S T U D Y S T A T E M E N T S

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NORTHERN FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

MAY, 1976

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and Appraisal of tree pests and vegetative disturbances.

2. Title: Forest tree rusts of western North America.

3. New: Cont.: X 4. No.: NOR-1-026

5. Study Leader: Y. Hiratsuka

6. Key Words: *Cronartium, Pucciniastrum, Peridermium, Melampsora, Chrysomyxa,* cytology, morphology, taxonomy, Uredinales, inoculation experiment, pathogenicity.

7. Location of Work: Edmonton (laboratory, greenhouse and mycological herbarium), Kananaskis Forest Experiment Station, Western North America with particular emphasis on Northern Region (field).

8. Problem:

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.

9. Study Objectives:

General:

To acquire a comprehensive knowledge and to improve diagnostic capability on 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 of conifer needle rusts, pine stem rusts, and poplar-conifer rusts of the region, and related species in the world.

10. Resources:

a. Starting date: 1968 Projects A-232 (1961) and A-254 (1965) were combined and redesigned in 1968.
b. Estimated year of completion: continuing
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.5 (Y. Hiratsuka)
Supp.	0.7 (P.J. Maruyama)
Casual	Nil
Total	1.2

11. Progress to Date:

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 stored 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 outlined.

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.

12. Surveys of the occurrence of *Tuberculina maxima* on pine stem rusts have been undertaken. Two papers on the occurrence have been published.

13. Field and herbarium surveys of the occurrence of the pine stem rusts in Canada have been carried out and distribution maps were prepared.

14. Manuscript of the proposed publication "Pine stem rusts of Canada" has been completed and in press.

15. Modified and improved sets of terminology of spore states in Uredinales (rust fungi) were proposed at the First International Mycological Congress (1970) and two papers on the subject have been published.

16. To clarify the nomenclatural confusion created by the discovery of a new life cycle of pine stem rusts, conservation of the generic name *Peridermium* has been proposed and published in Taxon.

17. Serious damage caused by two pine stem rusts to a lodgepole pine plantation in central Alberta was studied and a report has been published.

18. Study trip to Japan, India and Korea was successfully carried out and several significant results on pine stem rusts and other tree rusts have been obtained.

19. Two papers on the insects from the cankers and the litter samples under comandra blister rust cankers have been published.

12. Goals for 1975-76:

1. Present a symposium paper on the taxonomy, cytology and morphology of rust fungi at Purdue University in June as a part of special rust taxonomy symposium.

2. Complete a paper on taxonomy and morphology of *Pucciniastrum geoppertianum* (a fir needle rust).

3. Continue to compile the "Check list of Uredinales in Alberta".

4. Continue studies of gall formation and infection of western gall rust and prepare a paper on this subject for presentation at Canadian Botanical Association meeting in Saskatoon in August.

5. Conduct inoculation experiments and morphological comparisons of *Cronartium ribicola* and *C. coleosporioides* in our region and compare the results with information obtained in Asia in 1973.

6. Prepare a paper to the Report of the Tottori Mycological Institute on the terminology of rust fungi.

13. Accomplishments in 1975-76:

1. Presented an invited symposium paper on the taxonomy and terminology of rust fungi at the "J.C. Arthur Memorial Lectures" held in conjunction with the Northcentral Division of the American Phytopathological Society meeting at Purdue University, Indiana in June 1975.

2. Taxonomic and morphological studies of *Pucciniastrum goeppertianum* and *P. vaccinii* has been expanded to include forms in other areas of the world and a joint publication with Dr. S. Sato of Tokyo University of Education is planned.

3. Significant progress is made of compiling the "Check list of Uredinales of Alberta".

4. Histological study of the gall formation of the western gall rust was carried out and several interesting results has been obtained. A paper on the subject was presented at BEP Joint Meeting at Saskatoon in August 1975.

5. Conducted inoculation experiments of *Cronartium ribicola* on previously unknown hosts and obtained positive results with *Castilleja miniata*. This results together with new informations from Asian pine stem rusts are very important and may result in major re-arrangement of pine stem rusts taxonomy. A short note is published.

6. A paper on the controvercies of the terminology of rust fungi is published.

14. Goals for 1976-77:

1. Arrange a rust taxonomy symposium at the Second International Mycological Congress in 1977.

2. Continue morphological and inoculation studies of pine stem rusts expecially of *Cronartium ribicola*.

3. Prepare the first draft of the "Check list of Uredinales in Alberta".

4. Give advice to and consult with specialists on taxonomy, nomenclature and cytology of rust fungi especially of forest tree rusts.

5. Cooperate with Dr. S. Sato (Tokyo) to complete morphological and taxonomical study of *Pucciniastrum vaccinii* and *P. goeppertianum*.

6. Try to obtain informations of tree rusts in continental China and Siberian region of U.S.S.R., especially of pine stem rusts.

7. Re-survey pine stem rusts plots established by Mr. Baranyay in 1965-68.

15. Publications:

Up to 1975-76

Powell, J. M. and W. Morf. 1965. The occurrence of *Tuberculina maxima* Rost. on *Cronartium* rust infected trees in Alberta. Can. Dept. For., For. Ent. and Path. Br., Bi-Mon. Prog. Rept. 21(1):3.

Powell, J. M. 1966. A white spored *Peridermium stalactiforme* in Alberta. Plant Disease Reporter, 50:114.

Powell, J. M. and W. Morf. 1966. Temperature and pH requirements for aeciospore germination of *Peridermium stalactiforme* and *P. harknessii* of the *Cronartium coleosporioides* complex. Can. J. Bot. 44:1597-1606. + 1 plate.

Hiratsuka, Y., W. Morf and J. M. Powell. 1966. Cytology of the aeciospores and aeciospore germ tuber of *Peridermium harknessii* and *P. stalactiforme* of the *Cronartium coleosporioides* complex. Can. J. Bot. 44, 1639-1643. III Plates.

Hiratsuka, Y. and E. J. Gautreau. 1966. Occurrence of *Cronartium comptoniae* in Alberta and the Northwest Territories. Pl. Dis. Reptr. 50, 419.

Hiratsuka, Y., L. E. McArthur and F. J. Emond. 1967. Clarification of the identity of two needle rusts of alpine fir, *Pucciniastrum geoppertianum* and *P. epilobii* in Alberta. Can. J. Bot. 45, 1913-1915.

Hiratsuka, Y. and P. J. Maruyama. 1968. Nuclear condition of the term tubes of *Peridermium ephedrae*. Mycologia 60, 437-438.

Hiratsuka, Y. and P. J. Maruyama. 1968. Identification of *Peridermium harknessii* in eastern Canada on the basis of nuclear condition of aeciospore germ tubes. Pl. Dis. Reptr. 52, 650-651.

Hiratsuka, Y. 1968. Morphology and cytology of aeciospores and aeciospore germ tubes of host-alternating and pine-to-pine races of *Cronartium flaccidum* in northern Europe. Can. J. Bot. 46, 1119-1122. IV plates.

Hiratsuka, Y. and J. M. Powell. 1969. Cytology and taxonomy of autoecious pine stem rusts. (Ab.). XI International Botanical Congress. Seattle, Washington, Abstracts: 91.

Hiratsuka, Y. 1969. *Endocronartium*, a new genus for autoecious pine stem rusts. Can. J. Bot. 47, 1493-1495.

Powell, J. M. and Y. Hiratsuka. 1969. Nuclear condition and germination characteristics of the aeciospores of *Cronartium comandrae* and *C. comptoniae*. Can. J. Bot. 47, 1961-1963. 2 plates.

Hiratsuka, Y. 1970. Identification and morphology of the aecial state of *Pucciniastrum sparsum* in northwestern Canada. Can. J. Bot. 48, 433-435.

Hiratsuka, Y. 1970. Emergence of the aeciospore germ tube of *Cronartium coleosporioides (Peridermium stalactiforme)* as observed by scanning electron microscope. Can. J. Bot. 48, 1962.

Krebill, R. G. and Y. Hiratsuka. 1971. Possible life cycle and nuclear condition of *Peridermium ephedrae*. Southwestern Naturalist 16:431-459.

Powell, J. M. 1971. Occurrence of *Tuberculina maxima* on pine stem rusts in western Canada. Can. Plant Dis. Surv. 51(2):83-85.

Powell, J. M. 1971. Additional records of *Mycodiplosis* larvae (Diptera:Cecidomyicdae) feeding on rust fungi. Can. Plant Dis. Sum. 51(2):86-87.

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

Hiratsuka, Y. 1973. Sorus development, spore morphology, and nuclear condition of *Gymnosporangium gaeumanii* ssp. *albertense*. Mycologia 65:137-144.

Hiratsuka, Y. 1973. The nuclear cycle and the terminology of spore states in Uredinales. Mycologia 65:432-443.

Hiratsuka, Y. 1973. Nuclear cycle, taxonomy, and nomenclature of autoecious pine stem rusts in North America and Europe. Rep. Tottori Mycol. Inst. 10:243-248. (In Japanese with English summary.)

Powell, J. M. and Y. Hiratsuka. 1973. Serious damage caused by stalactiform blister rust and western gall rust to a lodgepole pine plantation in central Alberta. Can. Dis. Surv. 53:67-71.

Hiratsuka, Y. 1974. Proposal to conserve the generic name *Peridermium* (Link) Schmidt and Kunze with a conserved type species *Aecidium eleatinum* Alb. and Schw. (Fungi Imperfecti Uredinearum). Taxon. 23:428-429.

Powell, J. M. 1974. The role of natural biological agents in controlling a pine stem rust *(Cronartium comandrae)* Blue Jay 32:75-79.

Hiratsuka, Y. 1974. Spore morphology, nuclear cycle and terminology of rust fungi. Proceedings of Post-Congress (IAMS) Mycological Meeting, Tottori. p. 5.

D. M. Henderson and Y. Hiratsuka. 1974. Ontogeny of spore markings on aeciospores of *Cronartium comandrae* and peridermioid teliospores of *Endocronartium harknessii*. Can. J. Bot. 52:1919-1921.

Powell, J. M. and L. S. Skaley. 1975. Arthropods from forest litter under lodgepole pine infected with the comandra blister rust. Information Report NOR-X-130. 33 p.

Powell, J. M. 1975. Additional note on the incidence of *Cronartium coleosporioides* f. *album* on lodgepole pine. Pl. Dis. Reptr. 59:32-34.

1975-76

Hiratsuka, Y. and P. J. Maruyama. *Castilleja miniata* a new alternate host of *Cronartium ribicola*. Pl. Dis. Reptr. (In press).

Hiratsuka, Y. 1975. Recent controvercies on the terminology of rust fungi. Reptr. Tottori Mycol. Inst. 12:99-104.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-1-033

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and appraisal of tree pests and vegetative disturbances.

2. Title: Forest insect and disease survey

3. New: Cont.: X 4. No.: NOR-1-033

5. Study Leader: W.G.H. Ives, Y. Hiratsuka, H. R. Wong, R. A. Blauel

6. Key Words: Detection, appraisal, distribution, parasites, hosts, damage, predators, biological control, hazard, susceptibility, stability, management, parks, recreation, symptoms, damage, effluents, easement atmosphere.

7. Location of Work: Throughout region.

8. Problem:

Forest insects and diseases annually destroy or degrade large quantities of otherwise usable wood fibre. They cause important damage to nursery plantations, shelterbelts and park plantings which have high aesthetic or shelter values. The relations between insects, diseases and their hosts are complex and often obscure. Many of the problems confronting resource managers have their origin in insect or disease activities, but in other instances unsuspected factors may be responsible for the damage, and the insects or diseases are of secondary importance. Correct diagnoses therefore require a highly trained technical and professional staff.

The data collected by the Survey provide essential information on life cycles, ecology, natural control agents, distribution and general abundance, which is of value to research entomologists, pathologists and other biologists. Many of the species reported by the Survey have a wide distribution, and the regional data are part of a larger body of data collected by this and other regions. Requests for surveys and advisory services in environmental pollution problem areas are being directed with increasing frequency to the Canadian Forestry Service. The Forest Insect and Disease Survey (FIDS) can handle many of these requests.

The gathering of background information on the distribution and abundance of insect and disease pests in the Prairies Region has largely been completed. We know which pests are important, and where they are most likely to occur. The need for routine detection surveys has therefore decreased and, since management agencies are much closer to the problem than we are, they should be able to report any suspected damage. Although we will continue to monitor known outbreaks, we have decided to drop routine detection surveys and to concentrate our efforts on what might be called extension entomology and pathology, emphasizing impact and appraisal aspects. To facilitate this work we are establishing and strengthening contacts with provincial and federal agencies, and are initiating a number of training programs in the form of field trips, lectures or seminars, that are aimed at improving the capability of personnel in these agencies to diagnose the more common problems themselves. We will investigate any reported problems, and give advice on what the organism is and on control procedures, if available. This approach, we believe, will make better use of available resources and should improve the service that we are able to provide to management agencies concerned with problems involving shade and forest trees.

9. Study Objectives:

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

2. Provide management agencies with diagnostic impact and appraisal services relating to effects of insects, diseases, climatic influences and pollutants on trees and shrubs and other types of vegetation.

10. Resources:

a. Starting date: 1941 at Winnipeg and Indian Head
b. Estimated year of completion: Continuing
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1975-76 with costs: Nil
e. Essential new major equipment items beyond 1976 with costs: Nil
f. 1976-77 man-years

Prof.	0.5	(W.G.H. Ives)
	0.1	(Y. Hiratsuka)
	0.5	(R. A. Blauel)
Supp.	1.0	(J. Petty)
	1.0	(V. B. Patterson)
	1.0	(F. J. Emond)
	1.0	(R. M. Caltrell)
	1.0	(A. E. Campbell)
	1.0	(J. P. Susut)
	1.0	(G. N. Still)
	1.0	(R. C. Tidsbury)
Casual	-	
Total	9.1	

11. Progress to Date:

Infestations of all the major forest insects 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. Much of this information has been stored on magnetic tape or punch cards for easy analysis and retrieval. Life cycles and other biological data have been obtained for most of the major insects and diseases within the region. Numerous impact and appraisal surveys have been carried out in response to special needs.

12. Goals for 1975-76:

1. Known outbreaks of defoliating insects will be monitored as required. At the moment, these include forest tent caterpillar in the three Prairie Provinces, eastern spruce budworm in Manitoba and in the Fort McMurray area of Alberta, jack pine budworm in Manitoba, possibly western spruce budworm in Alberta, and fall cankerworm on the Red and Assiniboine Rivers in Manitoba.

2. The reported infestation of Scleroderris canker in Jasper National Park will be evaluated. (Hiratsuka)

3. In Manitoba, limited detection surveys will be conducted in forested areas, particularly parks and high value fibre-producing areas.

4. Training seminars of courses will be given to staff of as many provincial and federal agencies as possible, in order to better acquaint them with common insect and disease pests of their area, with the anticipation that they will eventually be able to diagnose the more common problems.

5. Reported instances of damage attributable to insects, diseases or pollutants will be investigated, and wherever possible the cause of the damage determined and the remedial action prescribed, if available.

6. Illustrations for brochures on forest insects and diseases will be obtained whenever the required material is available. Some pictures will be taken in the field, others in the laboratory, depending upon circumstances. Assistance will also be given in the preparation of texts for brochures.

7. Available information, collected by our own staff and by other agencies, will be collated into an annual report outlining known pest problems in the Region.

8. Red belt studies will consist of a follow-up of conditions in the original plot and the establishment of additional plots in areas with different degrees of initial damage, in order to better assess the full impact of red belt in the area.

9. Maintenance and improvement of regional insect collection (Wong and Melvin).

   a. Enlarge and update the Edmonton collection by sending various groups of insects to specialists in Canada and United States for identification.

   b. Amalgamate parts of the Calgary and Winnipeg reference collections.

   c. The coding and correction of enclosure slips to facilitate the storing and retrieval of such data on magnetic tapes at the Biometric and Computer Science Branch, Ottawa.

   d. The rearing of forest insects to obtain determined mature and immature material for the reference collection.

10. Diagnostic services for forest insects (Wong and Melvin).

   a. Provide diagnostic services on mature and immature insects including their damage for in-service personnel and other agencies such as federal and provincial personnel and private citizens.

   b. Provide and check entomological nomenclature for personnel of the Northern Forest Research Centre.

   c. Provide information on life history and seasonal occurrence on forest insects in the Canadian Prairies for provincial, federal and university personnel and the general public.

   d. Provide specimens and data to taxonomists engaged in revisionary or systematic studies of certain groups of insects.

   e. Lecture and arrange displays of forest insects and their damage for students from the university and technical and public schools touring the Northern Forest Research Centre.

   f. Improve on the diagnostic services by studying the life history, seasonal development, hosts and parasites of the more common insects of the Canadian Prairies.

11. Following goals will be carried out by the forest disease diagnostic and taxonomic service group (Hiratsuka, Lawrence, Maruyama).

   a. Disease reference collection (Mycological Herbarium) will be maintained and upgraded. Emphasis will be placed on filing of specimens from previous years to the herbarium.

b. A fungus culture collection which contains more than 500 living cultures of major forest fungi will be reorganized and maintained. The collection had been maintained by wood decay study group but after discontinuation of the project, it was left unattended for several years.

c. Specimens of tree and shrub diseases, and other forest fungi will be identified for pest extension personnel of FIDS, liaison and service personnel and others in the Centre, and for outside agencies.

d. A check list of forest fungi collected in Prince Albert and Elk Island National Parks will be compiled.

e. An annotated check list of major diseases of trees and shrubs of the region will be prepared.

f. Illustrated glossary of forest pathology and forest mycology will be prepared.

12. Limited evaluations of suspect pollution damage will be made when the situations warrant such action. Possible areas are: Tar Sands, Flin Flon, Yellowknife and Carmacks.

13. A pre-season forecast of anticipated insect and disease problems for the summer of 1975 will be made.

14. Meetings will be held from time to time with officials of various agencies in order to facilitate the implementation of the foregoing goals.

15. The following reports will be completed (Blauel):

The Forest Condition and Ecological Benchmarking in the Athabasca Tar Sands Area.

Salt Water Spill Problems in the Forest.

Survey of a Forest Community near a Cement Production Industry.

16. R. A. Blauel will participate as a member of the Mackenzie Delta Gas Working Group. Summations of past survey information on natural vegetation problems resultant from the gas and oil extraction industry will be utilized in developing site specific guidelines for the assessment of the environmental impact of the Mackenzie Delta Gas Development.

13. Accomplishments in 1975-76:

1. Forest tent caterpillar infestations in Manitoba, Saskatchewan and Alberta were monitored. Infestation remained much the same in Alberta, declined in Saskatchewan and increased in Manitoba. Egg band sampling was carried out in Manitoba and Saskatchewan, at the request of and in cooperation with provincial government agencies, and 1976 infestation levels predicted. Spruce budworm infestations increased in size and severity in the Fort McMurray area of Alberta; in Manitoba moderate to severe defoliation was again present in the Spruce Woods Provincial Forest and Park and in the Interlake area. Infestations of jack pine budworm increased in severity in the Sandilands and Spruce Woods Provincial Forests, Manitoba. The two-year cycle spruce budworm caused light to moderate defoliation in Kootenay National Park. A decline in populations of fall cankerworm was noted in Metropolitan Winnipeg area. Defoliation ranging from light to severe was recorded along the Red River, west of Winnipeg to Brandon and around Dauphin. Infestations were also recorded in several areas of Saskatchewan.

2. Several field surveys of "Schleroderris canker" were conducted of the area in and around the location reported in 1974 in Jasper National Park and other locations in Alberta. Scleroderris canker was found in much larger areas in and around the original site in Jasper National Park but not detected in other parts of the park or other locations surveyed.

   Joint field survey and consultation meeting were organized in Jasper National Park with staff from PFRC and NFRC on Scleroderris canker.

   A visit was made to GLFRC to consult with specialists on Scleroderris.

3. Detection surveys were conducted in most areas of Manitoba except the Southwestern part of the province. Included were some Provincial Forest Reserves and Parks and Riding Mountain National Park. A number of insect species and disease organisms (other than those mentioned in #1 above) were reported on.

4. Slide lectures and field trips showing common insect and diseases of trees were given to personnel working in forestry, agriculture or horticultural fields and occasionally to interested groups at the request of agriculture or forestry personnel. About 790 persons attended 34 lectures presented within the Region.

5. The number of inquiries received from client agencies increased (over 1974) in both Edmonton and Prince Albert. Problems involving the identification and control of insects and diseases were most common, although queries on herbicides, pruning, transplanting etc. were handled. Extension calls in Alberta totaled 733 and in Saskatchewan 657. In Manitoba extension was handled by Liaison & Development personnel as well as Survey.

6. Photographic material for the planned brochures was obtained. Although not complete, a good percentage of the required insect photos and many of the disease photos have been taken. The quality of the slides appears to be very good. Some references have been gathered together for use in writing the text. In addition to providing illustrations for the brochures, the slides are a valuable asset in presenting lectures on common insects and diseases. Copies of the slides (or prints made from them) will be made available for other agencies to purchase, provided that the Canadian Forestry Service is acknowledged as the source.

7. Information on insect and disease conditions in the Region during 1975 has been compiled for inclusion in the Annual Report of the Forest Insect and Disease Survey. More detailed information will be made available to client agencies within the Region. Reports outlining 1974 conditions were published.

8. The red belt studies are continuing. Four additional plots in the Hinton area and two in southern Alberta foothills were established for the purpose of monitoring long-term mortality, making a total of eight plots for this study.

9. a. The following insect orders were submitted to specialists in Ottawa for identification and subsequent incorporation into the required reference collection: Lepidoptera 7 specimens, Hymenoptera 87 specimens, Homoptera 8 vials containing several specimens, Arachnida 31 vials containing several specimens. About 300 adults and larvae have been added to the regional reference collection in 1975. Sixteen diseased insects were sent to the insect pathologists at Sault Ste Marie for identification.

   b. About 200 specimens from the Calgary and Winnipeg reference collections have been amalgamated.

c. Two hundred and seventy enclosure slips were coded and the codes on about 400 old enclosure slips corrected and returned to the Biometric and Computer Science Branch, Ottawa.

d. Over 200 larvae were reared either to obtain adults for determination or for photographic purposes.

10. a. Over 500 samples were identified for in-service personnel (at Edmonton, Winnipeg and Prince Albert), private citizens, cooperators, outside agencies and Dr. J. E. Guthrie, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba (110 samples).

b. Provided and (or) checked entomological nomenclature in Ranger Reports and scientific papers.

c. Provided information on life history and seasonal occurrence to personnel at the laboratory engaged in chemical control and biological studies.

d. Loaned or provided specimens to the following for scientific research:

Dr. William E. Miller, U.S.D.A. Forest Service, St. Paul, Minnesota.	*Phyacionia*
Gerald Hilchie, Uni. of Alberta	*Buprestis* spp
Joseph Belicek, Un. of Alberta	Coccinellids
Gary Gibson, Biosystematic Research Institute, Ottawa	*Macrophya* spp
Dr. J. C. Roskam, Netherlands	chalcids
Dr. W. C. McGuffin, Biosystematic Research Institute, Ottawa	Geometrids spp

e. Arranged displays and lectures to about 25 groups representing about 600 people touring the Northern Forest Research Centre last year.

f. Studied the life history of *Enargia decolor* (Walker) attacking trembling aspen in Northern Alberta.

