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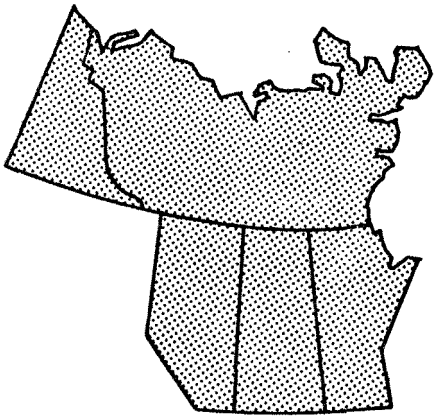
Study Review Statements 1971-72 -73



NORTHERN FOREST RESEARCH CENTRE
EDMONTON, ALBERTA
MAY 1972

Environment Canada | Environnement Canada
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CANADA

DEPARTMENT OF THE ENVIRONMENT

STUDY REVIEW STATEMENTS

NORTHERN FOREST RESEARCH CENTRE

1971-72

CANADIAN FORESTRY SERVICE

EDMONTON, ALBERTA

MAY 1972

DETECTION OF TREE PEST DAMAGE

Forest insects and diseases cause mortality, growth loss and disfigurement to forest stands, shelterbelts, plantations, and trees having important wood fiber, recreation, and/or aesthetic values.

Objectives of this project are to detect, identify, appraise, distribution and impact and advise on remedial action when necessary. Collect, collate, analyze and report to client agencies results of assessments. Maintain and upgrade insect and disease collection.

Benefits from this project include continually posting client agencies on tree damage and/or mortality resulting from insect, and disease pests. Advisement is provided on remedial measures resulting in reduced losses. Assistance in identification of insect and disease pests is provided by reference to herbarium and museum collections.

As this is a continuing service, goals are similar to preceding year. However, degree of general survey will be reduced somewhat with commitment increases in numbers of special surveys as requested by clients and concerned specifically with economic problem pests.

Program Plan { Ives 0.3 = 4 mo. Blauel 0.4 = 5 mo. Hiratsuka 0.5 = 6 mo. Wong 0.5 = 6 mo. 21 mo. = 15 in Statement

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STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre — Date Prepared: March 1972

2. Title: Forest Insect and Disease Survey

3. Investigators: W.G.H. Ives, R.A. Blauel, Y. Hiratsuka and H.R. Wong.

4. Year of Commencement: 1941

5. Estimated Year of Completion: Original: a continuing project.

6. Key Words not in Title: Detection, appraisal, distribution, parasites, hosts, damage, predators, biological control.

7. Discipline: Forest Insect and Disease Survey.

8. Project: Detection and estimation of tree pest damage.

9. Estab. Study No: NOR 033 — Serv. Study No.: NOR 033

10. Status at time of statement preparation: Active

11. Estimated total man-months utilized to date: from 1970 — Prof.: 20 Other: 72

12. Man-months utilized in fiscal year under review: Prof.: 20 Other: 72

13. Man-month requirements in next fiscal year: Prof.: 15 Other: 72

14. Location of Work: Manitoba, Alberta and Saskatchewan, National Parks, Yukon Territory Mackenzie District of N.W.T.

15. Background Statement:

a. Study proposed by: Canadian Forestry Service

b. Objectives: To gain an improved knowledge of of forest insects and diseases in the region for the purpose of minimizing damage to the forest attributable to these organisms and to provide an advisory service to management agencies and the public.

c. Need for Study: Forest insects and diseases annually destroy and/or degrade large quantities of otherwise useable wood fibre. They cause important damage to nursery plantation, shelterbelts, and park plantings which have high aesthetic or shelter values. Many complex problems confronting resource managers have their origin in insect or disease activities. In other instances, these organisms may appear to be primary causes of damage when in fact they are symptoms of the effects of other factors. It is essential for amelioration of the problem that diagnosis be correct. When diagnoses have been completed it is often necessary that some measure of impact, in quantitative terms, be obtained. For these reasons the Forest Insect and Disease Survey is maintained as a large group and staffed by specialists. The relations between insects, diseases and their hosts are complex, most often obscure, and require highly trained personnel to make correct assessments. The biological data collected by the Survey and systematically analyzed and stored provide essential information on life cycles, natural control agents, and geographic distributions to research entomologists, pathologists and other biologists. Many of these species are widely distributed across Canada, and the regional data are part of a larger body of data collected by this and other regions. Outside agencies such as universities and provincial governments, utilize data collected by the Forest Insect and Disease Survey. Improved insight into phenomena responsible for fluctuating insect, disease plant and animal populations are attributed to contributions by this group.

d. Co-operating Agencies: Alberta Department of Lands and Forests, Manitoba Department of Mines and Natural Resources, Saskatchewan Department of Natural Resources, Alberta Department of Agriculture, Manitoba Department of Agriculture, Saskatchewan Department of Agriculture, Entomology Research Institute, Plant Research Institute, Biometrics and Computer Science Branch, Yukon and Mackenzie District Forest Services, National Parks Branch.

16. Accomplishments to beginning of fiscal year under review: Infestations of all of the major forest insects of the region have been assessed since the inception of the Survey and more recently a large amount of information on diseases of the region has also been obtained. Life cycles and other biological data have been accumulated for all the major insects and diseases within the region and where circumstances required, intensive studies were carried out on specific organisms. Numerous impact and appraisal surveys have been carried out in response to special needs.

17. Goals set for fiscal year under review: 1. The detection and appraisal of insect and disease outbreaks in forested areas will continue, augmented by aerial surveys where warranted. Particular attention will be given to the accessible forested areas presently under utilization.

2. Spruce budworm and spruce beetle damage appraisal surveys will be carried out.

3. A study will be carried out in co-operation with the Alberta Forest Service to determine decay degradation rates, strength reduction factors and fastening device retention qualities of Atropellis cankered pine stock that may be utilized in the commercial post and pole industry.

4. Maintenance and improvements of regional insect and disease identifications, biologies and reference collections will be carried out.

5. Editing of historical data on insects will be completed.

18. Accomplishments during fiscal year under review: During 1971 there were no major outbreaks of forest insects, but there were marked increases in the intensity of many foliar diseases. Spruce budworm defoliation was severe in much of the Sprucewoods Provincial Park and Forest in Manitoba and increased slightly along the Chinchaga River in Alberta; elsewhere there was little change from 1970. Infestations of the large aspen tortrix declined in Alberta, but increased in west-central Saskatchewan and parts of Manitoba, especially in the Interlake and Winnipeg Lake Narrows area. There were few changes in the abundance of the forest tent caterpillar. However, some increases in populations occurred in Alberta north of Rocky Mountain House and infestations appear to be building up in the Interlake area of Manitoba. Very few new attacks of the spruce beetle were detected in the Crowsnest Forest of Alberta. There were more 1970 attacks than anticipated, so there could be a substantial flight of beetles in 1972 if overwintering conditions are favorable. Larch sawfly populations persisted in southeastern Manitoba, with little change elsewhere, except for a small area of severe defoliation near Pibroch, Alberta.

Foliar diseases of all types increased in intensity in many parts of the Region; spruce needle rusts and pine needle cast were especially noticeable. Severe red belting occurred in the Rocky Mountain foothills and severe winter damage of ornamental trees was noted in several Alberta towns and cities. High populations of the varying here caused important damage to regeneration in many areas, and fume damage to forested areas was noted occasionally.

The study on the effects of Atropellis piniphila on fence degradation rates and staple retention was set up as planned. A preliminary aerial survey of a few of Alberta's gas and oil fields showed some limited damage occurring from accidental emission releases, but relatively little widespread fume damage. Some severe smoke damage was detected to the forest in the Thompson smoke casement area of Manitoba. A reconnaissance survey of the Dwarf Mistletoe problem in the Athabasca Forest was performed and preliminary

assessment regarding management possibilities is currently underway. Laboratory studies on the effects of sulphur emissions were initiated this winter and summarizing of the impact of Hypoxylon canker and the information on Atropellis distribution is underway.

In addition to providing identification services for our own field staff, our insect and disease taxonomists have provided a large number of identifications for C.F.S. Liaison and Development personnel, universities, research institutes, and other agencies and the public. Without these identifications, control recommendations cannot confidently be made, since similar appearing organisms may have entirely different life histories. The accuracy of identification is largely dependent upon the adequacy of the reference collections available. Because of the diversity of species, it is necessary to maintain large reference collections. For these collections to be useful, they must be maintained, made available to other specialists, and upgraded whenever a major group has been revised by specialists. The work is additionally compounded when, as in this Region, a consolidation of two collections must be undertaken. These consolidations are progressing well in the disease herbarium, but have not been completed for the insect collection.

The Forest Insect and Disease Survey has continued to act in response to requests for special assessments of forest insect and disease problems.

Publications:

Anonymous. 1971. Special Report: Forest Insects and Diseases. edited by W.G.H. Ives, Can. For. Ser., Northern Forest Res. Centre, Forestry Report, Vol. 1, No. 3.

Anonymous. 1971. Forest Insects and Diseases. edited by W.G.H. Ives. Can. For. Ser., Northern Forest Res. Centre, Forestry Report Vol. 1, No. 4.

DeBoo, R.F., W.L. Sippell and H.R. Wong. 1971. The eastern pine shoot borer, Eucosma gloriola (Lapidopterata: Tortricidae) in North America. Can. Ent. 103:1473-1486.

Ives, W.G.H., R.A. Blauel and J.H. Robins. 1972. Important Forest Insects and Diseases, Prairies Region. In Annual Report of the Forest Insect and Disease Survey, 1971. Can. For. Ser. Dept. of the Environment, Ottawa. (In Press).

Whitney, H.S. & R.A. Blauel, 1972. Ascospore Dispersion in Ceratocystis spp. & Europhium Clavigerum in Conifer Resin. Mycologia (In Press)

Wong, H.R. 1971. Forest Entomologists in the Prairies Region. Bull. Ent. Soc. Canada. 3(1):15.

Wong, H.R. 1972. Dioryctria banksiella (Lepidoptera:Pyralidae) in the western gall rust, Endocronartium harknessii (Basidiomycetes: Uredinales). Can. Ent. 104:251-255.

Reports:

Blauel, R.A. 1971. A Field Inspection of a Forest Subjected to an Alberta Gas Trunk Pipeline Condensate Release - Can. For. Service, Northern Research Centre, Edmonton. A File Report.

Blauel, R.A. 1971. Pine Stands Infected with Dwarf Mistletoe in the Athabasca Forest. Canadian Forestry Service, Northern Forest Research Centre, Edmonton. Internal Report NOR-7.

Blauel, R.A. 1972. The 1971 Thompson smoke easement survey. Special Report currently being edited.

Blauel, R.A. and J.K. Robins, 1971. Preliminary report on impact of insects and diseases in strip cutting areas of the Grande Prairie Forest. Can. For. Ser. Northern Research Centre, Edmonton. File Report.

Ives, W.G.H. 1971. The forest tent caterpillar in Alberta. Northern Forest Res. Centre. Internal Report NOR-4.

Ives, W.G.H. 1972. Forest insects and diseases in eight of the western national parks, 1971. Northern For. Res. Centre. Information Report NOR-X-12.

Lawrence, J.J., and Y. Hiratsuka, 1972. Forest fungi collected in Banff National Park, Alberta. Information Report NOR-X-22.

Lawrence, J.J., and Y. Hiratsuka, 1972. Forest fungi collected in Jasper National Park, Alberta. Information Report NOR-X-21.

Lawrence, J.J., and Y. Hiratsuka. 1972. Forest fungi collected in Waterton Lakes National Park, Alberta. Information Report NOR-X-20.

Patterson, V.B. and G.N. Still. 1972. Forest insect and disease conditions in Manitoba Provincial Parks, 1971. Northern Forest Research Centre, Information Report NOR-X-24.

Mortenson, K.L., R.C. Tidsbury and E.J. Gautreau. 1972. Forest Insect and disease conditions in Saskatchewan provincial parks, 1971. Northern Forest Research Centre, Information Report NOR-X-25.

Petty, J., G.J. Smith, J. Susut and R. Caltrell. 1972. Forest insect and disease conditions in Alberta provincial parks, 1971. Northern Forest Research Centre, Information Report NOR-X-26.

Robins, J.K., et al. 1972. Annual district reports: Forest Insect and Disease Survey, Prairies Region, 1971. Northern Forest Research Centre, Internal Report NOR 13.

Safranyik, L., J. Petty and G.J. Smith. 1972. 1971 spruce beetle survey of the Crowsnest Forest, Alberta. Northern Forest Res. Centre, Internal Report NOR 11.

19. Goals for next fiscal year:

1. The detection and appraisal of insect and disease outbreaks in forested areas will continue, augmented by aerial surveys where warranted. Particular attention will be given to the accessible forested areas presently under utilization, and to high use recreational areas.

2. Spruce budworm and spruce beetle damage appraisal surveys will be carried out.

3. Maintenance and improvements of regional insect and disease identifications, biologies and reference collections will be carried out.

4. Editing of historical data on insects will be completed.

5. The historical file on insects and diseases will be used to provide annotated check lists of insects and diseases found in each of the western national parks, and in the Sandilands Provincial Forest.

Anticipated Reports and Publications:

Ives, W.G.H., R.A. Blauel and J.K. Robins. Annual Report of the Forest Insect and Disease Survey, Prairie Region, 1972.

Robins, J.K. et al. Annual District Ranger Reports, Forest Insect and Disease Survey, Prairie Region, 1972.

Robins, J.K. et al. Spruce beetle in the Crowsnest Forest.

Blauel, R.A. and J.C. Hopkins. The distribution of Atropellis canker disease of pine in Alberta, 1972.

Blauel, R.A. Hypoxylon canker disease on aspen in Alberta, 1972.

Mortenson, K.L. et al. Forest Insect and disease conditions in Saskatchewan provincial parks, 1972.

Patterson, V.B. et al. Forest insect and disease conditions in Manitoba provincial parks, 1972.

Petty, J. et al. Forest insect and disease conditions in Alberta provincial parks, 1972.

Robins, J.K. et al. Forest insect and disease conditions in eight western national parks, 1972.

Wong, H.R. et al. Insects and diseases attacking jack pine in the Sandilands Provincial Forest.

A series of annotated checklists of forest insects and diseases collected in western national parks.

Illustrated life histories of some of the major insects of western national parks are being contemplated.

20. Signatures:

W.G.H. Ives
Investigator

R.A. Blauel
Investigator

Y. Hiratsuka
Investigator

H.R. Wong
Investigator

March, 1972

REDUCTION OF DAMAGE FROM DISEASE CAUSING AGENCIES

Extensive areas of Alberta, Saskatchewan, and Manitoba contain jack or lodgepole pine severely damaged by mistletoe. Damage takes the form of growth loss, stem deformation, and sometimes mortality. Management agencies in the three provinces have requested assistance in detection and control. Hardwoods and conifers have been extensively planted in the Prairies Region. Stem cankers and dieback are common to these and shorten their life span. Stem cankers are also common to many other species planted in the agricultural zone as well as native species regenerating naturally or planted in the forested region.

Objectives of the project are as follows: Re mistletoe, study objectives are aimed at detection of mistletoe at an early stage of infection (i.e. at present infections are two years of age before visually apparent) and at establishing methods for accurately predicting rates of spread within a stand. Re cankers, studies are directed toward techniques for reducing canker incidence on planted stock.

Benefits expected are as follows. Re mistletoe. Earlier detection of mistletoe and ability to predict its rate of spread will enhance present control techniques with resultant reduction of growth losses and other damage in regenerating stands. Re cankers and dieback. More complete knowledge of canker origin and development will permit reduction of the incidence with savings realized in both forested and agricultural area tree planting programs.

Goals for next year will include a mistletoe research program review. The officer involved will be returning spring 1972. Some field work will be required to tidy up the program regardless of any decision. This work will be in the area of detection. Canker studies will continue as in previous years with emphasis on origin of cankers and techniques of control.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	The role of blue-stain fungi in bark beetle infested lodgepole pine.
3.	Investigator:	H.S. Whitney.
4.	Year of Commencement:	1959.
5.	Estimated Year of Completion:	Original, 1972. Revision I, 1973. Revision II, 1972.
6.	Key Words not in Title:	Pathogenesis, mycangia, host resistance, symbiosis, axenic insects, SAI, CL.
7.	Discipline:	Pathology.
8.	Project:	Reduction of losses from bark beetles.
9.	Estab. Study No. NOR 020	Service Study No. NOR 020
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 142 Other: 94
12.	Man-months utilized in fiscal year under review:	Prof.: 12 Other: 12
13.	Man-month requirements in next fiscal year:	Prof.: 4 Other: 4
14.	Location of Work:	Edmonton, Alberta; east Kootenay Region, Victoria, B.C.
15.	Background Statement:	
	a - Study proposed by:	Canadian Forestry Service.

b - Objectives: 1. To elucidate the role of the microorganisms in the death of coniferous trees attacked by bark beetles. Blue-stain fungi and yeast associated with mountain pine beetle attacked lodgepole pine will be the primary objects of study but other microorganisms associated with these and other bark beetles on other conifers will also be examined.

2. This project is part of an integrated study that includes population studies of the beetle and research on tree resistance (projects NOR 021 and NOR 022 respectively). The primary objective of the overall study is to provide forest managers with techniques for rating the bark beetle hazard to stands of lodgepole pine.

c - Need for study: The mountain pine beetle and its associated blue-stain fungi are responsible for significant annual losses of lodgepole, white and ponderosa pines in western Canada and adjacent U.S.A. Exclusive of Vancouver Island, some 190 million board feet of these pines were killed in British Columbia and the Rocky Mountain National Parks alone in the ten (10) years from 1951 to 1961. In addition to causing direct monetary loss, epidemics of mountain pine beetles reduce the aesthetic value of stands, alter the species composition, increase fire hazard and force changes in management plans. Current knowledge is insufficient to permit forest managers to accurately forecast outbreaks or efficiently control existing populations. Attainment of the primary objective of this integrated study will enable managers to greatly reduce present losses by removing high risk stands before they are infested by bark beetles.

From a phytopathological point of view the integrated study centres around a disease caused by bark beetles and their associated microorganisms. Little is known of the causal effects of the associated microorganisms. A symbiotic mutualism has been proposed between bark beetles and their associated blue-stain fungi. Also blue-stain fungi are reported to be pathogenic to beetle attacked trees. The present project (NOR 020) is directed at obtaining knowledge of these vital relationships so as to assist forest managers in establishing hazard ratings for pine stands.

d - Co-operating agencies: The B.C. Forest Service.

16. Accomplishments to beginning of fiscal year under review:

The blue-stain fungi, including four new species, and the yeasts associated with the mountain pine beetle were identified. Ceratocystis montia and Europhium clavigerum were the most frequent blue-stain fungi and Hansenula capsulata, H. holstii and Pichia pini the most common yeasts. Inoculations with C. montia and E. clavigerum resulted in resinous reactions similar to those of unsuccessful beetle attacks. Uninoculated controls produced a very minor reaction. It was concluded that the blue-stain fungi

were largely responsible for the resinous resistant response of the tree. It was observed that the greater the reaction to fungus inoculation, the greater the resistance to induced beetle attack. Trees were rated resistant or non-resistant on the basis of their resinous response but intermediates could not be rated satisfactorily. The more apparent cytological and histological changes in tissues associated with beetle and fungal colonization were described.

Resinous reactions were twelve times longer from live than killed (autoclaved) inoculum of Europhium. High dilutions (1:10,000) of Europhium produced similar but smaller (1/3) resinous reactions compared to full strength.

More resins and volatiles, some of which were toxic to blue-stain fungi, were present in sapwood associated with resistant reactions than in unaltered sapwood. Blue-stain fungi and yeasts were isolated from a mycangium in the cardo portion of the maxillae of the mountain pine beetle. The mycangium was described with the aid of a scanning electron microscope.

