as fire impact integrators. Water loss from the integrators was well correlated with the reduction of the organic layer; total depletion of slash fuel components was only vaguely related to the total water loss.

In 1965, the project was continued, but out of ten proposed burns, only one was executed. At this time the scope of the project was enlarged to include design and demonstration of ignition techniques and ignition patterns to interior land managers.

Prescribed fire for site preparation and hazard reduction

Traditionally, prescribed fire has been employed mainly as a means of reducing or eliminating wildfire hazard on cut-over lands. However, on many areas, removal of logging debris is prerequisite for programs of reforestation. Ecologically, fire is an important factor in the development of most forest types. The full potential of prescribed fire for forest management can only be realized when fire can be controlled and manipulated to create specific conditions and when the effect of fire on the ecosystem is understood. Adequate prescribed fire prescriptions cannot be written until fire intensity is defined and regulated.

Behavior studies of various intensities of prescribed fire and the effect of fire on the ecosystem were initiated in the coastal cedar-hemlock type during 1968. The intensity-of-fires studies over a wide array of fuels, fuel moisture, weather and other environmental conditions will be defined and related to fire effects.

During the summer of 1968, fire intensity was measured on 100 acres of cut-over cedar-hemlock, under various climatological conditions. Fuel consumed, duff reduction, mineral soil exposure and energy release rate data were collected. Soil samples were taken before and after the fire. Plant succession studies have been established. Seedlings have been planted on burned and unburned areas to study the effect of fire on their survival and growth. Study of fire effect on establishment, survival and growth of natural regeneration has been initiated. Burning will continue in 1969 and 1970. Prescriptions will be developed to regulate fire intensity and accomplish the desired management objectives.

Burning index tables

Recent expansion of the pulp industry in the Prince George forest district, and the resulting increase of traffic in the woods, necessitated the derivation of local fire danger tables. Existing tables were unsuitable for the Prince George region as they do not predict adequately the hazard for the area. To meet this need, a project was initiated in 1966.

Its objectives are:

1. Correlation of weather parameters and the moisture content of fine surface


*The physical effects of a good prescribed burn. Logging debris has been reduced to a minimum, thereby eliminating wildfire hazard and preparing the area for planting or natural regeneration.*

fuel and slower drying fuel samples in the open and within the stands to derive a fire weather index for strategic times of the day.

2. Derivation of burning index tables for white spruce - alpine fir and lodgepole pine forest covertypes through ignition and observation of 2-minute test fires.

An accurate estimate of fire danger is indispensible to the intelligent control and use of fire. Initially, the effect of weather and of fuel characteristics on fire danger will be evaluated separately as a basis for evaluating the more complex interrelationships among the three parameters.

The Fire Weather Index will reveal the influence of weather on both a fast-drying and slow-drying fuel model, while the Burning Index will relate some parameter of fire behavior in various fuel types to the drying rates of the fuel models. Correlation of the two Indexes will give the forest protection officer or ranger an accurate indication of the degree of fire severity that can be expected from a potential fire.

Physiology and behavior of bark and ambrosia beetles

Studies have continued on odor attraction of bark and ambrosia beetles, which attack standing and felled trees, respectively. Responses of several beetle species to odors of different kinds of logs in the field were examined, and comparisons will be made between insect selection and gas chromatograph records of the volatile chemicals from the logs. Work is in progress to analyze factors controlling beetle response to odor sources, such as wind velocity, light, temperature and air dispersion rate, and on the transport of odors in the forest environment at different times of day and in different kinds of weather. This is necessary for the effective use of synthetic chemical attractants currently being developed in the United States in sampling and controlling these insects.

Studies of flight behavior, to understand the natural dispersion and odor responses of these beetles, have revealed that overwintered beetles change from climbing to level flight at a certain distance above ground. Vision probably controls this change, which is significant in relation to atmospheric dispersion and transport of the beetles and to their flight and response range.

Studies in insect pathology

At present, there are two major projects in insect pathology in British Columbia. The first is a comparative study of the polyhedrosis virus diseases of two closely related insects, the western oak looper, *Lambdina fiscellaria somniaria* Hlst., and the western hemlock looper, *Lambdina fiscellaria lugubrosa* Hlst.

Since 1964, field studies on the hemlock looper have been carried out at Rolley Lake to determine the behavior of the virus in relation to the variations in population density. The population increased slowly but steadily up to the 1968 field season but the incidence of virus continued low. Parasitism by the Tachinid, *Eusisyropa virilis* (A & W) was high.

In the laboratory, studies on *in vivo* metabolic changes in diseased insects are in progress to determine the effect of different viruses on the hosts at the cellular level. These exploratory tests are designed to help establish some basis for separation of the insect viruses. So far, the effects of nuclear polyhedrosis, cytoplasmic polyhedrosis, *Tipula* Iridescent virus, *Sericesthis* Iridescent virus and Densonucleose virus on DNA, RNA, leucine and glutamic acid

metabolism have been studied. The results show wide differences in the metabolic patterns of the nucleic acids and leucine but not in glutamic acid.

The second major project involves an insect disease survey and general insect pathology. Since 1963 some 3,000 dead insects have been examined for disease with the recovery of the pathogenic fungi *Beauveria globulifera*, *Entomophthora* sp., *Harmodendrum* sp., *Spicaria* sp., and *Cephalosporium* sp.; viruses, *Microsporidia*, and spore-forming bacteria. The bacteria were recovered from 40 insect species. They are identified as *Bacillus thuringiensis*.

As a prelude to field tests, studies were done on the physiological properties of several commercial preparations of *Bacillus thuringiensis* from the United States, France and U.S.S.R. The following tests were made:

1. Bioassay of the various commercial products (i.e., spore/crystal complex and estimation of viable spores).
2. Optimal cultural conditions for spore and toxic crystal production.
3. Miscibility of 9 sticker-spreaders with 7 commercial products.
4. Effect of the additives on the bacterial physiology.
5. Antibiotic effect of host foliage extracts on bacterial growth.

Detailed field tests showed that third-instar western tent caterpillar, *Malacosoma pluviale*, and first- to third-instar black-headed budworm, *Acleris variana*, may be efficiently controlled by Thuricides 90TS and S7-150, respectively, when mixed with Lovo 192 (Fison's) and applied by mist blower.

In 1968, mixtures of phosphamidon, malathion or pyrethrum-piperonyl butoxide with a *B. thuringiensis* liquid formulation were tested against *Halisidota argentata*, *M. pluviale*, *M. disstria*, *variana*, and *Choristoneura fumiferana* in the laboratory, and some field tests were done using phosphamidon - *B. thuringiensis* against *A. variana*. The results suggest that both pyrethrum-piperonyl butoxide and malathion mixed with *B. thuringiensis* are promising combinations in controlling some insect pests. Further tests are planned for 1969.

A needle miner of western hemlock

In May, 1965, about 83,000 acres of mature and overmature western hemlock were defoliated near Holberg on Vancouver Island. Of this, 17,400 and 18,240 acres were, respectively, moderately and heavily defoliated, with up to 80% of old and new foliage lost in some areas. The damage was caused by a moth larvae subsequently described by T.N. Freeman as *Epinotia tsugana*.

Life-history studies revealed that the eggs are laid and hatch in the summer. Larvae mine the needles of western hemlock in autumn, overwinter inside the needles in the fourth instar and complete feeding and development the following spring. In 1965 free-living larvae could be found until June, although many were already in cocoons; by July most adults had flown and most eggs were laid by mid-month. In 1966 larval development was completed about two weeks earlier, although adults emerged two weeks later than in 1965; these differences were related to weather.

The heavy defoliation in 1965 apparently occurred in March, when unusually warm temperatures (60-70 F) caused intense feeding by late-instar overwintered larvae. Damage was further increased by two factors:

1. The larvae, instead of mining the needles, chewed an entry hole in the lower surface of a needle and then wastefully abandoned it for another.

2. The needles, although only slightly damaged, dried and fell soon after.

Tests showed that a larva may mine 10 to 20 hemlock needles, with most of this feeding occurring in the last instar. The amount of foliage affected by wasteful feeding should be considerably greater.

The population of overwintered larvae was lower in the spring of 1966 than in 1965. The larvae mined the needles completely, and the relatively few partially-mined needles were retained on the trees along with undamaged ones. Little defoliation occurred on reproduction hemlock in either year as it was lightly infested, and the larvae mined the needles.

In 1966, the relation of insect numbers to defoliation was investigated. Insect numbers alone did not explain differences in defoliation. Trees with shorter, thinner needles were more heavily defoliated by *E. tsugana* than those with longer, thicker needles. Shoot lengths and numbers of buds varied between trees and were generally related to needle characteristics, suggesting considerable variation in amount of leaf tissue per tree. However, in 1965 the degree of defoliation would not have been significantly affected by variation in foliage characteristics because of the wasteful feeding.

As the population of *E. tsugana* in Holberg declined in 1966 further studies have been deferred.

Population build-up in previous years, followed by unseasonally warm weather in March of 1965, evidently caused aberrations in tree physiology and insect feeding behavior that resulted in heavy defoliation. Weather records indicate that such weather in March is unlikely to recur within a 20-year period. Such climatic aberrations coincident with rise in *E. tsugana* populations should occur rarely.

