STUDY STATEMENTS

1980-81

NORTHERN FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

APRIL 1980

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PROJECT NOR-1

Detection and appraisal of tree pests
and vegetative disturbances

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

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), 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 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 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.2	(Y. Hiratsuka)
Supp.	0.3	(P. J. Maruyama)
Casual	-	
Total	0.5	

11. Progress to Date:

1. Distribution, damage, and life cycle of pine stem rusts of the region were investigated and reported in three journal publications.

2. Comprehensive studies of cytology and morphology of pine stem rusts in the region resulted in new method of determining the type of life cycles of pine stem rusts by simple germination technique. This new method has been successfully applied not only in North America but also in Europe and Asia. Thirteen journal publications have been prepared on the related subjects.

3. White spored variety of *Cronartium coleosporioides* was discovered in 1960 in a small area in Banff National Park and annual observations were commenced in 1963. Occurrence of this form and results of the annual observations of canker growth and tree mortality were published in two journal publications.

4. Morphology and life cycle of several conifer needle rusts including *Pucciniastrum sparsum*, *P. goeppertianum* and *P. epilobii* have been studied and results have been reported in six journal publications.

5. Significant amount of information on hyperparasitic fungi and insects on pine stem rusts have been obtained. Five journal publications have been published on the subject.

6. A major publication entitled "Pine stem rusts of Canada" was published. This fully illustrated publication discusses aspects of identification, hosts, distribution, morphology, life cycle, cytology, damage, epidemiology, and control of all pine stem rusts which occur in Canada.

7. Based on the studies of forest tree rusts of the region, terminology of spore states of rust fungi were discussed in two journal publications.

12. Goals for 1979-80:

1. Complete a paper entitled "Morphology of spermogonia and taxonomy of rust fungi".

2. Edit the proceedings of the symposium on rust taxonomy and publish as a volume in the Reports of Tottori Mycological Institute.

3. With Dr. J. Powell (NFRC) and Dr. A. Van Sickle (PFRC) analyze data collected from 15 years of plot studies of pine stem rusts and the results will be analyzed for a report.

(Goals related to a visiting fellow, Dr. A. Tsuneda)

4. Publish two papers as follows:

Occurrence of *Scytalidium uredinicola* on *Endocronartium harknessii* in Alberta.

Cladosporium gallicola, a destructive hyperparasite of *Endocronartium harknessii*.

5. Present a paper on hyperparasites of western gall rust at the annual meeting of the Canadian Phytopathological Society in Lethbridge.

6. Cooperate with Prof. W. Ayer (Dept. of Chemistry, University of Alberta) to purify and identify an antibiotic substance isolated from a fungus.

13. Accomplishments in 1980-81:

1. A paper entitled "Morphology of spermogonia and taxonomy of rust fungi" is written and ready for internal review.

2. Seven manuscripts for the proceedings of the symposium on rust taxonomy have been submitted from authors and are under review and editing.

3. Little progress has been made for the analysis of field data on pine stem rusts with Dr. Van Sickle (PFRC) and Dr. Powell (NFRC).

4. Two journal papers have been published with Dr. A. Tsuneda (NRC Visiting Fellow) on hyperparasites of pine stem rusts (see item 15. "Publications").

5. Presented two papers at the Annual Meeting of the Canadian Phytopathological Society in Lethbridge.

6. Cooperated with Professor W. Ayer (Dept. of Chemistry, University of Alberta) on fungal metabolites (antibiotics) and prepared a joint journal paper.

7. A survey of pine stem rust at Pine Ridge Nursery was conducted with the help of Mr. Ted Evans who was on contract with CFS with the funds made available by AFS. A report has been prepared.

14. <u>Goals for 1980-81</u>:

1. A journal paper "Morphology of spermogonia and taxonomy of rust fungi" will be published as a part of the proceedings mentioned in 2. below.

2. Edit and coordinate the publication of symposium papers on taxonomy of rust fungi. The proceedings will be published from the Tottori Mycological Institute (Japan).

3. If time permits, complete analysis of data and the first draft of a paper on pine stem rusts plot study with Dr. A. Van Sickle (PFRC) and Dr. J. M. Powell (NFRC).

4. Three journal papers will be published with Dr. A. Tsuneda (NRC Visiting Fellow) on hyperparasites of pine stem rusts.

5. Cooperate with Professor W. Ayer (Dept. of Chemistry, University of Alberta) on fungal metabolites and publish a paper.

6. Co-author a chapter in a book entitled "The Rust Fungi" with Dr. S. Sato. The book will be published by Academic Press.

7. Help revise a book entitled "Illustrated Genera of Rust Fungi" with Dr. G. B. Cummins (University of Arizona).

15. Publications:

1978-79

Hiratsuka, Y. and A. Tsuneda. 1978. *Cladosporium gallicola*, an active hyperparasite of western gall rust, *Endocronartium harknessii*. Proceedings Joint Meeting CPS-CSPP Winnipeg 56.

Hiratsuka, Y. and J. M. Powell. 1978. Rouilles caulocoles des pins du Canada. Rapport technique de foresterie 4f, 109 p.

1979-80

Hiratuska, Y., A. Tsuneda, and Lynne Sigler. 1979. Occurrence of *Scytalidium uredinicola* on *Endocronartium harknessii* in Alberta, Canada. Pl. Dis. Rep. 63:512-513.