A new study statement covering Goals 9 and 10 in 1976-77 has been prepared.

11. a. A considerable number of specimens have been incorporated into the Mycological Herbarium. Exchanged specimens with other institutions such as Biosystematic Research Institute (Ottawa), Purdue University (Indiana) and Tokyo University of Education (Japan).

    b. Started the re-organization of the fungus culture collections. Contaminated and dead cultures were discarded and media for transfer were prepared. Several important cultures of forest pathogens were added to the collection of forest pathogens including pathogens of Dutch elm disease and Scleroderris canker.

    c. Identified tree disease specimens and other fungi for pest extension personnel of FIDS. Positive identification of fire blight disease samples of crabapple, apple and pear using isolation technique was the major work load in 1975.

    d. Check lists of forest fungi collected in Prince Albert and Elk Island National Park are in advanced stage of preparation.

    e. First draft of the "Annotated check list of diseases of trees and shrubs in the Prairie Provinces" was completed.

    f. Card index was prepared of common terms used in forest pathology and forest mycology for the proposed illustrated glossary.

    A new study statement covering Goal 11 in 1976-77 has been prepared.

12. Several limited evaluations were made of suspect pollutant damage situations. Among these were:

    a. An evaluation of forest vegetation impacts resultant from emergency flaring procedures conducted at the G.C.O.S. Tar Sands Oil extraction operation.

    b. A preliminary field survey of vegetation and soils conducted around the Flin Flon smelter.

    c. A preliminary field evaluation of forest condition around the Prince Albert pulp mill.

d) A field evaluation of catalyst disposal method at the Hudson Bay Brazeau Gas plant.

e) Examination and sampling of the Thompson smoke easement permanent plot system.

f) Evaluation of the salt-water spill plots in the Swan Hills area.

Other short examinations were made of limited stress situations including small oil and gas release incidents and residential ornamental tree problems.

File reports on the field aspects of these evaluations are completed.

Additionally an advisory service regarding forest ecosystem impacts from pollutants was provided to federal and provincial agencies.

During 1975-76 the following services were provided (not in order necessarily of priority):

Participation in the June hearing concerning the INCO-Thompson smelter complex. Manitoba-E.P.S. & Clean Air Commission.

Review of Recommendations concerning the Clean Env. Commission Order No. 483 (re: the INCO-Thompson smelter complex. Manitoba-E.P.S.

Advice concerning anticipation of impact from SO_2 released from the Wollaston Lake uranium mine acid plant. Sask. Dept. of Env. Air Control Branch.

Participation in the design and review of the Yellowknife Environmental Survey. Env. Canada-E.P.S.

Advice concerning current and projected SO_2 impacts in the Alberta Tar Sands. Alta. D. of E., Air Pollution Control Division.

Advice concerning salt water spill impacts on forest ecosystems. Alberta Energy Resources Conservation Board.

Advice concerning SO_2 deposition on soils in the Bathurst, N.B. area. C.F.S.-Maritimes Forest Research Centre.

13. A pre season forecast of major insect or disease conditions that were expected in 1975 was sent out to agencies most likely to be confronted with problems. Actual conditions were close to what was expected.

14. Several meetings were held with officials of Provincial Departments of Agriculture, Forest Services, Provincial and National Parks with regard to the type of surveys we would be engaged in, lectures etc.

15. Reports:

A decision to produce the report on the condition and ecological bench marking in the Athabasca tar sands area jointly with Dr. Hocking and his subsequent appointment to C.W.S. have resulted in a delay in report completion.

The report on survey of a forest community near a cement production industry has been deferred due to priority shifts.

Reports Completed:

1. Effects of Salt-Water Spills on Forest Land. I. K. Edwards and R. A. Blauel. Presented at the conference on The Environmental Effects of Oil and Salt Water Spills on Land. Nov. 75 and to be published in the proceedings.

2. Condensate Release Impacts on a Forest Area. R. A. Blauel and G. L. Lesko. Also presented at the conference on The Environmental Effects of Oil and Salt Water Spills on Land. Nov. 75 and to be published in the proceedings.

3. Environmental Stress in the Forest. March 75 Forestry Report.

4. Guidelines for the Assessment of the Environmental Impact of Air Pollution Released by the Nickel Smelter at Thompson, Manitoba. D. Hocking and R. A. Blauel. June 1975 file report.

16. Concerning the preparation of the guidelines for the Mackenzie Delta Gas Development System the following were undertaken and completed: A review was made of relevant decision models, environmental impact assessment principals and environmental guideline procedures; a technical seminar was attended where industry representatives presented their concepts concerning engineering designs, environmental

safeguards and socio-economic considerations for the development system; fourteen volumes of industry reports concerning the development system were reviewed; a compilation and analysis was made of the various environmental problems and forest impacts encountered from the oil and gas industry in the prairies region; a first draft entitled "Guidelines for the Mackenzie Delta Gas Development System" was prepared and submitted to the Chairman; a working group session where the final draft of the guidelines were extensively discussed and roughly spliced together was participated in and contributions were made in the final splicing, editing and proofing processes in assistance to the committee chairman.

The following reports were produced:

1. Guidelines for the Mackenzie Delta Gas Development System--A first draft (file report) by R. Blauel.

2. Guidelines for the Environmental Assessment of the Proposed Mackenzie Delta Development--(file report) by the Mackenzie Delta Working Group.

14. Goals for 1976-77:

1. In the summer of 1976, one man will be stationed at Winnipeg and will conduct special and routine impact and appraisal surveys in Manitoba. Two men will be stationed at Prince Albert during the summer and will be engaged primarily in extension work on insect, disease and pollutant problems in Saskatchewan. Two men will be stationed in Edmonton, and will engage in similar activities in Alberta. Two men will be assigned to special tasks as the needs arise, and will assist Prince Albert and Edmonton extension officers during peak work loads.

2. Provide a field diagnostic and pest extension service to client agencies and the public concerning the cause and control of problems of trees and shrubs attributable to insects, diseases and pollutants. When positive identification of the cause is impossible in the field, specimens will be referred to specialists--Study NOR-1-154 for insects, NOR-1-153 for diseases and other specialists as required.

3. Monitor known outbreaks of defoliating insects as required: forest tent caterpillar in the three Prairie Provinces; eastern spruce budworm in Manitoba and northern Alberta; jack pine budworm in southeastern Manitoba; and fall cankerworm along the Red and Assiniboine rivers in Manitoba.

4. Limited detection surveys will be conducted in Manitoba, particularly in parks and high-value fibre producing areas.

5. Training seminars or courses will continue to be given to staff of as many provincial and federal agencies as possible, in order to better acquaint them with common insect and disease pests of their area.

6. Available information on insect and disease pests will be collated into an annual report outlining known pest problems in the Region.

7. A limited number of photographs of insect and disease pests will be taken, to complete the illustrations for the brochures being prepared. Assistance will also be given in searching the literature when required.

8. A pre-season forecast of anticipated insect and disease problems for the summer of 1976 will be made.

9. Conduct limited detection surveys of *Scleroderris* canker and Dutch elm disease in Saskatchewan, Alberta and adjacent areas of B.C. A note will be prepared for publication on the added distribution of *Scleroderris* canker in Alberta and B.C. with Dr. Funk (PFRC). (Hiratsuka)

10. Limited evaluations of suspect pollution damage will be made when the situation warrants such action.

    Possible areas are: Flin Flon and Prince Albert.

11. The following reports will be completed (Blauel):

    The Forest Condition and Ecological Bench Marking in the Athabasca Tar Sands Area.

    Survey of a Forest Community near a Cement Production Industry.

12. An advisory service concerning the impact of air and land-spill pollutants on forest ecosystems will be provided (Blauel).

15. Publications:

Up to 1975-76

Blauel, R.A. 1974. Survey field problem definition regarding forest pollutant occurrences. File Report.

Blauel, R.A. and D. Hocking. 1974. Air pollution and forest decline near a nickel smelter. NOR-X-115.

Blauel, R.A. and D. Hocking. 1974. Problems of chloride and heavy metal contamination. In Proceedings on reclamation of disturbed lands in Alberta. NOR-X-116.

Blauel, R.A. and D. Hocking. 1974. Impact of an ammonia release on trees. File Report.

Blauel, R.A. and G.J. Smith. 1974. New Norway well site examination. File Report.

Caltrell, R.M. and J.C.E. Melvin. 1974. Forest Insects Collected in Elk Island National Park 1948-1971. NOR-X-111.

Emond, F.J. *et al.* 1974. Forest Insects and Diseases in Eight Western Canadian Parks 1973. 17 p. NOR-X-90.

Emond, F.J. and G.N. Still. 1974. Forest Insect and Disease Conditions in Manitoba Provincial Parks 1973. 17 p. NOR-X-91.

Gautreau, E.J. and J.C.E. Melvin. 1974. Forest Insects Collected in Waterton National Park 1948-1971. NOR-X-120.

Gautreau, E.J. and J.C.E. Melvin. 1974. Forest Insects Collected in Kananaskis Forest Experiment Area 1948-1971. NOR-X-88.

Hocking, D. 1974. Preliminary Survey of the Forest Condition near the Transmountain Pipeline Pumping Station. File Report.

Hocking, D. 1974. Effects on the Forest of Sulphur Dioxide from a sulphur Fire near Edson, Alberta. NOR-X-139.

Hocking, D. 1974. Interim report on long-term impact on the forest of emissions from a sulphur extraction plant.

Hocking, D. 1974. Decline of the forest in the Pine Point area, N.W.T. File Report.

Hocking, D. 1974. The forest impact of sulphur dioxide fumes from underground combustion of sulphide ores near Kimberley, B.C. File Report.

Hocking, D. and R.A. Blauel. 1974. Supplementary information for the Manitoba Clean Environment Commission on Air Pollution and Forest Decline near a Nickel Smelter. Appendix to NOR-X-115.

Ives, W.G.H, J.J. Lawrence and J.K. Robins. 1974. Important forest insects and diseases (in the) Prairies Region. *In* Forest Insect and Disease Survey Annual Report, 1973. pp. 70-77.

Mortenson, K. *et al.* 1974. Forest Insects Collected in Prince Albert National Park 1948-1971. 40 p. NOR-X-108.

Patterson, V.B. 1974. Regeneration Mortality Survey in North Western Pulp and Power Lease at Hinton. 14 p. NOR-X-80.

Patterson, V.B. *et al.* 1974. Forest Insect and Disease Conditions in Alberta Provincial Parks 1973. 14 pp. NOR-X-93.

Petty, J. *et al.* 1974. Forest Insect and Disease Conditions in Saskatchewan Provincial Parks and Trans-Canada Camp Grounds 1973. 31 p. NOR-X-95.

Petty, J. and R.C. Tidsbury. 1974. Shelterbelts in the Regina Plains area. File Report.

Robins, J.K. *et al.* 1974. Annual District Reports: Forest Insect and Disease Survey, Prairie Region 1973. 55 pp. NOR-X-73.

Robins, J.K. and J.P. Susut. 1974. Red belt in Alberta. NOR-X-99. July 1974. 6 p.

Smith, G.J. and R.A. Blauel. 1974. Vicary Creek Valley well site re-examined. File Report.

Smith, G.J. and J.C.E. Melvin. 1974. Forest Insects Collected in Yoho National Park 1948-1971. NOR-X-105.

Smith, G.J. and J.C.E. Melvin. 1974. Forest Insects Collected in Kootenay National Park 1948-1971. NOR-X-110.

Still, G.N. *et al.* 1974. Forest Insects Collected in Banff National Park 1948-1971. 37 p. NOR-X-104.

Still, G.N. *et al.* 1974. Forest Insects Collected in Riding Mountain National Park 1948-1971. NOR-X-106.

Susut, J.P. and J.C.E. Melvin. 1974. Forest Insects Collected in Jasper National Park 1948-1971. NOR-X-107.

Wong, H.R. and J.C.E. Melvin. 1974. Insects of Aspen catkins in the Canadian Prairies. Northern Forest Research Centre, Edmonton, Alberta. 27 p. NOR-X-76.

1975-76

Anon. 1975. Guidelines for the environmental assessment of the proposed Mackenzie Delta development. File report by the Mackenzie Delta Working Group.

Blauel, R.A. 1975. Guidelines for the Mackenzie Delta gas development system. A first draft. File report.

Blauel, R.A. and G.L. Lesko. 1975. Condensate release impacts on a forest area. Presented at the conference on the environmental effects of oil and salt water spills on land. November 1975. (To be published in the proceedings).

Drouin, J.A. and H.R. Wong. 1975. Biology,damage and chemical control of the poplar borer (*Saperda calcarata)* in the junction of the root and stem of balsam poplar in western Canada. Can. J. For. Res. 5:433-439.

Edwards, I.K. and R.A. Blauel. 1975. Effects of salt water spills on forested land. Presented at the conference on the environmental effects of oil and salt water spills on land, November, 1975. (To be published in the proceedings).

Ives, W.G.H., J.J. Lawrence, J. Petty and J.K. Robins. 1975. Important forest insects and diseases in the Prairies Region. *In* Forest Insect and Disease Survey Annual Report, 1974. Forestry Service, Environment Canada. pp. 75-81.

Patterson, V.B. *et al.* 1975. Annual district reports: Forest Insect and Disease Survey, Prairies Region, 1974. NOR-X-125.

16. Signatures:

Investigator

Investigator

Investigator

Program Manager

Investigator

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976-77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and appraisal of tree pests.

2. Title: Sawfly systematics

3. New: Cont.: X 4. No.: NOR-1-058

5. Study Leader: H. R. Wong

6. Key Words: Tenthredinoidea, Nearctic Region, distribution, hosts, keys, life history, morphology, new genera, new species, biogeography, revision, symphyta, evolution, phylogeny.

7. Location of Work: Edmonton, Alberta

8. Problem:

To study the systematics of the sawflies of Canada. Until sawflies are identified, they cannot be discussed or treated in a scientific way. Accurate identification of pest species can determine their area of spread and assist in confining their damage to a restricted area. Systematic studies can provide the means of making predictions and generalizations about probable habits, distribution, future importance of newly discovered species, and clues on possible methods of control. It is the means by which an orderly system is provided for storing information about sawflies and is an important retrieval device.

Success in this study is excellent provided time, funds and technician assistance are available. Since I am only one of two people in Canada, at the present time, actively engaged in the systematic study of sawflies, any results obtained would add to the knowledge of this group of insects in Canada, and their role in our environment. Such knowledge would also aid certain biological and ecological studies in North America.

The material is made available by a number of agencies requesting identification services, in particular the Forest Insect and Disease Surveys across Canada. Species identification is generally based

on the microscopic examination of the extracted genitalia, which are mounted on slides. After comparison with available types, any new species are described and illustrated together with other pertinent information on host, life history, distribution, immature stages, phylogeny etc. Keys are constructed to assist in future identification.

9. Study Objectives:

a. To make systematic studies of the sawflies of Canada, noting their mature and immature forms, distribution, host, seasonal occurrence, importance to forestry, subspecies, strains and phylogenetic relationships.

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

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

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

10. Resources:

a. Starting date: 1950
b. Estimated year of completion: a continuing project Revised:
c. Estimated total Prof. man-years required: indefinite
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.5
Supp.	0.0
Casual	0.0
Total	0.5

11. Progress to Date:

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 Prairies 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, U.S.A. and Europe); *Allantus* (Canada and U.S.A.); *Decanematus* (Canada); *Pristola* (Canada), *Melastola* (Canada and U.S.A.); and *Susana* (Canada).

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

Diagnostic keys to species in the following genera have been published: *Pristiphora* (South American adults, *abietina* group), *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, strains of *Pristiphora erichsonii* and *abietina* group of *Pristiphora* have been published. Two new genera *Sharliphora* and *Melastola* were established in the family Tenthredinidae.

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.

A brochure was prepared on the life history, damage and control of the three birch leaf-mining sawflies in the Prairies.

The *Pristiphora* section of the new Hymenoptera of America north of Mexico synoptic catalog was revised for Dr. D. R. Smith, Washington, D. C.

The study of the external morphology and genitalia of over 2,000 specimens of the larch sawfly indicate five strains. Two Eurasian strains (Ambleside and Thirlmire) were accidentally introduced into Canada from England by 1913. The Ambleside strain is resistant to the parasite *Mesoleius tenthredinis*. The early infestations in North America were caused by the native strains (Aweme and Fernie) and the later infestations by the introduced strains. The fifth strain (Salzburg) is confined to Eurasis.

The *abietina* group of *Pritiphora* has been studied and the lancets and penis values illustrated. In this group, a new species described, another synonymized, a species indicated as a variety was reestablished as a species and a new species name for a homonym.

12. Goals for 1975-76:

    1. Identify specimens of *Pristiphora* submitted by Dr. D. R. Smith, Systematic Entomology Laboratory, Agricultural Research Service, USDA, Washington.

    2. Publish the results on the revision of the *abietina* group of *Pristiphora*.

    3. Continue work on the revision of the genus *Pristiphora*.

13. Accomplishments in 1975-76:

    1. The sixty four specimens of *Pristiphora* submitted by Dr. D. R. Smith, Washington have been identified by studying the dissected genitalia.

    2. Published the "*abietina*" group of *Pristiphora* (Hymenoptera: Tenthredinidae). Can. Ent. 107:45-463.

    3. The following new species have been discovered:

        1. Species closely related to the mountain ash sawfly, *Pristiphora geniculata* (Hartig) from China.

        2. Species related to *Pristiphora chlorea* (Norton) and *P. fausta* (Hartig) feeding on *Quercus* from China.

        3. Species related to *Pristiphora brasiliensis* Malaise and *P. plaumanni* Wong from Mexico.

14. Goals for 1976-77:

    1. Publish: American species of *Pristiphora* south of the United States. Journal. *Pristiphora* species of southeast Asia (Hymenoptera: Tenthredinidae). Journal.

    2. Determine the life history of a willow shoot-boring sawfly, *Euura atra* (Jurine) in Alberta.

    3. Identify sawflies for research personnel, institutions, laboratories and the Canadian National Collection.

15. Publications:

Up to 1975-76

Lejeune, R. R. and H. R. Wong. 1949. Distribution of larch sawfly in Manitoba and Saskatchewan. Canada, Dept. Agric., For. Biol. Div., Bi-monthly Prog. Rept. 5(6):2.

Wong, H. R. 1950. Sawfly larvae of the subfamily Nematinae attacking conifers in the forests of the Canadian Prairies. Master thesis. Michigan State University: 1-33.

Wong, H. R. 1951. Cocoons of some sawflies that defoliate forest trees in Manitoba and Saskatchewan. Ann. Rept. Ent. Soc. Ontario 82:62-67.

Wong, H. R. 1954. Common sawflies feeding on white birch in the forested areas of Manitoba and Saskatchewan. Can. Ent. 86:154-158.

Wong, H. R. 1955. Nearctic larvae of the genus *Anoplonyx* (Tenthredinidae: Hymenoptera). Can. Ent. 87:224-227.

Wong, H. R. 1956. Preliminary notes on intersexes and gynandromorphs of the larch sawfly. Can. Ent. 88:545.

Wong, H. R. 1956. Common *Tenthredo* larvae feeding on deciduous trees in the Canadian Prairies (Tenthredinidae: Hymenoptera). Interim Rept. Forest Biology Lab: 19-25.

Wong, H. R. 1957. Sawflies of the genus *Platycampus* Schiodte on trembling aspen in the Canadian Prairies. Canada, Dept. Agric., For. Biol. Div., Bi-monthly Prog. Rept. 13(4):2.

Wong, H. R. 1958. The morphology of the adult of the larch sawfly, *Pristiphora erichsonii* (Htg.) (Tenthredinidae: Hymenoptera). Interim Rept. Forest Biology Lab., Winnipeg 1958-1: 1-43:

Wong, H. R. 1958. The morphology of the ultimate larval instar of the larch sawfly, *Pristiphora erichsonii* (Htg.) (Tenthredinidae: Hymenoptera). Interim Rept., Forest Biology Lab., Winnipeg 1958-1: 1-16.

Wong, H. R. 1960. Evolution of the sawfly genus *Pristiphora*. Doctor of Philosophy in Entomology Thesis. University of Illinois: 1-113.

Wong, H. R. and H. H. Ross. 1960. New Nearctic species of the genus *Pristiphora* Latreille (Hymenoptera:Tenthredinidae) Can. Ent. 92(3): 193-198.

Wong, H. R. 1960. Evolution of the sawfly genus *Pristiphora* Diss. Abs. 21(6): 1676.

Wong, H. R. 1963. The external morphology of the adults and ultimate larval instar of the larch sawfly, *Pristiphora erichsonii* (Htg.) (Hymenoptera:Tenthredinidae). Can. Ent. 95:897-921.

Wong, H. R. and R. B. Benson. 1965. A new species of *Pristiphora* from Brazil (Tenthredinidae:Hymenoptera). Can. Ent. 97(7):779-782.

Wong, H. R. 1966. A new species of *Allantus* Panzer on birch (Hymenoptera:Tenthredinidae) Can. Ent. 98(8):852-854.

Wong, H. R. 1967. The Nematine genera *Eitelius* and *Micronematus* in North America (Hymenoptera:Tenthredinidae). Can. Ent. 99:1101-1104.

Wong, H. R. 1968. *Decanematus*, a sawfly genus new to North America (Hymenoptera:Tenthredinidae). Can. Ent. 100(1):84-86.

Wong, H. R. 1968. *Pristiphora gelida*, a new species from Alaska (Hymenoptera:Tenthredinidae) J. Nat. Hist. 2:185-186.

Wong, H. R. 1968. A revision of the tribe Pristolini (Hymenoptera: Tenthredinidae) Can. Ent. 100:1049-1057.

Wong, H. R. 1969. Reassignment of the *ambigua* group of *Pristiphora* to a new genus *Sharliphora* (Hymenoptera:Tenthredinidae). Can. Ent. 101:332-335.

Wong, H. R. 1969. *Pristiphora acidovalva*, a new sawfly on willow (Hymenoptera:Tenthredinidae). Can. Ent. 101:970-972.

Wong, H. R. and W.G.H. Ives. 1969. The European spruce sawfly in Manitoba. Bi-monthly Res. Notes. 25(6):47.

Wong, H. R. 1972. The spread of the European spruce sawfly *Diprion hercyniae* (Hymenoptera:Diprionidae) in Manitoba. Can. Ent. 104:755-756.