Cirri of ascospores of C. montia, which stick to the insect, dispersed in pine resin but not in water. Cultures from dispersed spores were normal.

Larvae in rearing slabs became temporarily separated from all culturable microorganisms and fed in axenic phloem. Normal appearing adults were produced when this separation was made permanent.

Limited growth of axenic mountain pine beetles was obtained in unsupplemented autoclaved ground lodgepole pine phloem. Growth was greatly enhanced by killed brewers' yeast, mountain pine beetle associated yeasts, or the blue-stain fungi and inhibited by two killed common contaminants of broods, Trichoderma sp. Axenic beetles reproduced axenically in fresh bolts of lodgepole pine.

A Post Doctoral Transfer of Work was taken at the University of California, Berkeley. While there I collaborated with a research team studying tree diseases as factors predisposing trees to bark beetle attack. We found that an experimentally produced root disease on seedlings caused several pre-visual physiological changes in the seedlings. The pathogen studied also causes a root rot that predisposes mature trees to bark beetle attack. Two non-pigment producing fungi were found in non-stained dead sapwood of ponderosa pine attacked by the western pine beetle. The same fungi were associated with the bark beetle.

A comprehensive systems analysis and a statement of general theory on host-insect-micro-organisms

interactions was made relating to assessing hazard to lodgepole pine stands from the mountain pine beetle. This resulted in an improved perspective in the research plan for this project (NOR 020).

Thirteen publications and five reports were published up to 1971.

17. Goals set for fiscal year under review:

1. Compare the productivity of the mountain pine beetle with and without its associated micro-organisms in fresh bolts of lodgepole pine.

2. Compare the colonization of lodgepole pine stems by the mountain pine beetle with and without its associated microorganisms.

3. Complete experimental work on rearing mountain pine beetles in ground phloem supplemented with killed blue-stain fungi and yeasts that are associated with the beetle.

Proposed publications:

Whitney, H.S. Rearing mountain pine beetles in autoclaved lodgepole pine phloem supplemented with blue stain and other fungi. Journal publication.

Whitney, H.S. Growth and reproduction of the mountain pine beetle in lodgepole pine bolts in the absence of blue-stain fungi. Journal publication.

Whitney, H.S. Non-staining fungi associated with western pine beetle-attacked ponderosa pine in California. Journal publication.

Parmeter, J.R., and H.S. Whitney. An annotated list of Rhizoctonia species. Journal publication.

Safranyik, L., D.M. Shrimpton, and H.S. Whitney. The mountain pine beetle in the pine forests of western Canada (proposed brochure).

18. Accomplishments during fiscal year under review:

Two publications listed last year as in press reached publication as follows:

1. Whitney, H.S. 1971. Association of Dendroctonus ponderosae Hopk. (Coleoptera: Scolytidae) with blue-stain fungi and yeasts during brood development in lodgepole pine. Can.Ent. 103:1495-1503.

2. Helms, J.A., F.W. Cobb, Jr., and H.S. Whitney, 1971. Effect of infection by Verticicladiella wagenerii on the

physiology of Pinus ponderosa. Phytopathology 61:920-925.

The publication with R.A. Blauel is still in press with Mycologia. It is slated for the March-April, 1972, issue.

A 1.5 ft. section of the stems of four standing lodgepole pine (8-10 in. d.b.h.) was cooled to -15°F for 3-4 days in midsummer by using cooling coils. Experimentally applied mountain pine beetles and their associated blue-stain fungi which were unable to establish themselves prior to cooling treatment began to successfully colonize the stems above the cooled portion. These organisms were subsequently pitched out after the cooling treatment was ended and the stems had warmed up. The trees' diameters (dendrograph), sap flow (heat pulse velocity), and sapwood moisture (oven dry wts.) were reduced and water tension (Scholander pressure bomb) increased during the cold treatment. The trees looked healthy two months after treatment and were apparently recovered from the physiological stress produced by the cold treatment. The relation between rate of sap flow and tree resistance suggested a means of detecting susceptible (non-resistant) trees. Pre-attack detection of non-resistant trees would be a useful forest management tool.

The results obtained by stem chilling have also led to several new hypotheses pertaining to the mechanism of tree resistance to bark beetles and their associated microorganisms. A ten-day extensive field trip was made to gain knowledge of the variation in sites and hosts susceptible to mountain pine beetle.

19. Goals for next fiscal year: (a) Complete the following publications:

1. Safranyik, L., D.M. Shrimpton, and H.S. Whitney. The mountain pine beetle in the pine forests of western Canada. Brochure.

2. Safranyik, L., D.M. Shrimpton, and H.S. Whitney. Our understanding of the dynamic role of lodgepole pine in the ecology of the mountain pine beetle. Proposed for Can. Ent. A philosophy-position paper.

3. Whitney, H.S. Response of lodgepole pine to axenic virgin mountain pine beetles. Proposed Departmental Bi.MO.Res.Note.

4. Whitney, H.S. Controlled stem cooling a technique for temporarily stressing large trees in the forest.

5. Whitney, H.S., J. Reid, K. Pirozynski. A new fungus on Picca, Hbies and Psendotstuga. Proposed for Mycologia.

6. Whitney, H.S., and F.W. Cobb, Jr. 1972. Non-staining fungi associated with the bark beetle Dendroctonus brenicomis Lec., (Coleoptera:Scotylidae) on Pinus ponderosa Dougl.

(b) This project is being transferred to Pacific Forest Research Centre, Victoria, and will be revised as necessary to become part of an integrated study emphasizing reduction of losses caused by the spruce bark beetle.

20. Signature:

H.S. Whitney per RWR March, 1972.

H.S. Whitney,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Biology and epidemology of dwarf mistletoe on lodgepole pine.
3.	Investigator:	J. Muir.
4.	Year of Commencement:	1962.
5.	Estimated Year of Completion:	Original, 1973. Revision I, 1972.
6.	Key Words not in Title:	Arceuthobium americanuns, Pinus contorta, parasites, dissemination, germination, SAI, B19.
7.	Discipline:	Pathology.
8.	Project:	Reduction of damage from disease-causing agencies.
9.	Estab. Study No. NOR 029.	Service Study No. NOR 029.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 36 Other: 36
12.	Man-months utilized in fiscal year under review:	Prof.: 0 Other:
13.	Man-month requirements in next fiscal year:	Prof.: 0 Other:
14.	Location of Work:	Calgary, Kananaskis Forest Experimental Station, forested areas of southern Alberta.
15.	Background Statement:	
	a - Study proposed by:	Canadian Forestry Service, Alberta Forest Service.

b - Objectives: Record and describe normal intensification in young lodgepole stands, determine the effects of environmental factors on time, frequency and distance of seed dissemination; determine effect of environmental factors on growth, flowering and seed production; determine influence of hyperparasitism on dwarf mistletoe.

c - Need for study: In the Alberta region, surveys indicate 10 percent of lodgepole pine and jack pine are infected by dwarf mistletoe. Cumulative losses of up to 34 percent have been recorded in severely infected stands. Silviculture control studies are in progress at this laboratory (A063) and elsewhere. Information important to refinement of present control methods is lacking in areas of mistletoe epidemology and parasitism.

d - Co-operating agencies: None.

16. Accomplishments to beginning of fiscal year under review:

Preliminary analysis of data from a number of mistletoe infected stands indicate intensification tends to increase at a uniform rate, and no large differences in rate occurred between stands despite wide differences in inoculum source, stand density, exposure, soil moisture. Rates of intensification have been mathematically described. Ninety percent of seed dissemination occurred within a few days in late August, and variations in amount of seed dispersed were not correlated with any meteorological factors.

It was observed approximately 8 percent of the dwarf mistletoe seed naturally deposited, or inoculated on trees, in September, 1966, has caused visible infections by September 1968. Seed dissemination observations were continued, and considerable variation was observed between separate areas. Distance of spread averaged 28 ft. from uniform margins of infected stands and 45 ft. from single residual trees. Three interim reports are in preparation, together with one publication for scientific journal.

17. Goals set for fiscal year under review:

1. Summarize data from intensification study.
2. Continue observations of seed dispersal from infected trees and individual dwarf mistletoe plants.
3. Continue field inoculations and observations on naturally dispersed seed and development of infection in growth chambers and greenhouse.

18. Accomplishments during fiscal year under review:

Additional observations were made in the field on incubation and latent periods of mistletoe infection. This investigation has been on educational leave during the past two years.

19. Goals for next fiscal year:

1. Continue to monitor field plots.
2. Complete education commitm ents.

20. Signature:

J. Muir per RwR March, 1972.

J. Muir,
Investigator.

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STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Reduction of losses from canker and dieback.
3.	Investigator:	H. Zalasky.
4.	Year of Commencement:	1965.
5.	Estimated Year of Completion:	Original Revision I, 1973.
6.	Key Words not in Title:	Frost ring, canker, dieback, 'Braunfleckengrind', frost band, pitch pocket, bark pocket, conifers, hardwoods, winter injury.
7.	Discipline:	Pathology.
8.	Project:	Reduction of losses from stem diseases.
9.	Estab. Study No. NOR 044.	Service Study No. NOR 044.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 24 Other: 30
12.	Man-months utilized in fiscal year under review:	Prof.: 8 Other: 6
13.	Man-month requirements in next fiscal year:	Prof.: 8 Other: 7
14.	Location of Work:	Regionwide.
	a - Study proposed by:	Regional park services, Canadian Forestry Service.
	b - Objectives:	1. To assess variability of hardiness of poplar to physiologic canker and dieback for clones under field conditions.

2. To provide advisory services to outside agencies on establishment and maintenance of planted poplars.

3. To compile manuscript on role of winter injury and process of dieback and target canker formation.

4. To study similar dieback and canker condition in other hardwoods and in conifers affected by low temperature damage under natural and artificial conditions.

c - Need for study: Low temperature injuries have been observed since 1965 in different parts of this region. Detailed studies were made in poplar at Winnipeg and at Edmonton. Results of studies in other hardwoods and conifers are in many respects identical with the findings made on poplar. These results have a direct impact on earlier recommendations regarding canker and dieback condition in this region. The project should give new direction to research in establishment and maintenance of planted trees for amenity and fiber use.

d - Co-operating Agencies: Provincial Nursery at Oliver, Alberta, provided test plots and progeny material for study. Tree Advisory Committee, Edmonton,to execute changes in cultural practices.

16. Accomplishments to beginning of fiscal year under review:

Published Information Report A-X-39 on disease problems of poplar for liaison purposes. Planted clones of poplar for testing of winter hardiness on a hard columnar soil. Provided advisory services to outside agencies on establishment and maintenance of planted poplar. Collected spring and autumn injured poplar for analysis in the laboratory both histologically and biotically using an improved isolation technique.

17. Goals set for fiscal year under review:

Continue to inoculate poplar maintained in the field and greenhouse. Goal discontinued in 1970 because of transfer, and changes in direction of septoria canker research. Investigate variability in resistance of poplars and other hardwoods to canker and dieback of non-fungal origin. Make more extensive collections of Mycosphaerellas on willow and some additional collection on poplar.

18. Accomplishments during fiscal year under review:

Manuscript on role of winter injury and the process of canker and dieback formation is being revised for second review. A start has been made on detailed histology of 'Braunfleckengrind', canker and dieback in nine other hardwoods from specimens collected over the past year in the three Prairie Provinces. Similar studies of lodgepole pine from three

localities are under completion; a start has been made on five other conifer species.

Developed and tested a low temperature injury technique on lodgepole pine in the greenhouse and growth chamber under controlled conditions and accomplished the development of 'Braunfleckengrind', canker and dieback.

Planted five clones of poplar at Oliver and expanded the size of demonstration plot.

Liaison contacts were made in regard to problems in poplar, spruce and ornamentals in private and public properties.

Zalasky, H. 1972. Problems in spruce relating to soil, climate, and recreational land use in the Bragg Creek area, Alberta. Northern Forest Research Centre, Edmonton, Alta. Internal Report NOR-10.

Zalasky, H. Reaction of Populus balsamifera and P. deltoides var. occidentalis to septoria canker under greenhouse conditions. Manuscript under revision.

19. Goals for next fiscal year: Investigate frost ring in relation to canker and dieback incidence in conifers and hardwoods, and prepare a technical report. Five hundred cuttings of five clones of hybrid poplar planted at Oliver Tree Nursery for rooting and production of 1-year-old stock will be transplanted for two demonstration trials: (1) to show how to reduce and prevent loss from frost ring resulting in canker and dieback under plantation conditions, (2) to show how to prevent dieback and loss of vigor as well as prolong the life span and productivity of stooling stock in the nursery, (3) to follow up studies on artificial low temperature study.

Maintain advisory services to outside agencies on problems pertaining to planted poplars.

Planned Reports, Publications and Demonstrations:

Zalasky, H. Frost ring resulting in a destructive canker and dieback of poplar.

Zalasky, H. Stem infections in native and hybrid poplar caused by Septoria musiva and S. populicola.

Zalasky, H. Demonstration of frost ring in aspen and hybrid poplar and how to prevent it.

Zalasky, H. Demonstration of an improved method of extending the life expectancy of stooling stock of poplar.

Zalasky, H. Species of Mycosphaerella and their imperfect states on poplar and willow.

20. Signature:

H. Zalasky March, 1972.

H. Zalasky,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: A bark disease of poplar.

3. Investigator: H. Zalasky.

4. Year of Commencement: 1965.

5. Estimated Year of Completion: Original, 1969.
Revision I, 1971.
Revision II, 1972.

6. Key Words not in Title: Populus balsamifera, Rhytidiella moriformis, Phaeoseptoria, Caliciopsis, Amphisphaeria.

7. Discipline: Pathology.

8. Project: Reduction of losses from stem diseases.

9. Estab. Study No. NOR 069. Service Study No. NOR 069.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 24 Other: 18

12. Man-months utilized in fiscal year under review: Prof.: 3 Other: 0

13. Man-month requirements in next fiscal year: Prof.: 1 Other: 0

14. Location of Work: Regionwide.

15. Background Statement:

a - Study proposed by: Regional park services, Canadian Forestry Service.

b - Objectives: To provide knowledge on pathogenicity, tree damage, symptomatology, and cultural characteristics of R. moriformis: to determine various aspects of the life history and host parasite relationship, nutritional and physiological requirements; and to describe the fungus and its related species.

To provide advisory services to outside agencies on establishment and maintenance of planted poplars.

c - Need for project: Rough-bark, a newly described disease with no cambial necrosis, is common on balsam poplar. An ascomycete, Rhytidiella moriformis n. gen. n. sp. first found to be associated with infection of two-year old stems, causes infection to appear at the base of the stem. Later infections occur in the upper stem and crown. On maturing trees the bark becomes dark grey and furrowed into thick ridges throughout the entire trunk and main branches. All clones are susceptible with few exceptions.

d - Co-operating Agencies: Staff in two Mycological Institutes in Canada and in Europe examined and compared collections to verify if R. moriformis was a new fungus.

16. Accomplishments to beginning of fiscal year under review:

Rhytidiella moriformis, causing rough-bark of balsam poplar (Populus balsamifera) in Manitoba, Saskatchewan, and British Columbia produces pycnidia with two types of conidia, Phaeoseptoria and Phyllosticta both of which predominate on one to five-year-old infections. In older bark the perithecial production predominates persistently for about 65 years. Zalasky, H. 1968. Rhtidiella moriformis n. gen., n. sp. causing rough-bark of Populus balsamifera. Can. J. Botany 46, 1383-1387.

Cross-inoculations in the greenhouse showed that the fungus from balsam poplar infects aspen and balsam poplar but the aspen isolates inoculated into balsam poplar produced inconclusive results. Investigation of the total phenols and sugars extracted from balsam poplar bark indicates that the pathogen and two succession fungi are capable of utilizing both substances in liquid cultures.

Test plants of hybrid poplar were also successfully infected in the greenhouse. Histological studies of infected material showed conclusively that the fungus causes hypertrophy of the periderm and rough-bark.

The succession fungus Caliciopsis calicioides is now known to occur on cottonwood (P. deltoides), black cottonwood, balsam poplar, and poplar shade trees of hybrid origin in Alberta, Manitoba, Saskatchewan and eastern and western United States.

17. Goals set for fiscal year under review:

Complete histological investigation on pathogenicity and begin preparation of manuscript.

18. Accomplishments during fiscal year under review:

Specimens of the fungus R.moriformis have been deposited in various major herbaria in Canada, United States and Europe for study and reference. Prepared morphological data and

photographed the Perfect and Imperfect States of other species of Rhytidiella collected earlier. Prepared semi-permanent slides of greenhouse inoculated poplar material for detailed histological study.

Paper Published:

Zalasky, H., A. Nawai, W.P. Ting, and L.H. Wai. 1971. Dolabra nepheliac and its imperfect state associated with canker of Nephelium lappaceum and N. mutabile. Can. J. Botany 49, 559-561.

19. Goals for next fiscal year:

Proposed publication:

Zalasky, H. Histology of host-parasite relationships of Rhytidiella moriformis. Zalasky on poplar bark.

20. Signature:

H. Zalasky March 1972.

H. Zalasky,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Cinder gall of poplar.

3. Investigator: H. Zalasky.

4. Year of Commencement: 1967.

5. Estimated Year of Completion: Original 1971. Revision I, 1972.

6. Key Words not in Title: *Diplodia tumefaciens* fungi and succession, *Populus tremuloides*, *P. balsamifera*.

7. Discipline: Pathology.

8. Project: Reduction of losses from stem diseases.

9. Estab. Study No. NOR 070. Service Study No. NOR 070.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 4 Other: 3

12. Man-months utilized in fiscal year under review: Prof.: 1 Other: 3

13. Man-month requirements in next fiscal year: Prof.: 2 Other: 3

14. Location of Work: Regionwide.

15. Background Statement:

a - Study proposed by: Regional park services, Canadian Forestry Service.

b - Objectives: The objectives are to study successions and life histories of the parasites occurring in the bark tumors and in healed and unhealed branch stubs, to isolate and compare fungi from the branch stub with the fungi parasitic in the bark as a necessary step in formulation of control methods.

To provide advisory services to outside agencies on establishment and maintenance of planted poplars.

c - Need for study: This project is a continuation of PP-34a concerning the gall and rough-bark disease caused by Diplodia tumefaciens common on Populus tremuloides and P. balsamifera. The cinder gall occurs regionwide on particular clones of the species of poplar with poorly healed branch stubs and with bud gall mite injury. Severe damage occurs to the main trunk of all mature trees within a clone as a result of cankering of the centre portions of the gall by succession fungi or a syndrome of organisms.

In earlier research on the infection process of the branch stub preliminary to decay by primary fungi, it was found that Cytospora, Phoma and Libertella are presumably most important preliminary fungi. These fungi either provide stimulus and/or change the substrate (heartwood) sufficiently for the decay fungi that follow in the succession (Basham 1958 and Ethridge 1961). The common decadent areas are the branch stub and bud gall around which the bark forms a part of the tumorous healing tissue. Adjacent wood is frequently subject to decay and soft rot.

d - Co-operating Agencies: Regional foresty and park services.

16. Accomplishments to beginning of fiscal year under review:

The early disease symptoms are the same as those known for the gall and rough-bark of balsam poplar and aspen. One of the primary causal agents of the cinder gall is D. tumefaciens, the mycelia of which are perennial in the living cortex of the infected bark at the top and base of the gall. One other fungus is a species of Hendersonia presumed to be less important; it is also common on smaller swellings with no cinder-like bark. Succession fungi kill and degrade all of the tissues of the bark within the swellings. Some of the succession fungi are under investigation from material that was collected in several known localities in Manitoba. Presumably one or all of the succession fungi degrade the tissues of the bark within the mid-portion of the gall. The most frequent fungi in this association are Phomopsis, Cladosporium, Stenganosporium, Fenestella and an ascomycate not as yet familiar to me. A red-colored hyphomycate is often isolated from the heartwood.