Tsuneda, A. and Y. Hiratsuka. 1979. Mode of parasitism of a mycoparasite, *Cladosporium gallicola*, on western gall rust, *Endocronartium harknessii*. Can. J. Pl. Path. 1:31-36.

16. Signatures:

Y. Hiratsuka
Investigator

W. J. Johnson
Program Manager

G. T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

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: Y. Hiratsuka, H. Cerezke and (Vacant FO-1).

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.

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 are often able to report any suspected damage. Although we will continue to monitor outbreaks of important pests, we dropped routine detection surveys and now concentrate our efforts on extension entomology and pathology, emphasizing impact and appraisal aspects. To facilitate this work we have established and strengthened contacts with provincial and federal agencies, and have initiated 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, provide identification service and give advice on control options and procedures. This approach, we believe, will make best use of available limited 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, and to contribute to FIDS national overview of important pest conditions.

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 - Winnipeg and Indian Head, 1952 - Calgary
   1970 - Edmonton
b. Estimated year of completion: Continuous
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1980-81 with cost: Nil
e. Essential new major equipment items beyond 1981 with cost: Nil
f. 1980-81 man-years

	Prof.	0.4	(Y. Hiratsuka)
		0.3	(H. Cerezke)
		1.0	(FO - vacant)
	Supp.	1.0	(J. Petty)
		1.0	(F. J. Emond)
		1.0	(G. N. Still)
		1.0	(R. C. Tidsbury)
		1.0	(I/D Ranger - vacant)
		0.2	(H. Gates)
	Total	6.9	

11. Progress to Date:

Infestations of major forest insects and disease outbreaks have been monitored and reported on, including the forest tent caterpillar, large aspen tortrix, spruce budworm, jack pine budworm, mountain pine beetle and dwarf mistletoe. Special surveys have been conducted on a variety of problem insects and diseases throughout the three Prairie Provinces such as regeneration and nursery pests, Scleroderris canker, western gall rust, Hypoxylon canker, and elm bark beetles. The tree pest extension unit has responded to about 2,000 requests annually. Lectures and talks have been presented to many client agencies on insect and disease problems and representation has been provided on various provincial, regional and national pest advisory committees.

12. Goals for 1979-80:

1. Detect and report major pests (spruce budworm, jack pine budworm, forest tent caterpillar) in the three Prairie Provinces particularly in high-value fibre-producing areas (Petty and Still).

2. Conduct pest extension service to client agencies (provincial forest services, provincial agricultural representatives, forest industries and municipalities) and general public. Positive identification or in-depth investigation will often be referred to specialists (NOR-1-153, NOR-1-154, NOR-17-143 (Emond and Tidsbury).

3. Special surveys for particular pests or designated areas will be conducted. Some examples of special surveys which probably will be conducted in 1979 are:

   1. Scleroderris canker surveys in Jasper-Banff National Parks, and red pine plantations in Manitoba.

   2. Elm bark beetle surveys in southern Alberta and Saskatchewan.

   3. Mountain pine beetle in southwestern Alberta.

4. Information collected during the field season will be collated into an information report outlining known pest situations in the three Prairie Provinces.

5. Make representations in various advisory committees as required.

6. Prepare and give lectures and talks on forest insects and diseases as need arises (Hiratsuka, Cerezke, Emond and Tidsbury).

7. Make revisions and update a chapter (Ornamental and shelterbelt trees) of "Guidelines for the control of plant diseases in western Canada" (Hiratsuka).

8. Conduct reconnaissance surveys in selected areas in Alberta with the help of Procter & Gamble Cellulose, Simpson Timber, St. Regis, North Canadian Forest Products and Alberta Forest Service to assess the present and potential insect and disease problems in man-made and man-assisted forests (Hiratsuka, Cerezke, FO-1).

9. Summarize spruce budworm data collected in Manitoba in Namew Lake outbreak with view to extract and analyze for impact assessment (Cerezke and FO-1).

10. Evaluate incidence and growth impact of *Pissodes terminalis* on high value stands of jack pine in Saskatchewan and Manitoba (FO-1 and Cerezke).

11. Review and evaluate survey methods used elsewhere for major forest insects and produce standard survey instruction manual suitable for the region (FO-1 and Cerezke).

13. Accomplishments for 1979-80:

1. Aerial and ground surveys to monitor three major pests (jack pine budworm, forest tent caterpillar and spruce budworm) were conducted in the three Prairie Provinces. Extent and intensity of outbreaks were recorded and predictions for the 1980 season were made (Petty, Still, Gates).

2. Provided pest extension service to various client agencies (provincial forest services, provincial agricultural representatives, forest industries and municipalities) and to the general public. More than 2,000 samples and inquiries were handled including many on-site inspections. Reports for Alberta and Saskatchewan were prepared (Emond, Tidsbury with back-up identifications by Wong, Hiratsuka, Cerezke and Maruyama).