Wong, H. R. and H. E. Milliron. 1972. A Canadian species of *Susana* on western juniper (Hymenoptera:Tenthredinidae) Can. Ent. 104:1025-1028.

Wong, H. R. 1974. The identification and origin of the strains of the larch sawfly, *Pristiphora erichsonii* (Hymenoptera: Tenthredinidae), in North America. Can. Ent. 106:1121-1131.

1975-76

Wong, H. R. 1975. The *abietina* group of *Pristiphora* (Hymenoptera: Tenthredinidae. Can. Ent. 107:451-463.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-1-089

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and appraisal of tree pests and vegetative disturbances.

2. Title: Analysis and synthesis of Forest Insect and Disease Survey historical data and information.

3. New: Cont.: X 4. No.: NOR-1-089

5. Study Leader: W. G. H. Ives

6. Key Words: Population trends, computer mapping, data retrieval, insects and environment.

7. Location of Work: Edmonton and Ottawa

8. Problem:

The large body of data collected by the Forest Insect and Disease Survey since its inception has never been thoroughly examined to determine what information it contains regarding population trends and the environment.

Some of the data on general distribution and abundance and on rates of parasitism were in reports or on raw data sheets, but had not been transferred to forms suitable for computer input. Similarly, the format used by the Meteorological Branch of the Department of Transport for summarizing their weather data was not suitable for some of the analyses, and additional summaries had to be prepared.

This study has undertaken to consolidate all of the available information on common insects and weather records for Manitoba and Saskatchewan into a format suitable for computer input, and to subject these data to a thorough examination. Writing of the necessary computer programs will be undertaken by staff in Ottawa.

9. Study 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.

10. Resources:

a. Starting date: 1969
b. Estimated year of completion: 1978
c. Estimated total Prof. man-years required: 3
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years Prof. 0.2 (W.G.H. Ives)
Supp. -
Casual -
Total 0.2

11. Progress to Date:

Data have been placed on magnetic tape, edited and upgraded where necessary. These data include the FIDS historic file (for Manitoba and Saskatchewan) and ancillary data on weather, and infestation records and percentage parasitism for major defoliators.

12. Goals for 1975-76:

1. If time permits, begin preliminary investigation of possible relationships between weather and other defoliating insects. Possible candidates are the large aspen tortrix and jack pine budworm.

2. Hopefully, if a programmer is assigned to this study as promised, summaries of historic data may yet be forthcoming. Otherwise the task seems too large to handle locally with available resources and probably should be dropped. I would favor this action if no programmer is assigned by Ottawa during 1975-76.

13. Accomplishments in 1975-76:

1. Development of large aspen tortrix, based on head-capsule measurements, showed a large amount of variation both in time and space. Insects collected in northern areas required less heat to reach comparable stages of development than those collected farther south. In addition, collections made at a given time and place contained individuals in two or more instars or stages. This is presumably a reflection of differences in over-wintering location, since larvae in exposed situations, if alive, would start developing before those in sheltered areas at the base of the trees.

   Because of the variation, the use of heat units for predicting field development of large aspen tortrix does not seem practical.

   There were not enough jack-pine budworm larvae to establish any relationships.

2. A program has been developed by programmers in Ottawa that will provide preliminary data summaries for all variables. A test run has been made and this is currently being checked for accuracy.

14. Goals for 1976-77:

1. Complete the checking of test data, and have necessary corrections made to any errors in the program.

2. Obtain printouts of appropriate data summaries for 12 of the more common insects (there are 25 in all).

3. If Ottawa's funding permits, obtain additional printouts summarizing available data for the other 13 species.

4. Begin preliminary examination of the data to determine if any meaningful interrelationships can be detected.

15. Publications:

Up to 1975-76:

Ives, W.G.H. 1973. Heat units and outbreaks of the forest tent caterpillar, *Malacosoma disstria (Lepidoptera:basiocampidae)*. Can. Ent. 105:529-543.

Ives, W.G.H. 1974. Weather and outbreaks of the spruce budworm, *Choristoneura fumiferana*. Information Rept. NOR-X-118.

1975-76

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-1-110

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and estimation of tree pests and vegetative disturbance.

2. Title: Dutch Elm disease detection and diagnosis.

3. New: Cont.: X 4. No.: NOR-1-110

5. Study Leader: V. Hildahl

6. Key Words: entomology, pathology, detection, appraisal, insect control, disease control, tree species.

7. Location of Work: Manitoba

8. Problem:

Nature of Study:

The Dutch elm disease is a fatal disease of native and planted American elm. It is transmitted from diseased to healthy trees mainly by bark beetles. The causal fungus *(Ceratocystis ulmi)* was first found in North America in Ohio in 1930. Since then it has spread north and eastward into Canada from Ontario to the Maritime Provinces and westward in the United States to Idaho, Washington and California. During the past 45 years, the disease has affected more than 80 per cent of the natural range of American elm in North America and has spread to parts of the continent where the host tree occurs only as ornamental or shelterbelt plantings.

In 1975, the pathogen was isolated from American elm at three locations in Manitoba, namely Winnipeg, Selkirk and Brandon. The expansion of the disease to Manitoba is of great importance, especially to many urban centres in the southern part of the Prairie Provinces where American elm has been used extensively (and in some cases almost exclusively) for boulevard and ornamental purposes.

Benefits of Study:

Major benefits of the study will be to reduce the impact of the disease in outbreak areas, thus maintaining the aesthetic values and pleasant environments associated with natural stands and plantings of American elms. In many urban centres and park areas throughout the prairie region American elm represents up to 80 per cent of the tree cover.

Probability of Success:

Now that the disease is present, the probability exists that within the next few years it may spread to most parts of the southern prairie regions where elms occur. Early detection and diagnosis followed by proper recommended sanitation procedures are important factors in controlling Dutch elm disease. In areas where these practices have been emphasized elm losses have been reduced by 1-5 per cent per year as compared to 16-60 per cent where sanitation measures have not been carried out.

9. Study Objectives:

The objective of the study are primarily: 1) to carry out systematic detection and diagnostic services leading to early discovery of diseased trees or localized outbreaks of the Dutch elm disease in the Manitoba region; and 2) to provide technical advice, guidance and assistance to provincial, municipal and urban governments with respect to sanitation and chemical control procedures.

An important advisory function pertaining to the Dutch elm disease study is serving as a member on a Provincial Advisory Committee on Tree Protection established by the Minister of Agriculture.

10. Resources:

a. Starting date: 1970
b. Estimated year of completion: continuing
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs:
   An airflow cabinet at approximately $800 for laboratory culturing of wood and bark samples. Because other fungi exhibit similar symptoms to those of the Dutch elm disease, positive identification of *C. ulmi* is possible only through laboratory diagnosis. In addition, the discovery of Dutch elm disease in Manitoba in 1975 more than tripled (from 70 to 230) the amount of laboratory culturing as compared to previous years and further increases are expected in 1976. This facility would greatly improve the efficiency of laboratory staff as well as improve the quality of cultures.
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years: V. Hildahl 0.7

11. Progress to Date:

Since 1970, elm disease investigations in Manitoba have involved ground and aerial reconnaissance. Detection surveys have been concentrated along river valleys, and in urban centres and rural areas where major concentrations of American elm occur. During the five-year period to 1974, approximately 3,500 suspect trees (trees with characteristic external symptoms--flagging, dead branches or die-back in the crown) were sampled, of which about 35 per cent

exhibited evidence of peripheral stain in the wood. Laboratory diagnosis of material from these latter trees indicated widespread infections of Fusarium and Verticillium wilts, and occasional occurrence of Cephalosporium wilt. All of these wilts are part of the elm disease complex in Manitoba.

Aerial photography using infrared and color films was carried out in 1973 along the Red River as an aid to early detection of elm disease, especially Dutch elm disease. Two scales of photography were obtained as follows: high-level photography was taken of the area from Winnipeg to Emerson at 10,000 feet AGL using 3" lens and low-level photography from St. Norbert to Glenlea at 1,000 feet AGL using a 12" lens. The aerial photography was carried out by the Remote Sensing Group, Northern Forest Research Centre.

12. Goals for 1975-76:

1. Continue detection (aerial and ground) surveys throughout areas of concern in southern Manitoba, and provide diagnostic services as required for cooperating provincial and municipal agencies.

2. Continue to provide technical services to cooperating agencies concerned with the Dutch elm disease problem, especially in relation to sanitation practices and control procedures.

3. Complete Information Report entitled "Elm Diseases in Manitoba," including interpretation of aerial photography.

13. Accomplishments in 1975-76:

1. Through our regular detection and diagnostic services, Dutch elm disease was discovered for the first time in Manitoba at three localities (Selkirk, Winnipeg and Brandon). The causal fungus of Dutch elm disease was positively identified in cultures from 7 trees in the Brandon area, 5 trees in the Winnipeg area, and 17 trees in the Selkirk area. This announcement in August that Dutch elm disease was present resulted in more than a four-fold increase in the number of inquiries received from concerned citizens. During the field season, more than 1,000 trees on public and private properties were sampled, of which about 230 required laboratory culturing for diagnosis.

2. Technical advisory services to cooperating agencies (provincial and municipal) concerned with the Dutch elm disease problem were intensified, particularly with respect to sanitation programs and control procedures.

3. The Information Report "Elm Diseases in Manitoba" was not completed.

14. Goals for 1976-77:

1. Continue detection (aerial and ground) surveys throughout areas of concern in southern Manitoba, and provide diagnostic services to cooperating provincial and municipal agencies.

2. Continue to provide technical services to cooperating agencies concerned with the Dutch elm disease problem, especially in relation to sanitation practices and control procedures.

3. Complete Information Report entitled "Elm Diseases in Manitoba," including interpretation of aerial photography.

15. Publications: Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976-77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and appraisal of tree pests and vegetation distrubances.

2. Title: Forest diseases: Diagnostic and taxonomic services.

3. New: X 4. No: NOR-1-153

5. Study Leader: Y. Hiratsuka

6. Key words: mycology, herbarium, culture collection, nomenclature, identification,

7. Location of work:

8. Problem:

Accurate and prompt diagnosis of tree diseases and identification of causal organisms are essential to the pest extension services, damage appraisal studies, environmental assessment studies, and consideration of possible control measures of tree diseases. Besides, non pathogenic fungi in forest ecosystems also play important rolls in nature. Proper identifications of mycorrhizal fungi, decomposing fungi and hyperparasitic fungi in the forest are important to many research studies and provide better understanding of forest ecosystems.

Taxonomy and nomenclature of fungi are constantly being revised. Changes in the concepts and limits of species and application of new or different names for the same organisms often cause confusion. Proper applications of up-to-date information of taxonomy and nomenclature are necessary whenever names of the organisms are used in reports or publications. To provide satisfactory taxonomic and nomenclatural service, a highly trained technical and professional staff is required.

To maintain and improve diagnostic and taxonomic service capabilities, it is necessary to maintain a high quality disease reference collection, a fungus culture collection and a reference literature collection. The disease reference collection of the centre contains more than 20,000 catalogued specimens of forest fungi and it is the

biggest collection of forest fungi in the prairie provinces. The fungus culture collection includes more than 500 live cultures of major forest fungi. The centre maintains all major taxonomic literatures of the fungi.

9. Study Objectives:

1. To provide diagnostic and taxonomic service of tree diseases and other forest fungi.

2. To maintain and improve diagnostic and taxonomic service capabilities of tree disease pathogens and other forest fungi in the region.

3. To prepare check lists of forest fungi of important areas (e.g. national parks, provincial parks etc.), diagnostic keys for identification, and other related publications.

10. Resources:

a. Study date: 1976 (Included as a part of NOR-1-033 until 1975-76).
b. Estimated year of completion: Continuous
c. Estimated total Prof. man years required:
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.4
Supp.	1.3
Casual	Nil
Total	1.7

11. Progress to Date:

Reported as a part of NOR-1-033.

12. Goals for 1975-76:

Reported as a part of NOR-1-033.

13. Accomplishments in 1975-76:

Reported as a part of NOR-1-033.

14. Goals for 1976-77:

1. Provide tree disease diagnostic and identification service. Diagnostic and identification service will be provided mainly for the general public and outside agencies through pest extension service.

2. Maintain and upgrade the Mycological Herbarium. Exchange of specimens will be arranged with several institutions.

3. Complete the reorganization of fungus culture collection.

4. Make taxonomic investigation of a possible new fungus (*Marssonina* sp.) on balsam poplar. A short journal publication describing the fungus will be prepared if the fungus is new.

5. Complete check lists of forest fungi collected in Prince Albert and Elk Island National Parks.

6. "Annotated check list of diseases of trees and shrubs of the prairie provinces" will be completed for information report.

7. Make significant progress towards the publication of an information publication on diseases of trees and shrubs of the prairie provinces.

15. Publications:

N/A

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976-77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 28, 1976

1. Project: Detection and appraisal of tree pests.

2. Title: Forest Insect Diagnostic and Biosystematic Services

3. New: Cont.: X 4. No.: NOR-1-154

5. Study Leader: H. R. Wong

6. Key Words: Insects, larvae,damage, hosts, parasites, biological control, galls, seasonal occurrence, distribution, nomenclature, taxonomy, identification, reference collection, insectary, life history.

7. Location of Work: Edmonton, Alberta

8. Problem:

Insects play a very important role in the forest ecosystem. They attack every part and stage of living and harvested trees. Prompt and accurate identification of the adult and larval stages is necessary to determine the economic status of the different species, kind and type of chemical or biological control necessary to combat them and the best time of application. A reference collection of mature and immature insects, which is an essential prerequisite to diagnostic and biosystematic work, must be maintained and upgraded each year.

Since most of the damage is caused by the immature stages and insect identification is based mainly on the adult stage, a rearing program is a necessity. The rearing program not only provides adults for the identification of the larvae, but also information on seasonal occurrence,hosts, parasites and diseases. It also supplies material for the adult and larval reference collections.

Difficulties are often encountered in diagnosing sibling species or those closely resembling one another either in the adult or

larval stages. Life history studies are initiated when the opportunity arise to gain biological information, which will assist in separating these and other species in Central Canada. The success of the diagnostic and biosystematic services are excellent provided experienced personnel, good insect reference collections (adults, larvae and damage) and major taxonomic literature are available. Considerable time must be devoted to keeping abreast of the latest entomological literature and changes in nomenclature. To facilitate prompt and accurate diagnosis, keys must be devised not only to the adult and immature forms, but also to insect damage in the Canadian Prairies.

The material is provided by personnel of the Forest Insect and Disease Survey and by the investigator. The immature insects are reared in the laboratory at Edmonton and in the field. The adults obtained are submitted to specialists in Ottawa or elsewhere in North America or Europe for identification and the latest nomenclature. All adults identified by specialists and larvae and damage associated with these adults are placed in the reference collection.

9. Study Objectives:

1. Provide diagnostic and biosystematic services to clients, in-service personnel, outside agencies and scientists engaged in biological and taxonomic research on insects.

2. Maintain and improve the regional collection of insects and mites.

3. When the opportunity arise, initiate biological and ethological studies to improve the diagnostic and biosystematic services.

10. Resources:

a. Starting date: 1976
b. Estimated year of completion: A continuing project. Revised.
c. Estimated total Prof. man-years required: Indefinite.
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.5
Supp.	1.0
Casual	0.0
Total	1.5

11. Progress to Date: Recorded in NOR-1-033

12. Goals for 1975-76: See NOR-1-033

13. Accomplishments in 1975-76: Report in NOR-1-033

14. Goals for 1976-77:

    1. Provide diagnostic and biosystematic services.

    2. Maintain and improve regional reference collection of insects and mites.

    3. Provide information and specimens to scientists engaged in taxonomic and biological studies.

    4. Publish: Biological observations and larval descriptions of *Enargia decolor* on trembling aspen in northern Alberta (Lepidoptera: Noctuidae). Journal.

15. Publications:

    Up to 1975-76

    Recorded in NOR 033

    1975-76

    Recorded in NOR 033

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-7-114

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 4, 1976

1. Project: Reduction of damage from pollutants in the atmosphere.

2. Title: Symptomology of atmospheric effluent effects on the forest.

3. New: Cont. X 4. No.: NOR-7-114

5. Study Leader: R. A. Blauel, S. S. Malhotra, and J. Baker

6. Key Words: sulphur gases, vegetation, lodgepole pine, white spruce.

7. Location of Work: Region-wide.

8. Problem:

Industrial effluents discharged into the atmosphere in a number of locations have a real, imagined, or potentially deleterious effect upon adjacent trees and other plant life. Government agencies and the general public at all levels are expressing concern. Industrial groups are apprehensive as to restrictions which may be applied. Regulatory agencies in many instances lack essential scientific information describing cause and effect relations. Provincial government agencies, industry and the public request involvement by the Canadian Forestry Service in this environmental problem in the form of cooperative research programmes, detection and assessment surveys, and advisory services.

9. Study Objectives:

1. Develop and apply methods for measurement of air-borne pollutants released from various sources at they are removed from the atmosphere by settleout, by precipitation and by assimilation. (Blauel, Baker)

2. Describe vegetative symptom development resulting from known amounts of single and combined atmospheric industrial effluents, the sequence in which they are produced and develop diagnostic techniques based on these findings. (Malhotra)

3. Discern air pollutant injury thresholds and develop a species sensitivity index for different environmental conditions. (Blauel)

4. Test the Federal Air Quality objectives for air quality under defined environmental conditions. (Blauel)

10. Resources:

a. Starting date: 1971
b. Estimated year of completion: Revised: 1980
c. Estimated total Prof. man-years required: 2.8
d. Essential new major equipment items for 1976-77 with costs: Nil
fumigation chamber (also required for Studies NOR-24-990, 991, 992 and 993)
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	.3	(S. Malhotra)
	.2	(Vice Hocking)
	.2	(R. Blauel)
	.2	(J. Baker)
	.9	Total
Supp.	.3	(J. Shuya)
	.3	(J. Ridgway)
	.4	(O. Fenn)
	1.0	
Casual	0.6	
	2.5	Total

11. Progress to Date:

Good relations and cooperative working arrangements have been established with Provincial and Federal Government agencies involved with air pollution problems and with industry and the public in the field. The Canadian Forestry Service is regarded within the region as an important contributor of information relating to air pollution effects on vegetation.

Industry-government workshops have been sponsored.

Permanent sample plots have been located and vegetation described, in vicinity of gas processing plants and oil sands processing plants; including plume impingement areas.

Survey on the effects of air pollutants from industrial operations (Thompson, Man.; Flin Flon, Man. and Prince Albert, Sask.) on forest vegetation and soils was conducted in response to requests from various Provincial Government Agencies.

Reference collections of slides, photographs and specimens have been sorted and catalogued.

12. Goals for 1975-76:

1. Clear backlog of field reference collection work on forest species foliar materials by sorting and processing only top priorities. Fill revealed gaps in field symptomology. Continue collections.

2. Prepare a color handbook of comparative symptomology for regional forest species exposed to air pollutants designed for use in the field.

3. Order and supervise construction of the air pollutant fumigation chamber, and dependent on delivery to begin set up, stabilization and calibration of the chamber and ancillary equipment.

4. Adapt micro-chamber to pollutant use and stabilize and calibrate it and ancillary equipment.

5. Attempt exploratory exposures on micro-chamber and describe symptoms produced.

6. Conduct preliminary assessment on the effects of air pollutants from industry on forest ecosystems around Thompson, Flin Flon, Prince Albert and Hinton.

7. Develop and test a biomonitoring system for SO_2 from gas processing plants (R & D Contract - D. Vitt, Univ. of Alberta).

13. Accomplishments in 1975-76:

1. Atomic absorbtion spectrophotometric analysis of vegetative and soil samples is underway. Further collections were made concerning field symptomology.

2. Greenhouse and laboratory trials to clearify certain vegetative symptoms were carried out and photography was completed. The whole of the photographic collection is currently being reviewed and the handbooks preparation is underway.

3. The contract for the fume chamber has been let and construction has started. The delivery of the chamber is expected in July or August of 1976.

4,5. The search for hiring a qualified instrument technologist to achieve goals 4 and 5 was conducted and the final selection of the candidate awaits release of the position.

6. Initiated forest ecosystem impact assessments concerning smelter released air pollutants in the areas of Thompson and Flin Flon and concerning pulp mill air pollutants around Hinton and Prince Albert.

   File reports on the field aspects of these evaluations are completed. Laboratory examination and analysis of field sample collections are currently in progress.

7. Tree lichen inventory was completed around gas processing plants near Rocky Mountain House and a biomonitoring system for SO_2 was developed (final report under preparation - D. Vitt, Univ. of Alberta).

14. Goals for 1976-77:

1. Set up and calibrate the siemens microchamber and run preliminary fumigation trials (Co-ordinated with Study 990). (Blauel and Malhotra)

2. Set up and calibrate the "pollution fumigation chamber". (Blauel and Malhotra)

3. Clear backlog of soil and vegetation samples collected from Thompson, Flin Flon, Hinton and Prince Albert areas and report the findings (Co-ordinated with Study 990). (Blauel, Baker and Malhotra)

4. Complete the color handbooks on symptomology for regional forest species exposed to air pollutants designed for use in the field. (Blauel)

15. Publications:

Up to 1975-76

Loman, A. A. 1972. Atmospheric sulphur dioxide and foliar sulphur content. NOR-Y-48.

Loman, A. A., R. A. Blauel and D. Hocking. 1972. Sulphur dioxide and forest vegetation. NOR-X-49.

Blauel, R. A. 1972. Comments on vegetation section of the Canadian Petroleum Association submission to the Environment Conservation Authority, Alberta Department of the Environment, Edmonton. NOR-Y-73.

Blauel, R. A. 1973. Intervention by CFS-EPS on application by Gulf Oil for exemption from minimum sulphur recovery efficiency guidelines of the Energy Resources Conservation Board, Government of Alberta. January 5, 1973. File Report.

Hocking, D. and D. Reiter (Eds.). 1973. Proceedings of a workshop on sulphur gas research in Alberta. NOR-X-72. 21 papers.

Hocking, D. 1973. Some terms for symptoms on plants exposed to sulphur gases. *In* NOR-X-72.

Rowe, R. D. 1974. Delineation of Plume and Impingement Areas from a Sour Gas Processing Plant.

File Reports

Hocking, D. 1974. Effects on the forest of sulphur dioxide from a sulphur fire near Edson, Alberta.

Hocking, D. 1974. Preliminary survey of the forest condition near the Transmountain Pipeline Co. Ltd. pumping station at Jasper, Alberta.

Hocking, D. The forest impact of sulphur dioxide from underground combustion of sulphide ores near Kimberley, B.C.

1975-76

Hocking, D., S. S. Malhotra and R. Blauel. 1975. Environmental Stress in the Forest. Forestry Report Vol. 4, #2.

Blauel, R. 1975. Summary of Possible Impacts on Forests from Sulphur Dioxide and Other Air Pollutants. File Report NOR-114.