17. Goals set for fiscal year under review:

Obtain more information on the development of the disease in nature. Provide information to the Disease Survey personnel for work on geographic distribution and the amount of damage caused.

18. Accomplishments during fiscal year under review:

Progress to date: Objectives (1) and (2) have been completed. Cinder gall is initiated by bud gall mite and repeated attacks by the flat-headed borers in association with the fungus Diplodia tumefaciens. They are common on clones of aspen and balsam poplar that are highly susceptible to the organisms. Severe

damage occurs to the main trunk, both basal and upper parts. Branch clustering occurs on balsam poplar stems as a result of the infection.

Bud gall mite also follows D. tumefaciens infections but the resulting gall does not have the cinder-like characteristics. Similar galls on main stems result when D. tumefaciens establishes in the wood of dead branch stubs and stimulates, adjacent to it, excessive healing tissue of wood and bark.

19. Goals for next fiscal year: A final report should be ready by fall of this year and any further plans will be confirmed after the report is completed.

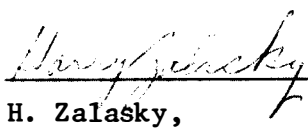
Planned reports and publications:

Zalasky, H. Incidence of D. tumefaciens in branch stubs of infected poplar. Canadian Journal Botany.

Zalasky, H. Root infections in poplar caused by D. tumefaciens. Canadian Journal Botany.

Zalasky, H. Perfect state of D. tumefaciens in poplar. Canadian Journal of Botany.

20. Signature:



March, 1972.

H. Zalasky,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Aerobiology of Comandra blister rust, Cronartium comandrae.

3. Investigator: J. M. Powell.

4. Year of Commencement: 1964.

5. Estimated Year of Completion: Original 1969.
Revision I 1971.
Revision II 1972.

6. Key Words not in Title: Pinus, - Spore dispersal, germination, viability, microflora, fauna, climate, SA 1, B 19.

7. Discipline: Pathology.

8. Project: Reduction damage from disease causing agencies.

9. Estab. Study No. Service Study No. NOR 094.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 64 Other: 95

12. Man-months utilized in fiscal year under review: Prof.: 4 Other: 1

13. Man-month requirements in next fiscal year: Prof.: 1 Other: 0

14. Location of Work: Calgary, Kananaskis Forest Experiment Station, in forested regions of Alberta and National Parks.

15. Background Statement:

a. Study proposed by: Canadian Forestry Service.

b. Objectives: To investigate the epidemiology and aerobiology of the Comandra blister rust on lodgepole pine and its alternate hosts in Alberta.

Interim: 1. Determine the duration of aeciospore production and factors affecting their release, transport, dispersal and deposition;

2. Determine the environmental factors affecting aeciospore germination and viability;

3. Determine the effect of the associated microflora and fauna on aspects of the aerobiology;

4. To conduct surveys to ascertain the distribution of the rust in the region, and the incidence and role of the associated rodents, insects and microflora.

c. Need for study: The rust is a disease of hard pines in North America. Although the damage of the rust is not spectacular, the infection may be heavy in trees of all ages and cause mortality by basal or stem girdling. It has recently become a plantation problem in south and southeastern United States and mature stands of lodgepole pine in western United States have been reported with 50 to 98% of the trees infected. Little is known about the distribution and role of the rust in Canada.

Important information is lacking on influence of climatic factors upon spread and intensification of aerial borne pathogens. This rust, which has an easily recognizable aeciospore stage was chosen as a suitable organism for studies on those relations, and because it is a potentially damaging organism, especially with the increase toward plantation forestry, for which little information was available.

d. Co-operating Agencies: None.

16. Accomplishments to beginning of fiscal year under review: Aeciospore production and duration was followed for four years in a number of locations, including production in two years from individual aecia and aecial pustules. Aecial production was limited by the activity of other fungi, insects and rodents. Sixty-four fungi and bacteria were identified as associated with the rust canker or spores; of these Tuberculina maxima and Cladosporium sp. are important in reducing the inoculum available. One hundred and sixty species of arthropods were collected in association with the rust. Of these Epuraea obliquus, Paracacoxenus guttatus and Mycodiplosis sp. play an important role, and information on their biology was obtained. Annual observations were made on the incidence of rodent, insect and microfloral organisms on 500 cankers at 23 locations, as well as observations on the growth and status of the cankers. Samples of duff material from around rust infected trees were collected on two occasions and yielded 160 species, which included 15 spiders, 21 mites, 19 Collembola, 20 Coleoptera, 43 Diptera (half Cecidomyiidae), and 22 Hymenoptera.

Seasonal and diurnal spore release data were collected during four years, and related to weather. Data were collected on the distance of spore dispersal from natural and experimental sources, and on the rate of spore fall in still air. Spore germination tests were made daily during the spore production period in three years. The temperature, humidity, light and pH requirements for spore germination were established. Different media were evaluated as spore germination substrates. The cytology of the aeciospores and aeciospore germ tubes were described. Inoculations were successful with aeciospores on Comandra, very poor on Geocalon, and negative results were achieved on pine. Information was obtained during four years on the build-up of uredial and telial infection on eight Comandra plots.

Papers were published on the development of a modified 24-hour spore collector, on a cage for collecting insects from cankers, and the first report of the rust on P. sylvestris and of the hyperparasite Tuberculina maxima on C. comandrae and other pine stem rusts in Alberta. A Ph.D. thesis entitled "The aerobiology of the aecial state of the comandra blister rust Cronartium comandrae Peck, in Alberta" was completed in 1969. A paper was published with Y. Hiratsuka on the cytology of the aeciospores and aeciospore germ tubes of C. comandrae and C. comptoriae. Papers on (1) the distribution and hosts of C. comandrae in Canada, (2) the fungi and bacteria associated with C. comandrae, and (3) the anthropod fauna collected from the rust on lodgepole pine in Alberta were accepted for publication. Three papers were also presented at scientific meetings; (1) "Insects associated with pine stem rusts" (2) "Comandra blister rust in Alberta, and biological factors affecting aeciospore production", and (3) (with Y. Hiratsuka) "Cytology and taxonomy of autoecious pine stem rusts".

17. Goals set for fiscal year under review:

Owing to the reassignment of the investigator only limited time will be available to continue the preparation of papers and reports for publication. Hopefully those papers submitted to journals or for Ottawa review will be accepted by the journals. One invited paper on "Dispersal of Cronartium comandrae aeciospores" will be prepared for presentation at the Western International Forest Disease Work Conference, at Medford, Oregon, in September, and for publication in the Proceedings. Work will continue on the four papers under local review, and hopefully some progress can be made on other proposed papers, including the joint paper with Y. Hiratsuka on the "Pine stem rusts of Canada".

Powell, J. M. Occurrence of Tuberculina maxima on pine stem rusts in western Canada (submitted to Can. Plant Dis. Survey).

Powell, J. M. Additional records of Mycodiplosis larvae (Diptera: Cecidomyiidae) feeding on rust fungi (submitted to Can. Plant Dis. Survey).

Powell, J. M. Incidence and effect of Tuberculina maxima on cankers of the pine stem rust, Cronartium comandrae (proposed for Phytoprotection - paper under Ottawa review).

Powell, J. M. Insects collected from Comandra umbellata ssp. pallida (Santalaceae) infected by the rust Cronartium comandrae in southern Alberta (submitted to Can. Field-Naturalist).

Powell, J. M. Seasonal and diurnal periodicity of Cronartium comandrae aeciospore release from stem cankers on lodgepole pine (proposed for Can. J. Bot. or Can. J. For. Res. - paper under local review).

Powell, J. M. Daily germination of Cronartium comandrae aeciospores. (proposed for Can. J. Bot. - paper under local review).

Powell, J. M. Environmental factors affecting germination and germ tube growth of Cronartium comandrae aeciospores (proposed for Can. J. Bot. - paper being revised for local review).

Powell, J. M. The effect of temperature, humidity and light on the viability of Cronartium comandrae aeciospores (proposed Inform. Rept. - paper being revised for local review).

Powell, J. M. Dispersal of Cronartium comandrae aeciospores (Invited paper for W.I.F.D.W.C., Medford, Ore., Sept. 1971).

Hiratsuka, Y. and J. M. Powell. Pine stem rusts of Canada (Proposed Dept. Publ.).

18. Accomplishments during fiscal year under review:

Measurements of canker growth rates, mortality, and incidence of associated fungi, insects and rodent damage were again obtained at 23 locations. Approximately 45% of the infected trees tagged in 1967 or earlier are now dead. Special attention was given to assessing the amount of current year and previous rodent damage on the cankers.

Good progress was made in realizing the publication goals for the year. Four of the journal papers listed in section 17 were published and two are "in press". One paper entitled "Aerobiology of the aecial state of the comandra blister rust" was presented at the Western International Forest Disease Work Conference in September, and will appear in the Proceedings. The first draft of the review paper on "Pine stem rusts of Canada" with Y. Hiratsuka was completed, and another with H. R. Wong, entitled "Anthropods collected from cankers of stem rusts on hard pines in the Canadian Prairies" is nearing completion. No time was available for revision of the 8th and 9th listed papers in section 17.

Concerning the satisfying of the study objectives: Under objective 1, one major paper on the factors affecting aeciospore release is currently "in press", and some of the results of aeciospore dispersal and deposition experiments were presented in a Conference paper. For objective 2, one paper on daily germination studies has been published, but two papers on factors affecting aeciospore germination and viability require revision. Most major aspects of the

studies relating to objectives 3 and 4 have now been published, except for a paper on the incidence and damage of the rust in lodgepole pine stands in Alberta, and a short paper on rodent damage to the rust cankers.

Papers published (including three "in press" the previous year), or presented during the year, and those currently "in press" are as follows:

Powell, J. M. 1970. Cronartium comandrae in Canada, its distribution and hosts. Can. Plant Dis. Survey, 50: 130-135.

Powell, J. M. 1971. Fungi and bacteria associated with Cronartium comandrae on lodgepole pine in Alberta. Phytoprotection, 52: 45-51.

Powell, J. M. 1971. The arthropod fauna collected from the comandra blister rust, Cronartium comandrae, on lodgepole pine in Alberta. Can. Entomol. 103: 908-918.

Powell, J. M. 1971. Occurrence of Tuberculina maxima on pine stem rusts in western Canada. Can. Plant Dis. Survey, 51: 83-85.

Powell, J. M. 1971. Additional records of Mycodiplosis larvae (Diptera: Cecidomyiidae) feeding on rust fungi. Can. Plant Dis. Survey, 51: 86-87.

Powell, J. M. 1971. Incidence and effect of Tuberculina maxima on cankers of the pine stem rust, Cronartium comandrae. Phytoprotection 52: 104-111.

Powell, J. M. 1971. Daily germination of Cronartium comandrae aeciospores. Can. J. Bot. 49: 2123-2127.

Powell, J. M. 1971. Aerobiology of the aecial state of the comandra blister rust. (Invited paper presented at the 19th Western International Forest Disease Work Conference, Medford, Oregon, September, 166 pp m.s. + 24 figs.)

Powell, J. M. 1972. Insects collected from the toadflax Comandra umbellata ssp. pallida (Santalaceae) infected by the rust Cronartium comandrae in southern Alberta. Can. Field-Naturalist (in press).

Powell, J. M. 1972. Seasonal and diurnal periodicity of Cronartium comandrae aeciospore release from stem cankers on lodgepole pine. Can. J. For. Res. (in press).

19. Goals for next fiscal year: Owing to the reassignment of the investigator to studies in forest climatology only limited time will be available to continue the preparation of papers and reports for publication. Emphasis will be given to completing the review paper with Y. Hiratsuka on the "Pine stem rusts of Canada", and the report with H. R. Wong on

Arthropods collected from cankers of stem rusts on hard pines". Drafts of other papers to satisfy the study objectives, will be revised or written if commitments to other studies allow.

Hiratsuka, Y. and J. M. Powell. Pine stem rusts of Canada. Identification, hosts, distribution, life cycle, cytology, epidemiology, and control (Proposed Departmental Publication).

Powell, J. M., H. R. Wong and J. C. E. Melvin. Arthropods collected from cankers of stem rusts on hard pines in the Canadian Prairies (Proposed Information Report).

20. Signatures:

J. M. Powell — March, 1972

J. M. Powell,
Investigator.

REDUCTION OF DAMAGE FROM DEFOLIATING INSECTS

The spruce budworm and larch sawfly are important defoliating insects in this region. In some areas of wood fiber production nearly 50% of the white spruce has been killed as a result of many years of spruce budworm feeding. In areas of chronic high budworm populations regeneration has been severely damaged. The larch sawfly has removed larch as a useful tree species to the forest industry due to many decades of severe defoliation. Defoliators in general are sensitive to climatic factors but relations between the two are not known in sufficient detail to provide predictive information.

The objectives of this project are as follows, re spruce budworm program: To provide management agencies with annual impact assessment for inclusion in regional cutting priority plans and to provide management with options for reducing damage to regeneration following cutting. Re the larch sawfly program: To mass rear and release a parasite found in earlier studies to be very effective in reducing larch sawfly populations. Re defoliators in general, analyze historical records of defoliator abundance and weather data.

The benefits expected from these studies are as follows, re spruce budworm. Important savings by salvage of affected spruce and development of methods which assure regeneration of the area free from depreciation by budworm. Re larch sawfly: Development and growth of larch in sufficient volume and of sufficient size to be useful as a forest product. Re defoliators - predictions of their increase or decrease in abundance will assist forest resource managers to reduce effect of epidemics.

Goals for next year are continuation of previous studies. Studies on methods of assessing for economic purposes budworm populations, their impact on both mature and regenerating stands will be employed. Mass rearing techniques for the larch sawfly parasite and distribution of the parasite to areas not presently containing the parasite will be emphasized. Complete analysis of defoliation and weather data.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Population studies of the mountain pine beetle.
3.	Investigator:	L. Safranyik.
4.	Year of Commencement:	1955.
5.	Estimated Year of Completion:	Original, 1970. Revision I, 1973. Revision II, 1972.
6.	Key Words not in Title:	Dendroctonus ponderosae, sampling, spatial pattern, insect population quality, lodgepole pine, SA 1, CL.
7.	Discipline:	Entomology.
8.	Project:	Reduction of losses from bark beetles.
9.	Estab. study No. PRS 021	Service study No. PRS 021
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 98 Other: 142
12.	Man-months utilized in fiscal year under review:	Prof. 7 Other: 14
13.	Man-month requirements in next fiscal year:	Prof.: 4 Other: 4
14.	Location of Work:	Edmonton, Alberta; Victoria, B.C.
15.	Background Statement:	
	a - Study proposed by:	British Columbia Forest Service and Canadian Forestry Service.

b - Objectives: 1. Describe the distribution of beetle attacks over the host and the factors that influence this distribution.

2. Develop a sampling system which will be of sufficient sensitivity to permit detection, evaluation and prediction of population changes within limits of practicability.

3. Assess the effects of mortality factors on beetle population.

4. Relate the effects of mortality factors to population changes.

5. Assess the role of variations in mountain pine beetle phenotypes and abundance in relation to the physical and nutritional quality of the host.

6. Ensure current knowledge is being utilized by management agencies.

c - Need for study: The mountain pine beetle and its associated blue-stain fungi are responsible for significant annual loss of lodgepole, white and ponderosa pine in the Rocky Mountain National Parks, British Columbia, and the adjacent United States. Exclusive of Vancouver Island, some 190 million board feet of western white, ponderosa and lodgepole pine were killed in British Columbia alone in the 10 years from 1951 to 1961. In addition to causing direct monetary loss, epidemics of the mountain pine beetle reduce the aesthetic value of stands and alter their species composition, increase fire hazard and force changes in management plans.

This project is part of an integrated study which includes research into tree resistance and the role of blue-stain fungi, PRS 020 and PRS 022, respectively. The primary objective of the study is to provide forest managers with techniques for rating stands of lodgepole pine for beetle hazard. With that knowledge managers can greatly reduce present losses by removing high risk stands before they are infested by bark beetles.

d - Co-operating agencies: B.C. Forest Service. The above agency gave permission to establish sample plots in infested stands under its jurisdiction.

16. Accomplishments to beginning of fiscal year under review:

The size, shape and orientation of the "optimum" sampling unit was established by studies of the relation of late stage brood and by a time study of sampling units of various sizes and shapes. The gradients of brood and attack density, both vertically and around the circumference of infested trees, were described and a mathematical description of attacks over the host, in terms of bark thickness, was developed. A two-stage sampling system was developed to measure within generation mortalities and

population trend. An equation was developed to predict infested bark surface area of lodgepole pine. "Surface area" tables have been drawn up covering trees in the 6 - 16 in. d.b.h. and 28 - 125 ft. height classes. These results represent the completion of objective 2 and a large part of objective 1. Work toward objective 3 progressed to the stage where 3 years data is available on mortality caused by woodpecker predation. Data is available to evaluate the accuracy and efficiency of the X-ray tehnique for sampling the larval and pupal stages of the mountain pine beetle. This data awaits analysis. Field studies of the vertical flight intensity profile in relation to wind speeds, temperatures and three kinds of trapping methods are completed. This study has been summarized in the form of a graduate thesis by Mr. R. Avis under my supervision. The thesis was submitted to the Faculty of Forestry, U.B.C., Vancouver, B.C. in the spring of 1971. Data has been collected and analysis completed for the study of the accuracy of the sine vave function for measuring heat units under Alberta conditions. A preliminary study of size-related mortality of the mountain pine beetle adults in laboratory storage has been completed.

The study of the characteristics of the attack pattern has been completed. In general, the spatial arrangement of attacks and their distribution over lodgepole pine stems were found to be largely determined by distribution of bark niches suitable for attack initiation and by the combined thicknesses of the inner and outer bark. Attack density, maximum attack height and the attack harboring potential of individual trees are governed by bark roughness and bark thickness.

A preliminary study of the relations of attack ht., aspect, and moisture content of the outer sapwood on to beetle size (indexed by the width of the prothorax) has been completed.

17. Goals set for fiscal year under review:

1. Prepare a brochure for management agencies on the important tree, stand, climatic, and other environmental factors that affect the build-up of mountain pine beetle populations in the pine forests of western Canada with the recommendations for control.

2. If necessary, arrange visits to management agencies for the purpose of describing dangers and losses associated with bark beetles in their management areas.

3. Initiate studies on the effects of low temperature on the larval stages of the beetle.

4. Commence studies of the effects of nutritional and physical characteristics of the host on brood survival.

Publications:

Safranyik, L., H.F. Cerezke, W. Chow. Evaluation of the accuracy of the sine function for measuring heat units (proposed journal publication).

Safranyik, L., M.D. Shrimpton and H.S. Whitney. The mountain pine beetle in the pine forests of western Canada (proposed brochure).

Safranyik, L. Size-related mortality of mountain pine beetle adults during laboratory storage (proposed research note).

18. Accomplishment during fiscal year under review:

In accordance with goal number two, I have attended a meeting of the "East Kootenays Forest Pest Control Committee" in Cranbrook, B.C., and described the dangers and losses associated with the mountain pine beetle in southeastern British Columbia. Furthermore, I corresponded with officials of the Nelson Forest District, B.C., and with surveys personnel at the Pacific Forest Research Centre with regard to the status and potential hazard to mature lodgepole pine forests posed by the current mountain pine beetle outbreak near Elk Creek, B.C.