3. The following special surveys were conducted:

   a. Scleroderris canker--The area of infestation in Jasper National Park was surveyed and increased infection level was observed. No survey was conducted in Manitoba (Hiratsuka).

   b. Elm bark beetle--No survey was conducted by CFS. Provincial agencies conducted surveys.

   c. Mountain pine beetle--The current outbreak has been monitored by air and ground surveys in co-operation with the Alberta Forest Service. Low level aerial photography of the main valley bottom was taken to assist in ground monitoring and impact assessment. A visit in September by Dr. L. Safranik (PFRC) to view the Alberta outbreak provided a better understanding of the current outbreak to both CFS and AFS staff. A status report on the outbreak was prepared. Also, presence of this insect in Cypress Hills Provincial Park, Alberta, is confirmed (Cerezke, Petty).

d. Jack pine dwarf mistletoe--An aerial survey was conducted with the cooperation of the Alberta Forest Service over some 3,000 km^2 of forest in northeastern Alberta to map areas of severe brooming on jack pine caused by dwarf mistletoe (Gates, Still, Miyagawa-AFS). A file report was prepared (Still). A subsequent ground inspection was made to observe some fire behavior patterns in dwarf mistletoe infected stands near Lake Athabasca (Gates, Miyagawa-AFS).

e. Pine stem rusts--At the request of AFS, a survey of pine stem rusts of 2-0 bare root nursery stock at Pine Ridge Tree Nursery was conducted. Mr. Ted Evans was on contract to do the survey with funds made available by AFS. A report was prepared. More than 6,000 seedlings were examined and about 2% infection of comandra blister rust and 0.02% of western gall rust were found (Hiratsuka, Evans).

4. An information report summarizing pest conditions of the Prairie Provinces is in preparation (Hiratsuka, Petty, Cerezke).

5. Represented CFS in following pest advisory committees (Dr. Cerezke's involvements are reported under NOR-17-143).

   a. Western Committee of Plant Disease Control (Hiratsuka).

   b. DED Action Committee--Alberta (Hiratsuka).

   c. DED Advisory Committee--Saskatchewan (Hiratsuka).

   d. Western International Forest Disease Work Conference (Hiratsuka).

6. Following lectures and talks were given by FIDS staff.

   a. Lectures on forest insects and diseases were given during a two-day training course for about 20 AFS staff including 12 newly designated forest protection officers (Hiratsuka, Cerezke, Petty, Still).

   b. A one-day seminar on forest tent caterpillar was given to parks and recreation personnel of the city of Saskatoon (Cerezke, Petty, Emond).

c. A one-day training session on nursery and greenhouse pests was conducted at Pine Ridge Tree Nursery (Hiratsuka, Cerezke).

d. Several tree pest talks were given during "Tree Pruning Courses" sponsored by Alberta Agriculture at Oliver, Brooks and Olds (Tidsbury, Emond).

e. A talk was given on forest tent caterpillar for property owners around Stony Plain (Emond, Tidsbury).

7. Prepared a revised edition of a chapter (Ornamental and Shelterbelt Trees) of "Guidelines for the control of plant disease in Western Canada" (Hiratsuka).

8. Reconnaissance survey in Alberta for potential pest problems in regeneration was not conducted.

9., 10., 11. The three objectives were not fulfilled due to other commitments and the loss of FO-1 position which was expected to be filled in 1979.

Additional Accomplishments not in Goals for 1979-80:

12. Made press releases, and conducted TV and radio interviews regarding tree pests including Dutch elm disease, forest tent caterpillar, fire blight and circular tree mortality (Hiratsuka, Petty, Emond, Cerezke).

14. Goals for 1980-81:

1. Aerial and ground surveys to monitor major pests will be conducted in the three Prairie Provinces (Petty, Still, Tidsbury, Ranger-vacant).

2. Provide pest extension service to various client agencies (Emond).

3. Special surveys for particular pests or of designated areas will be conducted. Some examples of special surveys which will probably be carried out in 1980 are:

   a. Conduct reconnaissance surveys in selected areas, especially western Alberta to assess and identify present and potential insect and disease problems in man-made and man-assisted forests (Hiratsuka, Cerezke).

   b. Mountain pine beetle surveys in southern Alberta including Cypress Hills (Petty, Cerezke).

   c. Scleroderris canker--Detection surveys will be conducted in Banff and Jasper National Parks and in red pine plantations in Manitoba (Hiratsuka).

d. Pine stem rusts--A follow-up survey of pine stem rusts at Pine Ridge Tree Nursery will be conducted (Hiratsuka).

e. Spruce budworm impact survey--Assessment of damage and impact will be conducted in western Manitoba (Cerezke).

4. Prepare a report on the mountain pine beetle in southern Alberta summarizing information on distribution, aerial and ground surveys--1979, biological observations, and a prediction for 1980 (Cerezke, Petty).

5. Information collected during 1980 field season will be collated into an information report (Hiratsuka, Petty, Cerezke).

6. Initiate an information series "Pest Report." This is a simple timely reporting format to inform CFS headquarters, other regional establishments, client agencies, and news media about important and interesting pest problems as they occur.

7. Follow-up on "FIDS Task Force Implementation Plan," as follows.

   a. Contribute to "Working Groups" as designated (deadline April, 1980):

      Western bark beetles, dwarf mistletoe (Cerezke, Hiratsuka)
      Rots, Scleroderris, DED (Hiratsuka)

   b. Prepare two "file monographs" on the two most important regional pests, bringing together existing information on incidence, distribution, damage, etc. (deadline April 1, 1981) (Cerezke, Hiratsuka).

   c. Make effort to establish and fill two positions, FO (damage appraisal) and a ranger.

   d. In collaboration with provincial agencies, apply best available depletion factors to provide general estimates of losses caused by major forest pests of economic and/or social importance.

   e. Assign one ranger during the field season in Manitoba.