Blauel, R. 1975. Plant selection for reclamation purposes. File Report NOR-114.

16. Signatures:

Investigators

Program Manager

Director G. T. Silver

NOR-7-162

CANADIAN FORESTRY SERVICE

STUDY STATMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 4, 1976

1. Project: Reduction of damage from pollutants in the atmosphere.

2. Title: Effects of atmospheric effluents on forest soils.

3. New: Cont.: X 4. No.: NOR-7-162 (Formerly NOR-7-970)

5. Study Leader: J. Baker

6. Key Words: soil profile, soil horizons, grey wooded soils, phosphate absorption, ammonium-nitrogen, sulphur compounds, air pollution, heavy metals.

7. Location of Work: Region wide.

8. Problem:

This study is necessitated by the fact that industrial operations emit various compounds into the atmosphere. These compounds react with the total environment and have the potential of causing serious damage.

The proposed study will concentrate on sulphur emissions from the Aquitaine Gas Plant and Northwest Pulp & Power Plant. Both direct and indirect effects of sulfur and their reaction products in soils will be studied. Short as well as long term effects will be given consideration.

Agencies, concerned with the potential hazards of air pollutants on the environment frequently lack essential scientific information describing cause and effect relationships. Information obtained from this study should prove beneficial in assessing both the immediate and long term hazards to the soil environment.

If results show positive adverse effects of atmospheric sulphur pollutants on the soil environment, then regulatory agencies will be in possession of additional essential information to set meaningful and safe limits on levels of atmospheric pollutants. On the other hand, if there are no real serious threats to the soil, any previous apprehension, on the part of the various interested agencies, may be dismissed.

9. Study Objectives:

To determine the influence of air pollutants, in the first instance sulphur dioxide gas, on: 1) amount, form and region of accumulation of chemical constituents in the soil, 2) soil micro-flora, especially sulphur and nitrogen organisms, 3) sulphur availability in the soil and the effect of this on sulphur up-take by plants.

10. Resources

a. Starting date: 1974
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 2.0
d. Essential new major equipment items for 1976-77 with costs:
Auto titration unit with "dead stop" feature 7,000
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.4
Supp.	0.5 (Caldwell)
Casual	0.2
Total	1.1

11. Progress to Date:

Twelve sampling sites were installed in the Aqutaine area (Strathmore) to monitor sulfur compound impingement in the area surrounding the Gas Plant. Two gas plants are operating in the area - Aquitaine and Gulf. Gross fall (or open rainfall), thrufall (intercepted rainfall) and stemflow (water flow down tree stems) collecting apparatus were installed at each site. From each site soil samples were removed for analyses. This stage was carried out 1974-75. Results have been reported - see publications #15. Six of the original sites were kept active during 1975-76 - see accomplishments 1975-76 - #13.

Six collection sites were established in the Hinton area to obtain some idea of sulfur impingement in that region in 1975. The collection units were placed in a direction similar to that of the prevailing wind. Only thrufall was collected. For results see accomplishments 1975-76 - #13.

12. Goals for 1975-76:

1. The identification of soil micro-flora will continue.

2. Analysis for SO_4-S, Fe, Al and other cations on soil samples will continue.

3. Investigation of atmospheric sulfur pollutants in the vicinity of Hinton.

13. Accomplishments in 1975-76:

1. A soil micro-flora study was undertaken in the summer of 1975 and resulted in the compilation of methods and techniques for the growth, isolation and identification of nuitrifiers, denitrifiers,sulfur oxidizers and reducers, and other soil micro-flora. Studies were undertaken on soil that had received fertilization with N, P & S in the spring of 1972.

   Neither N nor S oxidizers were detected in any of the fertilized or control samples. At this point it is difficult to decide if the failure to detect these is a result of too high dilutions or the absence of organisms in the soil.

   Denitrifiers were found in one sample of fertilized soil but results were inconsistent on other samples.

   It was found however, that bacterial count changed considerably in samples stored at 10°C. Thus, to obtain a more accurate picture of the micro-flora populations in soils only freshly taken samples should be used.

2. In the Aquitaine area sulfur returned to the soil surface via thrufall was essentially similar to that returned by grossfall. Approximately 6-8 kg S/ha during the 4 collection months (June - September) were returned to the soil surface.

   The much lower pH values of solutions of thrufall probably are the result of the leaching of acidic components from foliage and bark. The greater amounts of calcium, magnesium, potassium, etc. in the thrufall tend to confirm this conjecture.

   Whether by thrufall or grossfall, soil pH values tend to be more acidic within the sulfur impingement zone than in areas and sites more remote from the Gas Plants.

3. In the Hinton area sulfur returned to the soil surface ranged from approximately 7 kg/ha/year 60 kilometers south to about 30 kg/ha/year in the immediate vicinity of Hinton. At a site 16 kilometers northeast of Hinton sulfur returned to the soil by precipitation was about half that observed in the immediate vicinity of Hinton. It is possible that much of this sulfur had its source in the pulp and power plant at Hinton.

Much calcium and some magnesium was found in the same solutions. While some calcium may have had its origin in the pulping process, most of the calcium and magnesium probably is wind blown from beds of loess along the Athabasca flood plains.

14. Goals for 1976-77:

1. Soil micro-flora studies will continue but the extent and detail will depend on suitable support help.

2. Sampling units similar to those used in Hinton (some modification) will be placed throughout the Aquitaine area.

3. A report of the results of the Hinton and Aquitaine results is planned. No field work for the Hinton area is planned for this year.

15. Publications:

Up to 1975-76

Nil

1975-76

Baker, J., D. Hocking and M. Nyborg. 1975. Acidity of open and intercepted precipitation in forests and effects forest forest soils in Alberta, Canada. *In* Proc. First International Symposium on acid precipitation and forest ecosystems, Columbus, Ohio.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-7-974

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 4, 1976

1. Project: Reduction of damage from pollutants in the atmosphere.

2. Title: Effects of atmospheric effluents on biochemical processes of the forest vegetation.

3. New: Cont.: X 4. No.: NOR-7-974

5. Study Leader: S. S. Malhotra

6. Key Words: photosynthetic fixation, lodgepole pine, photosynthetic pigments, aqueous sulphur dioxide, Na $H^{14}CO_3$, biomass, spectrophotometry, pigment metabolism, *in vivo*, *in vitro*.

7. Location of Work: Northern Forest Research Centre.

8. Problem:

One of the major concerns in industrialized areas is the emission of effluents into the atmosphere. Most of these effluents have a great potential to cause irreversible damage to forest trees and other vegetation. Since there is not enough information available either on direct or indirect effects of air pollutants on plant life, regulatory agencies have difficulty in applying any meaningful and effective restrictions.

Sulphur dioxide is the principal atmospheric pollutant in many industrial areas. Research on this gas has been mostly limited to physiological studies (work with intact tissues) and description of the necrotic symptoms which develop on plant leaves. The mechanism of SO_2 toxicity at molecular level has not been examined in detail. An understanding of the biochemical mechanism of SO_2 toxicity in forest species would help to explain their pollution sensitivity and would provide information on the effects (positive or negative) of low levels of sulphur dioxide on biomass production. The regulating agencies when supplied with this vital information will be in a better position to set more rational levels of SO_2.

Since SO_2 has been shown to cause discoloration of leaves, we will examine the effects of SO_2 on the photosynthetic fixation of $H^{14}CO_3$ by lodgepole pine seedlings, and investigate the interaction between this gas and photosynthetic pigments extracted from forest trees.

9. Study Objectives

To determine the effects of air pollutants on some of the central biochemical processes in forest species,

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: Revised: 1976
c. Estimated total Prof. man-years required: 1.6
d. Essential new major equipment items for 1976-77 with costs:
spectrofluorometer 7,500
ultracentrifuge accessories 2,500
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years Prof. Nil
Supp. Nil
Casual -
Total Nil

11. Progress to Date:

Available world literature on biochemical and physiological action of SO_2 on vegetation has been assembled, reviewed and is currently in press.

Substantial experimentation has been carried out with different age pine needle tissues exposed to SO_2 in aqueous solution. The results have shown significant effects on (1) photosynthetic pigments (2) enzyme activity (3) Hill reaction activity (4) rate of $H^{14}CO_3$ incorporation into photosynthates (5) lipid composition of cells (permeability studies) (6) amino acids and organic acids metabolism.

12. Goals for 1975-76:

In order to determine the biochemical threshold levels of SO_2, the effects of SO_2 will be studied on the following mechanisms:

1. Incorporation of $H^{14}CO_3$ into photosynthetic products (photosynthetic efficiency).

2. Respiration of whole tissue by the use of Warburg apparatus.

3. Amino acid metabolism by the use of gas chromatography.

4. Write-up and report the results obtained in 1974-75.

5. Initiate gas phase studies on photosynthetic activity and respiration to confirm trends determined in aqueous phase studies.

6. Effect of SO_2 on tissue permeability.

7. Effect of SO_2 on total organic acids (organic acids are an important source of energy for various biochemical and physiological processes and are precursors for many cellular metabolites).

13. Accomplishments in 1975-76:

1. It was found that aqueous SO_2 inhibited the incorporation of $H^{14}CO_3$ into the alcohol soluble fraction of carbohydrates in pine needles (photosynthetic activity) even at very low concentrations (the concentrations that do not show any visible symptoms). It is suggested that this breakdown of chlorophyll molecules by SO_2 is reflected in the ability of pine needles to photosynthesize as measured by $H^{14}CO_3$ fixation.

2. The rate of intact tissue respiration followed almost the same pattern as photosynthetic activity. It appears that in the presence of SO_2, the lack of photosynthates may have an indirect effect on tissue respiration.

3. In order to further explain the effect of SO_2 on photosynthesis, the levels of total amino acids in the tissue were determined. SO_2 caused a significant drop in total amino acid content. The gas chromatographic analysis is in progress to determine effects of SO_2 on specific amino acids required for photosynthetic activities.

4. A part of the results from 1974-75 research work was written up and have been accepted for publication in New Phytologist.

5. The gas phase studies of biochemical research could not be initiated due to unavailability of "pollution chamber". The contract for construction of the chamber has been let and delivery is expected in July-August, 1976.

6. Since our electron microscopy work showed that low concentrations of SO_2 can drastically alter organization of chloroplast membranes (before the appearance of visual symptoms), the effect of SO_2 on tissue lipids (monogalactosyl diglycerides, digalactosyl diglycerides and sulfolipids) was determined. Extremely low concentrations of SO_2 resulted in highly significant drop in lipid biosynthesis. It has been reported that the above lipids may play a significant role in the permeability properties of the membranes. Our present work suggests that the lipid biosynthesis may be one of the primary sites of SO_2 action. This finding may provide us with an excellent tool for detecting the extent of SO_2 injury to vegetation.

7. Organic acids are very important source of energy for synthetic processes such as lipid biosynthesis and are also precursors for many other metabolities. It was found that SO_2 has an inhibitory effect on the total organic acid content in pine needle tissue (exchange resin column chromatography studies). The gas chromatographic studies are being initiated to determine the effects on specific organic acids.

   N.B. Work under this study will be continued under NOR 24 (Study 159) and study is terminated.

14. Goals for 1976-77:

Nil - Study terminated.

15. Publications:

Up to 1975-76

Nil

1975-76

Malhotra, S. S. and D. Hocking. Biochemical and cytological effects of SO_2 on plant metabolism (Review of World Literature). New Phytologist. *In Press*.

Malhotra, S. S. Effects of SO_2 on biochemical activity and ultra-structural organization of pine needle chloroplasts. New Phytologist. *In Press*.

Hocking, D., S. S. Malhotra and R. Blauel. 1975. Environmental stress in the forest. Environ. Can., North. For. Res. Cent. For. Rep., Vol. 4, No. 2. March.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-7-978

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 4, 1976

1. Project: Reduction of damage from pollutants in the atmosphere.

2. Title: Effects of atmospheric effluents on sub-cellular structure of forest vegetation.

3. New: X Cont: No.: NOR-7-978

5. Study Leader: S. S. Malhotra.

6. Key Words: sub-cellular structural organization, necrotic symptoms, electron microscopic analysis, aqueous sulphur dioxide, fixation, staining.

7. Location of Work: Northern Forest Research Centre and University of Alberta, Edmonton.

8. Problem:

Sulphur dioxide is one of the most toxic constituents of polluted air. It has a great potential to cause irreversible damage to forest trees and other vegetation. Since there is not enough information available either on direct or indirect effects of SO_2 on plant life, regulatory agencies have difficulty in applying any meaningful and effective restrictions. Studies on this gas have been mostly limited to acute or chronic injuries. Low concentrations of SO_2 that do not produce any visible symptoms (before chronic injury symptoms) may affect growth by interfering with the sub-cellular structure.

The mechanism of SO_2 action at the level of sub-cellular structure has not been studied in detail. At low concentrations, the effects of SO_2 on vegetation may be due to (a) interference with some of the bio-chemical processes in plants, (b) interference with the sub-cellular structural organization, (c) combinations of (a) and (b). Integrated studies comprising biochemical (Study-7-974) and electron microscopic analysis would help to explain the effects of low levels of SO_2 on

biomass production. The regulatory agencies when supplied with this vital information will be in a better position to set more rational levels of SO_2.

9. Study Objectives:

To determine the effects of SO_2 on sub-cellular organization and relate these results with those obtained by the biochemical studies (Study NOR-7-974).

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: Finished in 1975-76
c. Estimated total Prof. man-years required: 0.6 (Including 1974-75)
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	Nil
Supp.	Nil
Casual	Nil
Total	Nil

11. Progress to Date:

The effect of various concentrations of aqueous SO_2 on sub-cellular structural organization was determined during 1974-75.

12. Goals for 1975-76:

1. Write up and report the results. Proposed title: "Effect of SO_2 on Hill reaction and ultrastructure in lodgepole pine".

2. Terminate study.

13. Accomplishments in 1975-76:

1. The results were written up and reported. S. S. Malhotra. Effects of SO_2 on biochemical activity and ultrastructural organization of pine needle chloroplasts. New Phytologist *(In Press)*.

2. Study terminated.

14. Goals for 1976-77:

Nil (study completed)

15. Publications:

Up to 1975-76

Nil

1975-76

Malhotra, S. S. Effects of SO_2 on biochemical activity and ultrastructural organization of pine needle chloroplast. New Phytologist *(In Press)*.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

NOR-7-979

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 4, 1976

1. Project: Reduction of damage from pollutants in the atmosphere.

2. Title: The fate of atmospheric sulphur compounds.

3. New: Cont. X 4. No.: NOR-7-979

5. Study Leader: J. Baker

6. Key Words: air pollution, sulphur dioxide, hydrogen sulphide, isotope partitioning, acid precipitation.

7. Location of Work: Region-wide.

8. Problem:

Industrial effluents discharged into the atmosphere in a number of locations have a real, imagined, or potentially deleterious effect upon adjacent trees and other plant life. Government agencies and the general public at all levels are expressing concern. Industrial groups are apprehensive as to restrictions which may be applied. Regulatory agencies in many instances lack essential scientific information describing cause and effect relations. Provincial government agencies, industry and the public request involvement by the Canadian Forestry Service in this environmental problem in the form of cooperative research programmes, detection and assessment surveys, and advisory services.

Of particular concern to regulatory agencies is the potential long-term effect of atmospheric emissions. Predictions of long-term effect depend on an accurate and detailed understanding of the fate of the emissions: where do they go?

9. Study Objectives:

1. Develop and apply methods for measurement of atmosphere-borne sulphur compounds wherever they are removed from the atmosphere: by settle-out, by precipitation, and by active assimilation.

2. Using data from (1) above, develop and refine a "sulphur budget" for an individual source of emissions.

3. Apply "sulphur budgeting" to other sources for which data are available or can be gathered.

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: Not applicable
c. Estimated total Prof. man-years required: 4
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	Nil
Supp.	Nil
Casual	Nil
Total	Nil

11. Progress to Date:

Plots have been established for the measurement of sulphur "settling-out" and in rainfall near the Aquitaine Ram River gas plant and near Fort McMurray, in cooperation with Drs. M. Nyborg and F. Bentley (Soil Science, University of Alberta). A sampling programme has been initiated for the partitioning of atmosphere and soil contributions to sulphur in vegetation. Separation is by characteristic stable isotope proportions determined by mass spectrometry, in cooperation with Dr. R. Krouse (Physics, University of Calgary).

Determinations on samples collected in 1973-74 suggest significant direct uptake by atmospheric SO_2 by trees and lichens. Much more sulphate is present in intercepted than in open rainfall. Intercepted rain is also consistently significantly more acid.

12. Goals for 1975-76:

1. Continue collection of precipitation and settle-out data.

2. Analyze further, carefully partitioned soil, vegetation and atmospheric sulfation plate samples; for stable S isotope proportions from Aquitaine.

3. Collect similar samples from near other emission sources.

13. Accomplishments in 1975-76:

1. The precipitation and settle-out data were collected and reported.

2. Soil, vegetation and atmospheric sulphation plate samples were analysed for stable S isotope proportions from Aquitaine and the results were reported.

3. Due to staff resignation, other sample collection was suspended.

N.B. The goals of this study are transferred to studies NOR-7-114 and NOR-24-993 and study is terminated.

Further results of the 75-76 work will be reported in the above studies in 1976-77.

14. Goals for 1976-77:

Nil - study terminated.

15. Publications:

Up to 1975-76

Baker, J., D. Hocking and M. Nyborg. 1973. Effect of atmospheric sulphur dioxide on the pH or rain intercepted by forest trees. In: Hocking and Reiter (Eds.). Proceedings of a workshop on sulphur gas research in Alberta. NOR-X-72.

Hocking, D. and M. Nyborg. 1974. The problem of soil acidification by sulphur dioxide. In: NOR-X-116. Proceedings of a workshop on reclamation of disturbed land in Alberta. D. Hocking and W.D. Macdonald (Eds.).

1975-76

Nyborg, M., J. Crepin, D. Hocking and J. Baker. 1975. Effect of SO_2 on precipitation and on the sulphur content and acidity of soils in Alberta, Canada. In: Proc. of the First International Symposium on Acid Precip. and Forest Ecosystems (Columbus, Ohio).

Nyborg, M., A. C. Dick, J. Crepin, R. F. Klemm, J. Baker and D. Hocking. 1975. Current results on the fate of atmospheric SO_2 and its effects on soil water and vegetation. In: Proceedings of the First International Symposium on Acid Precipitation and Forest Ecosystems (Columbus, Ohio).

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1975 - 76

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 21, 1976

1. Project: Reduction of damage from disease causing agencies.

2. Title: Reduction of losses from canker and dieback.

3. New: Cont. X 4. No.: NOR- 8-044

5. Study Leader: H. Zalasky

6. Key Words: Frost burl, frost canker and dieback, bark pitch pocket, low temperature, hyper- and hypoplasia, interlocking and spiral grain, brachiate tracheids, sclereid-like cells, scabby bark, conifers, hardwoods.

7. Location of Work: Region-wide.

8. Problem:

Studies of distribution of hosts and geographic distribution and the histology of the bark and wood damage by low temperature was undertaken in 1971 to define the impact and symptoms on trees of different species. Investigations included annual rejuvenating capability, development and maturation of still-living woody tissues in annual growth rings around the frost-canker, and freeze-killing of new abnormal tissues. In frost hollows and frost risk localities, frost cankers are perennial because of the annual monthly or seasonal pattern of freeze-thaw conditions. Freeze-thaw is defined as a drastic variation between the high temperature during the day, the low of the night and the high of the next day regardless of season or month of the year. The range in which diurnal temperatures are required to drop from a high to a low and rise again to effect damage in plant tissues is known from field observations and from cell biology experiments. In nature wind-chill may bring on a risk of frost even if the temperature is slightly above freezing such as 33° to 35°F.

Physiographically our land mass, bordered by the cold pre-Cambrian Shield in the east and the Rockies in the west, rises sharply westward from the Manitoba escarpment. It is influenced by a cold Continental air mass pressure system from the Arctic and by a warm

air mass from the Pacific. The two systems bring about rapid diurnal freeze-thaws so common during the winter months along the eastern slopes of the Rockies with greatest turbulence and gusty winds. Risk of frost is also increased by radiation diurnal cooling in broad valleys throughout the region. Disked surfaces tend to be cold and raised surfaces warm; but on long slopes night frost settles at the bottom and top of the slopes, and the warm layer is sandwiched in between. Risk of frost injuries increases from east to west and the eastern slopes of the Rockies have the greatest instability of temperature.

In reforestation, frost risk areas should be designated for wild-life use rather than timber because of stand openings and successions of herbaceous ground cover suitable for grazing. Such designations may be permanent, or temporary if a complete canopy cover is established. But trees with deformed crowns make a useful habitat for larger nesting birds rather than timber for fiber use.

Low temperature damage may have some impact on redirection of disease appraisal, research on regeneration by natural or artificial means, and on some of the cultural practices such as hardening-off of seedlings, pruning, thinning and selection of adaptable species.

9. Study Objectives:

a. To assess variability of hardiness of poplar to frost canker and dieback for clones under field conditions.

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

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

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

10. Resources:

a. Starting date: 1971
b. Estimated year of completion: 1973 Revised: 1976.
c. Estimated total Prof. man-years required: 3
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years Prof. 0.1.

11. Progress to Date:

Frost damage in woody stems results in a dual phenomenon that of killing areas of the cambium and of stimulating the uninjured cambium to produce chimeral tissues or burl. The oblique and whorled

arrangement of these tissues, their disorientation from the longitudinal-radial arrangement of normal woody tissues, and their darker color characterizes the morphological features of chimeral bark and sapwood. The darker color is due to the gummy and resiniferous ray tissues most of which die and form a continuous overlay in the phloem and a continuous underlay in the sapwood. Burl sapwood is mostly cross-grained except for the upper part of the growth ring which may be straight grained. The phloem overlay of ray tissues in conifer and hardwood species investigated is also provided with a covering of pseudocork.

The pseudocork has several layers of cells devoid of cell contents, the upper cells having dentate thick walls and recurvate lobes, and the lower layers of cells having angular thin walls. The rays within the phloem and sapwood contain two-cell types, regardless of the species. The dead sclereid-like cells are empty and have thick netted walls and the living cells are isodiametric and often have tube-like structures protruding from the walls.

In cell deformities, hyperplasia and hypoplasia of sapwood tissues, the somatic deviations induced by low temperature are very similar to that induced by the fungi, *Keissleriella* and *Rhytidiella*. However, these fungi do not induce an underlay of ray tissues in the sapwood and the rays within differ only in the structure of the sclereid-like cell which does not have a netted wall. The fiber tracheids in poplar occur less frequently in low temperature-induced than in fungus-induced chimeral sapwood. They appear, as in most chimeral tissues of hardwoods, more like the vascular tracheids with distinct pits but with or without rounded ends.