Studies were initiated on the effects of low temperatures on the larval stages of the mountain pine beetle. The data indicates that cold hardiness increases with larval stage (i.e. from first instar to fourth instar) and that the effects of size-related mortality are increased average adult size and an increase in the female-to-male ratio of the adults.

Goal number four was modified to study of the relation between tree diameter and brood productivity of lodgepole pine trees. This study involved the sampling of 50 infested trees at Toby Creek, near Invermere, B.C. The data is analysed and the results indicate that on the average, trees greater than 9" in d.b.h. are required in order to affect an increase in population levels. The modification of goal number four was necessitated by my transfer to the P.F.R.C., Victoria, B.C. effective April 1, 1972. Thus, there was an urgency to obtain data on brood productivity for the development of the contents of the brochure on the population phenomena of the mountain pine beetle in lodgepole pine. For the same reason, a two-week tour was made of pine stands in B.C. where outbreaks of this mountain pine beetle were currently in progress or occurred in the past.

A preliminary test of the range of attraction of the pheromone trans-verbanol plus α - pinene was carried out in a mature lodgepole pine stand in Francis Creek Valley, near Invermere, B.C. The test was hindered by the lack of adequate marking technique for the beetles. Of the variety of marking techniques used, branding the elytra by burning with a hot probe proved most satisfactory. About 10% of the 4,000 beetles released at various distances from a susceptible tree baited with the pheromone α - pinene combination eventually attacked this tree and its neighbors within a radius of 16 feet. However, less than 2% of the released beetles were attracted to the baited tree from distances greater than 100 feet.

During the year priority was given (1) to the preparation of a display on bark beetles for the opening of the Northern Forest Research Centre, (2) survey and evaluation of spruce beetles damage and population trend in southern Alberta and (3) preparation of the program for the Western Forest Insect Work Conference of which I was the Program Chairman. These activities took about 1.5, 2.0, and 3.0 months of my time. Consequently, work on the brochure and on the preparation of the other two papers proposed for publication in 1971 had to be delayed.

19. Goals for next fiscal year: Analysis of data and preparation for publication of the following papers:

Safranyik, L., H.F. Cerezke, W. Chow. Evaluation of the accuracy of the sine function for measuring heat units (proposed journal publication).

Safranyik, L., M.D. Shrimpton and H.S. Whitney. The mountain pine beetle in the pine forests of western Canada (proposed brochure).

Safranyik, L. Size-related mortality of mountain pine beetle adults during laboratory storage (proposed research note).

Safranyik, L., M.D. Shrimpton, and H.S. Whitney. Our understanding of the dynamic role of lodgepole pine in the ecology of the mountain pine beetle-blue-stain fungi complex, (proposed journal publication).

This study is being terminated in current year (1972) and research program transferred to Pacific Forest Research Centre in Victoria.

20. Signature:

March, 1972.

L. Safranyik,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: The response of Lodgepole pine to attack by Bark Beetles and associated micro-organisms.

3. Investigator: D.M. Shrimpton.

4. Year of Commencement: 1965.

5. Estimated Year of Completion: Original 1972.

6. Key Words not in Title: Terpenes, phenolics, carbohydrates tissue culture, water, SA2, CL.

7. Discipline: Tree biology.

8. Project: Increased productivity of wood fibre.

9. Estab. Study No. NOR 022 Service Study No. NOR 022

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 96 Other: 116

12. Man-months utilized in fiscal year under review: Prof.: 12 Other: 12

13. Man-month requirements in next fiscal year: Prof.: 4 Other: 4

14. Location of Work: Canal Flats, Invermere and Victoria, B.C.; Edmonton, Alberta.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: The objective of this study is to define the resistance mechanisms of lodgepole pine stems to attack by mountain pine beetles and their associated fungi. The

central concept in this study is that trees resist attack by sealing off the infected area with resinous compounds. Trees vary in their resistance and hence the course of outbreaks is determined at least in part by the tree. Since the gross form of the tree's response has been defined the current specific objectives are to define the changes that take place in the stem, both chemical and anatomical, when it is attacked and then to determine those factors which influence the ability of the tree to resist insect attack.

c - Need for study: The mountain pine beetle and its associated blue-stain fungi are responsible for significant annual loss of lodgepole pine, western white and ponderosa pine in western Canada and the adjacent United States. Exclusive of Vancouver Island some 190 million board feet of western white, ponderosa and lodgepole pine were killed in British Columbia alone in the ten years from 1951 to 1961. In addition to causing direct monetary loss, epidemics of the mountain pine beetle reduce the aesthetic value of stands and alter their species composition, increase the fire hazard, and force changes in management plans.

This project is part of an integrated study which includes research into tree resistance, also insect behaviour and the role of blue-stain fungi NOR 020 and NOR 021 respectively. The primary objective of the study is to provide forest managers with techniques for rating the bark beetle hazard to stands of lodgepole pine. With that knowledge managers can greatly reduce present losses by removing high risk stands before they are infested by bark beetles.

The natural methods for controlling insect populations are a variety of predators, insects, birds, etc., and the tree's natural attraction and resistance. The question of predators has been studied in this and other laboratories. Pheremone studies are under way in other laboratories. Little is known of the chemical and physiological mechanisms of tree resistance. When sufficient knowledge is on hand variations in the resistance of stands can be measured and hazard ratings for stands can be established.

d - Co-operating agencies: B.C. Forest Service.

16. Accomplishments to beginning of fiscal year under review:

Resistance by lodgepole pine to invasion by bark beetles and/or blue-stain fungi is effected by an initial flow of oleoresin from the lesion out of the severed resin canals. This is followed by a gradual impregnation with resinous substances of the tissues adjacent to the wound. Chemical changes that occur in resistant stems around the point of attack are: a rapid

decrease in sugars and fatty acids, a rapid increase in terpene, and a more gradual increase in resin acids, neutrals, and phenols. Individual chemical components have been identified and all are normally present in lodgepole pine, furthermore, no unusually high or unusually low levels of any compound were observed. Generally speaking, the initial synthesis of terpene enhances the flow of oleoresin from severed resin canals but the long term response is the formation of "pathological heartwood".

For experimental purposes the tree response can be initiated by artificial inoculation with blue-stain fungi. In this way trees can be evaluated for resistance irrespective of beetle activity. In any stand there are resistant trees, non-resistant trees (incapable of resin formation after wounding) and all intermediate levels. The number of resistant trees varies from stand to stand and varies with the seasons. The greatest number of resistant individuals occurs in early July and then gradually lessens, thus resistance is declining at the usual time for beetle flight, i.e. mid-July to early August. However, for any given resistant tree, resistance is greatest in the lower bole i.e. in that part of the stem attacked by the beetles.

Moisture stress, as measured by the pressure bomb technique, increases as the growing season progresses, reaching a maximum in midsummer. Resistant trees undergo lesser moisture stress during hot periods than non-resistant trees. The insect flight has been observed to coincide with this period of greatest moisture stress for the tree.

17. Goals set for fiscal year under review:

1. The extractive data will be finalized.

2. Lodgepole pine trees of all age classes from seedlings to overmature trees will be inoculated with Europhium at the end of June and again in late July, coincident with the beetle flight. Sufficient trees will be inoculated to allow a correlation of resistance with age and growth characteristics within each 20-year age class.

3. Beetles will be caged on white pine, ponderosa pine and white spruce and the development of the tree response determined.

4. Since seedlings show the same gross changes as mature trees in response to blue-stain fungi, a histological study of the changes that occur in seedlings after inoculation has commenced and will continue this year.

5. Efforts will be continued to grow tissue cultures of lodgepole and ponderosa pines to be utilized for studies on oleoresin synthesis.

Proposed publications:

1. Heartwood extractives of lodgepole pine.

2. Production of terpenes and resin acids by lodgepole pine in response to wounding.

3. The mountain pine beetle in lodgepole pine forests of western Canada. A monograph prepared for the forest manager in co-operation with L. Safranyik and H.S. Whitney.

18. Accomplishments during fiscal year under review:

1. Extractive data has been finalized.

2. Generally the greatest number of resistant lodgepole pines occurs about age 60, older and younger trees have less resistant individuals. Also for trees about 90 years and older, the number of resistant individuals decreases rapidly as the summer progresses. Hence, the bark beetle habit of attacking mature trees in late July correlates well with the observed decrease in number of resistant trees.

Resistant trees have better radial growth and thicker phloem than non-resistant trees.

3. A consideration of other species was postponed pending the transfer of bark beetle research to the Pacific Forest Research Centre.

4. After inoculation there is an initial flow of oleoresin from damaged resin canals. This is followed by a formation of resinous substances in all parenchyma cells near the wound. Resins accumulate in parenchyma cells and are finally excreted into the surrounding tracheids and sieve elements. Nuclei remain viable but enlarged, in spite of the large resin accumulation, for up to three months following inoculation.

5. The strains of lodgepole and ponderosa pine tissue cultures have been maintained.

Publications:

1. Information report NOR-X-18. Variation in the extractives from lodgepole pine sapwood and heartwood.

2. The production of resinous compounds by lodgepole pine after wounding,in manuscript form.

3. When do lodgepole pine stands become susceptible to mountain pine beetle, and how do we recognize this? Prepared with L. Safranyik and H.S. Whitney, in preparation, a brochure for the use of forest managers.

19. Goals for the next fiscal year:

1. To re-examine the resistance of stands rated by R.W. Reid in the mid-60's and to evaluate beetle damage since that time in relation to past and present resistance.

2. Complete the brochure designed for the forest manager on the subject of mountain pine beetle activity in lodgepole pine stands, together with L. Safranyik and H.S. Whitney.

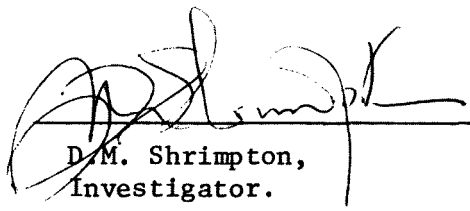
3. Publish the data on variation of tree resistance with age.

4. Publish cytological studies on resin formation after inoculation.

5. Develop a program on spruce response to spruce beetle at the Pacific Forest Research Centre.

6. This project is being transferred to Pacific Forest Research Centre, Victoria, and will be revised as necessary to become part of an integrated study emphasizing reduction of losses from the spruce bark beetle.

20. Signature:



March, 1972.

D.M. Shrimpton,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Impact, biology, and control of the spruce budworm in northern Alberta and Northwest Territories.
3.	Investigator:	H.F. Cerezke.
4.	Year of Commencement:	1968.
5.	Estimated Year of Completion:	Original 1973, subject to annual revision.
6.	Key Words not in Title:	Choristoneura fumiferana; Picea glauca; sample; defoliation; clearcutting; regeneration.
7.	Discipline:	Entomology.
8.	Project:	Reduction of losses from defoliating insects.
9.	Estab. Study No. NOR-023.	Serv. Study No.NOR-023.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 16 Other: 25
12.	Man-months utilized in fiscal year under review:	Prof.: 4 Other: 3
13.	Man-month requirements in next fiscal year:	Prof.: 6 Other: 7
14.	Location of Work:	High Level, Alberta; Ft. Smith, N.W.T.
15.	Background Statement:	
	a - Study proposed by:	Alberta Forest Service, Mackenzie Forest Service, Canadian Forestry Service.

b - Objectives: 1. Determine the distribution and impact of budworm in the commercial forests during the current year, and provide Alberta Forest Service, Mackenzie Forest Service and northern National Parks personnel with a seasonal assessment of the budworm, and advise on its likely hazard. Other staff members will assist in this appraisal.

2. Determine the biology of the insect with emphasis on selected parts of the life history and development of techniques for measurement of budworm populations.

3. Determine the formulation of control measures to be implemented as the need arises.

c - Need for study: The spruce budworm was first reported along the Mackenzie River in 1947. Since then it has been found in most stands of white spruce in the Mackenzie, Liard, Lower Hay and Slave River drainages of the Territories, and along the Athabasca, Peace, Wabasca and Chinchaga Rivers of northern Alberta. These areas support most of the merchantable mature and overmature white spruce timber in northern Alberta and the Territories. Logging companies are currently operating in several stands in the Footner Lake and Athabasca Forest Management Units in Alberta, in Wood Buffalo National Park and in the Mackenzie Forest of the Territories, where an annual harvest in excess of 70 MM f.b.m. is removed. Obvious spruce budworm damage currently exists throughout many of these stands in the form of defoliation, tree mortality and dead tops. In one such area in northern Alberta a realignment of the cutting program has occurred following recommendations of the Canadian Forestry Service to give priority for removal of high-risk stands, and thereby reduce overall losses. In another area the pattern of clearcut has been designed to decrease the hazard of budworm build-up in residual trees and to increase the salvage of budworm-damaged trees. As a further consequence to the budworm damage, salvage operations are costly and fire and budworm hazard reduction costs are increased. Thus there is an annual need to appraise timber berth areas for spruce budworm abundance and its effects upon the host, and to provide management with guidelines to reduce losses where possible.

With removal of the timber the problem of budworm damage to spruce regeneration becomes important. Ground surveys have shown that spruce regeneration and advanced growth are generally lacking in many of the mature and overmature stands, and are severely damaged by the budworm in other stands. Little is known of the potential risks to young stands adjacent to or removed from mature timber, nor of the relative susceptibility of different stand types and age classes. Information is also lacking on the behaviour and survival of budworm populations in spruce regeneration.

Good cone crops of white spruce occur every 4-6 years, and budworm larvae are known to feed on the staminate flowers as well as in the developing cone. The potential destruction of cone crops by the budworm is unknown as is the relationship between good cone years and budworm population density and survival.

d - Co-operating agencies: Co-operating agencies include the Alberta Forest Service, Mackenzie Forest Service, Canadian National Parks and various lumber companies. The type of co-operation has involved planning and executing of aerial and ground surveys of the budworm, in establishment of experimental areas and in the establishment and maintenance of a field station at Footner Lake in northern Alberta.

16. Accomplishments to beginning of fiscal year under review:

Budworm infested stands along the Peace, Chinchaga, Wabasca, and Slave rivers were located and outbreaks were mapped during 1968, 1969 and 1970, from aircraft. Other infested stands were located from the ground. Collections of 360 branch samples were made from 30 non-infested trees and the following characteristics were measured on each: shoot length, numbers of terminal buds, branch surface area, number of needles and dry needle weights. Patterns of these characteristics within tree crowns were determined and are being used in the development of budworm sampling techniques. Other branches from budworm defoliated trees were examined similarly. Radial increment patterns were determined for all sampled trees.

Semi-permanent field plots were established for budworm population measurements, and to obtain information on the defoliation pattern within trees and between trees within large stands and within residual leave strips of uncut timber.

Collections of the budworm life stages were made throughout 1969; from these data the number, size range and duration of larval instars were determined. Phenological measurements of the host and temperatures were made to relate with larval development. Other collections of pupae established sex-ratios and size distributions of the sexes. Adults reared from pupae provided several additional criteria useful for characterizing populations.

Field trapping of male moths with two types of 'female-baited' traps provided relative population estimates, information on the duration of the adult stage; male flight activity and the choice of best trap design.

Studies were made toward development of a sampling plan for the egg stage. Limited sampling and field observations were also made on 2nd-3rd instar larvae. These

data have helped to determine which stages of the life cycle can be feasibly sampled for population estimates.

Preliminary work was done toward relating budworm population density to degree of defoliation, and in estimating percentage defoliation of current shoot growth.

Four major insect parasites of late instar larvae and pupae, and 23 potential bird predator species have been identified.

17. Goals set for fiscal year under review:

(1) Aerial and ground surveys of commercial forests in northern Alberta and N.W.T. will be made and a report summarizing the current budworm distribution, impact and hazard will be distributed to forest management agencies.

(2) Test and evaluate two methods for sampling spruce budworms.

(3) Describe the life history of the budworm, and how its life stages relate to the seasonal phenological development of the host.

(4) Determine the distribution and behavior of late-instar larvae within foliage of the host tree for selection of sampling universe and sample units.

(5) Test methods of collecting, preserving and measuring foliage and budworm material.

(6) Complete arrangements for planting of 2,000 white spruce seedlings.

(7) Undertake preliminary work toward relating years of budworm feeding to tree-top killing and tree mortality.

(8) Prepare a paper for publication jointly with L. Safranyik and B. Chow on the topic:
"The evaluation of the sine wave function for heat-unit accumulations under Alberta conditions".

18. Accomplishments during fiscal year under review:

Under item 17 above, (1), (3) and (6) completed above and described in a report which follows. No studies were attempted with late-instar larvae because of low field populations and the critical period coincided with "open-house" of Northern Forest Research Laboratory. Pheromone testing was successfully applied for male population attraction (2), and summarized in report below. (3) summarized and abstracted in 1971 proceedings of Entomological Society of Alberta. Shortage of field funds and time did not allow for progress on (5), and (7). About 1-man-month technical help supplied toward completion of graphs for (8).

1. Cerezke, H.F. 1971. 1971 studies of the spruce budworm in northern Alberta. Internal Report NOR-8, 17 pp.

2. Cerezke, H.F. 1971. Life cycle development of the spruce budworm (Choristoneura fumiferana) in northern Alberta. (Two tables, 5 figs). Presented at 19th Annual Meeting of Ent. Soc. of Alberta.
3. Cerezke, H.F., R. Dunbrock and R. Gordey. 1971. Bird species in a spruce forest infested by the spruce budworm in northern Alberta. Typed spp. To be submitted for local natural history publication.

19. Goals for next fiscal year: Aerial and ground surveys of commercial forests in northern Alberta and Northwest Territories will be made and a report summarizing current budworm distribution, impact and hazard will be prepared for distribution to management agencies (objectives 1, 3). Test two methods of sampling spruce budworm populations, one for late-instar larvae (by branch sampling), the other for adult male moths using traps baited with synthetic pheromone supplied from the Great Lakes Forest Research Centre (objective 2). Estimates of current defoliation will be made to relate to late-larval instar and adult abundance (objectives 1,2). Determine the distribution of late-instar larvae within foliage of host trees (objective 2). Re-examine survival of spruce seedlings planted in 1971 (objectives 1,3). Work toward completing the following paper jointly with L. Safranyik and B. Chow on the topic:
"The evaluation of the sine wave function for heat-unit accumulations under Alberta conditions".

20. Signature:

H.F. Cerezke _____ March, 1972.

H.F. Cerezke,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March 1972.
2.	Title:	Biology and control of Warren's collar weevil.
3.	Investigator:	H.F. Cerezke.
4.	Year of Commencement:	1960.
5.	Estimated Year of Completion:	Original 1968. Revision I 1980.
6.	Key Words not in Title:	Hylobius warreni, Pinus contorta var. latifolia, regeneration, growth reduction, stand treatments, B 19, sampling.
7.	Discipline:	Entomology.
8.	Project:	Reduction of losses from root-inhabiting insects.
9.	Estab. Study No. NOR 024.	Service Study No. NOR 024.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof. 81 Other: 64
12.	Man-months utilized in fiscal year under review:	Prof.: 1 Other: 3
13.	Man-month requirements in next fiscal year:	Prof.: 2 Other: 0
	(Estimates in 11, 12 and 13 exclude time spent by survey collectors and special surveys conducted by 'Damage Appraisal' group.)	
14.	Location of Work:	Alberta Foothills, Edmonton Laboratory.

a - Study proposed by: This study was proposed by Canadian Forestry Service, in response to requests of industry. It entails damage impact studies to lodgepole pine and studies of the behaviour of the weevil within stands subjected to various treatments.

b - Objectives: The overall objective is to obtain information necessary for implementing pilot studies to test control methods, and thereby make concrete recommendations for weevil control in problem areas. Specific objectives are as follows:

1. Establish the time of initial invasion and subsequent spread and damage patterns of the weevil in young pine stands subjected to thinning, in newly stocked areas following clearcutting with and without scarification treatments, and in stands having fertilizer treatment.