8. Prepare and present lectures and talks on forest insects and diseases to various client agencies as requested.

15. Publications:

1978-79

Campbell, A. E., V. Hildahl and G. Still. 1978. Summary of forest insect and disease conditions in Manitoba, 1977. File Report NOR-1-033.

Patterson, V. B. 1978. Dying lodgepole pine - Cypress Hills Provincial Park, Alberta, 1977. File Report NOR-1-033.

Patterson, V. B. and J. Petty. 1978. Forest tent caterpillar, Saskatchewan, 1977. File Report NOR-1-033.

Patterson, V. B. and J. Petty. 1978. Insects and diseases recorded in Banff National Park, 1977. File Report NOR-1-033.

Patterson, V. B. 1978. Insects and diseases recorded in Jasper National Park, 1977. File Report NOR-1-033.

Patterson, V. B. 1978. Insects and diseases recorded in Yoho National Park, 1977. File Report NOR-1-033.

Petty, J. and V. B. Patterson. 1978. Forest tent caterpillar post-harvest survey, Saskatchewan. File Report NOR-1-033.

Wong, H. R. and J. Petty. 1978. The mountain pine bettle in Alberta. Bi-Monthly Research Notes 34(b):38.

Hiratsuka, Y. (Ed.) 1978. Forestry Report (issue on forest insect and disease survey).

Cerezke, H. and Y. Hiratsuka. 1978. Reconnaissance survey of insect and disease conditions in coniferous regeneration in the Prairie Provinces. File Report NOR-1-033.

Petty, J. 1978. Mountain pine beetle - Crowsnest Forest, Alberta, 1978. File Report NOR-1-033.

Petty, J. 1978. Jack pine budworm post emergence survey - Nisbet Provincial Park. File Report NOR-1-033.

Still, G. and J. Petty. 1978. Trembling aspen defoliation in Alberta, 1978. File Report NOR-1-033.

Still, G. 1978. Jack pine budworm in Saskatchewan, 1978. File Report NOR-1-033.

Emond, F. J. 1978. Detection survey of native elm bark beetle in southern Alberta and Saskatchewan. File Report NOR-1-033.

Petty, J. and G. Still. 1978. Hail damage, Grande Cache area, 1978. File Report NOR-1-033.

Patterson, V. B. and J. Petty. 1979. Insects and diseases recorded in Waterton Lakes, Banff, Jasper, Kootenay and Yoho national parks. File Report NOR-1-033.

1979-80

Hiratsuka, Y. and J. Petty. 1979. Important forest insects and diseases. Prairie Region. *In*: Forest Insect and Disease Survey Annual Report, 1977 (In press).

Still, G. N. 1979. Jack pine budworm infestations in Manitoba, 1979, and forecasts for 1980. File Report NOR-1-033.

Still, G. N. 1979. Trembling aspen defoliation in Alberta, 1979. File Report NOR-1-033.

Petty, J. and G. N. Still. 1979. Forest tent caterpillar, *Malacosoma disstria* Hbn., Saskatoon, Saskatchewan. File Report NOR-1-033.

Petty, J. 1979. Forest tent caterpillar post-hatch survey, Saskatchewan. File Report NOR-1-033.

Emond, F. J. 1979. Tree pest extension report, Alberta, 1979. File Report NOR-1-033.

Tidsbury, R. C. 1979. Tree pest extension report, Saskatchewan, 1979. File Report NOR-1-033.

Still, G. N. and J. Petty. 1979. Forest tent caterpillar infestation forecasts for 1979, Central Alberta, File Report NOR-1-033.

Hiratsuka, Y. and T. Evans. 1980. A survey of pine stem rusts on nursery stock at Pine Ridge Tree Nursery, Smoky Lake, Alberta. Report prepared for AFS.

Still, G. N. 1979. Jack pine mistletoe distribution in the Fort McMurray - Lake Athabasca area. File Report NOR-1-033.

Cerezke, H. F. 1979. Mountain pine beetle outbreak - Crowsnest Forest. Status Report. File Report.

Hiratsuka, Y. Fungi. *In*: Natural History of Alberta. Provincial Museum of Alberta (In press).

Emond, F. J. 1980. Insect and Disease Survey, Saskatchewan Provincial Nurseries. File Report NOR-1-033.

16. Signatures:

Investigator

Program Manager

Herbert Ceraj

Investigator

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

1. Project: Detection and appraisal of tree pests.

2. Title: Sawfly systematics.

3. New: Cont.: 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:

Sawflies cause serious damage to forest and shade trees in 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 the most experienced of two people in Canada at the present time, actively engaged in the systemic 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, phylogency, etc. Keys are constructed to assist in future identification.

9. Study Objectives:

   1. To make biosystematic studies of the sawflies of Canada and maintain taxonomic expertise in this group of insects at the national and international level.

   2. To separate the various sawfly species in their mature and immature forms by means of keys, descriptions and illustrations.

   3. To study the evolution and biogeography of the more important sawfly genera leading to their revision in North America, North of Mexico.