During cell division, chimeral meristim becomes somatically distinct from the normal diploid cambial daughter cells by heteroploidy and fragmentation of chromosomes. Differentiated cells are distinct also due to changes in size and shape, in the presence of composite structures and in the arrangement and position of perforations in vessels. The composite structures are due to failure of cell plate formation during cell division.

12. Goals for 1975-76

1. To obtain pathognomic data on reconstruction of cambium, phloem and xylem of field treated trees in clearcut areas held by North Western Pulp and Power Ltd. and after treatments in the spring and fall of 1973.

2. To determine duration and time of season when occlusion wood is formed. To be continued.

3. To complete construction of an electronic cell and to determine the rate of loss and thermal diffusion from tissues adjacent to the target freezing area in the stem.

4. To evaluate multinucleation and cellular aberration during the production and development of burl hyper- and hypoplastic tissues.

5. To complete the following manuscripts for journal publication:

   a. Zalasky, H. Low temperature induced cankers and burls in test conifers and hardwoods. Can. J. Botany.

   b. Zalasky, H. Cell and tissue deformities in burl and canker induced experimentally by low temperature. Can. J. Botany.

   c. Zalasky, H. Septoria canker and leaf spot in test seedlings of native species of poplar. Can. J. Botany.

   d. Zalasky, H. Frost damage in poplar. Forestry Chron.

   e. Zalasky, H. Structure of burl tissues in frost canker of poplar. Can. J. Botany.

   f. Zalasky, H. Hyperplastic and hypoplastic tissues evaluated by aberration and diversity in nucleation and cell groupings. Can. J. Botany.

   g. Zalasky, H. Structural malformation in woody tissues of *Malus* following experimental frost injury. Plant Sci.

   h. Zalasky, H. Frost injury in Caragana. Plant Sci.

   i. Zalasky, H. Chimeral xylem in galls of lodgepole pine caused by western gall rust, *Endocronartium harknessii*. Can. J. Bot.

   j. Zalasky, H. Abscission tissues in twigs affected by early autumn frost.

13. Accomplishments in 1975-76:

5. a. Published.
   b. Data combined with (a) in final draft.
   c. With the author.
   d. Published.
   e. Resubmitted.
   f. Published.
   g. Accepted for publication with minor revision.
   h. Accepted for publication
   i. Accepted for publication
   j. Published.

14. Goals 1976-77:

1. Complete publication of the following papers:

   a. Septoria canker and leaf spot in test seedlings of native species of poplar. Can. J. Botany.

   b. Structure of burl tissues in frost canker of poplar. Can. J. Botany.

   c. Abscission tissues in twigs affected by early autumn frost.

15. Publications:

Up to 1975-76

Zalasky, H. 1972. Ukrainian-English Translation OOENV TR159 Ottawa. Winter injuries to woody species in the process of acclimitization. Ms. 14 pages. Ukrainskyi Botanichnyi Zhurnal Vol. 22, No. 5, 1965. Co-authored by Borzakivska, I.V. and T. K. Maiko. 1965

Zalasky, H. 1973. Brachiate tracheids in deformed wood of *Abies*. Bi-Mon. Res. Notes 29, 23.

Environment Canada, Can. For. Serv. 1973. Septoria canker and leaf spot. Northern Forest Research Centre. Forestry Report 3:3-4.

Zalasky, H. 1973. Isolation and characteristics of sclereid-like cells in sapwood of *Pinus Populus*. Information Report NOR-X-48. 14 pp. Northern Forest Research Centre, Edmonton, Alberta.

Environment Canada, Can. For. Serv. 1974. Defect in poplar. Northern Forest Research Centre. Forestry Report 4:5.

1975-76

Zalasky, H. 1975. Chimeras, hyperplasia and hypoplasia in frost burls induced by low temperature. Can. J. Bot. 53, 1888-1898.

Zalasky, H. 1975. Low-temperature-induced cankers and burls in test conifers and hardwoods. Can. J. Bot. 53, 2526-2535.

Zalasky, H. 1975. Frost damage in poplar. Forestry Chronicle. *In Press.*

Zalasky, H. Chimeral responses to frost injury in apple and mountain ash. Can. J. Plant Sci. *In Press.*

16. Signatures:

Harry Zalasky
Investigator

R. W. Reid
Program Manager

G. T. Silver
Director G. T. Silver

NOR-9-023

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Impact, biology and control of the spruce budworm in Alberta and Northwest Territories.

3. New: Cont.: X 4. No.: NOR-9-023

5. Study Leader: H. F. Cerezke

6. Key Words: *Choristoneura fumiferana, C. biennis, Picea glauca,* sample, defoliation, clearcutting, regeneration, pheromone.

7. Location of Work: Edmonton

8. Problem:

The recent large-scale outbreak of the spruce budworm in the prairie provinces, Yukon and NWT peaked in 1967-68 and declined over large areas in 1969-70. Smaller infestations have persisted since. Most infestations occurred in commercial mature-overmature white spruce stands along major river drainages and in several park and recreational areas. Defoliating damage during the outbreaks resulted in tree mortality, growth losses, dead tree tops, increased fire hazard and decreased aesthetic appearance, and caused concern to several agencies. In response to these, research efforts have been directed toward improving monitoring techniques, assessing hazard and examining control strategy.

9. Study Objectives:

1. Determine the biology and hazard of the budworm in northern spruce forests and suitable techniques for estimating its abundance.

2. Determine the formulation of control measures when required.

10. a Starting date: 1968
b. Estimated year of completion: 1975, no new studies are planned but completion of this study and new requests transferred to NOR-9-143.

c. Estimated total Prof. man-years required: Nil
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years Prof. Nil (H. Cerezke)
Supp. -
Casual -
Total Nil

11. Progress to Date:

Assistance has been provided annually since 1968 to Alberta Forest Service for monitoring of budworm outbreaks in northern Alberta. Several reports with information on extent and severity of outbreaks, and tree damage impact have been prepared to assist AFS timber management planning.

Impact studies of the budworm have been largely summarized in a technical report titled "Spruce budworm impact studies in spruce forests of northern Alberta".

Synthetic sex attractants have been field-tested in northern Alberta as part of a national study coordinated through Dr. C. Sanders, GLFRC. Results of these tests have been conveyed to Dr. Sanders and for annual preview by Eastern Spruce Budworm Working Committee.

12. Goals for 1975-76

1. Complete the proposed Information Report: "Spruce budworm impact studies in spruce forests of northern Alberta".

2. Prepare a file report on the "Sex attractant trap tests of *Choristoneura fumiferana* in northern spruce forests of Alberta".

3. Prepare a report for Bi-Monthly Res. Notes on "Spruce budworm development in northern Alberta in relation to spruce phenology and heat units".

4. Terminate this Study and handle all new enquiries on spruce budworm under Study NOR-143 (973).

13. Accomplishments in 1975-76

1. Proposed Information Rep. "Spruce budworm impact studies in spruce forests of northern Alberta" completed with local editorial review.

2. Field tests of sex attractants in 1975 completed and results summarized and conveyed to Dr. Sanders, GLFRC. Blend of pheromone mixture for optimum male moth catch near Fort McMurray, Alberta, was between 96-98% trans- and 2-4% cis-11-tetradecenal, and was the same as general trend of catches in eastern Canada.

No time was available to prepare a file report for consolidating all previous years sex attractant tests.

3. Proposed report for Bi-Monthly Res. Notes partially completed with analysis of new data and preparation of two graphs.

4. Several new enquiries on spruce budworm summarized under NOR-1-143.

5. Remaining goals transferred to NOR-1-143.

14. Goals for 1976-77

None, study terminated.

15. Publications:

Up to 1975-76

Cerezke, H. F. 1971. Spruce budworm. Forestry Report, Environment Canada, Edmonton. 1(4):7.

Sanders, C. J., G. R. Daterman, R. F. Shepherd and H. F. Cerezke. 1974. Sex attractants for two species of western spruce budworm, *Choristoneura biennis* and *C. viridis* (Lepidoptera: Tortricidae). Can. Ent. 106:157-159.

16. Signatures:

H Cerezke
Investigator

Rew Reid
Program Manager

G.T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Biology and control of Warren's root collar weevil.

3. New: Cont.: X 4. No.: NOR-9-024

5. Study Leader: H. F. Cerezke

6. Key Words: *Hylobius warreni, Pinus contorta* var. *latifolia,* regeneration, growth reduction, stand treatments, B19, sampling.

7. Location of Work: Alberta foothills, Edmonton.

8. Problem:

H. warreni is trans-Canadian in distribution, occurs in most native spruce and pine forests in the Prairie provinces and southern NWT, and is abundant on high productivity sites of lodgepole pine along the Alberta foothills and in moist sites of white spruce and jack pine in central Saskatchewan and western Manitoba. Healthy trees are attacked when a few years old and until mature. Girdling damage by larvae causes death of trees and growth losses, which may cumulate during life of tree. Damage has been most severe (up to 63% mortality) in plantation-type situations, indicating this insect to be a potential economic pest during at least the first 30 years after seeding and planting.

9. Study Objectives:

Broad objective is to obtain information to make concrete recommendations for weevil control. Specific objectives are:

1. To determine the subsequent population changes and damage patterns of the weevil in young pine stand subjected to thinning.

2. Determine experimentally the relationship between amount of girdling and its effects on tree growth.

10. Resources

a. Starting date: 1960
b. Estimated year of completion: 1975; remaining goals transferred to NOR-9-143.
c. Estimated Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.0
Supp.	-
Casual	-
Total	0.0

11. Progress to Date

Considerable background knowledge on the biology of *H. warreni* and its damage in lodgepole pine stands in Alberta has been accumulated from 1961 to 1972. A thesis, several reports and publications listed under item 15 summarize much of this information:

A pilot study of the effects of thinning young lodgepole pine on subsequent changes in populations of the weevil, its cumulative damage and other side effects on tree growth was initiated in 1967, and is slated for completion in 1975. Data on weevil numbers, girdling damage and tree growth in thinned and control plots were gathered at 2-year intervals since 1967.

12. Goals for 1975-76

1. Resample thinned plots in 1975 for measurement of weevil populations and accumulated damage history since 1967. This will conclude field work on this Study.

2. Complete preparation of the proposed journal publication: "The spatial and temporal patterns of distribution of the weevil, *Hylobius warreni* Wood in lodgepole pine stands in Alberta".

3. Prepare first draft copies if time permits of:

   (a) "Behavior patterns of *Hylobius warreni* Wood in relation to mating, egg laying, feeding, dispersion and daily and seasonal activity". (Proposed Journal publ.).

   (b) Technical Report on *H. warreni* in the prairie provinces aimed at forest management agencies.

4. Terminate this study and handle all future requests on *H. warreni* under NOR-9-143 (973).

13. Accomplishments in 1975-76

1. All thinned and control plots were resampled in fall of 1975, and a preliminary summary report prepared of data accumulated since 1967. The main conclusions of the study appear to be as follows:

   a. Thinning effected a higher incidence of attacked trees than in control trees, and after 8 years, 55% of trees in thinned plots had one or more weevil wounds compared to 25% in control plots.

   b. Weevil numbers per tree rose gradually from 1969 to 1975 in control plots, whereas in thinned plots they decreased slightly from 1967 to 1969, rose sharply from 1969 to 1973, then declined. The declines may be a natural phenomenon associated with thinning, but may also relate to severe hail storm damage in 1967 and 1973.

   c. Weevil numbers per tree increased with tree diameter but were more linearly related to diameter in thinned than in control plots.

   d. On trees with stem girdling, the amount of root-collar circumference girdled in thinned plots decreased with tree diameter consistently in 1971, 1973 and 1975, and was on the average lower (24.2%) than on control trees (av. 31.7%).

   e. While more trees were attacked and weevil density per tree and per acre was apparently higher on thinned trees, average radial growth was still higher than on control trees; effects of thinning on increased growth rate appeared to have more than compensated for increased weevil populations and damage. In this stand, thinning at age 25 years and about 6-ft spacing did not appear to appreciably alter through weevil damage the benefits gained by thinning. Thinning at an earlier age (i.e., 10-15 years) on high productivity sites would likely have resulted in more severe tree damage.

2, 3. No progress made toward preparation of publications for lack of time.

4. All new requests in 1975 handled under NOR-9-143.

5. Remaining goals transferred to NOR 9-143.

14. Goals for 1976-77

None, study terminated.

15. Publications:

Up to 1975-76

Cerezke, H. F. 1967. A method for rearing the root weevil, *Hylobius warreni* (Coleoptera: Curculionidae). Can. Ent. 99:1087-1090.

Cerezke, H. F. 1969. The distribution and abundance of the root weevil, *Hylobius warreni* Wood in relation to lodgepole pine stand conditions in Alberta. Ph.D. thesis, University of British Columbia, xvii + pp. 221.

Cerezke, H. F. 1970. A method for estimating abundance of the weevil, *Hylobius warreni* Wood, and its damage in lodgepole pine stands. For. Chron. 46:392-396.

Cerezke, H. F. 1970. Biology and control of Warren's collar weevil, *Hylobius warreni* Wood, in Alberta. Internal Report A-27. pp. 28.

Cerezke, H. F. 1972. Survey report of the weevil, *Hylobius warreni* Wood, in the foothills of Alberta. Internal Report A-38. pp. 40.

Cerezke, H. F. 1972. Effects of weevil feeding on resin duct density and radial increment in lodgepole pine. Can. J. For. Res. 2:11-15.

Cerezke, H. F. 1973. Some parasites and predators of *Hylobius warreni* in Alberta. Bi-monthly Res. Notes 29:24-25.

Cerezke, H. F. 1973. Survival of the weevil, *Hylobius warreni* Wood, in lodgepole pine stumps. Can. J. For. Res. 3:367-372.

Cerezke, H. F. 1973. Bark thickness and bark resin cavities on young lodgepole pine in relation to *Hylobius warreni* Wood (Coleoptera:Curculionidae) Can. J. For. Res. 3:599-601.

Cerezke, H. F. and V. Hildahl. 1973. Insect and rodent damage associated with regeneration. Forestry Report 3(2):2-3.

Cerezke, H. F. 1974. Effects of partial girdling on growth in lodgepole pine with application to damage by the weevil *Hylobius warreni* Wood. Can. J. For. Res. 4:312-320.

16. Signatures:

H. F. Cerezke
Investigator

R. W. Reid
Program Manager

G. T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Larch sawfly biological control

3. New: Cont.: X 4. No.: NOR-9-061

5. Study Leader: J. A. Muldrew

6. Key Words: *Pristiphora erichsonii*, *Olesicampe benefactor*, *Mesoleius tenthredinis*, *Mesochorus dimidiatus*, parasites, encapsulation, hyperparasites, *Larix*, Boreal Region "B".

7. Location of Work: Throughout Northern Forest Region.

8. Problem:

This study is an attempt to control the larch sawfly by the introduction of exotic biotic natural enemies. 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. The benefits from success would be reduced mortality of tamarack and appreciable increases in the total incremental growth of tamarack and western larch. The increased vigor of tamarack would allow it to better fulfill its role in the ecology of the forest as a pioneer species invading areas not previously occupied by trees.

The project is a success to date in that host populations have been reduced to a low level in the areas where the parasite has been present for five or more years.

Because of the success in Manitoba, releases of *O. benefactor* have been made in New Brunswick, Nova Scotia, Prince Edward Island, Maine and Minnesota and consideration is being given to making releases in British Columbia and in the larch plantations of southern Ontario.

9. Study Objectives:

1. To achieve biological control of the larch sawfly.

2. To contribute to the population dynamics study of the larch sawfly by determining the factors affecting parasite effectiveness, abundance and impact.

3. To monitor the spread of *Olesicampe benefactor* from release points in Manitoba, Saskatchewan, Alberta and the Northwest Territories.

4. To monitor the incidence of parasitism of *O. benefactor* by the hyperparasite *Mesochorus dimidiatus* Holmgren.

10. Resources:

a. Starting date: 1950
b. Estimated year of completion: 1975 Revised: 1977
c. Estimated total Prof. man-years required: 0.2
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.2 (J.A. Muldrew)
Supp.	0.1 (R.M. Smith)
Casual	-
Total	0.3

11. Progress to Date:

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, has been recovered from most release points in Canada. Studies in cooperation with the Entomology Research Institute, Ottawa, revealed that the hyperparasite had a holarctic distribution before *O. benefactor* was released in America.

Maximum detected dispersal from the Pine Falls release point was 1.8 miles in 1967, 8.3 miles in 1968, 45 miles in 1969 and 65 miles in 1970. In 1971 a spectacular apparent increase in dispersal was found; *O. benefector* being recovered at Ignace, Ontario 225 miles from the release point. In 1972 an extension of 50 miles beyond this was detected. A survey made in 1974 indicated that dispersal had not increased greatly over that of 1972. Possible explanations were low host densities resulting in low parasite densities, adverse effects of the hyperparasite *M. dimidiatus* and absence of weather conditions required for long distance dispersal. A marked decrease in larch sawfly populations occurred throughout southeast Manitoba and northwest Ontario beginning in 1972. At the Pine Falls release point populations decreased progressively from over 500,000 per acre in 1964 to 871 in 1972 to 0 in 1973 and 1974. The decrease in sawfly populations in southeastern Manitoba occurred in spite of high rates of attack by *M. dimidiatus* on *O. benefactor* eg.94% at Elma in 1974; 63% at South Junction and 96% at McMunn.

Dispersal of *O. benefactor* from a release made near The Pas, Manitoba, in 1968 was given special attention since it may prove to be a suitable location for future mass collections of *O. benefactor*. A heavy sawfly infestation has occurred 40 miles south of the release point for several years. By 1974 *O. benefactor* had dispersed 10 miles south of the release point and *M. dimidiatus* had not been detected in this area.

Parasitism by the Bavarian strain of *M. tenthredinis* in the Rennie plot decreased from a high level in 1970 to a low level in 1972 as *O. benefactor* moved in and increased to a high rate of attack, indicating that *M. tenthredinis* discriminates against hosts already attacked by *O. benefactor* as was found by workers in Europe.

12. Goals for 1975-76:

1. To complete publications, the tentative titles of which are:

   a. Dispersal of the introduced larch sawfly parasite, *Olesicampe benefactor* from the Pine Falls release point, 1966 to 1974.

   b. History and etiology of two major continental outbreaks of the larch sawfly in North America.

2. a. To monitor the 1972 release points in Alberta and the N.W.T. and the 1973 release near Ellscott for establishment of *O. benefactor* by collection larvae both for rearing to the cocoon stage and for preservation for parasitism estimation by the clearing technique.

   b. To report on the release program for *O. benefactor* in Alberta and the N.W.T. as the results warrant.

3. To monitor the dispersal of *O. benefactor* and *M. dimidiatus* in western Manitoba and Saskatchewan.

4. To report on the survey for *O. benefactor* made in Manitoba and Ontario in 1974.

13. Accomplishments in 1975-76:

1. a. Title changed to "Dispersal and impact of the introduced larch sawfly parasites, *Olesicampe benefactor* and *Mesoleius tenthredinis* from 1966 to 1974 in Central Canada". Manuscript is partly completed. Summarization of data and preparation in map form not yet finished.

   b. Withdrawn.

2. a. Collections were made at the three 1972 Alberta release points. Parasitism by *O. benefactor*, based on cocoon size, at Jarvie was 41% for 175 cocoons. Parasitism here in 1973 was estimated at 34%. At Grovedale the attack rate for *O. benefactor* was 63% for 102 cocoons reared. In 1973 the estimate was 82% for a small sample of 11 larvae. Larch sawfly populations at Primrose Lake have been extremely low since 1972 and a collection of 6 larvae made on Aug. 7th, 1974, was the first post-release sample. None of these larvae were parasitized by *O. benefactor*. Sawfly populations at Hay River, N.W.T., were again extremely low and no sawflies were collected. At Ellscott, Alberta, where releases were made in 1973, parasitism of 288 reared sawflies was 61% by *O. benefactor*. The attack rate here in 1974 was 14%. Sawfly populations decreased considerably at this location in 1975.

   A small release of 124 *O. benefactor* adults (73 mated females) was made near Obed Lake, Alberta, on July 4th and 8th, 1975. Eight cocoons collected here on Aug. 6th showed 87% parasitism.

   b. This information will be summarized in the publication listed in 1 (a).

3. Only a few collections were received from southeastern Manitoba. Larch sawfly populations remain very low. Attack rates by *O. benefactor* appear to be lower than in 1974. Some evidence was obtained of an appreciable degree of encapsulation of *O. benefactor* larvae by the larch sawfly in a collection from McMunn, Manitoba. Prior to this encapsulation of these larvae had been found only extremely rarely.

   At The Pas, Manitoba, dispersal of *O. benefactor* to the north end of "The Bog" was detected, 35 miles south of the release point. At Freshford, 13 miles south of the release point, parasitism was 39% but the rate of attack dropped off rapidly south of this point.

4. A report on the 1974 survey for *O. benefactor* was completed. A total of 14,600 cocoons were reared. Samples removed for dissection and rearings indicated an expected emergence of 2,074 *M. dimidiatus*, 341 *O. benefactor*, 604 *B. harveyi* and 249 larch sawfly adults. Estimated percentage attack on *O. benefactor* by *M. dimidiatus* was 96 at McMunn, 94 at Elma and 51 at South Junction, Manitoba. Encapsulated *O. benefactor* larvae were found in about half of 38 fourth- and fifth-instar larvae from McMunn, that had been attacked by this parasite.

14. Goals for 1976-77:

1. Completion of the paper "Dispersal and impact of the introduced larch sawfly parasites, *Olesicampe benefactor* and *Mesoleius tenthredinis* from 1966 to 1974 in Central Canada".

2. To survey the McMunn location and locations approximately five miles to the east and to the west to determine if the encapsulation of *O. benefactor* larvae found there was anomolous or characteristic of this population.

15. Publications:

Up to 1975-76

Muldrew, J. A. 1950. *Mesoleius aulicus*, a parasite of the larch sawfly. Bi-Mon. Prog. Rep., Can. Dept. Agric. 6(6):2.

Muldrew, J. A. 1953. The natural immunity of the larch sawfly *(Pristiphora erichsonii* (Htg.)) to the introduced parasite *(Mesoleius tenthredinis* Morley), in Manitoba and Saskatchewan. Can. J. Zool. 31:313-332.

Muldrew, J.A. 1955. Parasites and insect predators of the larch sawfly. Can. Ent. 87:117-120.

Muldrew, J.A. 1956. Some problems in the protection of tamarack against the larch sawfly, *Pristiphora erichsonii* (Htg.). For. Chron. 32:20-29.

Muldrew, J.A. 1964. Liberation of Bavarian *Mesoleius tenthredinis* (Morl.) against the larch sawfly. Bi-Mon. Prog. Rep., Can. Dep. For. 20(2):2-3.

Turnock, W.J. and J.A, Muldrew. 1964. Liberations of additional species of parasites against the larch sawfly. Bi-Mon. Prog. Rep., Can. Dep. For. 20(2):3.