## Spruce beetle studies

The spruce beetle, *Dendroctonus obesus* Mannerheim, is the most destructive insect of the extensive spruce forests in interior British Columbia. It is a native bark-beetle associated with these forests throughout the range of spruce in North America. Widespread damage occurred from 1961 to 1964 in the central region of the province, and during 1967 and 1968 in the southeast, near the Alberta and United States borders. These periodic attacks on mature but healthy trees often occur after extensive wind-throw, followed within a year or two by mild winters and an abnormally hot, dry summer. Under these circumstances large numbers of beetles can mature in one season and trees are more likely to be attacked the following spring.

Development and survival studies of immature beetles in logs at different locations show that in most seasons the majority require two years to complete development. However, temperature variations due to shade, elevation, and inversions may allow differences of from 1 to 96 per cent of the population to mature within one season. Larval diapause, related to temperature changes and day-length also may reduce the size of the mature population. Beetle reproduction in logging slash has been found to be potentially high but, due to exposure to temperature extremes, the broods often may not survive. Beetles in felled or wind-thrown trees in the forest shade produce large broods nearly every season.

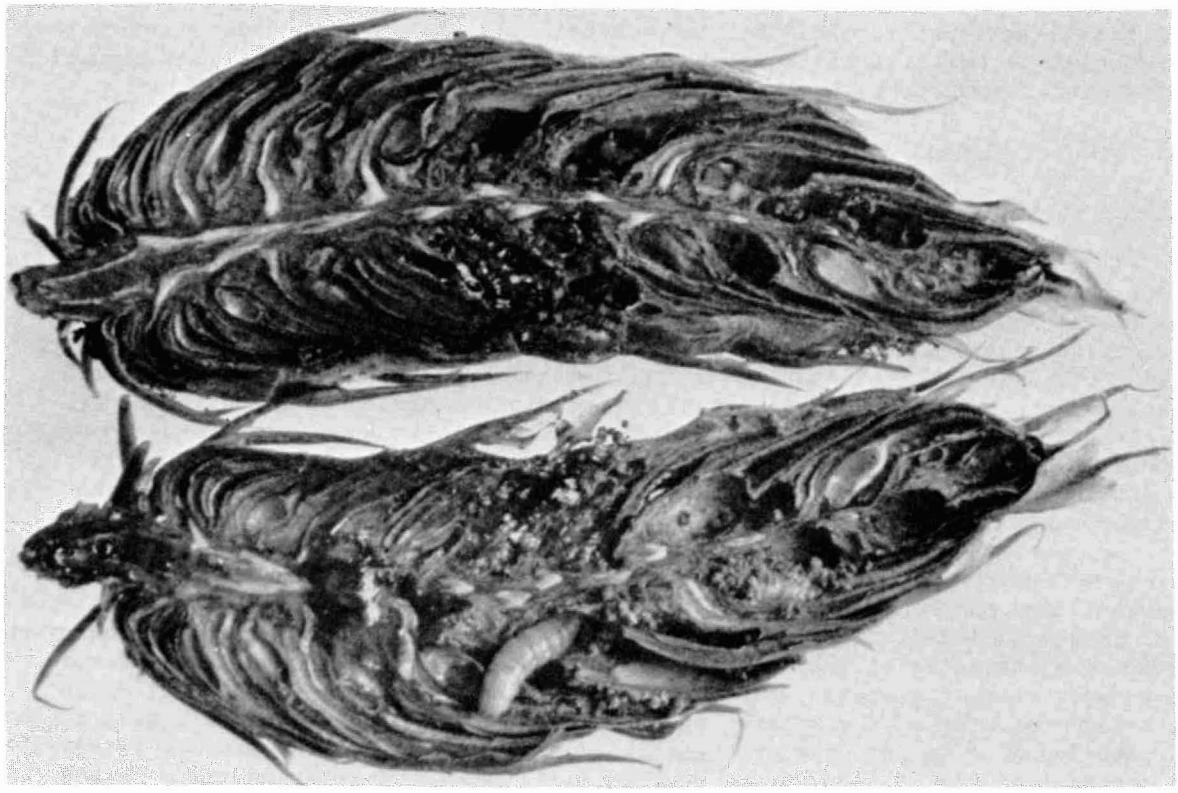
A secondary attraction created by unmated female beetles when entering the bark of logs or trees, aggregates both males and females to the host. If unmated females are protected from the males, the attraction is prolonged and the host log can be used as a trap. In field experiments 89 per cent of the beetles caught were at logs containing unmated females. Manipulation of the beetle populations by attractants may become more practical when synthetic pheromones are available for field testing.

Insects affecting seed production

Sex attraction studies of the Douglas-fir cone moth, *Barbara colfaxiana* (Kft.), conducted in 1967 and 1968, showed that the males were strongly attracted to virgin females. The moths are active in April, and were observed to fly freely in late evening when temperatures were above 50 F and winds were light.

Larvae of *B. colfaxiana* were reared on artificial medium in the laboratory at different temperatures (20 and 28 C) to determine if temperature differences during the larval stage influence prolonged pupal diapause. This study is still in progress.

Preliminary studies conducted on white spruce in the Smithers area showed that *Pegohylemyia* sp., *Laspeyresia youngana* (Kft.) and three species of cecidomyiids are common in the cones. Observations were made during the summer to determine the type and extent of damage and relative importance. *Pegohylemyia* was the most important seed-destroyer. Larvae of this species were present in 19 per cent of all cones examined.



*Serious seed destruction by the Douglas-fir cone moth.*

A pilot chemical control experiment was conducted against spruce cone insects using the systemic insecticides dimethoate, Meta-Systox-R and Bidrin. All materials showed promise at 0.5% and 1.0% active ingredient when applied as sprays to young cones and foliage in mid-June.

Balsam woolly aphid studies

The balsam woolly aphid occurs in outbreak proportions in the south coastal regions of British Columbia, and is found in over more than 2,000 square miles of forests containing true firs. In addition, it has been found on isolated ornamental *Abies* in the Okanagan Valley. Mortality is occurring mainly in stands of amabilis and grand fir and in alpine fir at Harrison Lake, the eastern edge of the currently known coastal infestation. The insect poses a significant threat to the expanding pulp industry in this province. The research here has been directed primarily toward understanding factors related to the potential distribution of the insect and to the acquisition of knowledge which may aid in impeding further spread.

A climatic analysis of British Columbia, in relation to the known behavior of the aphid, was conducted and maps were prepared showing where the greatest aphid hazard exists. The majority of the large interior *A. lasiocarpa* stands are in a low hazard area (see Map on page 16).

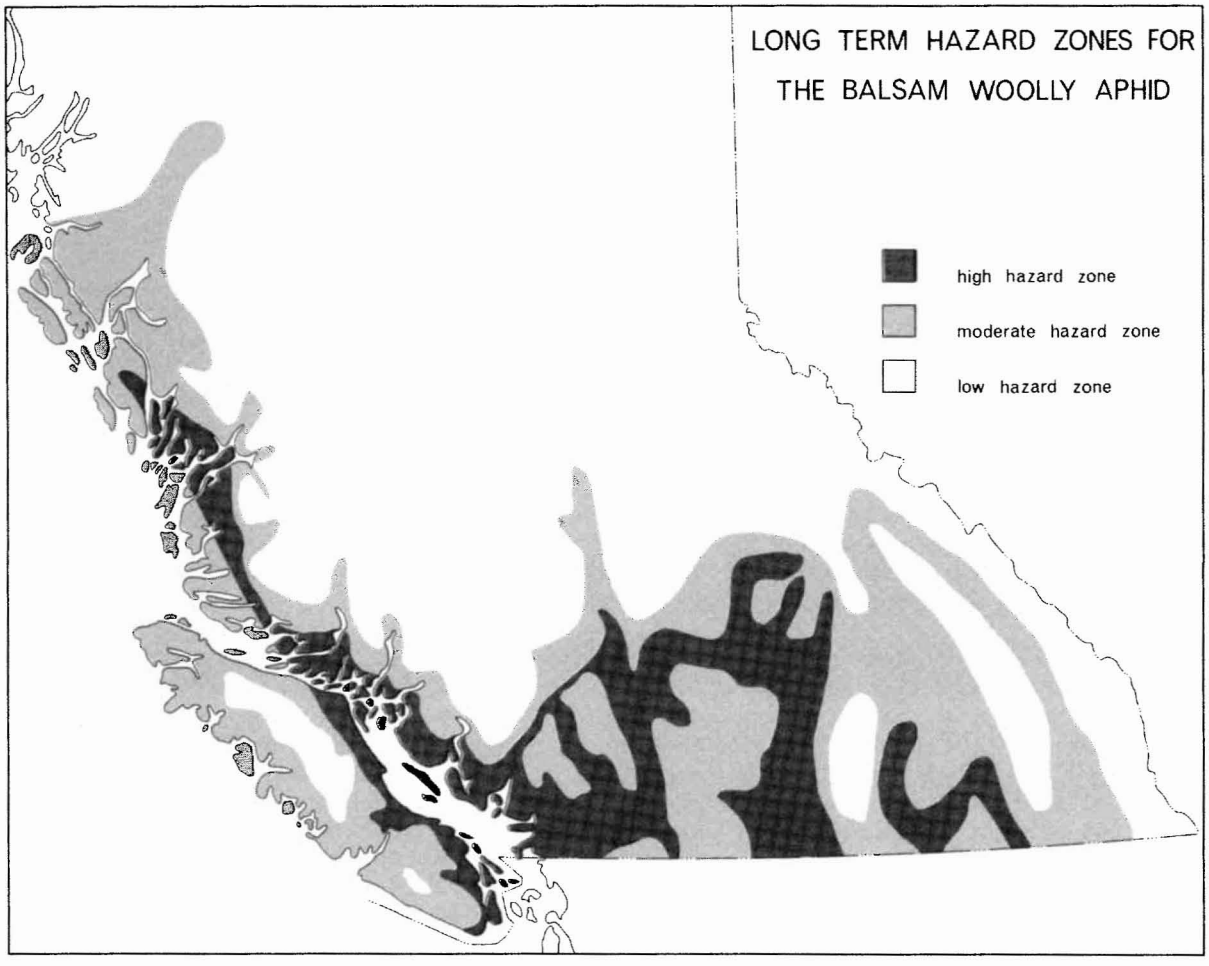
Movement of logs and trees has been a concern due to the threat of increasing the distribution of the aphid. Studies of the insect on logs under various conditions have resulted in recommendations regarding transport of logs. Active stages survived on felled trees for as long as five months, and crawlers often established and completed a second generation on the logs. Dormant stages on autumn-felled trees persisted overwinter and resumed development in the spring. Active and dormant stages survived submergence in salt water for 7 and 28 days, respectively. Active stages on logs sprinkled with seawater every second day survived for three weeks. The aphid did not survive the normal period of use on *Abies* used as Christmas trees, indoors. On similar trees left outdoors, the insect started development but soon died when subjected to room temperature.