   4. 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 1980-81 with costs: Nil
   e. Essential new major equipment items beyond 1981 with costs: Nil
   f. 1980-81 man-years

1980-81 man-years	Prof.	0.5
	Supp.	0.0
	Casual	0.0
	Total	0.5

11. Progress to Date:

Over thirty scientific papers have been published in this study. The subject matter and the species or genera treated are indicated in previous study statements.

12. Goals for 1979-80:

   1. Identify sawflies for research personnel, institutions and laboratories.

   2. Determine the life history of *Nematus fulvicrus* Provancher, a sawfly causing serious damage to willows in Alberta.

   3. Prepare slides and make illustrations of a number of species of *Pristiphora* from Asia, Europe and North America to determine their relationship to one another.

13. Accomplishments in 1979-80:

   1. (a) Identified nearly 500 larval and adult sawflies for the forest insect and disease survey of the Northern Forest

Research Centre; Canadian National Museum; United States National Museum; Chinese Academy of Forestry, Peking; regional clients and in-service personnel.

(b) Examiner. Ph. D. Thesis on a subfamily of sawflies. University of Delhi, Delhi, India, 539 pp.

(c) Reviewer. Revision of a sawfly genus. Memoir. Entomological Society of Canada. 432 pp.

(d) Reviewer. Sawfly papers submitted to Bull. Nat. Sci. Mus. Tokyo and Proc. Entomol. Soc. Washington.

2. Populations of *Nematus fulvicrus* Provancher declined in 1979 and material was not readily available for study. Limited material suggests the species overwinter in the cocoon stage, eggs laid at the apex of leaf, and at least two generations a year.

3. Over 200 slides and nearly 50 illustrations of *Pristophora* have been prepared from Asia, Europe and North America and their relationships deduced.

14. Goals for 1980-81:

1. Identify sawflies for research personnel, institutions and laboratories.

2. Obtain additional information on the life history of *Nematus fulvicrus* Provancher, if populations are available.

3. Determine the species of *Pristophora* that are new to science in North America and determine their phylogenetic relationship.

15. Publications:

Up to 1979 - 80

35 publications

1979-80

Nil

16. Signatures:

Investigator

W. J. Johnson
Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

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

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

3. New: Cont.: 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 roles 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 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

	Prof.	0.4	(Y. Hiratsuka)
	Supp.	0.7	(P. J. Maruyama)
	Casual	-	
	Total	1.1	

11. Progress to Date:

Diagnostic and identification service of forest tree diseases has been provided for CFS personnel, outside agencies and the general public. The identification service has been closely coordinated with the pest extension service (NOR-1-033) and supported by an extensive disease reference collection and a fungus culture collection. The two collections have become the best and the most extensive depository of forest disease specimens and cultures in the Prairie Provinces. An annotated checklist of tree and shrub diseases in the Prairie Provinces and several minor mycological papers were published. Several papers on DED with the cooperation of Dr. Takai (GLFRC) have been published.

12. Goals for 1979-80:

1. Provide diagnostic and identification service of tree and shrub diseases.

2. Maintain and upgrade the Mycological Herbarium (disease reference collection) and a fungus culture collection.

3. Publish a paper entitled, "A new leaf spot fungus *Marssonina balsamiferae* on *Populus balsamiferae* in Manitoba and Ontario".

4. Continue work on preparing first draft of an information publication on common tree diseases of the Prairie Provinces.

5. Cooperate with Dr. Takai (GLFRC) on the study of DED and publish several papers jointly.

6. Two pest leaflets (western gall rust and silver leaf) will be prepared.

13. Accomplishments for 1979-80:

1. Provided diagnostic and identification service of tree and shrub diseases.

2. Maintained and upgraded the disease reference collection and the fungus culture collection.

3. A journal paper entitled, "A new leaf spot fungus *Marssonina balsamiferae* on *Populus balsamiferae* in Manitoba and Ontario" is ready for review.

4. Some progress has been made to prepare the first draft of an information publication on major tree diseases of the Prairie Provinces.

5. Three journal papers were published or accepted for publication on DED with Dr. S. Takai (GLFRC) (see 15. Publications).

6. Two pest leaflets (western gall rust and silver leaf) have been prepared and are ready for review.

14. Goals for 1980-81:

1. Provide diagnostic and identification service of tree and shrub diseases.

2. Maintain and upgrade the Mycological Herbarium and a fungus culture collection.

3. Publish a journal publication on a new leaf spot fungus on poplar.

4. Complete the first draft of an information publication on major tree diseases of the Prairie Provinces.

5. Cooperate with Dr. S. Takai (GLFRC) on the study of DED especially on the aspect of SEM examinations.

6. Two pest leaflets (western gall rust and silver leaf) will be published.

15. Publications:

1978-79

Hiratsuka, Y. and S. Takai. 1978. Morphology and morphogenesis of synnemata of *Ceratocystis ulmi*. Can. J. Bot. 56:1909-1914.

Takai, S. and Y. Hiratsuka. 1978. Ceratoulmin, a wilting toxin of *Ceratocystis ulmi*: Some features of a pathotoxin. *In*: Proceedings, Joint CPS-CSPP Meeting, Winnipeg.

1979-80

Takai, S., W. C. Richards, Y. Hiratsuka and K. J. Stevenson. 1979. Cerato-ulmin, a semipathotoxin of *Ceratocystis ulmi*. *In*: Recognition and specificity in plant host parasite interactions. Tokyo University Press. pp. 147-151.