2. Determine experimentally the critical level of partial girdling necessary to cause tree death, and to establish a relationship between degree of girdling and amount of growth loss.

c - Need for study: Past studies of Warren's collar weevil have shown it to be present in pine and spruce stands throughout the Boreal Forest Region of Canada; white spruce and jack pine are its major hosts in Manitoba and Saskatchewan while lodgepole pine is the major host in Alberta. Larvae of this insect feed in the sub-cortical tissue in the root-collar zone of healthy trees, causing partial or complete girdling, open wounds and resinosis. Trees may be killed by girdling of the main stem and roots, suffer growth losses from partial girdling and repeated attacks, or the wounds may serve as points of entry for root and stem diseases.

Investigations in Alberta have been conducted in several even-aged lodgepole pine stands throughout the foothills area; the important findings of these studies are summarized as follows:

Populations of the weevil occur throughout the Lower and most of the Upper Foothills Sections (defined by Rowe, 1959). These Sections contain most of the prime pine pulp-growing stands in the province. Tree mortality due to larval feeding is usually less than 5% and occurs mostly in stands less than 30 years old; trees older than 30 years appear more resistant. Trees most frequently killed occur in the dominant and co-dominant classes.

Natural stands are invaded at age 6-10 years and attacks continue throughout stand development.

Damage incidence normally increases directly with stand age, reaching a maximum near 60 years. At this age, 90-100% of trees have wounds of varying intensities so that growth losses radially and vertically on the stem can be expected on a large portion of the trees and at intervals throughout the growth of the stand, depending upon the frequency and intensity or re-attacks. For example, on 20-year-old trees with single attacks of 50% girdling of the root-collar circumference, there was an av. 17.2% reduction in radial increment and an av. 11.5% reduction in terminal shoot length during a two-year period after attack. Further work is now necessary to determine what losses occur at lower and higher percentages of girdling and in different stand age classes. The proportion of trees within stands having 50%+ girdling of the root collar varies widely but may exceed 10% in stands supporting high weevil populations.

The pattern of weevil attack within stands is influenced by tree diameter, tree age, stand density and depth of duff material at tree bases. Therefore, these stand variables should be taken into account for silvicultural control or when any manipulation of the stand is undertaken. Tree diameter was the single most important variable affecting weevil abundance. These results indicate that greater emphasis should be placed upon studies of the weevil in relation to clearcutting, scarification, planting, fertilization and especially thinning since this treatment is necessary in many of the over-stocked stands in the Alberta foothills.

d - Co-operating Agencies: The co-operating agencies include forest insect and disease survey and liaison and management disciplines within the department, and also Alberta Forest Service and Northwestern Pulp and Power. All are co-operating mostly in an execution capacity.

16. Accomplishments to beginning of fiscal year under review:

Two 1/5-acre plots thinned in 1967 were re-examined for weevil populations and damage in 1969 and in 1971. After two years, there was a decline in weevil abundance, a decrease in the percentage of trees with current attacks and an increase in the percentage of trees with old attacks. It was suggested that thinning resulted in an initial concentration of the weevil on the residual trees since the percentage of trees with old and current attacks was still considerably higher than in control plots. Tree mortality was less than 1% and the percentages of trees with 50%+ girdling of the root collar circumference were 1.6 and 5.0 for the two plots. The results of this study will partly satisfy Objective 1 but the long term effects of the weevil are still unknown.

Four series of mil-acre plots established in 1963 on sites which were clearcut and scarified during

1958-60 could not be re-examined in 1969 due to shortage of funds, assistance and temporary inaccessibility. Observations in the plots had been made in 1963, 1965 and 1967 for evidence of adult weevil feeding, larval damage, seedling heights, species and stocking/mil-acre. No evidence of the weevil had been found at the time of the last check.

An experiment was established in 20-25-year-old pine to determine the critical level of partial girdling necessary to cause tree death, and to establish a relationship between degree of girdling and amount of growth loss. The trees were partially girdled to simulate larval feeding and results of this study will be obtained at the end of the 3rd (1971) growing season. These results will contribute toward solving Objective 2.

17. Goals set for fiscal year under review:

The experiment on partially girdled trees will be terminated in late August 1971 and the data will be gathered for analysis. The two 1/5-acre thinned plots will be re-examined, and if time is available, all other mil-acre plots in pine regeneration will be re-examined. No new plot establishments are anticipated in 1971-72. Time will be spent on completing 3 papers, 1, 2 and 3 under item 19.

18. Accomplishments during fiscal year under review:

Thinning experiment in young pine: Since 1969 a 4-fold increase in weevil abundance has occurred on thinned trees compared to a 1.3-fold increas on control trees. A high proportion of young larvae and new attacks in 1971 suggest a high survival of eggs during last June and July. At present 19.8% of all thinned trees have old weevil damage of which the average girdling per tree of the root-collar circumference is 33.2%. On the control trees 12.6% have old damage of which the average girdling per tree is 43.6%. Thus the accumulated damage effects in both control and thinned plots need to be followed for several years, but some information is now at hand to satisfy Objective 1.

Girdling experiment in young pine: All 58 experimental trees were dug up and pertinent measurements and samples brought to the laboratory for analysis. Annual radial and vertical growth losses during the 3-year period were quantified on the main stem, leader and main lateral roots, and these were related to different percentages (ranging from 0-90%) of girdling of the root-collar circumference. The results roughly simulate the effects of weevil damage in natural stands and provide a basis for estimating actual losses, thus satisfying Objective 2.

Paper Published:

Cerezke, H.F. 1972. "Effects of weevil feeding on resin duct density and radial increment in lodgepole pine". IN press. Can. J. For. Res.

Because of heavy commitments on projects NOR 023 and NOR 025 no progress

could be made on papers 1, 2 and 3 under item 19.

19. Goals for next fiscal year: No field studies are planned in 1972 but time available will be devoted toward completing the following papers.

    1. "Effects of clearcutting on the survival of the weevil. Hylobius warreni Wood, in lodgepole pine stands in Alberta". Proposed Journal publication.

    2. "The spacial and temporal patterns of distribution of the weevil, Hylobius warreni Wood, in lodgepole pine stands in Alberta". Proposed Journal publication.

    3. "Behaviour patterns of Hylobius warreni Wood in relation to mating, egg-laying, feeding, dispersion and daily and seasonal activity. Proposed Journal publication.

    4. "Effects of partial girdling of the root-collar on growth impact of stem, leader and lateral roots of lodgepole pine, with special application to damage by the weevil, Hylobius warreni". Proposed Journal publication.

20. Signature:

H.F. Cerezke, March 1972.
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Biology, impact and control of woodborers.

3. Investigator: H. Cerezke.

4. Year of Commencement: Commenced in 1967 by A.G. Raske and T. Szabo; transferred to H. Cerezke 1970.

5. Estimated Year of Completion: Continuous.

6. Key Words not in Title: Cerambycidae, Monochamus, Tetropium, white spruce, pine, sampling.

7. Discipline: Entomology.

8. Project: Increased productivity of wood fibre, stand protection.

9. Estab. Study No. NOR 025. Service Study No. NOR 025.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 24 Other: 24

12. Man-months utilized in fiscal year under review: Prof.: 4 Other: 6

13. Man-month requirements in next fiscal year: Prof.: 2 Other: 2

14. Location of Work: Throughout region.

15. Background Statement:

a - Study proposed by: Regional forest services, Canadian Forest Service.

b - Objectives:

(1) Develop new, or improve existing sampling systems for estimating

numbers of woodborer insects in logs of different dimension, species and for fire-killed, blowdown and freshly cut trees decked and undecked;

(2) develop new, or improve existing sampling systems for estimating amount of degrade of timber and finished lumber caused by woodborers of different population densities as the need arises;

(3) develop and test different methods for control of woodborers in decked and undecked logs, infested lumber and on standing trees newly fire-killed as the need arises.

c - Need for study: In the past few years, numerous requests have been received from industry and Provincial forest services for information on damage impact and methods of control of woodborers. These requests tend to fall into 3 major areas of concern, relating to the salvage and disposal of cut timber.

The first area of concern is in standing fire-injured and blowdown trees which are subsequently attacked by a variety of woodborer species. Cutting operations usually follow after fires and blowdown in order to salvage the timber. If improperly timed, additional loss and degrade can result from "worm holes" which may extend 3 or more inches into the wood. This is the case for Monochamus spp. which are the most economically important of the woodborers in the Prairie provinces, Yukon and Northwest Territories.

A second area of concern is the risk of degrade from woodborer holes in freshly cut logs in mill yards, and in logs left lying in the forest. Studies in Alberta have shown that, on a per-log-basis, maximum monetary loss is about 30%, and that the losses are related directly to the number of woodborer holes per square foot of log surface (A.G. Raske and L. Safranyik, 1970). Thus, adequate population measuring techniques are necessary in order to relate population densities to the expected amount of degrade.

A third area of concern is in the finished product in which live insect material may remain in the wood after milling. Consequently, export lumber may be delayed or rejected, causing monetary losses or delays to the lumber company.

In order to provide answers to requests of industry and Provincial forest services on degrade and control aspects, studies are now required in testing and improving of woodborer population measuring techniques, for refining and testing techniques of estimating monetary losses and in developing and testing various control methods.

d - Co-operating Agencies: Include Provincial Forest Service, various lumber companies and Forest Products Laboratory, Vancouver, Alberta Forest Products Ass'n. and Mackenzie Forest Service, all of whom are assisting in the execution phase of studies.

16. Accomplishments to beginning of fiscal year under review:

Ecological and biological studies of the most economically important woodborer species in Alberta have been made, namely of Monochamus spp. and Tetropium spp. Other cerambycid and buprestid species have been studied to a limited extent, including woodborer-infested pine and spruce logs was made and identifications of these were completed.

A larval rearing program of woodborer species was undertaken with Dr. Gardiner at Sault Ste. Marie to establish species identity in the larval stages. Hybridization studies were conducted with crosses of Monochamus oregonensis and M. scutellatus to establish their taxonomic relationships. The identification of chromosome pairs was assisted by Dr. G. Lanier of this laboratory. Some of these data have been reported on.

Pine and spruce logs have been sampled in various parts of Alberta to establish densities of woodborers in decked and undecked pine and spruce logs, and in relation to position on log and position within decks. From these data a sequential sampling plan was developed for estimating the degree of Monochamus infestations. Infested pine logs have been sawn and the lumber product graded to establish a relationship between Monochamus damage intensity and percentage value-loss. Further refinements of this relationship and of the sampling technique are now required in addition to further testing on white spruce logs.

The effect of time of year of log felling was studied in relation to attack density of Monochamus. The main results were that logs cut in the fall and early winter were least attractive to Monochamus during the following summer, while logs felled during late winter, spring and early summer were most attractive. Preliminary tests of the chemical PDB (para-dichloro benzene) were made on small experimental log decks, but the testing has not been extended to large commercial decks. The preliminary results of these tests have been promising. However, further testing is necessary using both crystalline and liquid forms of PDB. Tests with PDB as a fumigant should be made on lumber piled for export and infested with live wood-boring insects.

17. Goals set for fiscal year under review:

The following reports and papers are planned for completion by Dr. A. Raske, except No. 5.

1. Wood borer control with plastic sheeting and fumigation with

Para-Dichloro Benzene in conifer logs. Jour. publication.
2. Distribution of Monochamus larvae and other wood borer larvae within pine logs. Jour. publication.
3. Review of biology and control of Monochamus and Tetropium; the economic wood borers in Alberta. Internal Report.
4. Effects of time-of-felling on density of Monochamus in pine and spruce logs. Information Report.
5. Mortality of Monochamus larvae in slash fires (By B.M.Dahl). Jour. publication.
6. Tetropium parvulum elevated to species rank based on morphological differences of larvae and adult, and difference in host preference between T. parvulum and T. cinnamopterum. Jour. publication.
7. Notes on the biology of Tetropium parvulum Casey. Jour. publication.
8. Taxonomic relationship between Monochamus scutellatus and M. oregonensis. Jour. publication.

Studies by H. Cerezke will include testing the sequential sampling plan on white spruce decked and scattered logs, taking into account sample size, log deck history and orientation of logs. The distribution of wood borer populations within white spruce log decks will be examined with respect to diameter and length of log, light penetration, cutting history and geographical location. Depth of penetration of wood borer larvae will be examined in relation to log diameter and thickness of sapwood and heartwood. Areas of fire-killed and fire-damaged timber will be examined to determine wood borer infestations in relation to geographical location, tree size, fire history and burning intensity. Information will be obtained on the interpretation of new 1970-71 lumber grading rules as they apply to "worm holes" and as a basis for estimating degrade of lumber due to borer damage.

18. Accomplishments during fiscal year under review:

Studies toward satisfying goals of Cerezke listed under item 17 were initiated except for those relating to fire-killed and fire-damaged timber. Ninety 4-ft-length logs acattered on the forest floor were examined externally for Monochamus attack patterns; 45 of these were dissected for internal damage patterns. Attack pattern was also examined on a spruce log deck from a sample of 240 ft^2 of log surface.

Although incomplete, the data show important differences in Monochamus development, survival, size of adults, attack density and damage characteristics along tree-length logs. For example the distribution of entrance holes around the log at the butt end showed one peak, whereas two peaks occurred elsewhere on the logs; density per square foot was highest at the top end of the log and there was a strong indication of log diameter influence. Log deck samples indicated higher populations on north aspect compared to south aspect. These results can improve sampling design on scattered and decked white spruce logs (Objectives 1 and 2) and have application for applying and interpreting control effects (Objective 3).

Information on wood borer damage and and potential losses was provided to three agencies.

First-drafts of papers 1 to 4 and 6 to 8 completed by A. Raske.

Dahl, B.M. 1971. Mortality of Monochamus larvae in slash fires. Bi-monthly Research Notes; 27(2):12.

19. Goals for next fiscal year: Papers 1 to 4 and 6 to 8 to be completed by A. Raske. No intensive field studies are planned in 1972 since some time will be required to complete the analyses of the 1971 log-sample data for incorporation into the existing sampling techniques to estimate Monochamus. Some time will be made available for investigating complaints by forest agencies on wood borer problems and in providing advisory services on control and damage impact losses.

20. Signatures:

H. F. Cerezke, March, 1972.
Investigator.

059

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre	Date Prepared: March 1972
2.	Title:	Larch sawfly ecosystem measurement
3.	Investigator(s):	W.G.H. Ives, J.A. Muldrew
4.	Year of Commencement:	1955
5.	Estimated Year of Completion:	Original: indefinite Revision I: 1972
6.	Key Words not in Title:	Insect population dynamics, life tables.
7.	Discipline:	Entomology
8.	Project:	Reduction of damage from defoliating insects.
9.	Estab. Study No. NOR 059	Service Study No. NOR 059
10.	Status at time of statement preparation.	Active
11.	Estimated total man-months utilized to date:	Prof.: 100 Other: 400.
12.	Man-months utilized in fiscal year under review:	Prof.: 3 Other: 18.
13.	Man-month requirements in next fiscal year:	Prof.: 1 Other: 3.
14.	Location of Work:	Edmonton, Alberta, Whiteshell Provincial Park, Pine Falls, Seddon's Corner, Manitoba.
15.	Background Statement:	
	a. Study proposed by:	Canadian Forestry Service
	b. Objectives:	1. To measure larch sawfly density in study plots.

2. To measure the density of parasites and predators attacking the larch sawfly.

3. To measure mortality attributable to various agents affecting the larch sawfly.

4. To monitor weather and water level fluctuations in the study plots.

5. To measure the amount of defoliation caused by the larch sawfly and the growth and survival of larch trees.

c. Need for study: The objectives of NOR 098 can only be attained through analyses of a comprehensive body of data on the larch sawfly and its environment. To attain this, the major elements of the ecosystem in which the larch sawfly occurs must be monitored.

d. Co-operating Agencies: Biometrics Research Services, Vertebrate Biology Section, Entomology Research Institute; Manitoba Departments of Natural Resources and Tourism and Recreation.

16. Accomplishments to beginning of fiscal year under review:

Sampling techniques for eggs, larvae, cocoons and adults of the larch sawfly were developed and standardized. Problems in measuring weather were solved by adapting available equipment for use in inaccessible areas without line power. Simple methods of measuring water table fluctuations and of estimating tree defoliation were developed. More data have been processed, placed on punch cards, and preliminary summaries and analyses completed.

17. Goals set for fiscal year under review:

1. Monitor larch sawfly populations and mortality factors, especially the parasite complex, in sufficient detail in three study plots to provide data for assessing the impact of O. benefactor, Mesochoru dimidiatus and the Bavarian strain of Mesoleius tenthredinis on population trends.

18. Accomplishments during fiscal year under review:

The required measurements were made and the data transferred to punched cards. Populations in the three study plots continued to decline. The remaining backlog of biological data has been transferred to punch cards.

19. Goals for next fiscal year:

1. To obtain emergency data for the 1971 generation on the three study plots.

2. To obtain cocoon population and mortality data for the 1972 generation on the same three study plots.
(Data for 1. and 2. above will be obtained from studies described in NOR 061)

20. Signature(s):

What about completion date of 1972

W.G.H. Ives
Investigator

J.A. Muldrew
Investigator

March, 1972

061

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Larch sawfly biological control.

3. Investigator: J.A. Muldrew.

4. Year of Commencement: 1950.

5. Estimated Year of Completion: 1975.

6. Key Words not in Title: Pristiphora erichsonii, Olesicampe benefactor, Mesoleius tenthredinis, Mesochorus dimidiatus, parasites, encapsulation, hyperparasites, Larix, Boreal Region "B".

7. Discipline: Entomology.

8. Project: Reduction of losses from defoliating insects.

9. Estab. Study No. NOR 061 Service Study No. NOR 061

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 260 Other: 284

12. Man-months utilized in fiscal year under review: Prof.: 7 Other: 2

13. Man-month requirements in next fiscal year: Prof.: 5 Other: 3

14. Location of Work: Headquarters - Edmonton.
Field work - Red Rock Lake Field Station, Rennie P.O.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: 1. To achieve control of the larch sawfly in North America.

2. To contribute to the population dynamics study of the larch sawfly and thereby to gain understanding of the role and relative importance of the various factors and processes that determine its abundance.

c - Need for study: Tamarack is the fastest growing conifer in the Boreal forest. If protection from the larch sawfly could be obtained there would undoubtedly be an increased use of tamarack for pulpwood, sawtimber, piling, poles, ties, veneer, etc., and its use in forest plantings would increase. Moreover, with sawfly control, Larix spp. would be used more frequently in park, boulevard and home-ground ornamental plantings.

d - Co-operating agencies: Canada Department of Agriculture; Research Institute, Belleville,and Entomology Research Institute, Ottawa (execution); Biometrics Research Services.

16. Accomplishments to beginning of fiscal year under review:

The death of Mesoleius tenthredinis eggs in the resistant larch sawfly strain was found to be due to their encapsulation by host blood cells. The spread of the resistant strain from Manitoba almost to the limits of tamarack was monitored. A strain of M. tenthredinis from Bavaria was found to have a greater ability to avoid encapsulation in the resistant sawfly than had the "native" strain. Hybridization experiments showed this ability was transmitted as a dominant factor. Releases of this strain in Manitoba have resulted in lower levels of encapsulation and a progressively increasing percentage parasitism by M. tenthredinis. From 1961 to 1964, six species of parasites from overseas were released. One of these, Olesicampe benefactor, is well established. Parasites reared from hosts collected in Manitoba have been successfully relocated in Saskatchewan, New Brunswick, Nova Scotia and Maine. Where first released, parasitism reached a high level within three to four years and has remained high. Host densities have progressively decreased and life table data indicate that O. benefactor has played a key role in causing this. The parasite is dispersing well. Studies were completed on differentiating the smaller hosts parasitized by O. benefactor from the larger normal hosts. The hyperparasite Mesochorus dimidiatus, which attacks O. benefactor in Europe, was recovered from three release points in Manitoba. Studies in co-operation with the Entomology Research Institute, Ottawa, revealed that the hyperparasite had a holarctic distribution before O. benefactor was released in America.