Observations indicated that dispersal by small animals is probably restricted and has an insignificant effect on the overall pattern of distribution.

Studies of the behavior of crawlers, in relation to light and temperature, have shown that they generally do not orient in a predictable way, although very young individuals show some photopositive orientation. Dropping of crawlers from their host increases with increased temperature and light. Crawler activity may also influence dropping. Thus populations at stand margins, because of higher temperature, light and air movement there, would be more subject to long-distance dispersal by wind than those within the stands.

The initiation of development in the spring occurs mainly in March. The number of generations per year varies with weather and elevation. During 1967, with its warm dry summer, two generations occurred in all areas with evidence of a partial third generation in the warmest location. In 1968, a cool year, there was evidence of only a partial second generation at higher elevations.

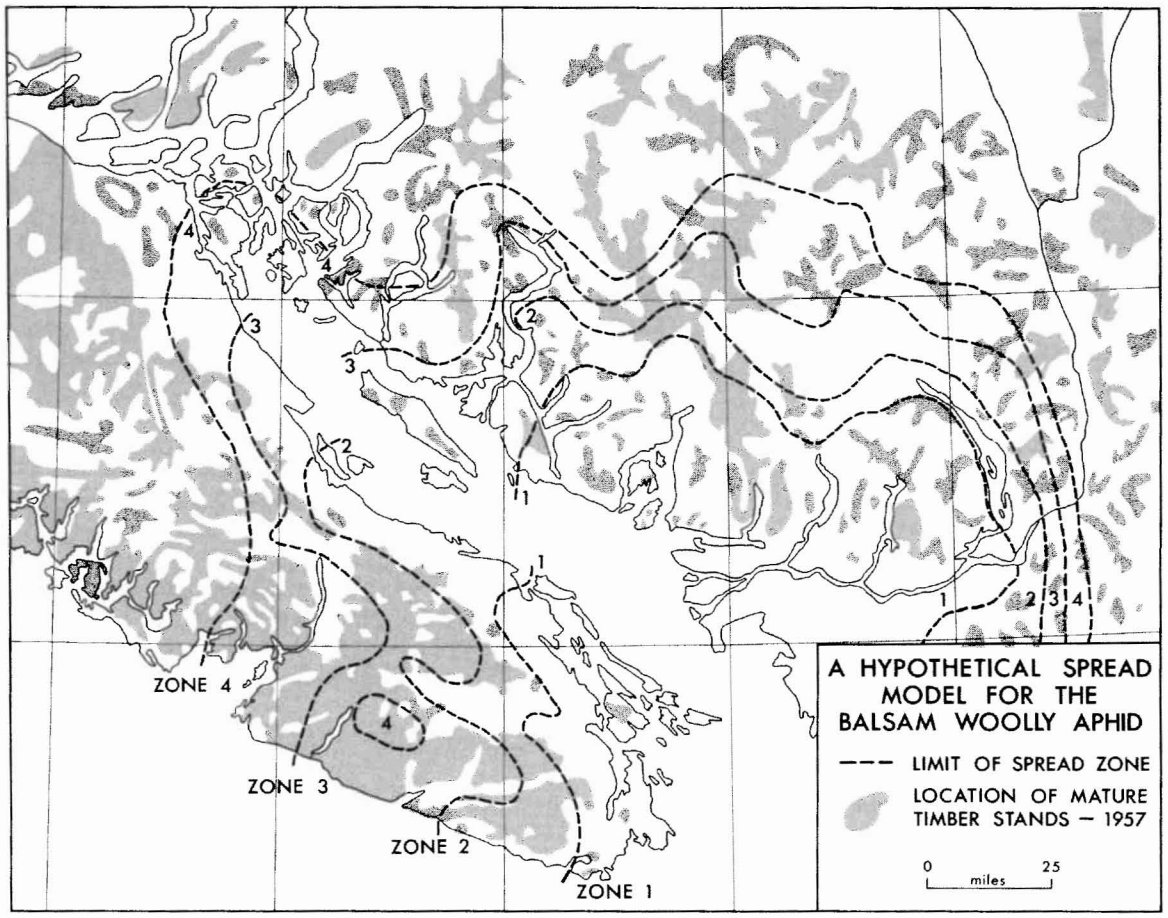
Application of 1% ammonium nitrate to the foliage of potted *Abies* under greenhouse conditions resulted in a decrease in the aphid population, whereas populations increased on control trees and on those treated with 1.5 and 0.5% urea and 0.3% ammonium nitrate. Ammonium nitrate applied to foliage of trees in the field reduced the establishment of crawlers.




The prospect of heavy losses in the large volume of balsam fir species in the province, due to attack by the balsam woolly aphid, is of considerable concern. A study was undertaken to examine the losses to be expected in the next 20 years; and to outline the economic significance of these losses.

With the help of Department entomologists, factors influencing the spread and establishment of the insect were examined. The pattern of spread in the next 20 years will probably be similar to that illustrated in the map on page 17. Zone 1 on the map represents the area covered by the present aphid infestation. Assuming epidemic rates of spread, the boundary of Zone 2 is likely to be reached by 1973; the boundary of Zone 3 by 1978, and that of Zone 4 by 1988. It should be noted that these rates of spread do not allow for the human transport of the insect from Victoria to Campbell River, or Port Alberni, for example. If this were the case the area covered by the insect might be much larger than that illustrated. Similarly, it is possible that the insect could spread into the interior of the province, although no infestation in forest stands has been found to date.

Volume losses of mature balsam within the 20-year spread zone have been estimated, based on data published by the Inventory Division of the British Columbia Forest Service. Allowances for logging depletion since 1957 and for the 20-year period (1968-1987) were made. Since the volume impact of balsam woolly aphid is likely to vary with the climatic hazard zone and the productivity of the forest




site, these factors were also taken into account. The location of susceptible balsam stands was determined, using information from ecological investigations carried out by the Research Division of the British Columbia Forest Service.

Preliminary calculations of the 20-year volume losses suggest that they will not exceed 1 per cent of the volume of all species likely to be logged in the Vancouver Forest District in the same period. While this volume is relatively insignificant, its impact on individual company timber inventories may be severe.

The results of the study should provide a measure of the magnitude of the balsam woolly aphid problem which will assist future decisions on quarantine measures to control the spread of the insect, salvage operations in mature timber, and the allocation of resources to research on the chemical or biological control of the insect in both mature and immature stands. More detailed studies of the economic impact in particular sub-regions may be necessary in the future.

## Western hemlock dwarf mistletoe

In coastal British Columbia, hemlock dwarf mistletoe occurs most extensively on western hemlock, and in localized areas on shore pine. It is found occasionally on amabilis fir, grand fir, white pine and Sitka spruce. Artificial

inoculations have increased its known hosts to include ponderosa, interior lodgepole, Monterey and Scots pine, western larch and white, Engelmann and Norway spruce. These inoculations have also shown that hemlock trees from interior provenances are highly susceptible even though hemlock mistletoe is not found in the interior.

To demonstrate the importance of small, residual infected trees as sources of inoculum, dwarf mistletoe seeds, disseminated from a 35-foot western hemlock tree, were trapped and counted for several years. The tree, only 10 feet in height but infected at the time of logging, was typical of understory trees often left as advanced growth after logging. In the most fruitful year nearly 42,000 seeds were dispersed on an area of 5,800 square feet surrounding the tree. Investigation firmly established that all residual hemlock infected with dwarf mistletoe, regardless of size, must be removed during or immediately following logging if satisfactory dwarf mistletoe control is to be achieved.