Muldrew, J.A. 1964. The biological control program against the larch sawfly. Proc. Ent. Soc. Man. 20:63.

Muldrew, J.A. 1965. The biological control program against the larch sawfly. Proc. North Cent. Br. Ent. Soc. Amer. 20:157.

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

Elliott, K.R. and J.A. Muldrew. 1967. A knockdown metal cage for rearing larch sawfly larvae. Can. Ent. 99(3):321-323.

Hinks, J.D. and J.A. Muldrew. 1968. Clearing and staining insect larvae to detect internal parasites. Manitoba Ent. 2:81-84.

Turnock, W.J. and J.A. Muldrew. 1971. *Pristiphora erichsonii* (Hartig), larch sawfly (Hymenoptera:Tenthredinidae). In: Biological control programmes against insects and weeds in Canada 1959-1968. Commonw. Inst. Biol. Contr. Tech. Commun. 4:175-194.

Turnock, W.J. and J.A. Muldrew. 1971. Parasites. In: Toward Integrated Control. Proceedings of the Third Annual Northeastern Forest Insect Work Conference, New Haven, Connecticut. February 17-19, 1970. 59-87.

Turnock, W.J. and J.A. Muldrew. 1973. Characteristics of *Bessa harveyi* (Diptera:Tachinidae) suggesting the historic introduction of the larch sawfly to North America. Manitoba Ent. 6:49-53.

Muldrew, J.A. 1973. Larch sawfly, a biological control success story. Forestry Report, Can. For. Serv., Edmonton. 3(2):1-2.

Reports

Muldrew, J.A. 1953. Population studies on *Bessa harveyi*. Bi-Mon. Prog. Rep., Dep. of Agric. 9(3):2.

Muldrew, J. A. 1959. Studies on the distribution and inheritance of the resistance of the larch sawfly to *Mesoleius tenthredinis* Morley. Interim Rept., For. Biol. Lab, Winnipeg. pp. 52.

Turnock, W. J. and J. A. Muldrew. 1964. Biological control attempts against the larch sawfly, *Pristiphora erichsonii* (Htg.) in Manitoba, 1961-1963. Inf. Rep., For. Ent. Lab., Winnipeg. pp. 40

Muldrew, J. A. and W. J. Turnock. 1965. Biological control attempts against the larch sawfly, *Pristiphora erichsonii* (Htg.), 1964. Interim Res. Rep., Forest Ent. Lab., Winnipeg. pp. 35.

Muldrew, J. A. 1965. Biological control against the larch sawfly *Pristiphora erichsonii* (Htg.) in Canada. Interim Res. Rep., Forest Ent. Lab., Winnipeg. pp. 73.

1975-76

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Natural control of the larch sawfly.

3. New: Cont.: X 4. No.: NOR-9-098

5. Study Leader: W.G.H. Ives

6. Key Words: *Pristiphora erichsonii*, *Larix*, population dynamics, ecosystem modelling, biological control.

7. Location of Work: Manitoba and Edmonton.

8. Problem:

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 programmes utilizing larch for fibre production or aesthetic purposes cannot be encouraged.

The large body of data amassed since the study of larch sawfly population dynamics was started in 1956 has never been thoroughly analyzed. This study was established to undertake these analyses.

9. Study Objectives:

1. To elucidate the population dynamics of the larch sawfly by exploring the ecological relationships between the insect and its environment.

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

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

10. Resources:

a. Starting date: 1966
b. Estimated year of completion: 1976
c. Estimated total Prof. man-years required: 0.1
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.0 (W.G.H. Ives)
Supp.	-
Casual	-
Total	0.0

11. Progress to date:

Field work on this study was terminated in 1973. Since then, data have been edited, analyses conducted, and a draft manuscript prepared.

12. Goals for 1975-76:

1. Complete the revision of the above manuscript and submit it for publication (probably as a Departmental Publication).

2. Examine ancillary data on other invertebrates for possible inter-relationships. If any found, consider if results warrant publication.

13. Accomplishments in 1975-76

1. A manuscript titled "The dynamics of larch sawfly populations in southeastern Manitoba" has been accepted by the Canadian Entomologist.

   The population and related data collected during the life of this study have been summarized into two file reports that will be made available to serious students of population dynamics.

2. Two notes, based on ancillary data, have been prepared and submitted to the Canadian Entomologist.

3. The study was terminated.

14. Goals for 1976-77:

None. Study terminated.

15. Publications:

Up to 1975-76

Anonymous. 1964. Larch Investigation Team of Winnipeg. Population dynamics of the larch sawfly. Can. Ent. 96:160-161.

Buckner, C. H. 1957. Population studies on small mammals of southeastern Manitoba. Jour. Mammal. 38:87-97.

Buckner, C. H. 1957. Home range of *Synaptomys cooperi*. J. Mammal. 38:132.

Buckner, C. H. 1958. Mammalian predators of the larch sawfly in eastern Manitoba. Proc. Tenth Internat. Congr. Ent. (1956) 4:353-361.

Buckner, C. H. 1959. Mortality of cocoons of the larch sawfly, *Pristiphora erichsonii* (Htg.) in relation to distance from small-mammal tunnels. Can. Ent. 91:535-542.

Buckner, C. H. 1959. The assessment of larch sawfly cocoon predation by small mammals. Can. Ent. 91:275-282.

Buckner, C. H. 1964. Metabolism, food capacity and feeding behaviour in four species of shrews. Can. J. Zool. 42:259-279.

Buckner, C. H. 1966. Populations and ecological relationships of shrews in tamarack bogs of southeastern Manitoba. J. Mammal. 47:181-194.

Buckner, C. H. and W. J. Turnock. 1965. Avian predation on the larch sawfly *Pristiphora erichsonii* (Htg.) (Hymenoptera: Tenthredinidae). Ecology 46:223-236.

Heron, R. J. 1960. The relative effects of cocoon submergence on the mortality of the larch sawfly, *Pristiphora erichsonii* (Hymenoptera:Tenthredinidae) and its parasite *Bessa harveyi* (Diptera: Tachinidae). Ann. Ent. Soc. Am. 53:476-481.

Heron, R. J. 1961. A note on temperature and postdiapause development of the larch sawfly and its parasite (Tnsd.). Can. Ent. 93:431-433.

Heron, R. J. 1966. The reproductive capacity of the larch sawfly and some factors of concern in its measurement. Can. Ent. 98:561-578.

Heron, R. J. 1967. Heat tolerance of last-instar larvae of the larch sawfly. Can. Ent. 99:1150-1156.

Heron, R. J. 1968. Vital dyes as markers for behavioral and population studies of the larch sawfly, *Pristiphora erichsonii* (Hymehoptera:Tenthredinidae). Can. Ent. 100:470-475.

Heron, R. J. 1971. Temperature tolerance of pronymphs and pupae of the larch sawfly. Can. Ent. 103:1153-1155.

Heron, R. J. 1972. Differences in postdiapause development among geographically distinct populations of the larch sawfly, *Pristiphora erichsonii* (Hymenoptera:Tenthredinidae) Can. Ent. 104:1307-1312.

Hinks, J. D. and J. A. Muldrew. 1968. Clearing and staining insect larvae to detect internal parasites. Manitoba Ent. 2:81-84.

Ives, W.G.H. 1955. Estimation of egg populations of the larch sawfly. Can. J. of Zool. 33:370-388.

Ives, W.G.H. 1958. Foliage and shoot production of tamarack as factors in population studies of the larch sawfly, *Pristiphora erichsonii* (Hartig). Proc. Tenth Int. Congr. Ent. (1956) 4:407-416.

Ives, W.G.H. 1959. A technique for estimating tamarack foliage production, a basis for detailed population studies of the larch sawfly. Can. Ent. 91:513-519.

Ives, W.G.H. 1960. Developmental rates of larch sawfly *(Pristiphora erichsonii* (Htg.)) larvae in an insectary and in field shelters. Can. Ent. 92:668-674.

Ives, W.G.H. 1962. Population and mortality assessment during the egg and larval stages of the larch sawfly, *Pristiphora erichsonii* (Htg.).Can. Ent. 94:256-268.

Ives, W.G.H. 1963. Effects of defoliation on survival of the larch sawfly *Pristiphora erichsonii* (Htg.). Can. Ent. 95:887-892.

Ives, W.G.H. 1967. Relations between invertebrate predators and prey associated with larch sawfly eggs and larvae on tamarack. Can. Ent. 99:607-622.

Ives, W.G.H. 1967. Determination of premature larval drop and other causes of larch sawfly mortality. Can. Ent. 99:1121-1131.

Ives, W.G.H. 1968. Larch sawfly survival in relation to water levels and microtopography in tamarack bogs. Can. Ent. 100:373-385.

Ives, W.G.H. and L. D. Nairn. 1966. Effects of defoliation on young upland tamarack in Manitoba. For. Chron. 42:137-142.

Ives, W.G.H. and L. D. Nairn. 1966. Effects of water levels on over-wintering survival and emergence of the larch sawfly in a bog habitat. Can. Ent. 98:768-777.

Ives, W.G.H. and W. J. Turnock. 1959. Estimation of cocoon populations of the larch sawfly, *Pristiphora erichsonii* (Htg.) Can. Ent. 91:650-661.

Ives, W.G.H., W. J. Turnock, C. H. Buckner, R. J. Heron and J. A. Muldrew. 1968. Larch sawfly population dynamics: techniques. Manitoba Ent. 2:5-36.

Kemp, J. G., W.G.H. Ives and G. Hergert. 1965. A machine to prepare coniferous foliage samples for analysis. For. Chron. 48:248-251.

Mott, D. G., L. D. Nairn and J. A. Cook. 1957. Radial growth in forest trees and effects of insect defoliation. Forest Sci. 3:286-304.

Nairn, L. D., W. J. Turnock, W.G.H. Ives and C. H. Buckner. 1961. Investigations of the population dynamics of the larch sawfly in Manitoba. Proc. Ent. Soc. Manitoba. 17:31-46.

Turnock, W. J. 1957. A trap for insects emerging from the soil. Can. Ent. 89:455-456.

Turnock, W. J. 1960. Estimation of adult populations of the larch sawfly, *Pristiphora erichsonii* (Htg.) Can. Ent. 92:659-662.

Turnock, W. J. 1960. Ecological life history of the larch sawfly, *Pristiphora erichsonii* (Htg.) (Tenthredinidae: Hymenoptera) in Manitoba and Saskatchewan. Can. Ent. 92:500-516.

Turnock, W. J. 1972. Geographical and historical variability in population patterns and life systems of the larch sawfly. (Hymenoptera:Tenthredinidae). Can. Ent. 104:1883-1900.

Turnock, W. J. and W.G.H. Ives. 1957. An instrument for measuring the radii of tree crowns. For. Chron. 33:355-357.

Turnock, W. J. and W.G.H. Ives. 1962. Evaluation of mortality during the cocoon stage of the larch sawfly, *Pristiphora erichsonii* (Htg.) can. Ent. 94:897-902.

Turnock, W. J. and J.C.E. Melvin. 1963. The status of *Bessa harveyi* (Tnsd.) (Diptera:Tachinidae). Can. Ent. 95:646-654.

Heron, R. J. and J. A. Drouin. 1969. Methods of collecting, rearing and handling the larch sawfly for experimental studies. Information Report MS-X-15 Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., M. T. Onysko and D.G.H. Ray. 1964. Annual report of forest research technicians: larch sawfly populations dynamics studies, 1963. Interim Research Report, Forest Entomology Laboratory, Winnipeg, Manitoba.

Drouin, J. A., D.G.H. Ray and R. Smith. 1965. Annual report of forest research technicians: larch sawfly population dynamics studies, 1964. Interim Research Report, Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., D.G.H. Ray and R. M. Smith. 1966. Annual report of forest research technicians: larch sawfly population dynamics study, 1965. Internal Report MS-32, Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., R. M. Smith and M. J. Pocatello. 1966. Procedures manual for larch sawfly population dynamics studies, 1966. Internal Report MS-38 Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., D.G.H. Ray, R. M. Smith and M. J. Pocatello. 1967. Annual report of forest research technicians; larch sawfly population dynamics studies, 1966. Internal Report MS-40, Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., D.G.H. Ray, R. M. Smith, L. Campbell, and P. Mandziuk. 1968. Annual report of forest research technicians: larch sawfly population dynamics study, 1967. Internal Report MS-65, Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., R. M. Smith, D.G.H. Ray, R. Bilodeau and P. Mandziuk. 1969. Annual report of forest research technicians: larch sawfly population dynamics study, 1968. Internal Report MS-95 Forest Research Laboratory, Winnipeg, Manitoba.

Drouin, J. A., R. M. Smith, R. Bilodeau and P. Mandziuk. 1970. Annual report of forest research technicians: larch sawfly population dynamics studies, 1969. File Report, Forest Research Laboratory, Winnipeg, Manitoba.

Ives, W.G.H. 1958. Preliminary studies on the estimation of larval populations of the larch sawfly, *Pristiphora erichsonii* (Htg.). Interim Report 1958-3, Forest Biology Laboratory, Winnipeg, Manitoba.

Ives, W.G.H. 1960. Estimation of larval populations of the larch sawfly, *Pristiphora erichsonii* (Htg.). Interim Report, Forest Biology Laboratory, Winnipeg, Manitoba.

Ives, W.G.H. 1960. A preliminary study of the wandering of starved larch sawfly larvae. Interim Rept., For. Biol. Lab., Winnipeg. pp. 9.

Ives, W.G.H. 1964. Temperatures on or near an exposed tamarack tree. Interim Res. Rept., For. Entomol. Lab., Winnipeg. pp. 12.

Ives, W.G.H. 1968. Weather and larch sawfly survival. Inform. Rept. MS-X-11, For. Res. Lab., Winnipeg. pp. 28.

Ray, D.G.H. 1967. A portable automatic camera system for recording animal activity. Information Report MX-X-5. Forest Research Laboratory, Winnipeg, Manitoba.

Turnock, W. J. 1956. Preliminary life tables for the larch sawfly. Interim Rept., 1955-7, For. Biol. Lab., Winnipeg. pp. 15.

Turnock, W. J. 1959. Emergence of the larch sawfly, *Pristiphora erichsonii* (Htg.), in relation to the soil temperature and weather patterns. Interim Rept. 1958-5, For. Biol. Lab., Winnipeg. pp. 130.

1975-76

Ives, W. G. H. 1975. Larch sawfly population dynamics. Data summaries. II. Temperature and precipitation. About 900 pp. File Report, May 1975.

Ives, W. G. H. The dynamics of larch sawfly populations in southeastern Manitoba. Can. Ent. *(In press)*.

Ives, W. G. H. A note on population trends of *Semiothisa Sexmaculata* with comments on a recent paper by Bergeron and Buckner on the same topic. Can. Ent. *(In press)*.

Ives, W. G. H. Trends in population of three species of sawfly infesting tamarack in southeastern Manitoba (Hymenoptera: Tenthredinidae). Submitted to Can. Ent.

Ives, W. G. H., and R. M. Smith. 1975. Larch sawfly population dynamics. Data summaries. I. Larch sawfly population and mortality estimates and related information. 250 pp. File report, January 1975.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of losses from insects.

2. Title: Controls for pests of shade, shelterbelts and ornamental trees and shrubs.

3. New: Cont.: X 4. No.: NOR-9-132

5. Study Leader: J. Drouin

6. Key Words: Efficacy, spraying toxicology, pesticides, registrations, residuals, formulations.

7. Location of Work: Prairie Region.

8. Problem:

Insects and disease cause injury and/or mortality to ornamentals, shrubs and shade tree plantings. Economically these high cost plantings have amenity values greatly surpassing their forest counterparts resulting in more frequent requests to the Canadian Forestry Service concerning their condition. Frequently controls known to be safe and effective cannot be subscribed because they are not registered for the specific organism. All chemicals must be registered by Federal law, through Canadian Department of Agriculture, Ottawa.

Many chemicals (including microbials) are known to be effective and biologically safe but are registered for a very limited number of pests. In most instances there is a need to obtain additional field data before these chemicals can be recommended for use against other pests. The most important part of the study will involve gathering the necessary technical data to support Canadian registration of the successful candidate materials.

Resource managers in parks and recreation areas and citizens in both urban and farm locations expect the Canadian Forestry Service to provide information on the occurrence of pests, their damage potential and more importantly on effective, low cost, low hazard control measures that are non-damaging to the environment. An

integrated approach by supplementing natural means with chemical or biological controls is not only warranted but essential.

This study serves as a vehicle for the expansion of work on pest problems under a single coordinating project. Studies anticipated to extend longer than three (3) years will not be initiated.

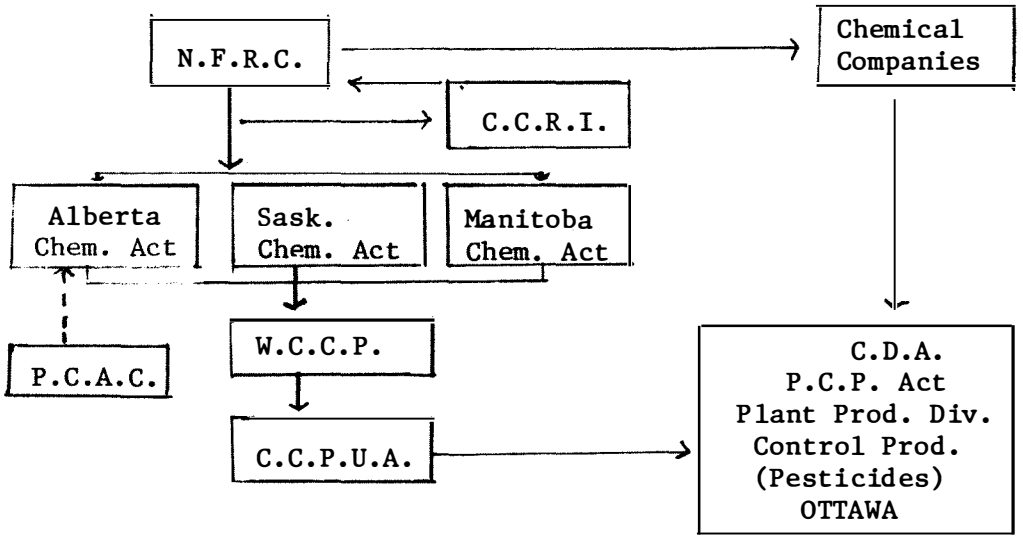
Where controls are not feasible, or economically or biologically justified, such will be reported and included in Canadian Forestry Service control recommendations to the chemical firms.

A shade and shelterbelt pest priority outline has been established and is subject to annual review to meet current demands. The target pests have been selected from those recommended by the Canadian Forestry Service field staff, the Western Committee on Crop Pesticides and as compiled by the Chemical Control Research Institute.

The programme initiated in 1972 was primarily spray applications with a mist blower and numerous soil drenches and bark paint evaluations. Field trials using these methods will continue in 1973. particularly in the soil drench and bark paint evaluation techniques using systemics (tests have proven very successful) as an effective, low hazard, (drift) low cost, (minimal equipment) control.

During 1973 field trials will also be expanded to the use of a newly designed, specialized high pressure, hydraulic ground sprayer unit with 4 interconnected 45 gallon stainless steel tanks enabling the operator to conduct multiple efficacy trails concurrently at one location.

A schematic of other organizations in relation to chemical controls of insects and diseases.



9. Study Objectives:

1. To develop control methods for pest or disease problems using chemical, microbial and/or integrated control methods.

2. Efficacy trials for various dosages and formulations timing and to determine percent mortality of target species and phytotoxicity.

3. Provide data to aid registration recommendations for selected chemical products.

10. Resources:

a. Starting date: 1972
b. Estimated year of completion: 1974 Revised: 1978
c. Estimated total Prof. man-years required: 0
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years Prof. -
Supp. 1.9 (J. Drouin 0.9 D. Kusch 1.0)
Casual -
Total 1.9

11. Progress to Date:

Implemented a viable working unit, established contacts at the Federal, Provincial levels, municipal agencies and private industries involved in the use, manufacture and distribution of pesticides and related products. Determined and selected safety clothing, equipment, ground spray instruments, techniques and methods. Established a pest priority list of 13 insect species requiring control recommendations. In 1972, conducted 59 efficacy tests consisting of mist blower, soil drench and bark paint applications. Analyzed the data, summarized the results and submitted performance reports to 9 chemical firms, a report of treatments and conclusions to the Western Committee on Crop Pesticides and prepared a file report NOR-Y-66. In 1973, 25 insecticides were tested at 99 field treatments on 20 insect species using hydraulic mist blower, Ultra low volume, soil drench and bark paint applications. Collaborated with C.C.R.I., C.W.S. and Fisheries Research (Manitoba) on large scale spruce budworm aerial and ground sprays with insecticides and microbials and evaluation of air-emulsion spray adjuvants and song/game birds and small mammals censusing. Analysed the data, submitted performance reports to 14 chemical firms, report of tests, conclusions and recommendations to W.C.C.P., report on insecticide field development to joint Can. Ent./ Alta. Ent. Societies at Banff, input into technical sessions on Biocides for the Alta. Environmental Conservation Board. Prepared Information Report NOR-X-81 and special report to C.C.R.I. on Furadan

(carbofuran) tests for proposed registrations. During 1974, 6 insecticides were being considered for registration as a result of 77 efficacy tests of 26 pesticides.

Analyzed the data and submitted performance reports to 14 chemical firms, submitted a summary of pesticide efficacy tests from 1972-74 (230 treatments) to the Pesticide Research Report (C.C.P.U.A.), a report to the American Phytopathological Society for publication in the Fungicide and Nematicide Tests for 1974 and a report of tests with conclusions and recommendations to the Western Committee on Crop Pesticides.

12. Goals for 1975-76

1. A large number of insecticides (33) tested since 1972 require one more year of field trials to complete the data required prior to proposing registrations. Of these, 17 show promise; Cygon 4E, Thiodan 4E, Sevin 50 WP, Galecron 50 EC, Lannate L, Basudin 50 EC, Supracide 40 EC, Imidan 1E, Nexion 25W, Lorsban 25 WP, Malathion 50EC, Volaton 50EC, Orthene 75WP, K-840, Baygon 1.5 EC,Gardona 75 WP and RH 218 50 EC.

2. Complete boxelder twig borer control studies with foliar sprays, foaming adjuvants and efficacy of some contact/ systemic insecticides.

3. Biology, chemical control of the chokecherry midge *Contarinia virginianiae* (Felt) with foliar spray and systemic insecticides. (requested by W.C.C.P.)

4. Continue foliar spray and soil drench treatments on yellow-headed spruce sawfly.

5. Foliar spray applications for control of birch leaf miner to determine timing, dosage of successful candidate chemicals.