17. Goals set for fiscal year under review:

This was the final year of intensive plot studies.

(a) A combined release of O. benefactor and M. dimidiatus (approximately equal numbers of each) in the Agassiz life table plot to determine if the former can survive

and increase in spite of the detriment of the latter when each starts "on an equal footing".

(b) A collection of approximately 40,000 larch sawfly larvae from the O. benefactor release areas to be reared at the Whiteshell Field Station to provide material for a "demonstration biological control release" in 1972 probably along the Trans-Canada Hwy. east of McMunn, Manitoba.

(c) Completion of analysis of the study involving marking of larch sawflies with vital stains.

(d) Completion of analysis of the O. benefactor fecundity study.

(e) Obtaining additional data on the relative food-consumption and damage potential of hosts parasitized by O. benefactor versus non-parasitized hosts.

(f) Continuation of impact and dispersal studies for both O. benefactor and M. dimidiatus.

(g) Monitoring sawfly populations at and around the release points for Bavarian M. tenthredinis.

(h) Monitoring of collections of larch sawfly received from the Maritimes (on a reduced scale) and Pennsylvania with respect to resistance to M. tenthredinis.

(i) To co-operate with W.J. Turnock in the preparation of a paper tentatively entitled "History and etiology of two major continental outbreaks of the larch sawfly in North America.

(j) Co-operate with H.M. Kulman in releasing O. benefactor in Minnesota.

18. Accomplishments during fiscal year under review:

Releases of Olesicampe benefactor and Mesochorus dimidiatus were made on seven occasions over the period June 30 to July 21. Total numbers released were O. benefactor: 245♂♂ and 262♀♀ and M. dimidiatus: 118♂♂ and 253♀♀ . The Bavarian strain of Mesoleius tenthredinis (98♂♂ and 170♀♀) was again released near St. Labre, Manitoba.

Mass collections of larch sawfly larvae were made, mainly near Lac du Bonnet, Manitoba, to obtain O. benefactor material for release in 1972. Over 37,000 larvae were collected and reared and parasitism, based on cocoon size, was approximately 56%. Help was provided to associates of H.M. Kulman enabling them to collect over 20,000 sawfly larvae to provide O. benefactor for release in Minnesota in 1972.

Studies on the hyperparasite M. dimidiatus revealed that it attacked mainly second-instar larch sawfly larvae, randomly, searching for O. benefactor larvae in which to oviposit. Information on egg development, time of eclosion and larval development of this hyperparasite was also obtained.

Monitoring of the Bavarian Mesoleius tenthredinis release at the Rennie plot showed that this situation was greatly influenced by the remarkable increase in O. benefactor parasitism here from 2% in 1970 to 85% in 1971. Total parasitism by M. tenthredinis as indicated by dissection of a small sample decreased from 58% to 43%. In cases of multiple parasitism with O. benefactor, M. tenthredinis was successful only about half the time. Host populations decreased from 403,800 cocoons per acre to 33,500.

At the Pine Falls plot where O. benefactor parasitism dropped from 91% to 85%, host populations decreased from 35,300 to 4,350 cocoons per acre. Larch sawfly populations at the Agassiz plot increased from 206,300 crowns per acre in 1970 to 432,300 in 1971 but here M. tenthredinis remained at a low level and O. benefactor showed a high rate of attack for the first time (4% in 1970 and 69% in 1971).

Reports on the current status of the dispersal and impact of the introduced O. benefactor and the history and etiology of two major continental outbreaks of the larch sawfly are currently in preparation.

19. Goals for next fiscal year: 1. As O. benefactor is rapidly invading the area selected as a possible site for a demonstration release, as mentioned above, the material collected in 1971 will be released near Pibroch, Wembley and Cold Lake in Alberta, and Hay River in N.W.T. At these locations cocoons typically parasitized by O. benefactor, as determined by size, will be placed out in screen cages in mid-May -- approximately 4,000 cocoons per location.

2. Mass collections of larch sawfly larvae in Manitoba to provide O. benefactor material for release in Alberta and Saskatchewan in 1973.

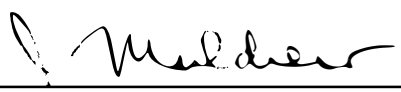
3. Continuation of impact and dispersal studies for O. benefactor, M. dimidiatus and the Bavarian strain of M. tenthredinis, as time permits.

4. Studies on the increase in percentage parasitism by O. benefactor as larch sawfly larval development proceeds to determine whether this is due to a greater rate of mortality amongst the "normal" sized host larvae and whether this is related to bird predation, as time permits.

5. Studies to determine the fecundities of O. benefactor and M. dimidiatus, as time permits.

6. Monitoring the Agassiz plot releases of 1971 and the St. Labre releases of 1970 and 1971.

20. Signature:



March, 1972.

J.A. Muldrew,
Investigator.

088

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment:	Northern Forest Research Centre	Date Prepared: March 1972
2.	Title:		Dispersal of Oleisicampe benefactor Hinz.
3.	Investigators:		J.A. Muldrew and W.G.H. Ives
4.	Year of Commencement:		1965
5.	Estimated Year of Completion:		Original Revision I, 1975. Revision II, 1972.
6.	Key Words not in Title:		Larch sawfly, Pristiphora erichsonii, tamarack, Larix laricina, Mesochorus dimidiatus Holmgren.
7.	Discipline:		Forest Insect and Disease Survey.
8.	Project:		Reduction of damage from defoliating insects.
9.	Estab. Study No. NOR 088		Service Study NO. NOR 088
10.	Status at time of statement preparation:		Active
11.	Estimated total man-months utilized to date:		Prof.: 1 Other: 2
12.	Man-months utilized in fiscal year under review:		Prof.: 2 Other: 1
13.	Man-month requirements in next fiscal year:		Prof.: 2 Other: 2.5
14.	Location of work:		Northwestern Ontario as far as the lakehead.

15. Background Statement:

a. Study proposed by: Canadian Forestry Service.

b. Objectives: 1. To monitor the spread of Olesicampe benefactor Hinz from release points in Manitoba and Saskatchewan.

2. To monitor the incidence of parasitism of O. benefactor by the hyperparasite Masochorus dimidiatus Holmgren.

c. Need for Study: The larch sawfly is a serious defoliator of larch throughout central Canada. Outbreaks at the turn of the present century have been credited with killing most of the merchantable tamarack in this area. An earlier attempt at biological control, involving Mesoleius tenthredinis (Morley), was successful at first, but became ineffectual when the host developed resistance to the parasite by means of encapsulating the parasite's eggs.

Olesicampe benefactor Hinz, an Ichneumonid parasite of the larch sawfly, was introduced from Europe and first released near Pine Falls in 1961. Subsequent releases were made near Riverton in 1962 and 1963, Crutwell in 1964, 1965 and 1966, Hodgson in 1967 and The Pas in 1968. The parasite is known to be successfully established at all of these locations, thus providing a unique opportunity to study the dispersal of a parasite in a new environment.

The initial dispersal from Pine Falls, Riverton and Hodgson was under the surveillance of the Larch Sawfly Problem Area Group (Muldrew 1967). The Forest Insect and Disease Survey has been monitoring the spread at Crutwell since the time of release, and has been monitoring the spread from Pine Falls and Riverton since 1967. The high level of Lake Winnipeg in 1966 practically eliminated the larch sawfly at the Riverton release point. Consequently, very little information on long-range dispersal is available for this area. So far, most of the dispersal data have been collected for the Pine Falls release area.

Reference: Muldrew, J.A. 1967. Biology and initial dispersal of Olesicampe (Holocremnus) sp. nr. nematorum (Hymenoptera: Ichneumonidae), a parasite of the larch sawfly recently established in Manitoba. Can. Ent. 99: 312-321.

d. Cooperating agencies: The Entomology Research Institute provides identification of the parasites when needed.

16. Accomplishments to beginning of fiscal year under review:

In 1967, O. benefactor was recovered 1.7 miles north of the Pine Falls release point and 1.8 miles south. Corresponding figures for 1968 are 7.2 and 8.3 miles. In 1969 it was recovered about 45 miles from the release point and in 1970 had reached the Rennie life table plot. Additional dispersal data are not available for 1970, but the available data indicate a rapidly accelerating rate of spread.

17. Goals set for fiscal year under review:

1. To continue to monitor the spread of O. benefactor in as much detail as possible.

2. To monitor the spread and/or build-up of the hyperparasite M. dimidiatus in as much detail as possible.

18. Accomplishments during fiscal year under review:

Extensive collections of sawfly from northwestern Ontario showed a rapid rate of spread and build-up. The known distribution now covers an egg-shaped area extending from Lake Winnipeg to Fort Frances and Ignace in Ontario, a maximum distance of about 225 miles from the point of release. Near the edge of the known distribution, the rates of parasitism are quite low but the percentages increase rapidly when one moves in from the perimeter. The rates of parasitism averaged 90% for nearly half of the total area in 1971, in areas where the 1970 parasitism had been less than 10%. There has therefore been a very spectacular population explosion of the parasite accompanied by long range dispersal.

19. Goals for next fiscal year:

1. To monitor the spread of O. benefactor in northwestern Ontario through NOR 061 and co-operators in Ontario.

This study will be terminated in 1972. A continuing monitor of O. benefactor will be carried on within NOR 059.

20. Signatures:

J.A. Muldrew
Investigator

W.G.H. Ives
Investigator

March 1972

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Analyses and synthesis of Forest Insect and Disease Survey historical data and information.
3.	Investigator:	W.G.H. Ives.
4.	Year of Commencement:	1969.
5.	Estimated Year of Completion:	Original indefinite. Revision I, 1974.
6.	Key Words not in Title:	Population trends, computer mapping data retrieval, insects and environment.
7.	Discipline:	Forest Insect and Disease Survey.
8.	Project: 8.	Reduction of damage from defoliating insects.
9.	Estab. Study No. NOR 089.	Service Study No. NOR 089.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 9 Other: 24
12.	Man-months utilized in fiscal year under review:	Prof.: 6 Other: 12
13.	Man-month requirements in next fiscal year:	Prof. 6 Other: 12
14.	Location of Work:	Edmonton, Alta.
15.	Background Statement:	
	a - Study proposed by:	Canadian Forestry Service.
	b - Objectives:	To determine if the large amount of data on insect infestations collected by the Forest Insect and

Disease Survey during the past years can be utilized to help explain fluctuations in populations of forest insects, and thus lead to a better understanding of the factors contributing to insect outbreaks.

c - Need for study: Summaries prepared in the "Annual district ranger reports" contain a wealth of information on the incidence of the major forest insects throughout the region, as well as notes on some of the species of lesser economic importance. There is a large body of information on insects and diseases in files of the Survey. These data were on Remington Rand data cards and have now been transferred to magnetic tape. When the editing is complete (hopefully sometime in 1972) they should be available for various summaries and analyses.

Additional data on parasites are also available, but these required transferring to data sheets suitable for computer input, as they were recorded only on rearing sheets.

No thorough examination of the data for the Prairie Region has been undertaken. Only a thorough, comprehensive examination of the information compiled to date will reveal whether or not it is useful in furthering our understanding of fluctuations in forest insect populations. This project will undertake such an examination.

d - Co-operating agencies: Biometrics and Computer Science Branch: provide programming services, key-punching and eventually technical advice on appropriate analystical techniques.

16. Accomplishments to beginning of fiscal year under review:

Annual infestation histories for 11 of the most common forest insects in Manitoba and Saskatchewan have been mapped. The information has been transferred to data sheets and recorded on I.B.M. data cards.

Parasite rearing or dissecting records for 15 of the more common forest insects have been transferred to specially designed forms suitable for computer input, the data key-punched and edited.

The procedure for summarizing weather records contained in the "Monthly Record" has been decided upon, all of the necessary forms devised and printed, and most of the temperature data have been transferred to these forms, key-punched and edited.

17. Goals for fiscal year under review: a. To complete editing of historical file.

b. Devise appropriate methods for summarizing data on historic file in format compatible with weather and parasite summaries.

c. Begin preliminary analyses to study the relationships between insect abundance and environment factors.

18. Accomplishments during fiscal year under review:

Editing of historical file is well advanced, but may not be completed until 1972-73.

Examination of the relationships between the published records of forest tent caterpillar outbreaks and temperature records, expressed as heat units, shows that warm springs and cool winters favor the build-up of populations, while cool springs and sometimes warm winters accompany a good proportion of the population creashes. In addition, outbreaks appear to be triggered by favorable weather 2-4 years prior to the first widespread defoliation.

Compilations of insects and diseases collected in each of the western National Parks are nearing completion.

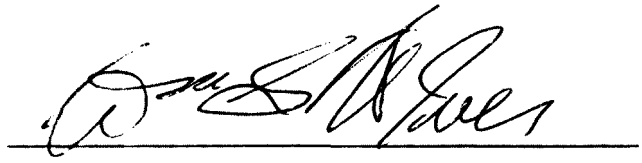
19. Goals for next fiscal year: a. To complete the examination of relationship between heat units and forest tent caterpillar outbreaks and to publish the results.

b. To complete the editing of the historical file.

c. To devise appropriate methods for summarizing data on the historic file in a format compatible with weather and parasite summaries.

d. To begin preliminary analyses of possible relationships between insect abundance and environmental factors.

20. Signature:



March, 1972.

W.G.H. Ives,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Development of survey sampling techniques.

3. Investigator: W.G.H. Ives.

4. Year of Commencement: 1968.

5. Estimated Year of Completion: Original indefinite.

6. Key Words not in Title: Larch aspen tortrix, Choristoneura conflictana, sequential sampling.

7. Discipline: Forest Insect and Disease Survey.

8. Project: 1 Detection of tree pest damage.

9. Estab. Study No. NOR 090. Service Study No. NOR 090.

10. Status at time of statement preparation: Temporarily in abeyance.

11. Estimated total man-months utilized to date: Prof.: 0.5 Other: 3.0

12. Man-months utilized in fiscal year under review: Prof.: 0 Other: 0

13. Man-month requirements in next fiscal year: Prof.: 0 Other: 0

14. Location of Work: Large aspen tortrix sampling was conducted in western Manitoba and in the Interlake Region. Other sampling might be conducted anywhere in the Region depending on the insect under consideration.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: To develop or modify survey sampling techniques for forest insects, as the opportunities arise, in order to improve the quality of the population estimates

obtained by the Forest Insect Survey. Specifically, to develop a sequential sampling system for the large aspen tortrix.

c - Need for study: The Forest Insect and Disease Survey collects samples for a large number of insect species, and consequently must use general sampling methods for most of its work. The two methods most commonly used are beating and hand-collecting. Beating is a very satisfactory method for collecting most defoliating insects, but it is difficult to make the sample quantitative, as the sampling unit is largely undefined. Hand-picking is entirely qualitative. There is therefore a need for more quantitative sampling methods, especially for the most important insects. However, the time required to conduct this sampling must be kept to a minimum, otherwise the technique is impractical for survey use.

Sequential sampling, because it requires a smaller number of sample units for the equivalent degree of accuracy, is much more suitable for survey purposes than is conventional sampling. Sequential sampling techniques have been developed for several forest insects and have proved invaluable. The populations are still rated into broad categories, usually light, medium or heavy, but these terms are defined within meaningful limits, based on experience for each particular insect. The very subjective element involved in rating infestations based on beating or hand-picking is therefore removed and greater uniformity of results is obtained.

The large aspen tortrix is characterized by a rapid build-up and decline of populations, but no sampling techniques for measuring these have been devised. Preliminary data were therefore collected in 1968 to test the feasibility of developing a sequential sampling technique that might be used in the prediction of outbreaks of this serious aspen defoliator.

d - Co-operating agencies: Possibly some input by Biometrics and Computer Science Branch.

16. Accomplishments to beginning of fiscal year under review:

1. The collections of egg masses made in 1968 yielded data that were encouraging. There were some sampling problems in heavily defoliated stands, as the oviposition sites were largely destroyed by feeding. The frequency distribution of numbers of egg-masses per leaf cluster appeared to follow the Poisson distribution.

2. Larval and egg mass samples were collected in 1969. The data have not yet been analyzed.

17. Goals set for fiscal year under review: Inactive.

18. Accomplishments during fiscal year under review: Nil.

19. Goals for next fiscal year: No field work planned as reductions in staff and funds have made this impractical at the present time. The development or improvement of techniques suitable for survey use is considered to be important, but has been deferred until funding, at least, is more adequate.

20. Signature:

March, 1972.

W.G.H. Ives,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre	Date Prepared: March 1972
2.	Title:	Natural Control of the Larch Sawfly
3.	Investigator(s):	W.G.H. Ives and J.A. Muldrew
4.	Year of Commencement:	1966
5.	Estimated Year of Completion:	Original: Indefinite Revision I. 1972 Revision II. 1976 Revision III. 1972
6.	Key Words not in Title:	Pristiphora erichsonii, larix, population dynamics, ecosystem modelling, biological control.
7.	Discipline:	Entomology
8.	Project: Reduction of damage from defoliating insects.	
9.	Estab. Study No.: NOR 098	Service Study No.: NOR 098
10.	Status at time of statement preparation:	Active
11.	Estimated total man-months utilized to date:	Prof.: 300. Other: 480.
12.	Man-months utilized in fiscal year under review:	Prof.: 4. Other: 6.
13.	Man-month requirements in next fiscal year:	Prof.: 4. Other: 6.
14.	Location of Work:	Whiteshell Provincial Park, Manitoba, and Edmonton, Alberta.

15. Background Statement:

a. Study proposed by: Canadian Forestry Service

b. Objectives: 1. To determine the causes for the continuing damage by the larch sawfly to larch growth throughout Canada.

2. To explore the ecological relationship between the insect pest and its environment.

3. To elucidate the population dynamics of the larch sawfly.

4. To expose possible methods of reducing the damage done by the larch sawfly.

5. To determine the effects of sawfly defoliation of host stands.

c. Need for study: Since 1940, defoliation by the larch sawfly has severely affected larch growth and survival throughout Canada. Because of these attacks, larger trees have died - younger trees have failed to produce normal growth. Unless methods of preventing larch sawfly attacks can be developed, large areas of land will continue to be unproductive and planting programs utilizing larch for fibre production or aesthetic purposes cannot be encouraged.

d. Co-operating Agencies: Biometrics Research Services.

16. Accomplishments to beginning of fiscal year under review:

The major effort within this project has been in planning and directing the implementation of projects designed to develop and test sampling techniques, to determine the relationships between variables in the system, and to apply existing analytical procedures to the population data. Comprehensive syntheses have been delayed because the sawfly populations were declining throughout most of the history of the project. A minor peak of populations occurred in the years 1965-1968 and the data now cover an almost complete gradation.

Sampling procedures have been thoroughly reviewed. Essential data for studying the impact of Olesicampe benefactor, Mesochorus dimidiatus and the Bavarian strain of Mesoleius tenthredinis can be collected with less staff than previously utilized by eliminating time-consuming or specialized sampling procedures. The first category has been dictated by cuts in student support, the latter by loss of key personnel.

Flow charts have been prepared outlining procedures to be followed for calculating the proportions falling into various categories for data collected on larvae at three periods in the life cycle: 1) feeding larvae; 2) falling larvae; and 3) larvae in cocoons. These data sources provide a comprehensive set of estimates of the various parameters and require approximately 300 different estimates to give all possible combinations of factors.