The impact of dwarf mistletoe on western hemlock and methods of damage appraisal were investigated by dissecting the boles and examining infections of lightly, moderately and severely infected trees (see illustration). Current growth losses attributable to dwarf mistletoe were estimated to be over 70 cubic feet per acre per year in 110-year-old dominant and codominant trees in a heavily infected stand near Cowichan Lake, B.C. For estimating growth losses, evaluation of the middle portion of the tree was superior to methods utilizing the whole tree; the middle portion contained the most live infections (average 13 per main branch for severely infected trees) and was easily visible from the ground.

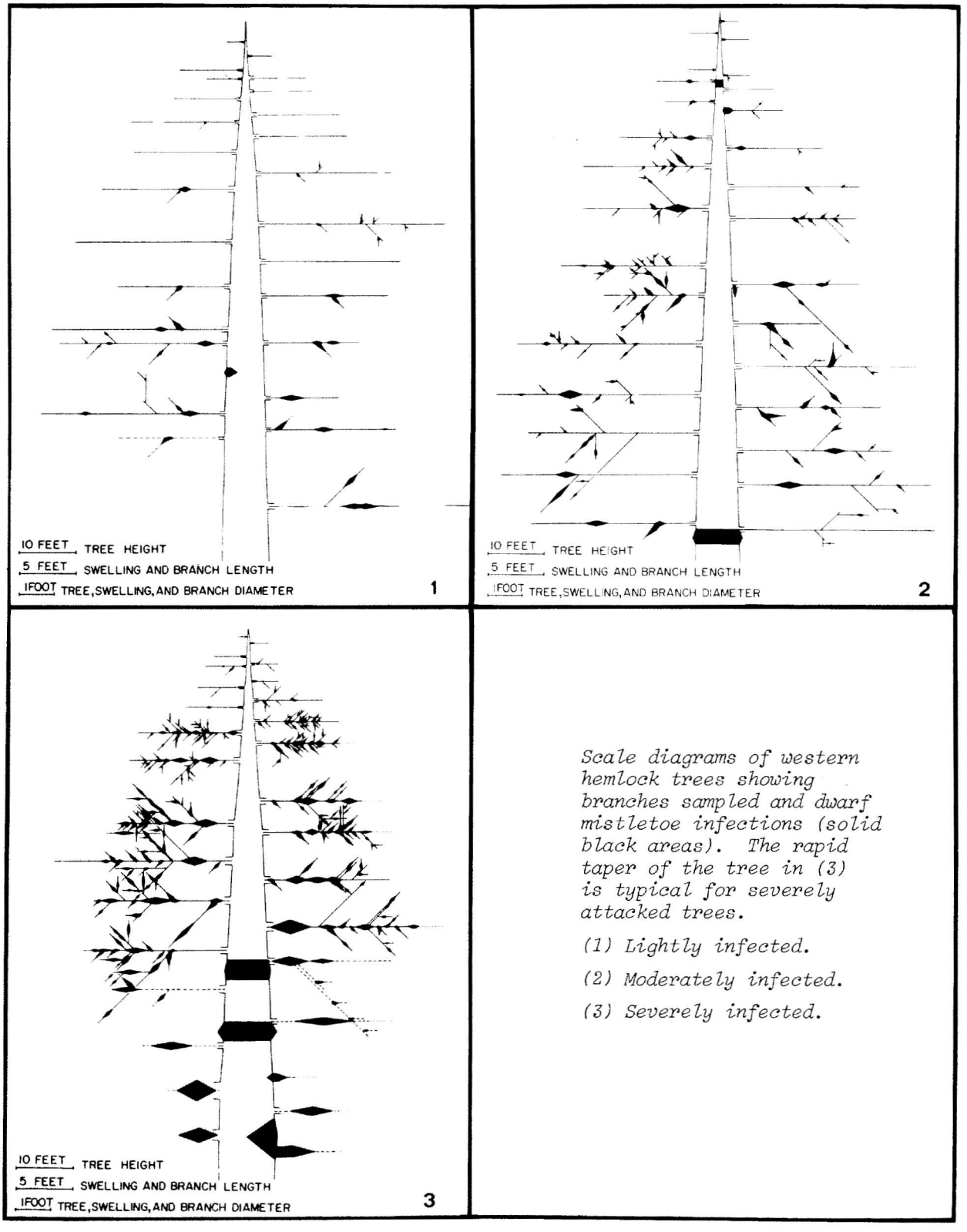
Annosus root and butt rot

A study of *Fomes annosus* in coastal stands indicated losses could be significant in an era of intensive management. The air-spore population is high throughout much of the year. Stumps of most commercial coniferous species are susceptible to spore infection. The fungus appears to be passed readily from infected to healthy roots in the stands investigated. The finding of infection centers comprising 15-20 trees in young-growth western hemlock stands and 3-6 trees in Douglas-fir stands suggests that this disease is already more extensive than had been formerly believed.

No economically feasible control has been found to prevent the spread of the fungus once it has become established in a stand. Attempts to control spore infection of stumps using urea, sodium nitrite, copper oxychloride and borax have met with only partial success; a liberal application of borax appears to be most promising at present.

Poria root rot

Poria root rot caused by *Poria weirii* Murr. continues to cause concern in the forest industry because of the extensive damage in some young-growth stands of Douglas-fir. Infection, for the most part, is initiated from mycelium in stumps of the previous stand. Attempts to control spread using the chemicals Chemagro 2635, Dexon, ammonium sulphamate, sodium arsenate, Phytoactine and Actidione applied directly to the trees and as a soil drench proved unsuccessful. The possibility of controlling the spread of poria root rot by removing the inoculum from the soil is under investigation. Infected stumps have been removed from a diseased stand using standard land-clearing equipment. Survival of *Poria weirii* in roots of various sizes left in the soil is being studied, as is progress of infection in various coniferous and deciduous species planted on the treated and untreated areas.




*Scale diagrams of western hemlock trees showing branches sampled and dwarf mistletoe infections (solid black areas). The rapid taper of the tree in (3) is typical for severely attacked trees.*