Takai, S. and Y. Hiratsuka. 1980. Accumulation of the material containing the toxin cerato-ulmin on the hyphal surface of *Ceratocystis ulmi*. Can. J. Bot. (In press).

Takai, S., Y. Hiratsuka, J. Krywienczyk, W. C. Richards and Y. P. Davies. 1980. Evidence for the presence of the toxin cerato-ulmin in the synnema head fluid of *Ceratocystis ulmi*. Can. J. Bot. (In press).

16. Signatures:

Investigator

H J Johnson
Program Manager

G. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

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 arises 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 arises, 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 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

	Prof.	0.5	
	Supp.	1.0	(J. C. Melvin)
	Casual	0.0	
	Total	1.5	

11. Progress to Date:

Recorded formerly in NOR-1-033.

12. Goals for 1979-80:

1. Provide diagnostic and biosystematic services for the more difficult determinations on mature and immature insects damaging forest and shade trees.

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 on insect damage to old oak beams in Manitoba.

5. Prepare a paper on parasites recovered by rearing overwintering larvae of the large aspen tortrix on artificial diet.

13. Accomplishments in 1979-80:

1. Diagnostic and biosystematic services made several thousand determinations and handled over a thousand inquiries for in-service personnel, clients, outside agencies, scientists and the general public.

2. (a) One hundred and seventy-seven insect specimens have been sent to specialists in Ottawa for identification, and 99 specimens which were identified by the specialists have been added to the reference collection.

   (b) Over 300 insect samples were reared and over 25 overwintered to obtain biological information and specimens for the reference collection.

   (c) Over 200 insect specimens were pinned, spread, labelled or preserved for the reference or store collections.

3. Biological information and/or specimens were provided to the following:

   Dr. Laurent Le Sage, University of Waterloo, Waterloo, Ontario
   Dr. I. Ryan, McCourt Management Ltd., Edmonton, Alberta

4. Published: Quaestiones Entomologicae 15:335-339. 1979.

5. Published: Bi-Monthly Research Notes 35(4):21. 1979.

14. Goals for 1979-80:

1. Provide diagnostic and biosystematic services for the more difficult determinations on mature and immature insects damaging forest and shade trees.

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

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

15. Publications:

Up to 1979-80

62 publications

1979-80

Wong, H. R. 1979. Insect damage to old oak beams at Lower Fort Garry, Manitoba. Quaestiones Entomologicae 15:335-339.

Wong, H. R. 1979. Biological observations on overwintering larvae of the large aspen tortrix in Alberta. Bi-Monthly Research Note 35(4):21.

Wong, H. R. 1978 (Pub. 1979). Structural timber damaged by larder beetles. Proc. Ent. Soc. Alberta 26:19.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

PROJECT NOR-3

Resource opportunities and policy guidelines

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Resource opportunities and policy guidelines.

2. Title: An assessment of the forest-based economy of the Prairie Provinces.

3. New: Cont.: X 4. No.: NOR-3-123

5. Study Leader: W. Ondro

6. Key Words: Sawmills, pulp mills, products, employment, markets, costs, benefits, economic impacts, forest industry.

7. Location of Work: Northern Forest Research Centre, Edmonton, Prince Albert, Regina, Winnipeg.

8. Problem:

The forestry sector accounts for nearly 500 million dollars in value added in manufacturing to the provincial economies in the Prairie Provinces. Many of the smaller population centres are directly dependent on the forest industry. All levels of government, the forest inudstry and private land owners benefit from the use of the forest resource to some extent. Protection expenditures continue to account for a major portion of funds spent on resource management, but reforestation activities are accelerating at a relatively faster rate. As a result, there is an increasing demand for economic analyses of problems to provide a realistic information base for decision-making.

This study will provide recommendations and guidelines to resource planners, managers and researchers for the improvement of the competitive position of the forest industry, provision of national statistics, management of the forest economy, regulation of trade and commerce and improvement of employment opportunities. It will contribute to the coordination of federal inputs into forestry in the Region.

The probability of success in terms of achieving the study objectives is high. The probability of the results or conclusions reached being put into practice or being seriously considered in policy formulation is not readily known as it is almost totally dependent upon the decisions of individuals other than the investigators.

The methods employed in this study can be viewed as survey methods in general. Data collection from government, industry and the general public is conducted by telephone, letter and personal interview. In some cases, data is collected by the use of questionnaires.

9. Study Objectives:

1. To provide socio-economic information to regional forestry programs for rational policy formulation and program development by identifying and estimating the major economic benefits, product flows and impacts of the forest resource and its utilization in W & N Region.

2. To provide input to regional forestry programs by participating as a team member in interdisciplinary studies.

3. To provide economic statistics and guidelines on costs and benefits concerning the forest resource, impacts of forest management, marketing, and related socio-economic factors.

10. Resources:

a. Starting date: 1972
b. Estimated year of completion: Continuing
c. Estimated total Prof. man-years required: N/A
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	1.9	(W. Ondro 0.9, Vacant 1.0)
Supp.	3.0	(R.A. Bohning, H.M. Stewart, G.R. Stevenson)
Casual	-	
Total	4.9	

11. Progress to Date:

Studies were completed to provide comprehensive statistical descriptions of some major economic impacts of forestry and forest-based industry to the prairie economies for the purpose of more effective utilization and management of forest resources. Three information reports, covering Alberta, Manitoba and Saskatchewan, were published between 1972 and 1975. A directory of primary wood-using industries in west-central Canada was prepared in 1973. No economist on staff between 1975 to February 1978. A new expanded "Directory of Primary

Wood-Using Industry in Alberta 1979" prepared. Alberta industry survey information being processed and analyzed manually and by computer to serve also as a data base for computerized information system at N.F.R.C.