Data on adult populations have been coded and are ready to send to Biometrics Research Services for key punching.

17. Goals set for fiscal year under review:

1. To determine the relative importance of various mortality factors affecting the immature stages of the larch sawfly.

2. To begin preliminary analyses of larch sawfly population and mortality data to determine the relationships between population trends and the biological and physical components of the environment.

3. Particular attention will be given to determining the role of the three aforementioned parasites in population regulation.

18. Accomplishments during fiscal year under review:

Summaries of mortality and survival based on samples of feeding larvae, falling larvae and larvae in cocoons have been prepared. The large amount of data has not been examined yet, although preliminary examinations are underway. Once completed, they will provide a very comprehensive evaluation of most of the mortality occurring during the immature stages of the larch sawfly.

19. Goals for next fiscal year:

1. To determine the relative importance of various mortality factors affecting the immature stages of the larch sawfly.

2. To analyse larch sawfly population and mortality data to determine the relationships between population trends and the biological and physical components of the environment.

3. To evaluate the role of recently introduced parasites in population regulation.

This study will be terminated in 1972. Data and analysis will be carried out within NOR 059.

20. Signature(s):

W.G.H. Ives
Investigator

J.A. Muldrew
Investigator

March 1972

CONTROL FOR PESTS OF ORNAMENTAL AND SHADE TREE AND SHRUB PESTS

Insects and diseases cause injury and/or mortality to many ornamental and shade tree plantings. Resource managers in the park and recreation field and householders expect the Canadian Forestry Service to provide information on occurrence, damage assessments, and most important - controls. Numerous requests for assistance are received by the Canadian Forestry Service. Stringent regulations restricting the use of chemicals known to be effective against many of the pests require that substitute treatments be developed. The objectives of the project are to develop controls for the numerous ornamental and shade tree pests which are causing concern to resource managers and the public.

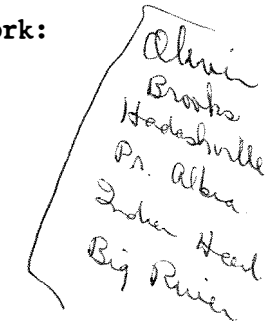
Goals for next year are to select candidate pests and candidate chemicals for treatment experiments. Establish dosages and effectiveness. Have successful chemicals registered for that treatment. Registration is a highly complicated procedure.

This is a new program and work is presently being carried out under a study proposal which is not included in the present report.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Nursery Tree Disease.
3.	Investigator:	L.W. Carlson.
4.	Year of Commencement:	1966.
5.	Estimated Year of Completion:	A continuing study.
6.	Key Words not in Title:	Fungicides and disease control, damping-off, Pythium, Rhizoctonia, Fusarium, Pinus, Picea Caragana, Populus, seedling mortality, storage and physiology, phytotoxicity, respiration, photosynthesis.
7.	Discipline:	Liaison and management.
8.	Project:	Improved forest tree nursery production (#11).
9.	Estab. Study No. MS 054.	Service Study No. NOR 062.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 52 Other: 106
12.	Man-months utilized in fiscal year under review:	Prof.: 8 Other: 12
13.	Man-month requirements in next fiscal year:	Prof.: 1.2 Other: 1.2
14.	Location of Work:	Northern Forest Research Centre, Edmonton, Alta., Alberta Provincial Nursery, Oliver; Alberta Horticulture Research Station, Brooks; Pineland Nursery, Hadashville, Manitoba; Saskatchewan DNR nurseries, Prince Albert and Big River; PFRA Tree Nursery, Indian Head, Saskatchewan.



15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: 1. To determine the more effective chemical treatments for disease control, particularly conifer damping-off.

2. To determine the nature of phytotoxicity caused by certain fungicides and to determine whether or not "safe" fungicides are detrimental to the physiology of tree seedlings.

3. To investigate new nursery tree disease problems and to determine their relative importance to nursery tree production.

c - Need for study: Successful afforestation programs for wood fibre, recreation, or aesthetic purposes depend on the supply of high quality nursery stock, whether they be container seedlings or nursery transplants. Nursery tree diseases account for much of the loss in quality. Damping-off in some conifer seedbeds is as high as 80%, but generally averages 30-35%. Although some standardization of disease control practices has resulted from studies by previous workers, new chemicals showing promise for better control need continuous evaluation. Evaluation of new and "old" chemicals has to be done in several phases. First the chemical has to prove its effectiveness in controlling the disease organism. Secondly its phytotoxic activity must be shown. Knowing the phytotoxic activity of a fungicide is as important as knowing its fungitoxicity if we are to obtain its most efficient use. Disease control is not restricted to the use of fungicides, but can be and is related to nursery cultural practices. To understand the relationship of seedling diseases to cultural practices the entire nursery system has to be studied. Despite apparent advances in nursery techniques, seedling production is still an art and not a science.

Results obtained from work in this project area will hopefully lead to a reduction in disease losses and an improvement of the nursery production techniques. At the present time it costs about 3 cents to produce a seedling of plantable size. The average annual production in the Prairies Region forest nurseries is approximately 8 million seedlings with nursery operational costs of about 240,000 dollars. Recently (1969) losses in jackpine outplantings in Manitoba were over 45% or 1 million seedlings. There is strong evidence that mortality was related to problems in the nursery system and they appear to be both cultural and pathological. Solving these problems and others like them could possibly prevent similar losses in the future.

d - Co-operating agencies: 1. PFRA Tree Nursery (Department of Regional Economic Expansion) - planning and execution.
2. Saskatchewan DNR - planning and execution.
3. Manitoba Department of Mines and Natural Resources - planning and execution.
4. Alberta Department of Agriculture - planning.
5. Alberta Department of Lands and Forests - planning and execution.

16. Accomplishments to beginning of fiscal year under review:

a. Laboratory bioassays for fungitoxicity of seed treatment chemicals against isolates of Pythium spp, Rhizoctonia spp. and Fusarium spp. (causal agents of conifer damping-off) have been run on 226 seed treatment chemicals. Of these 190 have exhibited a high degree of activity either against all three pathogens or against one or another of them. Laboratory seed germination tests for phytotoxicity have shown that jack pine, lodgepole pine and white spruce react differentially to many of the chemicals. Greenhouse damping-off control tests have included 111 chemicals, of which 63 have been selected for future testing.

b. Seed treatment experiments continue to give varying results under field conditions. No significant control of damping-off of conifers or caragana has been obtained.

c. Significant control of conifer damping-off has been attained by use of Mylone soil treatment with or without treated seed.

d. Respiration of poplar cuttings stored under varying conditions was affected by temperature of storage and interactions between storage temperature, clone, size of cutting and length of storage were evident. Significant differences in respiration were noted between clones, between temperatures, and between size of cutting.

e. Isolations from wilting caragana have led to the conclusion that a Rhizoctonia sp. is the causal agent of caragana seedling blight.

f. Mortality of first year outplantings of jack pine nursery stock was investigated. From the data collected the causes of the mortality are thought to be the use of 3-0 jack pine seedlings with a very poor shoot-root ratio and the poor storage ability of these seedlings.

17. Goals set for fiscal year under review:

a. To continue laboratory, greenhouse and field evaluation of fungicides for control of conifer damping-off.

b. To continue chemical control studies of caragana wilting and seed rot.

c. To study the effect of different types of storage and packing conditions on the survival of 3-0 conifer seedlings.

d. To study rates of photo-synthesis and respiration of different conifer seedlings to find the most useful species for chemical treatment studies.

e. To study the effectiveness of several fungicides in controlling poplar leaf spots and cankers in nursery cutting beds.

f. To monitor the conifer seedling production system at the Oliver nursery.

18. Accomplishments during fiscal year under review:

a. Laboratory and greenhouse testing of fungicides for control of conifer damping-off has been held in abeyance because of the time needed to test the promising fungicides under field conditions.

b. Seed treatment experiments on jack pine (at Prince Albert, Sask.), and logepole pine (at the Alberta Forest Nursery, Oliver) gave varying results again this year. As in previous years, survival of jack pine at the P.A. nursery was relatively poor. Significant increases in stand were shown by 13 of the 17 treatments. The better treatments were Polyram 80, Arasan 75, Captan 50, and Captan 75. Survival of lodgepole pine seedlings at the Oliver nursery was mediocre and as in previous years in this nursery no significant increases in stand were attained. Several of the chemicals used were highly phytotoxic. Survival of white spruce seedlings at both nurseries was poor. No significant increases in stand were observed for any of the treatments.

c. The review on storage and packing of conifer nursery stock appears under Study Review Statement of NOR 039.

d. The review on monitoring nursery productions appears under NOR 930.

e. Caragana seedling blight and seed rot were moderate this year as was shown by little differences

between percent survival and germination. There were no significant increases in total germination or survival.

f. A total of seven fungicides were tested at the Alberta Hortifulture Research Station, Brooks and at the PFRA Tree Nursery, Indian Head, Saskatchewan for control of poplar leaf spots (causal agents are Septoria spp. and Marssonina spp.). Effective control was obtained with 4-5 applications of either Benlate or NF-44. The other five chemicals tested also gave some degree of control.

Reports and Publications:

Carlson, L.W. and J. Belcher. 1971. Lodgepole pine damping-off. p. 126. In K.D. Hickey (Ed), Fungicide-Nematicide Tests, Results of 1970. American Phytopathological Society.

_____. 1971. Jack pine damping-off. p. 125. In K.D. Hickey (Ed), Fungicide-Nematicide Tests, Results of 1970. APS.

_____. 1971. Seed-treatment fungicides for control of conifer damping-off: Laboratory and greenhouse tests, 1968-1969. Can. Plant Dis. Surv. 50:63-73.

_____. 1972. Lodgepole and jack pine damping-off. .143. In E.I. Zehr (Ed), Fungicide-Nematicide Tests, Results of 1971. APS Vol. 27.

_____. 1972. White spruce damping-off. p 152-153. In E.I. Zehr (Ed), Fungicide-Nematicide Tests, Results of 1971. APS Vol. 27.

Carlson, L.W. and R. Esau. 1971. Caragana seedling blight and seed rot. p. 125. In K.D. Hickey (Ed), Fungicide-Nematicide Tests, Results of 1970. APS.

_____. 1972. Caragana seedling blight and seed rot. p. 140. In E.I. Zehr (Ed), Fungicide-Nematicide Tests, Results of 1971. APS Vol. 27.

Carlson, L.W. 1971. Seed treatment for conifer damping-off: A necessity. Forestry Report. 1(4):2.

19. Goals for next fiscal year: a. Study number NOR 040 will be closed out and any further related work will be under this study.

b. To study the effect of mylone soil treatment on the germination and survival of conifer seedlings at the Oliver nursery. (Co-op experiment with the Alberta Dept. of Agriculture).

c. To continue chemical control studies of poplar leaf spots with special emphasis on time of fungicide application.

d. To study the effect of fungicides in controlling storage molds.

Carlson, L.W. 1972. Fungicidal control of poplar leaf spots.

_____. 19__. Timing of fungicide applications for control of poplar leaf spots.

Carlson, L.W. and J. Belcher, 19__. Seasonal development of conifer damping-off.

Carlson, L.W. et al. Reports to Fungicide-Nematicide Tests, Results of 1972 (on soil treatments and storage molds).

20. Signature:

Lester W. Carlson March, 1972.

L.W. Carlson,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Forest tree rusts of western North America.
3.	Investigator:	Y. Hiratsuka.
4.	Year of Commencement:	Project A-232 (1961) and A-254 (1965) were combined and redesigned in 1968.
5.	Estimated Year of Completion:	Original, indefinite. Revision I, 1978. Revision II, 1973. ?
6.	Key Words not in Title:	Cronartium, Pucciniastrum, Peridermium, Melampsora, Chrysomyxa, cytology, morphology, taxonomy, Uredinales, inoculation experiment, pathogenicity.
7.	Discipline:	Pathology.
8.	Project:	Taxonomy, physiology and ecology of species and ecosystems under management.
9.	Estab. Study No. NOR 026.	Service Study No. NOR 026.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 69 Other: 56
12.	Man-months utilized in fiscal year under review:	Prof.: 10 Other: 11
13.	Man-month requirements in next fiscal year:	Prof.: 6 Other: 6
14.	Location of Work:	Edmonton (laboratory, greenhouse and mycological herbarium), Kananaskis Forest Experiment Station, western North American with particular emphasis on Northern Region (field).

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: General: To acquire a comprehensive knowledge of the forest tree rusts of western North America with particular emphasis on the Northern Region in terms of identity, host range, life history, distribution and pathogenicity.

Specific: To study aspects of cytology, taxonomy, life history and host-parasite relationship to conifer needle rusts, pine stem rusts, and populus-conifer rusts of the region and related species in the world.

c - Need for study: Rust fungi are known to attack vigorously growing plants rather than weakened ones because of their obligate parasitism. Damage caused by this group of fungi tend to be increased by intensive cultural practices as evidenced by such cases as, white pine blister rust in North America, poplar rusts in Europe, comandra blister rust of hard pines in southeastern North America, and wheat stem rusts and coffee rust in many parts of the world.

An estimate of the losses attributable to forest tree rusts in the region has not been obtained but significant growth loss and mortality of several major forest tree species, including lodgepole pine, jack pine, white spruce, black spruce, balsam fir and subalpine fir, have been suggested. In addition, several rust species endemic to the region have been recognized as serious pathogens in other areas where forestry practices are more intensive.

Our knowledge of western forest tree rusts has been inadequate to solve present and future problems which are and will be caused by this group of fungi and studies of this group of fungi on identity, life history, host range, cytology, morphology, distribution and pathogenicity are necessary.

d - Co-operating agencies: Forest Insect and Disease Survey organizations across Canada (for distribution data and samples). Mycological Herbarium, Plant Research Institute, Ottawa (consultations and specimen examination). Several foreign institutions (exchange of specimens). Scanning Electron Microscope Centre, Dept. of Entomology, University of Alberta (scanning electronmicroscope).

16. Accomplishments to beginning of fiscal year under review:

1. Comparative studies of the nuclear phenomena of the aeciospores and germinating aeciospores of P. harknessii and P. stalactiforme have been completed and the results have been published. Further nuclear studies have been carried out with the aeciospores of P. harknessii material from other regions. Similar studies with C. comptoniae and C. comandrae were completed and results have been published.

2. Studies on temperature and pH requirements for an orange and white spored aeciospore germination of P. harknessii and P. stalactiforme have been completed and published.

3. White spored P. stalactiforme (Cronartium coleosporioides f. album) was discovered in 1960 in a small area in Banff National Park and annual observations were commenced in 1963. Occurrence of this form and the results of the annual observations of canker growth and tree mortality up to 1965 were published in 1966. Annual surveys of the white spored form and the typical yellow spored form in the area were continued.

4. A study trip to northern Europe (Norway, Sweden, Netherlands, Scotland) was conducted during May and June of 1967 to study germ tube cytology of host alternating and pine-to-pine races of Cronartium flaccidum (Peridermium pini). About 300 fixed slides of germinating spores have been prepared and brought back for cytological studies. Significant differences between the two races were found and the results have been published.

5. Study of aeciospore germ tubes of pine gall rust from Quebec and New Brunswick showed clearly that they are Peridermium harknessii rather than Cronartium quercuum as previously reported. A note has been published.

6. Study of aeciospore germ tubes of Peridermium ephedrae from New Mexico indicated an unusual nuclear cycle and a note has been published.

7. Pucciniastrum vaccinii complex: Inoculation experiments and preliminary morphological comparisons have been completed.

8. Yellow-spored Peridermia on Abies: Morphological comparisons and literature survey have been completed and compilation of results for publication has been started.

9. Spruce needle rusts: Several inoculation experiments have been done. Inoculation of Pucciniastrum sparsum from Artostaphylos rubra to Picea glauca was successful. This presents the first record of this rust on Picea in North America and the results have been published.

10. Taxonomic revision of pine stem rusts, including the establishment of a new genus for autoecious species, is completed and results have been published.

11. Morphological study of forest tree rusts by scanning electron microscope is in progress and significant results have been obtained. Two papers on the subject have been published.

17. Goals set for fiscal year under review:

a. Continue comparative morphological studies of pine stem rusts and other forest tree rusts by scanning electron microscope and transmission electron microscope.

b. Start greenhouse inoculation experiments of pine stem rusts to study host penetration, disease establishment and symptom development. Special emphasis will be on the gall formation by Endocronartium harknessii.

c. Plan and start experiments to study interruption of water translocation by different pine stem rusts. Non-toxic dye (such as highly diluted acid fuchsin) will be used for the study. Histology of cankers will be studied in connection with the water translocation.

d. Continue life history and taxonomic studies of several spruce and fir needle rusts.

e. Continue survey of Cronartium coleosporioides f. album in Banff National Park.

f. Complete morphological and cytological study of Gymnosperangium gaeumannii ssp. albertensis.

18. Accomplishments during fiscal year under review:

a. Observation of forest tree rusts, spores and germ-tubes under a scanning electron microscope is in progress and significant results have been obtained. New "critical point drying" method has been used successfully to observe fragile material without shrinkage.

b. Greenhouse inoculation of western gall rust (Endocronartium harknessii) was successful and initial process of gall formation has been studied.

c. Morphological and cytological study of Gymnosperangium gaeumannii ssp. albertensis has been completed and a manuscript of a paper on the results has been completed.

d. An invited symposium paper entitled "Nuclear cycle and the terminology of spore states in Uredinales" was presented at the First International Mycological Congress, Exeter, England, and a manuscript for a publication based on the presentation and the subsequent discussions has bbeen completed.

Publications:

Hiratsuka, Y. Sorus development, spore morphology, and nuclear condition of Gymnosperangium gaeumannii ssp. albertensis. Mycologia (In press).

Hiratsuka, Y. 1971. Spore surface morphology of pine stem rusts of Canada observed under scanning electron microscope. Can. J. Bot. 49:371-372. 6 plates.

Hiratsuka, Y. The nuclear cycle and the terminology of spore states in Uredinales. Mycologia (In press).

Reports:

Hiratsuka, Y. Morphology and cytology of Gymnosperangium gaeumannii ssp. albertensis. A paper presented at the Mycological Society of America, Annual Meeting, University of Alberta, Edmonton, June 1971.

Hiratsuka, Y. Nuclear cycle and the terminology of spore states in Uredinates. Invited symposium paper presented at the First International Mycological Congress, University of Exeter, Devon, England, Sept. 1971.

Hiratsuka, Y. Morphology of forest tree rust spores observed under a scanning electron microscope. A display at the First International Mycological Congress, University of Exeter, Devon, England, Sept. 1971.

19. Goals for next fiscal year: a. Complete the proposed departmental publication entitled "Pine stem rusts of Canada" with J.M. Powell.

b. Continue detailed morphological comparison of spruce needle rusts with scanning electron microscope and other forest tree rusts.

c. Continue greenhouse inoculation experiments of pine stem rusts to study host penetration, disease establishment and sympton development.

d. Continue life history and taxonomic studies of several spruce and fir needle rusts.

e. Continue survey of Cronartium coleosporioides f. album in Banff National Park.

f. Complete two manuscripts on the taxonomy and nomenclature of endocyclic rust fungi.

g. Survey and study Cronartium ribicola in Jasper National Park and Banff National Park.

h. Plan and start the impact study of Cronartium ribicola in southern Rocky Mountain region.

Proposed publication:

Hiratsuka, Y. and J.M. Powell. Pine stem rusts of Canada. (Departmental publication).

Hiratsuka, Y. Taxonomy and nomenclature of endocyclic Uredinales.

Hiratsuka, Y. Nomenclature of the genus Endocronartium.

20. Signature :

March,1972

Y. Hiratsuka,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Identification and life history studies of miscellaneous forest insects in the Prairies Region.