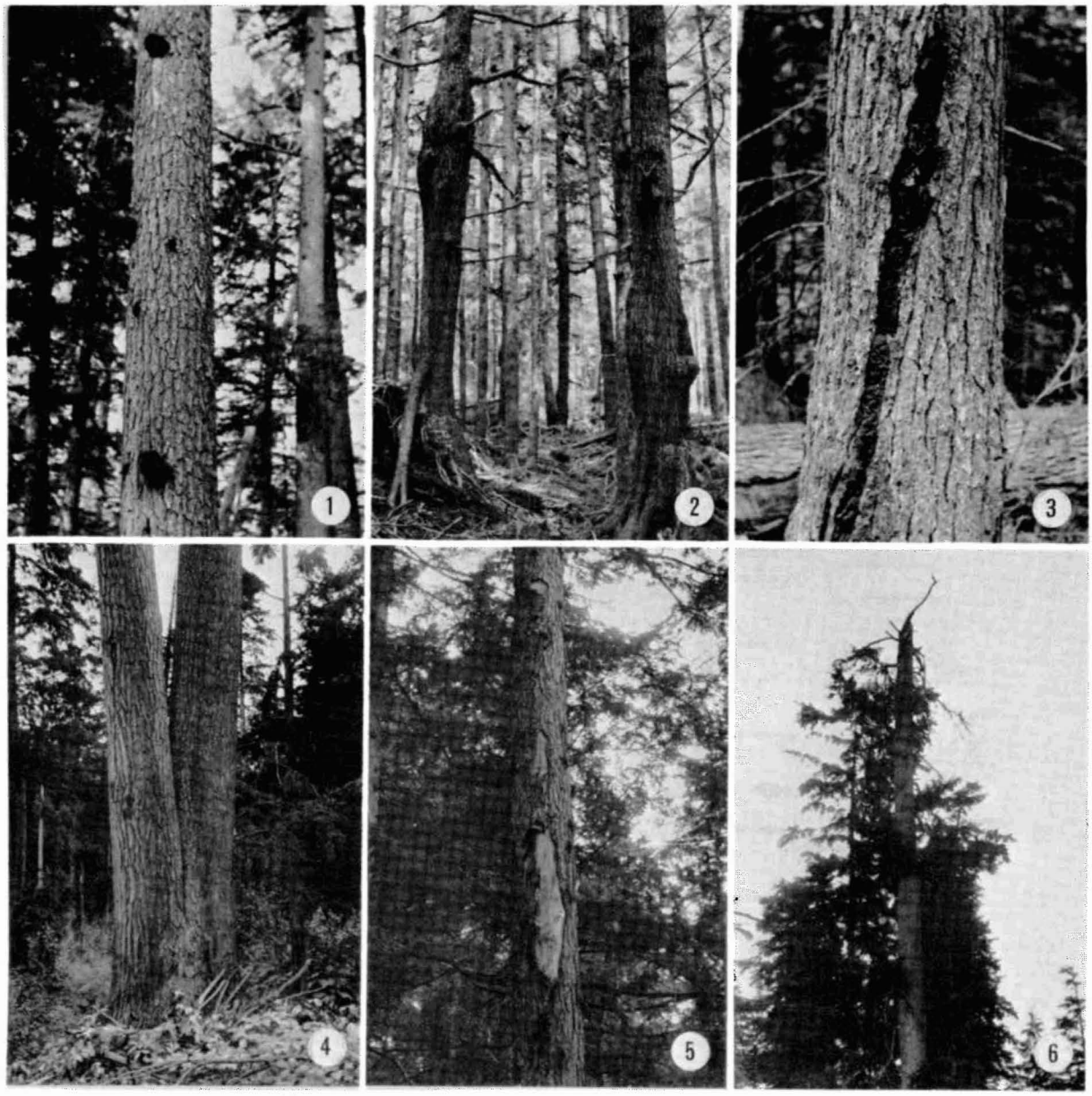
*(1) Lightly infected.*

*(2) Moderately infected.*

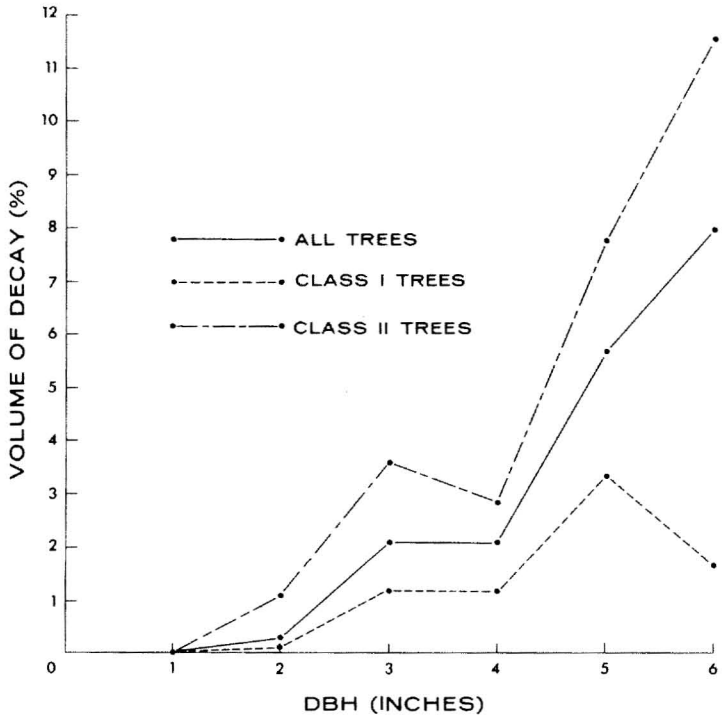
*(3) Severely infected.*

Decay in conifer stands

Decay accounts for the loss of an estimated 10-15% of the gross merchantable volume of British Columbia's softwood forests. Tree dissectional studies in mature stands have shown that the volume of decay could be correlated with tree age and diameter, provided the species and external conditions, i.e., suspect indicators, are known (see illustration). These indicators now form an integral part of the provincial forest inventory procedures. Recent studies in advanced regeneration of alpine fir have confirmed the usefulness of tree diameter and suspect indicators in assessing decay in relatively small trees (see chart).




*Signs and defects indicative of decay in standing trees: (1) conks, (2) trunk infections of mistletoe, (3) frost crack, (4) fork, (5) scars, (6) dead or broken top.*




*Decay as a percentage of total tree volume in relation to diameter (dbh) and decay suspect class (class I = no indicator; class II = at least one suspect indicator) in advanced regeneration of alpine fir in the Kamloops district of British Columbia (basis: 509 trees).*

Prevention and control of decay losses through the application of silvicultural and management procedures, based on a sound knowledge of the fungi involved, is now receiving serious research attention. Success in this area depends not only on a knowledge of the fungi which cause decay, but also of the precise conditions that affect their establishment in living trees. For example, of the three fungi, *Echinodontium tinctorium*, *fomes pini* and *Stereum sanguinolentum*, which cause over 75% of the decay in softwood species in British Columbia, only the latter one has been studied in sufficient detail that the conditions for infection are known and can be discussed realistically in terms of decay prevention and its control.

Extension and refinement of the research on *Stereum sanguinolentum* ~~and~~ to *Echinodontium tinctorium*, known to cause the major portion of decay in interior stands of the true firs and western hemlock, has been underway for the past year. Spore discharge and germination as well as factors affecting host susceptibility are being investigated in various localities. Answers are being sought to the important questions of how this fungus gains entry into the heartwood of living trees and why it is so prevalent in some interior stands and not in coastal stands.

Nursery diseases

An increase in a root disease (known locally as corky root) of Douglas-fir seedlings has been observed in several coastal British Columbia forest nurseries; closure of one nursery has been partly due to the disease, and losses at several others are about 20-30%. Symptoms are a swollen tap root, paucity or absence of lateral roots, and severe stunting, usually accompanied by chlorosis of the shoot. Corky root occurs in ever-increasing patches in nurseries that have been cropped with Douglas-fir for many years or have previously supported a Douglas-fir forest.

*See facing page*

*(1) Diseased (corky root) and healthy 1-year-old Douglas-fir seedlings. (2) Corky root characterized by truncated main root and swollen tips of laterals. (3) Photomicrograph by ultraviolet light showing well-developed xylem core of a healthy seedling root. (4) Photomicrograph by ultraviolet light showing poorly-developed protoxylem of corky root. (5) Two* Xiphinema bakeri *nematodes in typical feeding position on a root tip of Douglas-fir. (6)* Xiphinema bakeri *with stylet starting to penetrate a Douglas-fir seedling root.*

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The nematode *Xiphinema bakeri* Williams 1961 and the fungus *Cylindrocarpon radicicola* Wollenweber are most commonly associated with the disease. *Xiphinema bakeri* is confined to coastal nurseries, and large populations (25-100 per pint of soil) are found always in affected seedbeds. The nematode is virtually absent from nurseries that do not have the disease. Low residual populations were detected in Douglas-fir stands surrounding the nurseries, suggesting that the nematode is indigenous. Recently, the nematode has been observed feeding on roots of Douglas-fir seedlings grown *in vitro*. The role of the nematode in disease development is under investigation.

*Cylindrocarpon radicicola* has been isolated with frequencies greater than 40% from diseased seedlings and less than 10% from healthy seedlings in all affected nurseries. Stained sections of roots showed heavy masses of fungal cells just below the periderm. Disease rating of sections from infected roots, based on density of fungal growth, were almost four times that of healthy sections. Pathogenicity studies using various combinations of the nematode and the fungus are being carried out.

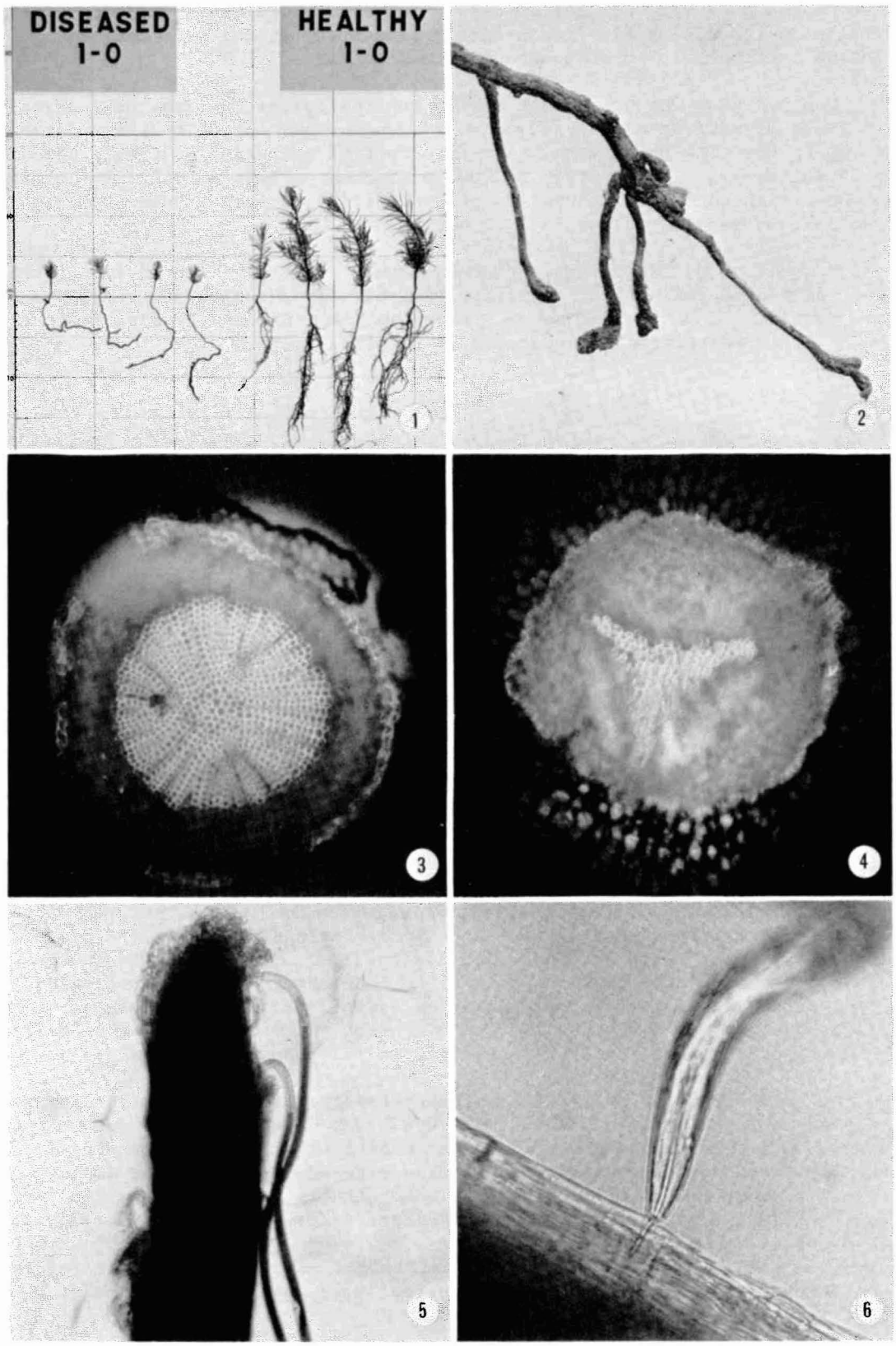
Potential control methods currently receiving attention, are summer fallow and treatment of infested soil with the nematocide D-D, both of which greatly reduce *Xiphinema bakeri* populations.