12. Goals for 1979-80:

1. Publish Forestry Report - Improvements of forestry in Manitoba, 1979.

2. Complete data collection and initiate analysis for the study on the "Forestry sector in the economy of Alberta".

3. Prepare study plan, methodology and experimental design to determine regional harvesting and transportation costs in Saskatchewan.

4. Collect and summarize data for Forestry Report - Economic impact of forestry sector in Alberta.

5. Recruit 2nd and 3rd forest economist.

6. Contribute economic data to regional data base.

7. Provide economic expertise and conduct feasibility studies to ensure effective implementation of DREE agreements in Prairie Provinces as required.

8. Develop work plan to compare economic benefits of reforestation alternatives.

Goals Added:

9. Prepare a regional forest resource policy and economics inputs into federal forest policy, 1979.

10. Prepare "A Directory of Wood-Using Industries in Alberta, 1979".

11. Publish paper "Socio-economic Impact of Climate on Forestry in Alberta" Proceedings of the Workshop and Annual Meeting of the Alberta Climatological Association, 1980.

13. Accomplishments in 1979-80:

1. Forestry Report - Importance of forestry in Manitoba, 1979 - published.

2. Data collection completed and computer processing started on the study "Forestry Sector in the economy of Alberta".

3. Study plan to determine regional harvesting and transportation costs in Saskatchewan not carried out, since second economist not recruited.

4. Data for Forestry Report - Economic Impact of forestry sector in Alberta - collected and summarized.

5. No forest economist recruited.

6. Regional data base not defined, so economic data not provided.

7. Economic expertise to ensure effective implementation of DREE agreements in Prairie Provinces not required.

8. Work plan to compare economic benefits of reforestation alternatives not prepared, since second economist not recruited.

Accomplishments Added:

9. Regional forest resource policy and economics inputs into federal forest policy provided.

10. "A Directory of Wood-Using Industries in Alberta 1979" was prepared.

11. Paper "Socio-economic Impact of Climate on Forestry in Alberta, 1980" published.

14. Goals for 1980-81:

1. Complete data collection and initiate analysis for the study on the "Forestry Sector in the economy of Saskatchewan".

2. Complete data collection and initiate analysis for study on the "Forestry Sector in the economy of Manitoba".

3. Prepare "A Directory of Wood-Using Industries for Saskatchewan and Manitoba, 1980".

4. Publish "A Directory of Wood-Using Industries in Alberta 1979"- joint publication with Alberta Forest Service.

5. Publish Information Report, "Alberta's Primary Wood-Using Industry, 1979".

6. Contribute economic data to regional data base as required.

7. Provide economic expertise and conduct feasibility studies to ensure effective implementation of DREE agreements in Prairie Provinces as required.

8. Costs of harvesting and chipping of aspen stands for energy production (supervise ENFOR contract P - 163).

15. Publications:

Up to 1978-79

W. J. Ondro, D. V. Love. Growth Response of Northern Hardwoods to Partial Cutting in Southern Ontario. For. Chron. Vol. 55:1 (13-16).

1979-80

W. J. Ondro. Forestry Report - Importance of forestry in Manitoba, 1979.

W. J. Ondro. Socio-economic impact of Climate on Forestry in Alberta *in* J. M. Powell (compil.) Socio-economic impacts of climate: Proceedings of the Workshop and Annual Meeting of the Alberta Climatological Association. Environ. Canada. North. For. Res. Centre. Inf. Rep. NOR-X-217, 1980.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

PROJECT NOR-4

Yields of managed stands

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Yields of managed stands.

2. Title: Growth and development of three native conifers in treated and untreated stands.

3. New: Cont.: X 4. No.: NOR-4-045

5. Study Leader: I.E. Bella

6. Key Words: *Pinus banksiana, P. resinosa, P. contorta* var. *latifolia, Picea glauca,* tree and stand growth, density, yield, stocking, site, yield tables, thinning methods and intensities, spacing.

7. Location of Work: Various locations in Manitoba, Saskatchewan and Alberta.

8. Problem:

Jack pine is one of the most widely occurring species in the Boreal Forest. It regenerates readily and grows relatively fast even on dry, sandy soils. Improved management of the species requires reliable methods of forecasting growth and yield of stands of different density and site quality. This kind of information is also necessary to make decisions about density control treatments designed to increase merchantable yield or shorten rotation. This information is needed now and its use is assured as it becomes available.

Red pine grows in association with jack pine, generally on better sites. White spruce is a major component of the mixedwood forest. All these tree species are now being the backbone of planting programs, which is becoming an increasingly important method of reforestation. Growth and yield in plantations depends, to a large extent, on spacing of the trees and appropriate selection of species. This study is to provide such needed information.