3. Investigator: H.R. Wong.

4. Year of Commencement: 1948.

5. Estimated Year of Completion: Original - a continuing project. Revision I, 1973.

6. Key Words not in Title: Galls, damage, distribution, hosts, parasites, seasonal occurrence.

7. Discipline: Forest Insect and Disease Survey.

8. Project: Taxonomy, physiology, and ecology of species and ecosystems under management.

9. Estab. Study No. NOR 057. Service Study No. NOR 057.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 44 Other: 64

12. Man-months utilized in fiscal year under review: Prof.: 2 Other: 5

13. Man-month requirements in next fiscal year: Prof.: 3 Other: 6

14. Location of Work: Edmonton, Alta.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: To determine the species, life history, distribution, damage, hosts and parasites of the more common forest insects in the Prairies Region.

c - Need for study: The efficiency of the Forest Insect Survey is dependent upon the

ability to recognize all stages and damage of the more common forest insects, new or relatively unknown species that are capable of causing appreciable damage, and those species observed to be on the increase in this area. Accordingly studies are initiated as the opportunities arise to identify and determine the life history, parasites, hosts and distribution of these species. The information obtained would aid in determining the abundance of these species, methods of control either by chemical or biological means, and the best time to apply these controls.

d - Co-operating agencies: Material and information are supplied by the Insect Taxonomy section, Canada Department of Agriculture, Ottawa, personnel of the Forest Insect and Disease Survey across Canada, and entomologists in Canada and the United States.

16. Accomplishments to beginning of fiscal year under review:

The identification and description of the complex of insects in the tops of black spruce have been made, together with a diagnostic key to separate them and the type of feeding damage caused by each species. The study showed no indication that insects caused the club-top condition on black spruce.

Field keys and description have been published on how to separate the adult June beetles attacking coniferous plantations in Manitoba, and galls of Saperda, Xyelid and Eurytoma.

The results of studies on the distribution, parasites and life history of the following insects in Manitoba and Saskatchewan have been published: Saperda prob. calcarata attacking root collars of poplar, Zeugophora scutellaris, Agrilus criddlei, Herculia thymetusalis, Pseudexenter oregonana, Eucosma gloriola, Rhyacionia frustrana and Eurytoma calycis.

The life history and importance of the syrphid predator Phalactodira nioritarsis in controlling Chrysomela crotchi have been published. Likewise the study on the distribution of the elm bark beetle, Hylurgopinus rufipes in Manitoba and Saskatchewan.

For the region of Manitoba and Saskatchewan, reports have been published on: Additions to the Forest Lepidoptera; The insect collection of the Forest Insect and Disease Survey Part I, Lepidoptera; The insect collection of the Forest Insect and Disease Survey Part II, Coleoptera; Some of the common galls and abnormal plant growths caused by insects and mites; and Insect parasites of some insect galls. The arthropod fauna of Dibotryon morbosum (Schw.) Theiss, and Syd for the same region has been published.

17. Goals set for fiscal year under review:

1. Record the distribution, host and seasonal occurrence of the five coniferous budworm in Alberta.

2. Prepare a paper on Dioryctria banksiella in the western gall rust Endocronartium harknessii.

3. Determine if spumulin covering egg bands of Malacosma californicum lutescens affect rate of parasitism. This project was initiated by N.R. Branch, Winnipeg, Manitoba.

18. Accomplishments during fiscal year under review:

1. Publication - DeBoo, R.F., W.L. Sippell and H.R. Wong. 1971. The eastern pine shoot borer Eucosma gloriola (Lepidoptera:Tortricidae) in North America. Can. Ent. 103:1473-1486.

2. Publication - Wong, H.R. 1972. Dioryctria banksiella (Lepidoptera:Pyralidae) in the western gall rust, Endocronartium harknessii (Basidiomycetes:Uredinales) Can. Ent. 104:251-255.

3. The jack pine budworm Choristoneura pinus pinus, is more widely distributed in Alberta than was indicated by Forest Lepidoptera of Canada Vol.4. Canada Dept. of Forestry Pub. 1142-1965. The distribution of C. fumiferana, C. lambertiana, C. biennis and C. occidentalis have been mapped in Alberta, and their hosts and seasonal occurrence recorded.

4. Tetrastichus malacosomae Girdult parasitized eggs of Malacosma californicum lutescens that were covered with and without spumulin. Egg bands of this species placed near the bottom of the host plant were more highly parasitized than those placed near the centre and top. The other main egg parasite Telenomus clisiocampe appears to occur much earlier than T. malacosmae.

19. Goals for next fiscal year:

1. Collaborate with Dr. J.M. Powell in preparing a paper on Arthropods collected from cankers of stem rusts on hard pines in the Canadian Prairies.

2. Collaborate with W.G.H. Ives on the internal report Insects and Diseases attacking jack pine in the Sandilands Provincial Forest, Manitoba.

3. Determine the seasonal occurrence, parasites and larval habits of a bur oak blotch miner, Cameraria macrocarpae.

20. Signature:

March, 1972.

H.R. Wong,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1. Establishment: Northern Forest Research Centre. Date Prepared: March, 1972.

2. Title: Sawfly systematics.

3. Investigator: H.R. Wong.

4. Year of Commencement: 1950.

5. Estimated Year of Completion: Original - a continuing project.

6. Key Words not in Title: Tenthredinoidea, Nearctic Region, Distribution, Hosts, Keys, Life History, Morphology, New Genera, New Species, Biogeography Revision, Symphyta, Evolution Phylogeny.

7. Discipline: Entomology.

8. Project: Taxonomy, physiology and ecology of species and ecosystems under management.

9. Estab. Study No. NOR 058. Service Study No. NOR 058.

10. Status at time of statement preparation: Active.

11. Estimated total man-months utilized to date: Prof.: 76.5 Other: 18

12. Man-months utilized in fiscal year under review: Prof.: 1 Other: 2

13. Man-month requirements in next fiscal year: Prof.: 3 Other: 6

14. Location of Work: Edmonton, Alta., and Ottawa, Ont.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service.

b - Objectives: 1. To make systematic studies of sawflies of Canada, noting their mature and immature forms, distribution, host, seasonal occurrence, importance to forestry, subspecies, strains and phylogenetic relationships.

2. To separate the various sawfly species by means of keys, descriptions and illustrations.

3. To study the evolution and biogeography of the more important sawfly genera.

4. To study the external and internal morphology of the more economic sawfly species.

c - Need for study: Since insects cannot be discussed or treated in a scientific way until they have been identified, the most fundamental branch of entomology is systematics. Taxonomic relationships must be determined, so that species which are economically important can be identified and their possible areas of spread determined. Systematic studies can provide the means of making predictions and generalizations about probable habits, distribution, future importance of newly discovered species, and clues on the possible means of control. Accurate identification is also essential in restricting the spread of pest species, which can cost millions of dollars. Systematics is the means by which an orderly system is provided for storing information about organisms and is an important information retrieval device.

d - Co-operating Agencies: The material is made available by the following agencies, and I make the identifications and supply any pertinent information if requested relating to these determinations: Insect Taxonomy Section, Canada Dept. of Agriculture, Ottawa; Insect Identification and Parasite Introduction Research Branch, U.S. Dept. of Agriculture, Washington; British Museum (Natural History), London; and various entomological departments and laboratories across Canada, United States, Europe and Asia. The Biometrics Research Service, Canada Dept. of the Environment has co-operated by determining the feasibility of separating the different strains of the larch sawfly by statistical means.

16. Accomplishments to beginning of fiscal year under review:

The value of cocoons in determining families and genera of sawflies has been published. Sawfly larvae of the subfamily Nematinae attacking conifers in the Canadian Prairie have been identified.

The Nearctic species of Pristiphora have been studied and several species placed in synonymy or in other sawfly genera, other species were found to be Holarctic in distribution and not restricted to North America or Eurasia. A phylogenetic study has been made of Pristiphora in an effort to obtain an understanding of the relationship of the species and the circumstances under which they evolved.

Descriptions have been published on the external morphology of the male, female and ultimate larval instar of the larch sawfly; and the intersexes and gynandromorphs of this insect.

The sawfly genus Decanematus was discovered to be new to North America and the genus Micronematus in North America was found to be a synonym of the European genus Eitelius.

New species were described in the following genera: Pristiphora (Brazil, Canada and U.S.A.), Allantus (Canada and U.S.A.), Decanematus (Canada), Pristola (Canada) and Melastola (Canada and U.S.A.).

Larval descriptions have been published on species in the following sawfly genera: Anoplonyx, Platycampus, Tenthredo, Nematus, Pikonema, Nematinus, Dimorphopteryx, Arge, Croesus, Cimbex, Trichiosoma, Empria and Priophorus.

Diagnostic keys to species in the following genera have been published: Pristiphora (South American adults), Eitelius (North American and European adults), Allantus (North American adults with black hind tibiae), Decanematus (North American, Japanese and European adults), Pristola (North American adults), Melastola (North American adults) and Sharliphora (Eurasian adults).

Diagnostic keys to genera of the tribe Pristolini have been published, and the new genera Sharliphora and Melastola were established.

It has been determined that the use of Mahalanobis D^2 statistic and discriminant function analysis failed to separate populations of the larch sawfly, which were resistant or susceptible to the parasite Mesoleius tenthredinis.

The European spruce sawfly has been discovered for the first time in southeastern Manitoba along with the parasite Palexorista bohemica, which was released against it in eastern Canada.

New species in the genera Susana and Pristiphora have been discovered.

17. Goals set for fiscal year under review:

1. Identify adults of Pristiphora, and other sawfly genera, which I am the specialist from across Canada in the Canadian National Collection, Ottawa.

2. Prepare a report on the spread of Diprion hercynide in Manitoba.

3. Describe new species of Pristiphora from the Canadian Arctic.

18. Accomplishment during fiscal year under review:

1. Sawflies representing a number of genera (Pristiphora, Pikonema, Susana, Anoplonyx, Caliroa,

Empria etc.) have been identified for the Canadian National Collection, Ottawa, Rocky Mountain Forest and Range Experimental Station, Shelterbelt Lab., Bottineau Branch, Bottineau, North Dakota, and for the larch sawfly life table plots in Manitoba.

2. A paper on the spread of the European spruce sawfly, Diprion hercyniae in Manitoba has been submitted to the Canadian Entomologist for publication.

3. Illustrations and descriptions of three new species of Pristiphora from the Canadian Arctic has been prepared.

4. Examined a large number of larch sawfly adults to determine any morphological defects after the larval stage was exposed to doses of gamma radiation exceeding 2,000 rad/hr. for Dr. W.J. Turnock.

19. Goals for next fiscal year: 1. Submit for publication in the Canadian Entomologist, a joint paper with Dr. H.E. Milliron of the Entomology Research Institute, Ottawa, on the new sawfly, Susana fuscala attacking western juniper in British Columbia.

2. Identify sawfly specimens in the Canadian National Collection, Ottawa.

3. Submit for publication a brochure on "Sawfly leaf miners of birch" outlining the life history and illustrating the damage caused by the three species in the Canadian Prairies together with methods of control.

20. Signature:

March, 1972.

H.R. Wong,
Investigator.

STUDY REVIEW STATEMENT

Fiscal Year: 1971-72

1.	Establishment: Northern Forest Research Centre.	Date Prepared: March, 1972.
2.	Title:	Liaison and technical advisory services re insect pests and diseases of forest, shelterbelt and ornamental trees.
3.	Investigator:	V. Hildahl.
4.	Year of Commencement:	1966.
5.	Estimated Year of Completion:	Continuing.
6.	Key Words not in Title:	Tree biology, entomology, pathology, pesticides, insect control, disease control, demonstrations, spraying, surveys, appraisals, wildlife.
7.	Discipline:	Liaison and Development.
8.	Project:	
9.	Estab. Study No.:	Service Study No. NOR 068.
10.	Status at time of statement preparation:	Active.
11.	Estimated total man-months utilized to date:	Prof.: 72 Other: 30
12.	Man-months utilized in fiscal year under review:	Prof.: 12 Other: 12
13.	Man-month requirements in next fiscal year:	Prof.: 10 Other: 6
14.	Location of Work:	Manitoba.

15. Background Statement:

a - Study proposed by: Canadian Forestry Service (at the request of Provincial Forestry, Park and Agricultural agencies).

b - Objectives: To develop and maintain regular contact with Provincial Forestry, Park and Agricultural agencies, woods operating industries, nursery operators and city and municipal officials and 2) provide these agencies with technical guidance and assistance in dealing with insect and disease problems of forest, park and shelterbelt trees within their jurisdiction.

c) Need for study: The primary need for the project is to develop harmonious working relationships and promote effective communication with administrative research and operational personnel associated with the fields of forestry, recreation and urban beautification in order to 1) ensure that the user agencies derive maximum benefits from the results of research and development programs in entomology and pathology; and 2) provide feedback on the needs and views of user agencies to research managers for the initiation of meaningful research programs which will effectively contribute to resolving insect and disease problems associated with forest and planted trees.

This involves keeping them informed of current insect and disease problems; interpreting and disseminating results of scientific research that has practical application in dealing with insect and disease problems; advising user agencies with respect to latest chemical controls; field testing of chemicals appropriate to insect and disease control; and developing, demonstrating and supervising large-scale operational control programs that are beyond the competence of the user agency.

d) Co-operating agencies: 1) Forestry Branch, Manitoba Department of Mines, Resources and Environmental Management

2) Parks Branch, Manitoba Department of Tourism and Recreation

3) Plant Protection Division, Manitoba Department of Agriculture

4) Urban and Rural Parks, City and Municipal officials

5) Entomology and Pathology Departments, University of Manitoba

16. Accomplishments to beginning of fiscal year under review:

1) Since the Liaison and Services Section (Tree Insects and Diseases) was established in 1966, contacts have been developed and maintained with federal, provincial, municipal and urban governmental agencies, and with industrial and university officials associated with forestry and tree growing problems.

2) Operational spray programs were conducted in 1967 at the request of the Manitoba Department of Mines, Resources and Environmental Management (Forestry Branch). The work was carried out in pine plantations in the Spruce Woods Provincial Forest and in natural jack pine stands in the Belair and Sandilands Provincial Forests to demonstrate chemical control techniques for suppressing jack-pine budworm larval populations with aerial application equipment.

3) At the request of the Manitoba Department of Tourism, Recreation and Cultural Affairs (Parks Branch), companion studies using hydraulic sprayers and mistblowers were conducted from 1967-1969 in the Whiteshell Provincial Park and at Rocky Lake in northern Manitoba. The work was carried out primarily to test the suitability of ground application equipment for treating localized jack-pine and spruce budworm outbreaks. In association with this study several insecticides were tested for efficacy, and application techniques were developed that could be readily used by park and forestry personnel.

4) Dutch elm disease detection programs have been carried out jointly with officials of the Manitoba Department of Agriculture and of Metropolitan Winnipeg. The possibility of this serious disease spreading to elm stands in Manitoba from adjacent Minnesota has caused considerable concern to various governmental agencies, and the need for early diagnosis of the pathogen is essential.

5) Detailed appraisals have been made of jack pine mistletoe infections in areas proposed for clear cutting in the Belair Provincial Forest and in the Western Region of Manitoba at the request of the Department of Mines, Resources and Environmental Management (Forestry Branch). Boundaries of the infected areas were delineated, and a report entitled "Management Control of the Jack-Pine Mistletoe in the Belair Provincial Forest" was prepared and submitted to the above agency. Other appropriate reports have also been provided as required.

6) Several appropriate special reports have been prepared and submitted at the request of the provincial Parks Branch and Forestry Branch, and Department of Agriculture. Liaison and Services publications produced are as follows:

   a) Hildahl, V., M. Pratt and A. Campbell. 1968. Bibliography of Forest Research. Canada Dept. of Fisheries and Forestry, Liaison & Services Note MS-L-2. 65 p.

   b) DeBoo, R.F. and V. Hildahl. 1968. Jack-Pine Budworm in Central Canada. Canada Dept. of Fisheries and Forestry, Liaison and Services Note MS-L-4. 9 p.

   c) Peterson, L.O.T. and R.F. DeBoo. 1969. Pine Needle Scale in the Prairie Provinces. Canada Dept. of Fisheries and Forestry, Liaison & Services Note MS-L-5. 9 p.

   d) Peterson, L.O.T. and V. Hildahl. 1969. The Spruce Spider Mite in the Prairie Provinces. Canada Dept. of Fisheries and Forestry, Liaison & Services Note MS-L-7. 9 p.

   e) Hildahl, V. and L.O. T. Peterson. 1970. Spruce and Balsam Fir Sawflies in the Prairie Provinces. Canada Dept. of Fisheries and Forestry, Liaison & Services Note MS-L-10. 10 p.

   f) DeBoo, R.F. and V. Hildahl. 1968. Aerial Spraying for Control of the Jack-Pine Budworm in Manitoba. Manitoba Entomologist. 1:21-26.

g) DeBoo, R.F. and V. Hildahl. 1972. Control of the Jack-Pine and Spruce Budworms with Ground Application Equipment in Manitoba. Manitoba Entomologist Vol. 5. (In press)

h) Hildahl, V. 1971. Dutch Elm Disease, a Threat to Prairie Elms. The Prairie Garden (published by Winnipeg Horticultural Society).

17. Goals set for fiscal year under review:

1) Continued liaison with resource managers throughout Manitoba; contacting appropriate governmental agencies and officials of wood-using industries.

2) Continue conducting insecticide testing and spraying in shelterbelt plantings, with emphasis on experimental spraying to control the poplar bud-gall mite on hybrid poplars . This mite is a serious pest of planted poplars in the prairie regions.

3) Continue detection programs for the Dutch elm disease in southern Manitoba with emphasis on the Red River Valley section, and provide laboratory services for diagnosis of unhealthy and suspect elm trees.

4) Preparation of appropriate special reports, scientific papers and Liaison and Servicespublications for distribution to resource managers and other user agencies.

18. Accomplishments during fiscal year under review:

1) Contacts with officials of the provincial Forestry Branches, Agriculture, National and Provincial parks, and city and rural parks were continued, and information provided as required on the status and control of various insect pests and tree diseases.

2) Detailed appraisal re jack pine mistletoe was continued in the Belair Provincial Forest and expanded to the Grand Beach Provincial Park, and to the western region of Manitoba. Appropriate special reports outlining recommendations were submitted to departmental officials as required.

3) Dutch elm disease investigations (including detection and diagnostic services) were continued jointly with Manitoba Department of Agriculture and Metropolitan Winnipeg officials. Some 540 suspect white elms were sampled and the material cultured for diagnosis of the disease.

4) An advisory service pertaining to insect and disease problems on shelterbelt, shade and forest trees was provided during the season under review. Approximately 335 individual inquiries were processed; the majority of which required control recommendations.

5) Spruce budworm outbreaks in the Spruce Woods Provincial Forest and Park were appraised preparatory to making chemical control recommendations (at the time of this study review the report has been submitted to appropriate authorities).

19. Goals for next fiscal year:

1) Liaison will be continued in Manitoba; contacting appropriate officials of government, municipal and industrial agencies. This will include providing technical and advisory services with respect to insect and disease problems of trees as required.

2) Experimental spraying to control insects and diseases of trees will be continued in association with R.F. DeBoo, Chemical Control Research Institute. Emphasis in 1972 will be placed on developing chemical control recommendations for the poplar bud-gall mite.

3) Insect and disease appraisals will be conducted as requested by the various governmental agencies, and appropriate special reports and Liaison and Services publications will be prepared for distribution to resource managers and other user agencies.

20. Signatures:

V. Hildahl
Investigator

H.J. Johnson
Head, Liaison and Development

L.D. Nairn
Officer-in-Charge (Acting)

M. H. Drinkwater
Regional Director

March 24, 1972