## FOREST INSECT AND DISEASE SURVEY

### Economic basis

Forest insect and disease agents cause heavy losses in British Columbia forests. Direct mortality and decay fungi account for an estimated annual loss of 670 million cubic feet of wood. Losses attributable to agents causing decline in growth and degrade in wood quality may be even greater. Immense losses, in the past, have been caused by introduced pests; for example, white pine blister rust and balsam woolly aphid have threatened the existence of two of our species. Early detection and vigorous action might have prevented or reduced such losses. Conversely, considerable panic-expenditures may be prevented by accurate assessment of an apparent threat.

The accuracy of forest inventories is seriously impaired by variable and often masked losses caused by insects and diseases. Improved diagnostic tools


DISEASED
1-0
HEALTHY
1-0
1
2
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4
5
6

and survey techniques are required to deal with these problems. Similarly, the diagnostic base for rating old-growth timber stands for priority of cut, to minimize losses attributable to decadence, is inadequate.

The decision for or against costly control operations and the critical timing of such operations must be based on a sound assessment of pest populations in time and space. The ability to call off a control operation on timely procurement of biological data saved about $80,000 on Vancouver Island. If this information had been inadequate and the interpretation faulty, a much greater sum might have been lost in inaccessible killed timber.

Prevention of catastrophic timber mortality may be achieved by foreseeing the advent of a damaging situation and applying timely controls. In areas where it is not possible to meet these needs, losses may be minimized by defining the geographic limits and timing of economically feasible salvage operations.

## Scientific basis

The first requirement for dealing with forest pest problems is recognition of the specific causal agent. Morphologically similar organisms, distinguishable only by microscopic characters, may differ vastly in their potential to cause damage. Symptoms, the host manifestations of the injurious condition, rarely provide specific diagnosis. Thus, it is necessary to catalogue the occurrence and geographic distribution of specific agents of forest damage and provide for their identification by local experts or those in cooperating institutes. A thorough knowledge of native pests and their potential is also necessary as a basis for recognition and interception of foreign pests entering the region or, failing interception, their early discovery and eradication. Thus, taxonomic studies, providing the broad base for specific diagnosis of damaging pests, must be the first step in insect and disease surveys.

The specific agents of forest loss are many and variable in their behavior and total impact. Their assessment in any one situation is rarely a true measure of their potential. It is necessary, therefore, to appraise them not only to improve the accuracy of inventories but to provide a basis for establishing research priorities to develop control methods.

The many agents of biological control, which serve to keep forest pests in check, vary in their effects in time and space. An assessment, first of their occurrence and then of their periodic fluctuation, is an important prerequisite to other control decisions and provides a base for developing tools for biological control. A proper understanding of population dynamics and epidemiology is impossible without this background. The Forest Insect and Disease Survey is well-equipped in experience and logistic capability to make these assessments.

As in other areas of population measurement, insect and disease appraisals cannot depend on total enumeration but must use a system of sampling. Unfortunately, superimposed on a very variable host population is an even more complicated distribution of the pest population. While adequate methods for broad impact evaluations for some organisms are now available, others need to be devised or perfected. It is axiomatic that insect and disease surveys of sufficient detail, on which a forest manager can base operational decisions, cannot be provided by this survey for all forest areas in British Columbia. It follows, therefore, that improved survey techniques which can be applied by the non-specialist must be devised.

# FOREST PEST CONDITIONS

## Insects

Defoliating insects are subject to enormous population fluctuations and major infestations may arise with little warning. The detection function of the survey strives to maximize forewarning by assessing annually the various developmental stages of insects and the impact of their natural enemies. During recent years a few well-known defoliating insects attained infestation levels in the province and a number of these appeared as problems for the first time. None of the infestations resulted in significant tree mortality, although some increment loss did occur.

Black-headed budworm, *Acleris variana* (Fern.), populations built up during the early 1960's, and reached defoliation levels in the interior wet belt in 1965. Damage escalated sharply in 1966 and some localized defoliation occurred in the Hope area during that year. Heavy defoliation continued during 1967, but egg surveys indicated a collapse in most areas, primarily from insect parasites. Only a few local infestations remained in 1968, although moderately high populations were recorded at some coastal points.

Larch sawfly, *Pristiphora erichsonii* (Htg.), persisting at endemic levels for many years, suddenly appeared at outbreak levels (over 360,000 acres) in the western larch stands of the southern Interior in 1965. Defoliation continued for three years, when heavy larval mortality in the hot, late summer of 1967 and very heavy overwintering parasitism of larvae brought an end to the outbreak. Again, fortunately, trees were not killed.

A previously unrecorded needle miner, subsequently described and named *Epinotia tsugana* Freeman, was discovered in 1965 at infestation levels in mature and overmature stands of western hemlock near Holberg and Buck Creek on Vancouver Island. A large-scale control operation, organized on a cooperative basis by private, provincial, and federal forest agencies, was cancelled in 1966 when egg surveys by the Forest Insect and Disease Survey indicated collapse of the infestation. The accuracy of the forecast was confirmed by 1967 surveys.

Larch casebearer, *Coleophora laricella* (Hbn.), a European introduction to North America, was discovered in the U.S. border area of the province in 1966, although it has been infesting larch stands adjacent to the United States for some years. Since then the infestation has expanded as far as the north end of Kootenay Lake and extends intermittently from the Okanagan to the Kootenay rivers. While it requires many years of infestation to kill trees, appreciable loss of growth may occur if natural control factors do not suppress the insect, or if other suitable control measures are not found.

Losses from bark beetles declined notably in 1966 and 1967, following particularly damaging infestations by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., in the Cariboo region, and the spruce beetle, *Dendroctonus obesus* Mann., to white spruce in the Prince George and Prince Rupert districts. Spruce beetle damage to Engelmann spruce increased sharply in the Nelson district in 1968, and Douglas-fir beetle populations showed signs of increase. Mountain pine beetle, *Dendroctonus ponderosae* Hopk., continued to cause heavy losses to pines, particularly following drought, such as was experienced in 1967.

Balsam woolly aphid, a pest introduced to the Northwest continued to kill amabilis fir on the lower mainland and grand fir on Vancouver Island. It was found

infesting amabilis fir on lower Vancouver Island in recent years and the eastward spread infested and killed alpine fir in the Harrison Lake area. It was discovered on ornamental white fir in the lower Okanagan in 1967, but intensive surveys suggested it was introduced many years ago on this resistant host and failed to spread to native true firs.

The British Columbia Forest Service and private industry have continued to collaborate with the federal Forest Insect and Disease Survey in the detection of pest populations and appraisal of their damage. Valuable and timely assistance was received in surveys of various bark beetles, the hemlock needle miner near Holberg, the balsam woolly aphid infestation, and the spruce weevil problem on Vancouver Island.

## Diseases

Decay fungi, mistletoes and root rots account for the major disease losses in British Columbia forests. Measurable annual fluctuations are difficult to obtain, and any attempt to reassess them on a short-term basis would be unrealistic except experimentally on small areas. Damage resulting directly from weather injury, or indirectly through host predisposition or other climatic factors favoring infection and disease development, generally appears suddenly and attains its maximum manifestation over a short period. Foliage disease and certain dieback, canker and blight diseases have these characteristics.

It will be apparent from this that the disease problems receiving attention during any one limited period are not representative of either the kind or magnitude of losses.

Direct weather injury appeared in the form of a severe late frost affecting 300,000 acres of primarily Douglas-fir in the Cariboo in April, 1966, resulting mainly in increment loss. The summer drought of 1967 resulted in indirect losses through predisposition to secondary diseases on the more severe sites.

Foliage diseases, particularly Hypodermataceae of conifers, were generally widespread and attained epidemic levels in local areas. A relatively low incidence of intensity of needle rusts was attributed to the 1967 summer drought.

Problems receiving specific attention during the past two years included:

The first extensive survey of annosus root rot in second-growth hemlock revealed the fungus to be more widespread than previously suspected.