6. Continue evaluations of foaming (air-emulsion) spray adjuvants and hardware to obtain data for registration.

13. Accomplishments in 1975-76

1. Completed data requirements on 17 insecticides to support registration,--these are: Cygon 4E, Thiodan 4E, Sevin 50 WP, Galecron 50EC, Lannate L, Basudin 50EC, Supracide 50EC, Imidan IE, Nexion 25W, Lorsban 25WP, Malathion 50EC, Orthene 75WP, K-840, Baygon 1.5EC, Gardona 75WP, and RH218 50EC--See summary attached for results. (Goal 1).

2. Did not complete boxelder twig borer sprays. Bulk of larval populations had migrated from the foliage to bore into the buds. Commenced trials with foaming adjuvants on deciduous foliage with systemics insecticides. (Goal 2).

3. Completed first year treatments and life history studies on chokecherry midge *(C. virginianiae)* with very good results (95-100%). (request by W.C.C.P.) (Goal 3).

4. Completed soil drench and foliar spray tests on the yellow-headed spruce sawfly (Goal 4).

5. No applications or controls were carried out on the birch leaf miner due to lack of time (Goal 5).

6. Continued evaluations on foaming and spray adjuvants. Report of results (showing some potential) sent to Atlas Chem-Co. on Atplus 526 and Atplus 540 (Goal 6).

7. Submitted summary of 1975 field evaluations/tests for publication in the Pesticide Research Report. (C.C.P.U.A.), Canada, Agriculture.

8. Prepared an Information Report "Pesticide Field Trials on Shade and Shelterbelt trees in Alberta 1975. NOR-X-150.

9. Presented seminar N.F.R.C. on field trials and pesticide registration March 7, 1975.

10. Submitted manuscript on biology, damage and chemical control of the poplar borer, Can. Jour. For. Res. Vol. 5, No. 3, Sept. 75.

11. Reviewed and edited 6 pest leaflets and prepared one on spraying, yellow headed spruce sawfly and pear slug.

12. Attended on request special hearings on Bird Biocides held by the Alta. Environmental Conservation Board.

13. Submitted report to Oliver nurseries (provincial) on biology and control results on a willow stem sawfly *Euura atra* and to Devon Nurseries on biology and control of pitch nodule maker *Petrova albicapitana*.

14. Presented lectures to Biology Teachers (4) and N.A.I.T. forestry students (60).

15. Submitted chemical safety procedures for Safety Manual N.F.R.C.

14. Goals for 1976-77

1. Continue evaluation of pesticides previously tested and showing promise with a view to completing 2-3 year data required for registration. These are: Basudin, Baygon, Carzol, Cygon, Dutox, Fundal, Furadan, Gardona, Galecron, Kelthane, K-840, Lannate L, Lorsban, Malathion, Meta-Systox, Omite, Orthene, Pirimor, R 28627, Sevin, Supracide, Temik, Vydate, and U.L.V.A.--see attached registration recommendations/chemicals requiring more data.

2. Continue boxelder twig borer control studies re: foliar spray controls.

3. Continue chemical control studies, biology of chokecherry midge *(C. virginianiae)* and an associated seed boring chalcid.

4. Continue chemical controls on the pitch nodule maker in nurseries. Prepare report for submission to bi-monthly as "Chemical control of the pitch nodule maker *(P. albicapitana)* in Alberta.

5. Continue chemical control, biology of a willow stem sawfly, *Euura atra* and publish as an information report "Damage by a shoot boring sawfly in Alberta" by Wong, Melvin, Drouin.

6. Continue chemical control and efficacy tests on the root collar weevil, if time permits.

7. Consult with W. G. Ives, L. Carlson prior to trials at 4, 5, 6 re statistical analysis of data.

15. Publications:

Up to 1975-76

Drouin, J. A. and D. S. Kusch. 1973. Summary of Insecticide Field Trials on Shade and Shelterbelt Trees in Alberta, 1972. Can. Dep. of Environment, N.F.R.C., Edmonton, Alta., File report NOR-Y-66.

Drouin, J. A. and D. S. Kusch. 1974. Insecticide Field Trials on Shade and Shelterbelt Trees in Alberta and Saskatchewan. 1973. Environment Canada, For. Serv., N.F.R.C., Edmonton, Alta. Information Report NOR-X-81.

Drouin, J.A. and D.S. Kusch. 1974. Controls of Poplar Leaf Spots, *Septoria musiva* Pk. and *Marssonina populi* L. Fungicide and Nematicide Tests, Vol. 30 Am. Phyto. Soc. 1974. Raleigh, N.C.

Drouin, J.A. and D.S. Kusch, 1974. Summary of field tests 1972-74. Pesticide Research Report 1974. Canada Agric., Can. Committee on Pesticide Use in Agriculture, Ottawa, Ont.

1975-76

Drouin, J.A. and D.S. Kusch. 1975. Pesticide Field Trials on Shade and Shelterbelt Trees in Alberta and Saskatchewan. 1974. Information Report NOR-X-131.

Drouin, J.A. and D.S. Kusch. 1975. Chemical Control of The Spruce Needle Miner in Alberta. Bi-monthly. Vol. 31, No. 2, May-June 1975.

Drouin, J.A. and H.R. Wong. 1975. Biology, Damage and Chemical Control of the Poplar Borer (*Saperda calcarata* in the Junction of the Root and Stem of Balsam Poplar in Western Canada. Nat. Res. Council, Canada, Can. Jour. of For. Res. Vol. 5, No. 3, 1975.

Drouin, J.A. and D.S. Kusch 1975. Pest leaflet series, Pear Slug, *Caliroa cerasi* L. Yellow headed spruce sawfly, *Pikonema alaskensis* Roh., and To Spray or Not to Spray. Environment Canada, For. Serv., N.F.R.C., Edmonton, Alta.

Drouin, J.A. and D.S. Kusch. 1975. Summary of field tests 1975, Pesticide Research Report. Can. Agric. Canada Committee on Pesticide Use in Agriculture, Ottawa, Ont.

Drouin, J.A. and D.S. Kusch. 1976. Pesticide Field Trials on Shade and Shelterbelt Trees in Alberta. 1975. Environment Canada, For. Serv. N.F.R.C., Edmonton, Alta. Information Report NOR-X-150.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

#	Malacosoma disstria Hbn.		%	
24	Basudin 50 EC	MB	100	*
27	Supracide 40 EC	MB	100	
28	Malathion 50 EC	MB	100	*
31	RH 218 50 EC	MB	100	
34	Resmethrin .69%	ULV	100	
22	Thiodan 4E	MB	95	
23	Sevin 50 WP	MB	95	*
25	Nexion 25 WP	MB	95	
26	Lorsban 25 W	MB	95	
32	Fundal 97 SP	MB	95	
35	Malathion 1.8%	ULV	90	*
21	Cygon 4E	MB	80	
36	Vapona-Methoxychlor	ULV	80	
4	Basudin 50 EC	MB	77	
29	Orthene 75 SP	MB	70	
3	Galecron 50 EC	MB	48	
33	Gardona 75 WP	MB	40	
30	Baygon 1.5 EC	MB	20	
37	Tetrachlorvinphos	ULV	20	
38	Systemic	ULV	20	

	Pikonema alaskensis Roh.			
64	Malathion 50 EC	MB	100	*
65	Basudin 50 EC	MB	100	
66	Lannate L 25%	MB	100	
67	Sevin 50 WP	MB	100	
68	Imidan 50 WP	MB	100	
69	Cygon 4E	MB	100	
9	Cygon 4E	SD	98	
10	Orthene 75 WP	SD	98	
16	Furadan 10G	SD	98	
17	Baygon 1.5 EC	SD	98	
62	Systemic	ULV	98	
61	Malathion 1.8%	ULV	95	*
60	Resmethrin .69%	ULV	91	
13	PP 505 10G	SD	67	
12	Galecron 50 EC	SD	64	
63	Vapona-Methoxychlor	ULV	51	
19	CGA 12223 10G	SD	47	
11	Volaton 10G	SD	0	
14	Supracide 40 EC	SD	0	
15	Hosdon 10G	SD	0	
18	Basudin 50 EC	SD	0	

	Caliroa cerasi Linn.			
56	Cygon 4E	SD	99	
59	Furadan 10G	SD	94	
57	Orthene 75 WP	SD	82	
58	Volaton 50 EC	SD	60	

#	Euura atra (Jurine)		%	
43	Cygon 4E	SD	93	
50	Baygon 1.5 EC	SD	81	
52	Meta-Systox-R 25%	SD	81	
53	Basudin 50 EC	SD	64	
48	Furadan 10G	SD	48	
49	Vydate L 25%	SD	25	
45	Volaton 10G	SD	20	
47	Supracide 40 EC	SD	19	
54	Temik 10G	SD	9	
44	Orthene 75 SP	SD	4	
46	Galecron 50 EC	SD	1	
51	Dacamox 10G	SD	0	
55	CGA 12223 10G	SD	0	

	Pristiphor erichsonii Htg.			
70	Cygon 4E	MB	100	
71	Sevin 50 WP	MB	100	
72	Galecron 50 EC	MB	100	
73	Basudin 50 EC	MB	100	
74	Dutox 23 EC	MB	100	
75	Vydate L 25%	MB	100	
76	Supracide 40 EC	MB	100	
77	Resmethrin .69%	ULV	100	

	Aphids (Saskatoon)			
88	Basudin 50 EC	MB	100	*
98	Lannate L 25%	MB	100	
91	Malathion 1.8%	ULV	98	*
92	Systemic	ULV	98	
93	Vapona-Methoxychlor	ULV	94	
90	Resmethrin .69%	ULV	45	*
94	Tetrachlorvinphos	ULV	36	

	Periphyllus negundinis Thos.			
95	Cygon 4E	MB	100	*

	Oligonychus ununguis Jac.			
78	Kelthane 18 EC	MB	100	*
80	R 28627 25 W	MB	100	
81	Carzol 92 SP	MB	100	
83	Basudin 50 EC	MB	100	
79	Omite 30 W	MB	98	
82	Pirimor 50 W	MB	90	
85	Basudin 50 EC	Hyd	90	

* = Registered

Petrova albicapitana Busck.

5	Cygon 4E	SD	67
8	Furadan 10G	SD	65
7	Orthene 75 SP	SD	42
6	Volaton 50 EC	SD	0

Contarinia virginianiae Felt

39	Basudin 50 EC	MB	100
40	Malathion 50 EC	MB	100
41	Resmethrin .69%	ULV	100

Archips cerasivorana Fitch

1	Dutox 23 EC	HP	82
2	Cygon 4E	HP	78

Neoborus aemoenus Reut.

86	Basudin 50 EC	MB	100
87	Cygon 4 E	MB	100

Proteoteras willingana Kft.

86	Basudin 50 EC	Hyd	34

Tourmeyella numismaticum
Petitt and McD.

20	Furadan 10G	SD	100

Gymnosprangium clavipes

42	Benlate 50 WP	MB	---

Dimilin 50 EC (Ciba-Geigy)

Malacosoma disstria Hbn.	1973 60%, 1975 77 and 100%	(MB)
Pikonema alaskensis Roh.	1974 95%, 1975 100%	(H & MB)
Pristiphora erichsonii Htg. *	1972 100%, 1974 100%, 1975 100%	(MB & H)
Lithocolletis sp. *	1972 95%, 1973 81, 1974 100%	(MB)

Dimilin 1.5 EC (Chemagro)

Lithocolletis sp. *	1973 100%, 1974 100%	(MB)

Cygon 4E (Cyanamid)

Malacosoma disstria Hbn.	1974 100%, 1975 80%	(MB)
Caliroa cerasi Linn.	1974 86%, 1975 99%	(SD)
Pikonema alaskensis Roh. *	1972 100%, 1974 100%, 1975 98 and 100%	(MB, H, SD)
Pristiphora erichsonii Htg. *	1972 100%, 1974 100%, 1975 100%	(MB & H)
Periphyllus negundinis Thos.	1972 85%, 1975 100%	(MB)
Saperda calcarata Say *	1973 51%, 1974 77 and 100%	(SD)
Proteoteras willingana Kft. *	1973 100%, 1974 66%	(SD)

Fundal SP 97% (Niagara)

Malacosoma disstria Hbn.	1973 75%, 1975 95%	(MB)

Furadan 10G (Niagara)

Pikonema alaskensis Roh. *	1973 80%, 1974 90%, 1975 98%	(SD)
Nematus ribesii Scop. *	1973 100%, 1974 100%	(SD)
Gracillaria syringella Fabr. *	1973 95%, 1974 95%	(SD)
Caliroa cerasi Linn.	1974 84 and 100%, 1975 94%	(SD)

Galecron 50 EC (Ciba-Geigy)

Pristiphora erichsonii Htg.	1972 90%, 1975 100%	(MB)

Imidan 1E and 50 WP (Chipman)

Malacosoma disstria Hbn. *	1973 75%, 1974 75%	(H)
Pikonema alaskensis Roh.	1973 100%, 1975 100%	(H & MB)
Lithocolletis sp. *	1973 100%, 1974 100%	(MB)

Lannate L 25 and 90 WP (Du Pont)

Malacosoma disstria Hbn. *	1973 95 and 95%, 1974 100%	(MB & H)
Pikonema alaskensis Roh.	1973 100%, 1975 100%	(MB)

Lorsban 25 W (Dow)

Malacosoma disstria Hbn.	1973 80 and 95%, 1975 95%	(MB & H)

* = Previously recommended.

Malathion 50 EC (Niagara)

Pikonema alaskensis Roh.	1972 100%, 1975 100%	(MB)
Malacosoma disstria Hbn.	1974 100%, 1975 100%	(MB)

Mitac-Systox-2 25% (Chemagro)

Saperda calcarata Say *	1972 70%, 1973 59%	(SD)

Nexion 25 W (Ciba-Geigy)

Malacosoma disstria Hbn.	1973 50 and 75%, 1975 95%	(MB & H)

Orthene 75 SP (Chevron)

Malacosoma disstria Hbn.	1974 100%, 1975 70%	(H &MB)
Caliroa cerasi Linn.	1974 81%, 1975 82%	(SD)

PP 505 10G (Chipman)

Pikonema alaskensis Roh.	1974 90%, 1975 67%	(SD)

RH 218 50 EC (Rohm & Haas)

Malacosoma disstria Hbn.	1974 95%, 1975 100%	(H & MB)

Sevin 50 WP and Sevimol 4 (Niagara & U. Carbide)

Pikonema alaskensis Roh. *	1972 100%, 1973 95%, 1974 100%, 75 100%	(H & MB)
Malacosoma disstria Hbn. *	1973 75 and 80%, 1974 100%, 1975 95%	(H & MB)
Pristiphora erichsonii Htg.	1972 90%, 1975 100%	(MB)

Suracide 40 EC (Ciba-Geigy)

Malacosoma disstria Hbn.	1974 100%, 1975 100%	(MB)

Temik 10G (Union Carbide)

Pikonema alaskensis Roh. *	1973 80%, 1974 95%	(SD)

Thiodan 4E (Niagara)

Malacosoma disstria Hbn.	1973 75 and 75%, 1975 95%	(MB & H)

Volaton 50 EC (Chemagro)

Caliroa cerasi Linn.	1974 78%, 1975 60%	(SD)

CHEMICALS REQUIRING ONE MORE TEST

Ambush 50 EC (Cibo-Geigy)

C. virginianiae	1975 100%	MB
E. atra	1975 64%	SD
O. ununguis	1975 90 and 100%	MB & H
N. aemoenus	1975 100%	MB
N. pratti banksiana	1972 95 and 100%	MB
P. nigundinis	1973 80%	MB
aphids (Sask.)	1975 100%	MB

Baygon 1.5 EC (Chemagro)

P. alaskensis	1975 98%	SD
M. disstria	1973 65%, 1975 20%	MB
E. atra	1975 81%	SD

Benlate 50 WP (Du Pont)

S. musiva	1974 75%	MB

Carzol SP 92% (FMC)

O. ununguis	1975 100%	MB

Cygon 4E (Cyanamid)

Lithocolletis sp.	1972 85,90 and 95%	MB & BP
Altica populi	1972 100%	MB
N. pratti banksiana	1972 100%	MB
A. cerasivoranus	1975 68%	HP
P. albicapitana	1975 67%	SD
E. atra	1975 93%	SD
N. aemoenus	1975 100%	MB
H. warreni	1974 86%	SD
C. virginianiae	1973 95%	MB
Eriophyes sp.	1973 80%	MB

Dicel 3.2 bt (Abbott)

M. disstria	1974 75%	H

Dutox EC 23% (Chipman)

A. cerasivoranus	1975 82%	HP
P. erichsonii	1975 100%	MB

Fundal SP 97% (FMC)

E. americanum	1973 100%	MB

JAN 14 1976

Carbaryl 10% (FMC)

P. albicapitana	1975 65%	SD
P. erichsonii	1973 95%	SD
P. plicifoliae	1973 100%	SD
T. numismaticum	1975 100%	SD

Cygon 75 WP (Shell)

M. disstria	1974 95%, 1975 40%	H & MB

Galecron 50 EC (Ciba-Geigy)

P. alaskensis	1975 64%	SD

Kelthane EC 18% (Rohm & Haas)

Lithocolletis sp.	1973 80%	MB
O. ununguis	1975 100%	MB

K 840 EC 48% (Uniroyal)

P. erichsonii	1972 60%	MB
N. limbatus	1972 90%	MB
Lithocolletis sp.	1972 60%	MB
E. americanum	1973 100%	MB

Lannate L 25% (Du Pont)

P. negundinis	1973 95%	MB
aphids (Sask)	1975 100%	MB

Lorsban 25W (Dow)

P. alaskensis	1973 95%	MB

Malathion 50 EC (FMC)

Lithocolletis sp.	1973 70%	BP
C. virginianiae	1975 100%	MB

Meta-Systox-R 25% (FMC)

E. atra	1975 81%	SD
Lithocolletis sp.	1972 90%	MB
P. negundinis	1972 90%	MB
M. disstria	1973 75%	H
Eriophyes sp.	1973 80%	MB

NF 44 70 WP (Ciba-Geigy)

S. musiva	1974 62%	MB

Omite 30 W (Uniroyal)

E. americanum	1973 100%	MB
O. ununguis	1975 98%	MB

Orthene 75 W (Chevron)

P. alaskensis	1975 98%	SD
P. albicapitana	1975 42% ?	SD

Pirimor 50 W (Chipman)

P. negundinis	1973 70%	H
O. ununguis	1975 90%	MB

R 28627 25 W (Chipman)

O. ununguis	1975 100%	MB

Sevin 50 W and Sevimol 4 (FMC and U. Carbide)

M. pratti banksiana	1972 100%	MB
C. cerasi	1972 100%	MB
C. pallipes	1972 100%	MB

Supracide 40 EC (Ciba-Geigy)

P. negundinis	1972 90%	MB
E. americanum	1973 100%	MB
Lithocolletis sp.	1973 56%	BP
A. cerasivoranus	1973 90%	MB
Eriophyes sp.	1973 90%	MB
C. pallipes	1973 100%	MB
P. erichsonii	1975 100%	MB

Temik 10G (Union Carbide)

G. syringella	1973 100%	SD
H. warreni	1974 54%	SD

Thiodan 4E (FMC)

P. erichsonii	1972 75%	MB
P. negundinis	1972 70%	MB

Thuricide HPC (Sandoz)

M. disstria	1974 70%	H

Vydate L 25 (Du Pont)

P. erichsonii	1975 100%	MB

Registration Recommendations

Malathion 1.8%

M. disstria	1974 100%, 75 90%
C. pallipes	1973 85%, 74 100%
P. alaskensis	1973 95%, 75 95%
aphids	1974 100%, 75 93%

Resmethrin 0.69%

M. disstria	1974 100% 75 100%
P. alaskensis	1974 100% 75 91%
P. erichsonii	1974 100% 75 100%
aphids	1974 81% 75 98%

Systemic —

aphids	1974 100%, 75 98%

Tetrachlorvinphos 2.5%

Vapona-Methoxychlor 6%

M. disstria	1974 85%, 75 80%
aphids	1974 98%, 75 95%

One more test required

Malathion 1.8%

C. cerasi	1973 95%
P. nagucdinis	1973 70%

Resmethrin 0.69%

P. cavicollis	1974 100%
C. pallipes	1974 89%
C. cerasi	1974 100%
T. vaporarium	1974 100%
C. virginianiae	1975 100%

Systemic —

C. pallipes	1974 63%
C. cerasi	1974 100%
P. alaskensis	1975 98%

Tetrachlorvinphos 2.5%

C. pallipes		1974 66%
M. disstria	?	1974 70%, 75 20%
C. cerasi		1974 100%
aphids	?	1974 60%, 75 36%

Vapona-Methoxychlor 6%

P. alaskensis	?	1973 70% 75 51%
C. cerasi		1973 95%

NOR-9-133

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Biological control of forest tent caterpillar.

3. New: Cont.: X 4. No.: NOR-9-133

5. Study Leader: J. A. Muldrew

6. Key Words: *Malacosoma disstria*, *Sarcophaga aldrichi*, *Pseudosarcophaga affinis*, parasites, nuclear-polyhedrosis virus, Boreal Region "B", trembling aspen *(Populus tremuloides)*.

7. Location of Work: Northern Forest Research Centre and Region.

8. Problem:

The forest tent caterpillar shows large population fluctuations with outbreaks of 3 - 6 years duration occurring at intervals of 6 - 16 years. Successive complete defoliation for three or more years can cause death of aspen but the more common effect is a reduction of diameter growth of up to 90%. Aesthetic benefits in recreation areas and home sites are reduced. Complaints and requests for control are common during outbreaks.

It is planned to develop methods of mass-rearing adults of *Sarcophaga aldrichi* and *Pseudosarcophaga affinis* and release them in considerable numbers during the initial stages of an outbreak in selected localities. Areas where outbreaks of the host are likely to occur will be determined using the method outlined by W.G.H. Ives using weather data. Adult parasites will be contaminated with nuclear and possibly cytoplasmic polyhedrosis virus shortly before releasing them into a population (possibly by spraying them with a suspension of the viruses). Since only the early stages of the host are susceptible to the NPV, increased control from this disease would be hoped for in the generation following the spraying. Since third to fifth instar hosts are susceptible to the CPV, this disease may produce more control in the year of release.

Control populations will be studied. G. R. Stairs (Can. Ent. 98:1100) sprayed virus over small areas of an infestation in 1963 and found that it had spread over 700 square miles by 1965. He concluded further that "*S. aldrichi* in the system may be essential to the rapid development of epizootics" (Ann. Rev. Ent. 1972, 17:355). The possibility of obtaining contaminated parasite adults by incorporating virus in the larval food medium will be studied.

9. Study Objectives:

1. To control outbreaks of the forest tent caterpillar in selected areas and reduce the duration and severity of outbreaks over larger areas by the introduction of large numbers of virus-carrying parasites to initiate epizootics.

2. To develop methods for mass-rearing the sarcophagids *S. aldrichi* and *P. affinis*.

10. Resources:

a. Starting date: 1973
b. Estimated year of completion: Transferred to form part of new study entitled "Integrated Control of Forest Tent Caterpillar", NOR-9-150.
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs:

e. Essential new major equipment items beyond 1977 with costs: See new study.
f. 1976-77 man years: Nil.

11. Progress to Date:

A literature survey was carried out. Consultation was made with Dr. G. R. Stairs on various aspects of the problem.

In developing a technique for mass rearing *S. aldrichi*, various food media were tried involving hog liver, salmon, northern pike and various mixtures of these. Different methods of sterilization were tried using heat and various concentrations of formaldehyde. Best results were obtained using a hog liver slurry containing 0.6% formaldehyde with no heat sterilization. The highest rates of oviposition were obtained when adult females were placed in small cages with pieces of hog liver placed near aspen leaves and forest tent caterpillar cocoons.

A supply of nuclear polyhedrosis virus was obtained by collecting diseased larvae in the field. Photographs of the polyhedral bodies were made.

12. Goals for 1975-76:

Work on this study was to be held in abeyance for one year.

13. Accomplishments in 1975-76:

A rearing medium for *S. aldrichi* consisting of 25% egg yolk, 25% whole milk, 1% agar and 49% water were tested. The larvae developed at a rate comparable to those fed on liver, becoming fully fed in about 7 days. The mean weight of puparia for this medium was less than for the liver (81 mg. vs 89 mg.) but a t-test indicated the difference was not significant at the 5% level. This medium allowed rearing to be done in the laboratory without the odor problem connected with rearing on decaying liver.

In the oviposition studies one female lived for 87 days and had a fecundity of 104 eggs. Oviposition began after 41 days and eggs were laid in five batches of about 20 eggs each at intervals of approximately 12 days.

The virus collected in 1974 was used in studies on developing a method of mass producing it. Foliage fed to forest tent caterpillar larvae was first sprayed with a comparatively concentrated suspension of the virus. Ideally, for optimum production of the virus, the larvae should die when they reach full size. This was accomplished when late III and early IV instar larvae were placed on the sprayed foliage. These larvae were reared in large plastic bags to facilitate recovery of the virus; the bags having a forced circulation of moist air through them.

14. Goals for 1976-77

None. Study terminated. (See Study 150).

15. Publications:

Up to 1975-76

Nil

1975-76

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976 - 77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects

2. Title: Control and damage impact of insects injurious to trees and shrubs.

3. New: X Cont. 4. NOR-9-143

5. Study Leader: H. F. Cerezke

6. Key Words: Forest habitats, shelterbelts, woodlots, parks and recreational areas, plantations, seed orchards, tree nurseries, urban landscapes, pesticides, insecticides, cultural control, integrated control, growth losses, population sampling.

7. Location of Work: region wide

8. Problem:

In the prairie provinces there exists the need to examine entomological problems which arise annually and seasonally, often on short notice, and cause concern in forested areas, park and recreational areas, nurseries, shelterbelts, private wood lots and ornamental plantings in urban and rural landscapes. In most cases, such problems may only require identification of the insect organism or other causal agents, and control recommendations are made according to established procedures, such as by chemical, pruning, tree removal or no controls. The nature of the recommendations are dictated by an assessment of the hazard ~~of~~ of the insect and its potential damage, and to some extent by the wishes of the owner(s) or forest manager. Staff of the Insect and Disease Survey and Pest Control Officers of C.F.S., and of other extension specialists of federal, provincial and municipal departments fulfill most of these needs.

Other entomological problems arise which require more comprehensive examination of short term studies. These may include population surveys in spruce budworm-infested timber, bark beetle hazard prediction, woodborer hazard in fire-killed timber, identification of causes of mortality and tree damage in plantations and natural

regeneration, development of special sampling techniques to measure insect abundance and to assist pre- and post-spray application in shelterbelts, urban and park areas, life cycle studies to establish proper timing of controls and impact studies to measure growth losses, predict long term effects on tree form, growth pattern and aesthetic value. Studies may also be initiated which can lead to new strategies of control or to increase effectiveness of control such as by integration of two or more control methods, such as with use of cultural techniques, biological agents, pheromones and other insect-specific chemicals. Opportunity may also exist to undertake field trial demonstrations for testing control procedure and long term effectiveness.

The main benefits of this study will be to advise and up-date information on insect control in new problem areas and to complement the services offered under studies NOR 033 and NOR 132. Increasing public awareness, more intensive forest management practices and increasing demands on the environment such as in park and recreational areas, have all contributed in recent years to many new and varied enquiries of entomological concern. This is a vehicle study and is aimed at fulfilling the needs of special enquiries.

9. Objectives:

1. To maintain up-to-date information on insect problems of trees and shrubs common to the region, laws related to pesticides and their usage, insect control methods and effects of pesticides on the environment.

2. To provide information on insect control, abundance, hazard and damage impact in new areas of concern to various clients.

10. Resources:

a. Starting Date: 1973
b. Estimated year of completion: Indefinite
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment beyond 1977:
f. 1976-77 man years Prof. 1.0 (H. Cerezke)
Supp. -
Casual -
Total 1.0

11. Progress to date:

Reporting and C.F.S. representation were provided at the following committees which meet annually: Western Committee on Crop Pests, Alberta Pest Control Advisory Committee, Saskatchewan Advisory Council on Insect Control and Shelterbelt Sub-Committee of Western Committee Shelterbelt and Horticulture.

Provided major input into the initial planning and development of a proposed information publication on "Common Insects of Trees and Shrubs in the Prairie Provinces of Canada", to include about 160 insect and mite species.

Provided a variety of consultory and extension services to various agencies and clients, including lectures, field and laboratory tours, insect identification and information on several insect and tree damage problems.

12. Goals for 1975-76

1. Complete the bibliography on remaining insect species with assistance of F.I.D.S. and write and edit descriptions of as many insects as time will permit on proposed Information publication: "Common Insects of Trees and Shrubs in the Prairie Provinces of Canada".

2. Provide guidance to F.I.D.S. photographers for accumulating color illustrations of insects and damage for proposed Information Publication: "Common Insects of Trees and Shrubs in the Prairie Provinces of Canada".

3. Provide Canadian Forestry Service representation and input into the following committees:

   a. Western Committee on Crop Pesticides
   b. Alberta Pest Control Advisory Committee
   c. Saskatchewan Pest Control Advisory Committee
   d. C.F.S. contact officer for Pest Control Products Act, re Trade Memorandum 104
   e. Shelterbelt Sub Committee of Western Committee Shelterbelt and Horticulture

4. Provide information and consulting services to various clients seeking information on insect control, abundance, hazard and damage impact related to forest management problems, including new requests on spruce budworm, root weevil and woodborers. These requests were formerly handled under NOR-023, -024 and -025, respectively.

5. Complete the proposed journal publication as indicated in NOR-025 as follows:

   Cerezke, H. F. Population and damage relationships of *Monochamus scutellatus* in tree-length white spruce logs in northern Alberta.

13. Accomplishments in 1975-76

1. Bibliography complete for about 40 species, partly complete for most others. Two sample reports were written, summarizing information on two insect groups. Format prepared with Table of Contents.

2. Guidelines on priority insects were provided for accumulation of selected photographs. About 80% of insects are probably now adequately illustrated on colored slides. Most of the available color slide material has been selected, from which prints are being made.

3. Reports were prepared and presented at the following meetings:

   a. Western Committee on Crop Pests (subsection Shelterbelt, Ornamental Tree and Shrub pests.

   b. Alberta Pest Control Advisory Committee.

   c. Saskatchewan Advisory Council on Insect Control.

   d. Shelterbelt Sub-Committee of Western Committee Shelterbelt and Horticulture.

4. a. Provided appraisal of woodborer damage in power poles and prepared file report: Cerezke, H.F. 1975. Report of examination of power poles near Whitecourt, Alberta, for evidence of woodborers. 5 pp.

   b. Two file reports prepared for Alberta Forest Service interests on spruce budworm in Alberta.

      Cerezke, H.F. 1975. Report of spruce budworm conditions in Timber Licence A2-L2, Athabaska Forest in 1974, 5 pp.

      Cerezke, H.F. 1975. Host preference and tree damage relationships of the spruce budworm--a literature review, 9 pp.

   c. Provided field evaluation of root weevil damage to assist soil and pollution experts diagnose pine deterioration and mortality.

   d. Numerous other requests of clients handled by letter, telephone and visits.

5. Two manuscripts were written and have had local editorial review:

   a. Cerezke, H.F. Population and damage relationships of *Monochamus scutellatus* in tree-length white spruce logs in northern Alberta. 21 pp. typed ms. (Proposed journal publ.).

   b. Cerezke, H.F. Sampling the woodborer *Monochamus* in white spruce logs. 5 pp. typed ms. (Proposed Bi-Monthly publ.).

14. Goals for 1976-77

1. Complete the processing of the following manuscripts:

   a. Population and damage relationships of *Monochamus scutellatus* in tree-length white spruce logs in northern Alberta. (Proposed journal publ.).

   b. Sampling the woodborer,*Monochamus* in white spruce logs. (Proposed Bi-Monthly publ.).

2. Prepare manuscripts on:

   a. The spacial and temporal patterns of distribution of the weevil, *Hylobius warreni* Wood in lodgepole pine stands in Alberta. (Proposed journal publ.).

   b. (If time permits)--The root weevil, *H. warreni*, in the prairie provinces in relation to forest management. (Proposed technical report).

3. Complete the reports:

   a. Spruce budworm impact studies in spruce forests of northern Alberta. (Proposed Information Report).

   b. Spruce budworm development in northern Alberta in relation to spruce phenology and heat units. (Proposed Bi-Monthly publ.).

4. Complete the compilation of photographs and prepare first draft copy of "Common Insects of Trees and Shrubs of the Prairie Provinces of Canada". (Proposed Information publ.).

5. Provide Canadian Forestry Service representation on:

   a. Western Committee Crop Pests
   b. Alberta Pest Control Advisory Committee
   c. Saskatchewan Advisory Council on Insect Control
   d. Shelterbelt Sub-Committee of Western Committee of Shelterbelt and Horticulture.
   e. C.F.S. contact officer for Pest Control Products Act.

6. Provide information and consulting services to other scientists and to clients seeking information on forest insect problems, especially related to spruce budworms, root weevil and woodborers.

15. Publications:

Up to 1975-76:

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976-77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 20, 1976

1. Project: Reduction of damage from insects.

2. Title: Integrated control of the forest tent caterpillar.

3. New: X Cont: 4. No.: NOR-9-150

5. Study Leader: W.G.H. Ives, J.A. Muldrew

6. Key Words: *Malacosoma disstria*, *Sarcophaga aldrichi*, *Populus tremuloides*, nuclear-polyhedrosis virus, integrated control, *Bacillus thuringiensis*, chemical control, parasites.

7. Location of Work: Prairie Provinces and Edmonton.

8. Problem:

The forest tent caterpillar, *Malacosoma disstria* (Hubner), attacks a wide range of hosts, and periodically occurs in outbreak numbers in all Canadian provinces and in most states in the U.S.A. In the Prairie Provinces its principal host is trembling aspen, *Populus tremuloides* Michx. Outbreaks on this host usually occur somewhere in the Prairie Provinces each year. In any given locality the interval between the start of outbreak varies from 6 to 16 years. During these outbreaks, populations of the forest tent caterpillar typically increase in numbers until limited by the amount of food available, and complete stripping of the foliage then occurs for a period of 3 to 5 years. Populations then often collapse to a level where it is difficult or impossible to find any larvae, even during extensive sampling.

The defoliation caused by the forest tent caterpillar causes a reduction in growth but relatively little immediate mortality, as the trees are able to refoliate and produce sufficient new foliage to minimize the effect of defoliation. However, there may be a delayed effect upon subsequent survival.

Since little, if any, tree mortality occurs as a result of forest tent caterpillar outbreaks, the pest is of relatively little concern to informed forest managers. Rural residents, however, are subjected to crawling masses of caterpillars and find this experience extremely annoying. Tourist operators, in particular, are very vocal in demanding government agencies to take remedial actions. Although Malathion (and other insecticides) can provide satisfactory control, such chemical application is often difficult to justify when one considers the problem objectively.

In Canada, most outbreaks appear to be terminated by unfavorable weather conditions, high levels of dipterous parasitism (primarily *Sarcophaga aldrichi* Parker), or epizootics of virus, particularly a nuclear polyhedrosis virus. These factors may operate along or in combination. Unfortunately, both the diperous parasites and the virus usually reach extremely low levels during endemic periods between outbreaks, simply because the host insect is so rare that there is little to sustain them. Consequently, both these factors usually require several years to increase in abundance before they become effective control agents.

This problem presents a unique opportunity in biological (or possibly integrated) control. If the sarcophagids and virus could be introduced into localities with incipient outbreaks, it might be possible to avert major outbreaks in these areas. This idea is not new, having been suggested by Tothill in 1918, but as far as we know has not been tried with the forest tent caterpillar, although a similar approach has been used successfully with one or two other insects. *S. aldrichi* is admirably suited to experimental manipulation of its numbers, as it can be reared successfully and easily on artificial media. Similarly, it is probable that the virus can eventually be propagated on tissue cultures. This has been done with other viruses, without loss of virulence, but has not yet (as far as we know) been done with the forest tent caterpillar, although tissue cultures of this insect have been established. It therefore seems probable that stock cultures of both the parasites and virus could eventually be maintained for use in applied biological control as needed. Before such a program is initiated, or advocated, it is essential that preliminary studies be undertaken to determine whether or not the required densities of parasites and virus can be produced and manipulated advantageously. For example, it will be necessary to determine the dispersal of released parasites under field conditions.

9. Study Objectives:

To determine whether or not localized incipient outbreaks of forest tent caterpillar can be prevented or their severity minimized by manipulation of natural biotic control factors, particularly *Sarcophaga aldrichi* and nuclear polyhedrosis virus, augmented where necessary by chemical or bacteriological control measures.

10. Resources:

a. Starting date: New
b. Estimated year of completion: 1980
c. Estimated total prof. man years required: 7.5
d. Essential new major equipment items for 1976/77 with costs: Nil
e. Essential new major equipment items beyond 1977 with costs: Nil
f. 1976-77 man-years

Prof.	0.8	(J. A. Muldrew)
	0.3	(W.G.H. Ives)
Supp.	0.9	(R. M. Smith)
	0.1	(J. A. Drouin)
Casual	-	
Total	2.1	

12. Goals for 1975-76:

New study

13. Accomplishments in 1975-76:

New Study

14. Goals for 1976-77:

1. The review of pertinent literature will be completed.

2. To determine whether or not virus and *B. thuringiensis* can be introduced into field populations and produce demonstrable mortality in current and/or subsequent generations. Two techniques will be evaluated:

   a. Ground applications of high concentrations of virus will be made to small plots of aspen as soon as the foliage flushes.

      Similar ground applications of *B. thuringiensis*, enhanced by sub-lethal doses of insecticide, will also be made.

   b. Egg bands of forest tent caterpillar will be dipped in a high concentration of virus particles, then tied adjacent to natural egg bands in an area of forest tent caterpillar infestation on regeneration aspen.

3. Techniques for propagating and storing the virus will be evaluated and adapted to suit our conditions.

4. Similar adaptations for rearing and storing the sarcophagid parasites will also be made.

5. Dispersal of marked *S. aldrichi* adults upon release under field conditions will be studied to determine if enough remain in the vicinity to create an impact on local forest tent caterpillar populations.

15. Publications:

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1976-77

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 29, 1976

1. Project: Liaison and Technical Advisory Services in Forest Management.

2. Title: Technical and Advisory Services re Insect Pests and Diseases.

3. New: Cont.: X 4. No.: NOR-17-068

5. Study Leader: V. Hildahl

6. Key Words: Tree biology, entomology, pathology, detection, insects, diseases, appraisals, protection, pesticides, chemical control, spraying, demonstrations.

7. Location of Work: Manitoba

8. Problem:

1) User agencies (provincial, federal, industrial, municipal, universities) must derive maximum benefits from results of research and development programs pertaining to tree protection, maintenance and establishment; and 2) research managers need feedback on the requirements and views of user agencies for the initiation of research and demonstrations aimed at resolving major insect and disease problems associated with forest, park and planted trees.

9. Study Objectives:

Provide technical guidance and assistance to resource managers of the province in developing tree protection and maintenance programs aimed at keeping tree losses due to insect and disease outbreaks within acceptable limits.

This is accomplished by: 1) interpreting and disseminating (in the form of bulletins, special reports and personal contact) results of scientific research that have practical application in dealing with insect and disease problems; 2) evaluating current insect and disease outbreaks with respect to impact on forest stands, and on park, shelterbelt and amenity plantings; and 3) advising and assisting with operational insect and disease control programs.

10. Resources:

a. Starting date: 1966
b. Estimated year of completion: Continuing
c. Estimated Prof. man-years required:
d. Essential new major equipment items for 1976-77 with costs: Nil
e. Essential new major equipment items beyond 1976 with costs: Nil
f. 1976-77 man-years Prof. 0.3 V. Hildahl
Supp.
Casual
Total 0.3

11. Progress to Date:

Since 1966, when the study was initiated, liaison has been developed and maintained with authorities of government and industry associated with forest utilization, reforestation and amenity programs in the Region, and a technical advisory service has been established to provide advice on tree problems, especially as they relate to insects and diseases. To date, the study has been highlighted by: 1) demonstrating and evaluating aerial applications of chemical insecticides for suppressing outbreaks of the jack pine budworm, spruce budworm and forest tent caterpillar in forest and park areas; 2) developing chemical control programs for ground and aerial application against cankerworms and other defoliating insects in urban centres such as Winnipeg; 3) demonstrating and developing application techniques with ground spray equipment suitable for use in suppressing local outbreaks of the spruce and jack pine budworms in park and resort areas; 4) evaluating the effectiveness of recommended insecticides under field operational conditions (especially for control of the jack-pine and spruce budworms, canker-worms, poplar bud-gall mite and spruce sawflies); 5) developing 10-year jack pine-mistletoe eradication programs in the Belair Provincial Forest and Western District of Manitoba, based on market demands for jack pine; and 6) preparing technical information brochures designed primarily for resource managers.

12. Goals for 1975-76:

1. Continue liaison with resource managers throughout the province, and provide technical advisory services, especially with regard to insect and disease problems in forest, urban and rural environments. Close contact will be maintained with the Forest Insect and Disease Survey and their facilities fully utilized in achieving this goal.

2. Continue to evaluate the effectiveness of operational spray programs at the request of resource managers -- fall cankerworm in southern Manitoba, spruce and jack-pine budworms in Spruce Woods area, forest tent caterpillar in central Manitoba -- and publish pertinent results.

3. Complete scientific publication "Control of Poplar Bud-Gall Mite With Insecticides" (Jointly with R. F. DeBoo, Chemical Control Research Institute).

4. Publish brochure entitled "Forest Tent Caterpillar in the Prairie Provinces".

5. Publish brochure entitled "Poplar Bud-Gall Mite in the Prairie Provinces" (jointly with R. F. DeBoo, Chemical Control Research Institute) if Furadan registration is completed.

6. Publish results of 1974 spray program to control spruce budworm in the Spruce Woods Provincial Forest and Park of Manitoba.

13. Accomplishments in 1975-76:

1. Contacts and liaison with resource managers were maintained and technical advisory services (including lectures and seminars) provided, especially on current insect and disease problems in forest, urban and rural environments. Regular contact was also maintained with Forest Insect and Disease Survey personnel in achieving this goal.

2. The effectiveness of operational chemical spray programs against the spruce and jack pine budworms and the forest tent caterpillar were evaluated, and the results provided to resource managers.

   These aerial spray programs covered approximately 45 acres of white spruce stands and 1023 of pine plantations in the Spruce Woods Provincial Park using the chemical Sumithion at 4 oz. a. i/acre in one application for spruce and jack pine budworm control respectively, and about 3015 acres of trembling aspen stands with malathion at 5 oz. a.i/acre in one application for forest tent caterpillar control -- the latter involving outbreak areas in the Whiteshell, Grand Beach, Heela Island and Asessippi Provincial Parks and the Camp Morton, Grand Memorial and Manipogo Provincial Campsites. Preliminary analysis of the data accumulated by field sampling during spray operations indicated that larval incidence of the spruce and jack-pine budworms was reduced by 70-75% and forest tent caterpillar by about 75-85%. These reductions in larval incidence resulted in good foliage protection, except in some instances in the forest tent caterpillar control programs where applications were made after defoliation was well advanced.

3. The scientific publication "Control of Poplar Bud-Gall Mite With Insecticides" is still in the early stages of preparation. All field spraying has been completed and data analyzed.

4. Brochure entitled "Forest Tent Caterpillar in the Prairie Provinces" was completed and distributed in early May 1975.

5. Brochure entitled "Poplar Bud-Gall Mite in the Prairie Provinces" was not prepared. Registration of Furadan for poplar bud-gall mite control has not been completed.

6. Results of the 1974 spray program to control spruce budworm in the Spruce Woods Provincial Forest and Park are currently being prepared. These data will be combined with the 1975 spray results.

7. Added goals for 1975-76: Two pest leaflets were prepared and published -- Fall Cankerworm Env. Can., Nor. For. Res. Cen., Pest leaflet NFRC PL 3-75 and Yellow-Bellied Sapsucker, Env. Can., Nor. For. Res. Cen., Pest leaflet NFRC PL 7-75.

14. Goals for 1976-77:

1. Continue liaison with resource managers throughout the province, and provide technical advisory services, especially with regard to insect and disease problems in forest, urban and rural environments. Close contact will be maintained with the Forest Insect and Disease Survey and their facilities utilized in achieving this goal.

2. Continue to evaluate the effectiveness of operational chemical spray programs against the spruce and jack pine budworms in the Spruce Woods area of Manitoba, and provide results to resource managers for the development of future control programs.

3. Complete scientific publication "Control of Poplar Bud-Gall Mite with Insecticides". (This publication to be prepared jointly with R. F. DeBoo, Chemical Control Research Institute).

4. Complete preparation of report depicting results of the 1974 and 1975 spray programs against the spruce budworm in the Spruce Woods Provincial Park and Forest.

15. Publications:

Up to 1975-76

Nil

1975-76

1. Hildahl, V. and A. E. Campbell. 1975. Forest Tent Caterpillar in the Prairie Provinces. Env. Can., Nor. For. Res. Cen., Inf. Rep. NOR-X-135. 12 p.

2. Hildahl, V. 1975. Fall Cankerworm. Env. Can., Nor. For. Res. Cen., Pest leaflet NFRC PL 3-75.

3. Hildahl, V. 1975. Yellow-Bellied Sapsucker. Env. Can., Nor. For. Res. Cen., Pest Leaflet NFRC PL 7-75.

16. Signatures:

N. Wildahl
Investigator

Program Manager

G. T. Silver
Director G. T. Silver