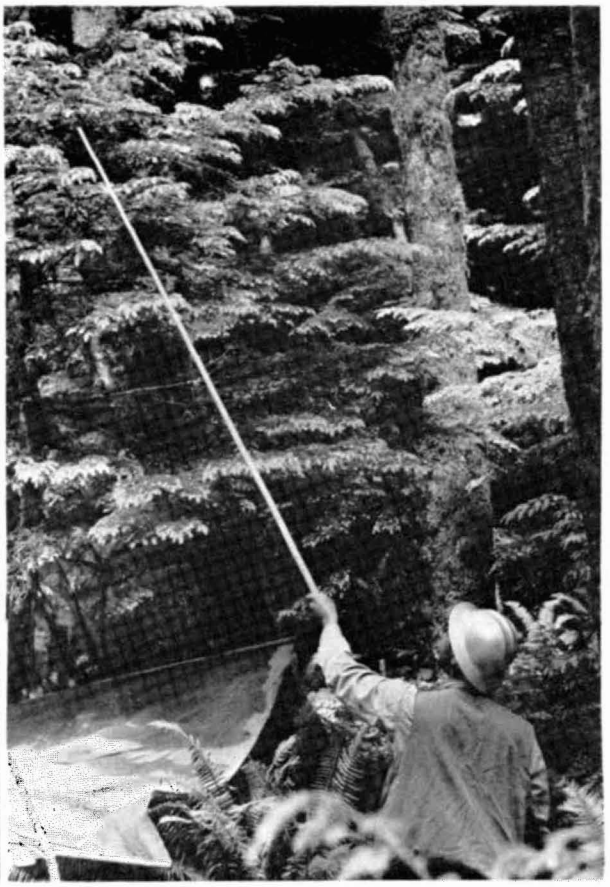
Rhizina root rot, caused by *Rhizina undulata* Fries, observed for the first time in southwestern British Columbia in 1967, is now known to be common on the coast and widely scattered in the interior wet belt. The fungus kills seedlings planted in slash-burn areas.

Surveys in the past two years have defined the distribution of *Atropellis piniphila* (Weir) Lohman and Cash in lodgepole pine stands. The distribution and intensity of several blister rusts infecting this host were also clarified.

## Methodology

In the area of methodology and technique development, a faster and more accurate method was developed for counting insect eggs by a process of solution and filtration. Encouraging progress has been made toward solving the problem of crown-sampling tall trees without felling, using a line gun to provide a means for

*Development of a special line-gun to obtain samples from crowns of tall trees.*



*Dislodging larval samples to measure insect defoliator population levels.*

*Appraisal of wood borer populations in logs stock-piled in flood area behind the Bennett Dam on the Peace River.*

raising branch cutters into tree crowns. This method, if successful, will eliminate the waste of felling sample trees and permit repeated sampling. It has already provided a quick reliable method for marking tree crowns to guide air surveys and aerial photography.

A detailed study to evaluate and improve the efficiency of sampling procedures used for insect defoliator populations was initiated in 1968.

## LIAISON, RESEARCH AND DEVELOPMENT

The regional liaison, management and services unit was reorganized in 1966 to administer federal-provincial shared-cost forestry programs, and to provide advisory services to managers of federal forest lands in British Columbia. Its purposes, mainly through shared-cost programs were: the improved management and the protection of the forest resource, and the fuller utilization of forest products.

With the termination of the federal-provincial agreements in 1967, the unit was again reorganized as the liaison, research and development section, to develop ways and means of linking the region's research program to forest practice. Its aim was to build a bridge between the researcher and the user of research to communicate knowledge to the user on one hand and to determine research needs on the other. A research development project demonstrating new and promising reforestation methods was chosen as one of the first and most suitable vehicles to achieve the unit's purpose.

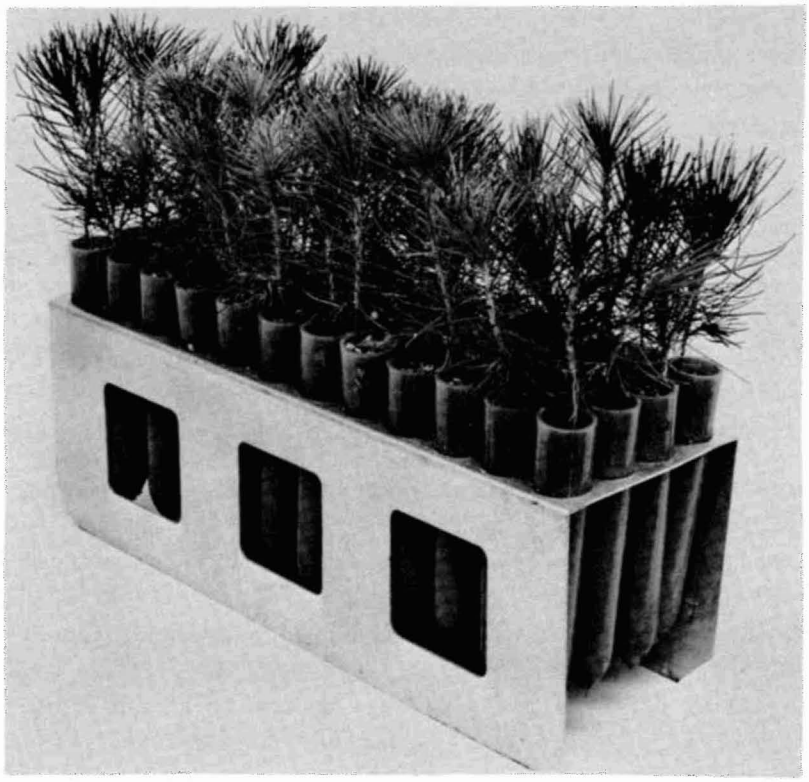
The primary objective of this first project was to determine the comparative economic and biological effectiveness (i.e., cost-effectiveness) of several reforestation systems under British Columbia conditions, with particular emphasis on the "bullet" container reforestation system. The project was split into the following tasks:

1. Field performance of container seedlings - B.C. coast.
2. Field performance of container seedlings - B.C. interior.
3. Cultural techniques for growing seedlings in containers.
4. Influence of containers on root structure.
5. Hardening of container seedlings.
6. Pilot scale "bullet" nursery and transportation system.
7. Pilot scale bullet planting system.
8. Design of large-scale, automated bullet system, (5,000,000 seedlings), B.C. Research Council.
9. Operation analysis of several reforestation systems.

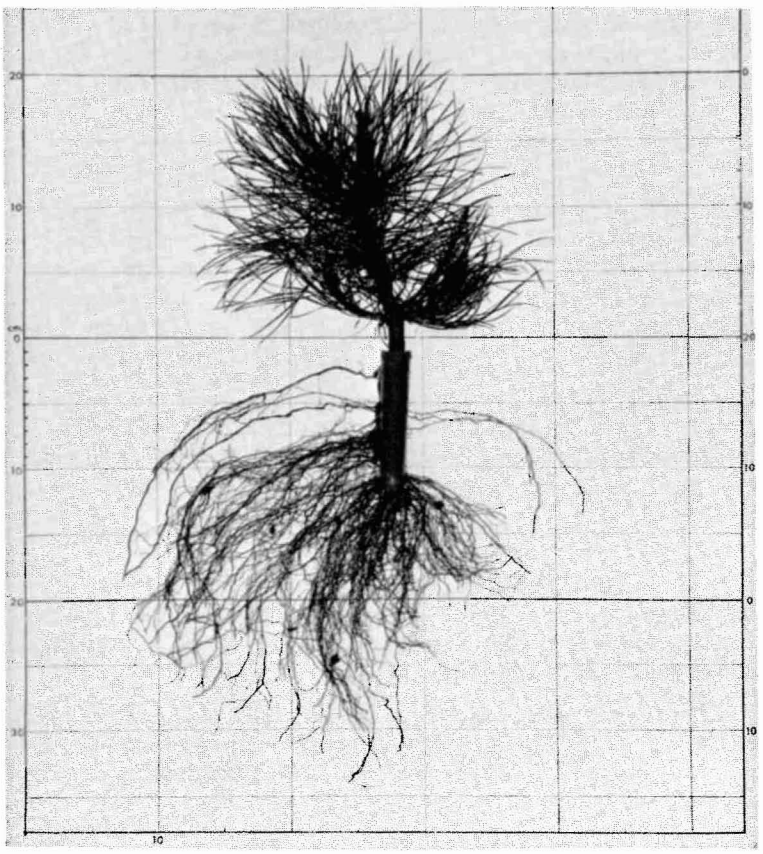
Current progress may be summarized as follows:

A. Field performance of container seedlings

Approximately 40,000 coastal Douglas-fir and western hemlock have been produced and planted, and observed over one growing season on a variety of low- and mid-elevation sites. Three containers ($2\frac{1}{2}$" and $4\frac{1}{2}$" Walter's bullets, $\frac{1}{2}$" x 3" Ontario "tubeling"), $4\frac{1}{2}$" plug seedlings (grown in $4\frac{1}{2}$" Walter's bullets) and 2-0 bare root



*Above: Sixteen-week-old lodgepole pine in 4½" Walter's "bullets" in aluminum nursery-planting tray.*



*Left: Two-year-old lodgepole pine seedling in 4½" Walter's "bullet". Lifted one year after transplanting.*

seedlings were planted in autumn, early and late spring of 1967-68.

Limited second-year replications of these trials are underway. Testing of container seedlings on high elevation coastal sites was begun in November, 1968.

Approximately 5,000 Douglas-fir, lodgepole pine and white spruce of three ages and in a variety of container types and sizes were outplanted on two sites near Prince George in September, 1967.

Two age classes of these species were planted at monthly intervals from June to September, 1968, on three sites in the Prince George forest district. These trials totalled approximately 10,000 seedlings, including 2-0 bare root stock. Replication is planned for 1969 as well as appraisal and outplanting of seedlings held in containers under varying conditions over winter at Red Rock Forest Nursery.

After one growing season, the following tentative conclusions can be drawn:

- Initial survival of good quality container seedlings on the coast and in the interior has been high. The survival rates of such stock ranges from 80% upwards in all species except western hemlock, where survival is in the order of 70%.
- In most instances container-grown stock survival rates were as good, or better than 2-0 mattock-planted trees.
- Slight differences in survival were observed between container types and sizes and between planting dates.
- Size and quality of container seedlings appear to govern closely field performance.
- First-year top growth (with some outstanding exceptions) was not vigorous. Chlorosis and leaf drop were common, but root development of excavated seedlings appeared adequate. An exploratory test of supplemental organic fertilizer added at the time of outplanting of coastal species greatly improved first-year performance and merits further investigation.

B. Operation trials

During 1968, approximately 100,000 seedlings were planted, using a variety of containers, tools, crew techniques and ground conditions. Planter performance was closely studied in seven separate trials. Equipment was modified or developed as experience accumulated. Approximately 10,000 seedlings were marked and observed. Data from this stock will be compared with that obtained from field performance trials.

Man-carried planting equipment, including planting tools, back-packs and side carriers have been simplified and greatly improved. The trials strongly indicate that container seedlings can be planted at least twice as fast as mattock-planted stock and that a three-fold gain will be feasible under some circumstances.

C. System components

In cooperation with the B.C. Forest Service, a semi-automated pilot nursery was built and operated at Duncan, during 1968. This nursery has been taken over by the Forest Service and will be expanded and improved during 1969, as will existing facilities for raising container seedlings at the laboratory.

The B.C. Research Council, working under contract and in close cooperation with the economics and liaison units, is completing a preliminary systems study of the planting of tree seedlings in containers. A mathematical model is being devised for assisting in comparative appraisal of various tree planting methods.

Prototype soil loading and seed sowing devices have been constructed and are ready for testing. The seed sowing device is particularly interesting in that it is capable of handling clean seed of all tree species with little more than minor adjustment.

The encouraging progress made in the testing and development of new and promising reforestation systems can be attributed to:

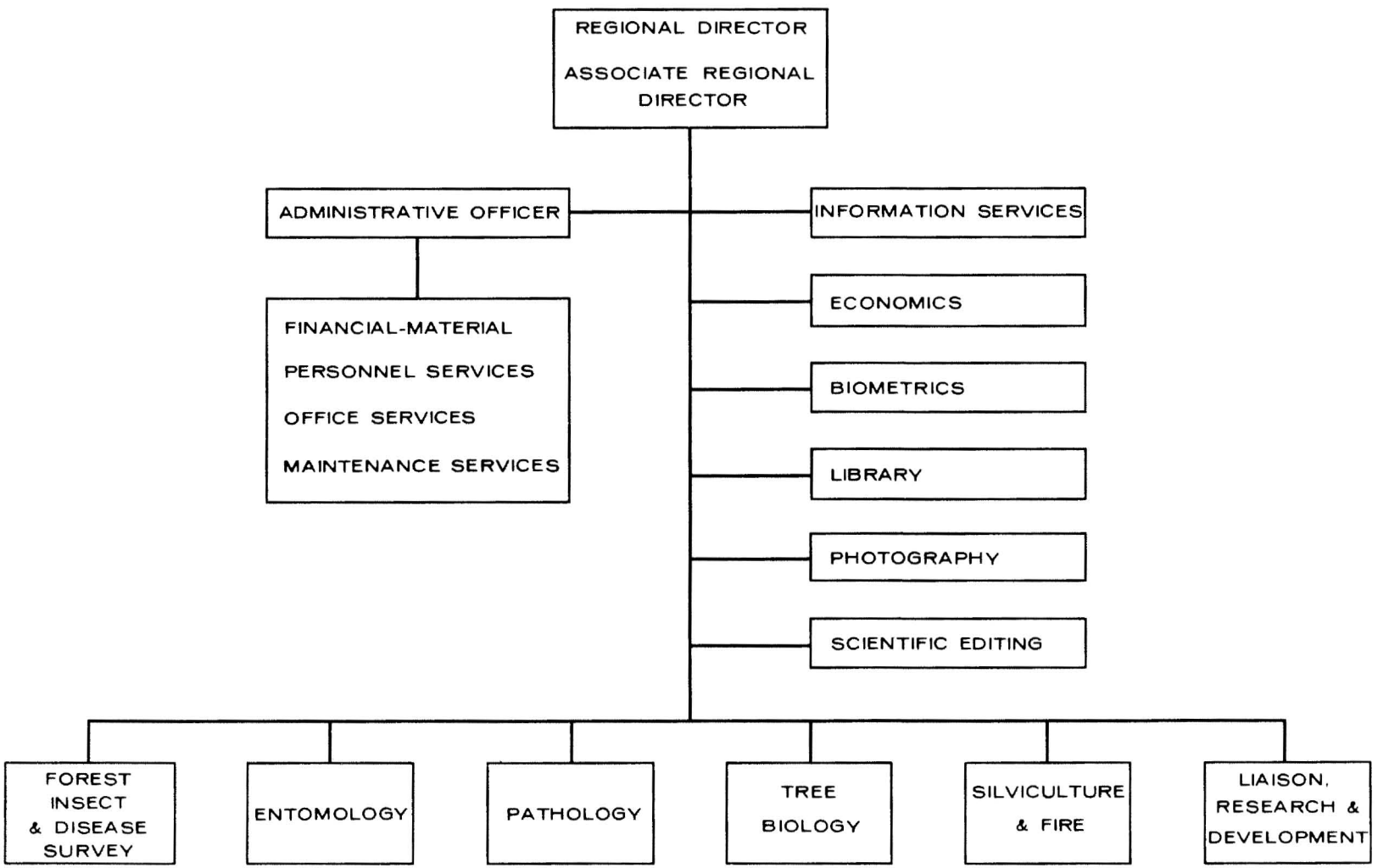
1. The need for new or improved reforestation systems is recognized by governments and industry.

2. Industry and the forest service have cooperated with enthusiasm and in depth with research development personnel responsible for the project.

3. Within the laboratory, multi-disciplinary approach to the solution of a common problem has brought together specialists in economics, tree biology, fire research, entomology, pathology, soils and equipment development with research development personnel.

It is apparent that research development in areas pertinent to the forest community can provide effective channels of communication between researcher and user. Thus a serious gap may be bridged, increasing the productivity of the researcher and the application of his product -- knowledge. In the same way, the user in his experience and with his responsibility is able to make an influencial and beneficial contribution in the development of management tools.

## ORGANIZATION CHART-BRITISH COLUMBIA REGION



# RESEARCH ESTABLISHMENT

(effective March 31, 1968)

| | |
|---|---|
| Regional Director | - R.R. Lejeune |
| Associate Regional Director | - G.T. Silver |
| Regional Administrative Officer | - J.G. Hughes |
| Public Information Officer | - T. C. Jones |
| Scientific Editor | - A. MacEwan |
| Computer-Programming | - K.M. Magar |
| Librarian | - (Mrs.) M. MacGregor-Greer |

ECONOMICS - Section Head G.S. Nagle

A.H. Vyse

ENTOMOLOGY - Section Head D.R. Macdonald

| | | |
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| M.D. Atkins | E.D.A. Dyer | L.H. McMullen |
| J.R. Carrow | D.K. Edwards | O.N. Morris |
| J.A. Chapman | A.F. Hedlin | T.S. Sahota |
| S.F. Condrashoff | A. Mansingh | D.N. Smith |

SILVICULTURE & FIRE - Section Head V.H. Phelps

| | | |
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| J. Baker | Y.J. Lee | M.J. Romaine |
| P.K. Diggle | K.J. Mitchell | R.N. Russell |
| R.C. Henderson | S.J. Muraro | B.D. Webber |
| R.R. Lafferty | T.W. Pierce | |
| B.D. Lawson | R. Quenet | |

FOREST INSECT & DISEASE SURVEY - Section Head A.C. Molnar

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| D. Evans | J.W.E. Harris | W.G. Ziller |
| J.H. Ginns | D.A. Ross | |

LIAISON AND RESEARCH DEVELOPMENT - Section Head J.M. Kinghorn

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| C.P. Brett | E. Van Eerden |

PATHOLOGY - Section Head G.W. Wallis

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| W.J. Bloomberg | R.G. McMinn | R.B. Smith |
| D. Etheridge | D. Morrison | J.R. Sutherland |
| A. Funk | A.K. Parker | L.C. Weir |

TREE BIOLOGY - Section Head H. Brix

| | | |
|---|---|---|
| L.F. Ebell | S. Eis | G.S. Puritch |
| D.G. Edwards | R.F. Piesch | |

# REPORTS AND PUBLICATIONS

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