Methods:

Thinning experiments. In the earlier ones, where trees were individually selected and cut, the intensity of thinning was defined in an arbitrary fashion, usually on the basis of crown class designation. In the more recent experiments, intensity was defined by spacing, basal area, or SDI. In strip thinning, intensity is the function of residual strip width, while the width of the cut strip is constant. Stands were thinned once in all but one experiment. Stand ages and site conditions usually differed by studies. Measurements and remeasurement: dbh to 1/10 inch of all trees, height of selected sample trees only. In most selective thinning experiments, the trees on the plots were mapped. More recently, some short term studies have been undertaken on testing thinning equipments (brush saws); and analyzing two thinning-fertilization-experiments in lodgepole pine, that was initiated by J. Soos.

Spacing experiments. Establishment 1963 and 1964. Four spacings were used: 4 X 4, 6 X 6, 8 X 8, and 10 X 10, 49 trees (7 X 7 matrix) on each plot with a surround of two rows. Each spacing was replicated four times per species per area. Trials established for the three species in Manitoba were:

Picea glauca - at Riding Mountain on fresh till.
- in Sandilands Forest Reserve on fresh sand.

Pinus banksiana - Sandilands Forest Reserve on dry and/or fresh sand.

P. resinosa - in Sandilands on fresh sand.

9. Study Objectives:

1. To determine the effect of different types and intensities of thinning on subsequent growth and yield of jack pine.

2. To determine growth and development of three indigenous conifer species, *Picea glauca, Pinus banksiana* and *P. resinosa* at various spacings on major site types, so that optimum spacing can be selected for specific management objectives in future planting.

10. Resources:

a. Starting date: as early as 1921
b. Estimated year of completion: Most of these studies generally extend over the life of the stand.
c. Estimated total Prof. man-years required: 3.0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.5	(I.E. Bella)
Supp.	0.5	(J.P. DeFranceschi)
Casual	0.0	
Total	1.0	

11. Progress to Date:

1. Thinning experiments;

a) Sample plots have been established and thinning treatment carried out where required. Trees on the plots were measured and remeasured. Empirical yield tables and interim results of the thinning experiments have been published.

b) Undertook the assessment of growth response to operational strip thinning programs in pine--jack pine in Manitoba, lodgepole in Alberta--by the respective provincial government agencies, and published results as became available.

c) Conducted performance trials with brush saws for thinning young lodgepole pine stands.

2. Spacing experiments:

a) The spacing trials were established in the spring of 1963 and 1964. First year mortality was filled in the first spring following planting. A cursory examination to determine mortality trends and general health status of trees was done in the autumn of 1971.

b) Spacing trials with adequate survival were remeasured in the late summer of 1973. (One replication of the jack pine trials that were located south of Sandilands on dry sites, were abandoned because of excessive mortality due to a severe drought in 1967.) An Information Report was written based on the remeasurement results.

3. Some 18 reports and journal articles have been published on growth and yield, on thinning and spacing response mainly on jP, but also on lP, rP, sP and wS by Bella, I.E. and J.P. DeFranceschi, Cayford, J.H., Steneker, G.A., and Wilson, G.M. between 1950 and 1978.

12. Goals for 1979-80:

1. Analyze data from spacing experiments in jP, rP and wS in Manitoba and initiate preparation of a report on optimum spacing guidelines for planting these species.

2. Review available growth and yield data for jP (and lP) in the Prairie Provinces and assess their suitability as input into a forest management decision model. In cooperation with other scientists, develop means to integrate these growth and yield data with similar information being obtained in the new site classification being developed for Alberta.

3. Remeasure mechanical thinning study in jP in Sandilands, Man. (Study 4e and 4g), 20 plots.

13. Accomplishments in 1979-80:

1. Results from jP, rP and wS spacing experiments in Manitoba were analyzed, and a report was written, entitled "Spacing effects 15 years after planting three conifers in Manitoba," providing spacing guidelines for these species.

2. Reviewed and summarized available growth and yield data for jP in the Region. Their suitability as input into a forest management decision model is being assessed. Contact was established with the site classification group for reviewing and assessing their data for the same purpose.

3. Mechanical thinning study in jP in Sandilands, Manitoba (Study 4e and 4g, 20 plots) was remeasured.

Added goal:

4. Cooperated with the MFS to design and establish a joint study for assessing growth response after operational selection thinning of rP plantations in Southeastern Manitoba.

14. Goals for 1980-81:

1. Publish manuscript on spacing effects in jP, rP and wS as an information report.

2. Participate in the development of a computerized growth and yield data bank for the region, and in the development, testing, and refinement of growth prediction model(s) for regional application.

3. As requested by the AFS, develop a study plan, direct field sampling and conduct analysis on the effect of cutting seismic lines in the forest, on tree and stand growth and yield in the commercial forest zones of Alberta.

15. Publications:

1978-79

Nil

1979-80

Nil

16. Signatures:

Investigator

Program Manager

Director

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE,

1980

Study No.	Location	Soil and Site	Stand age at establishment	Date of establishment	Date of remeas.*	No. of plots	Plot size (acres)	Thinning: Method	Thinning: Intensity
2	Sandi-lands, Man.	Stratified sand and gravel outwash; moist	15	1952	1957 1962 1967 1971 1977 (1982)	16	0.1	Low selection thinning to specified Stand Density Index every 5 years, except in 1971	Control, no thinning - 2 plots Thinned: To 40%, 50%, 60%, 70%, 80%, 100%, and 120% of control SDI; 2 plots each
3	Sandi-lands, Man.	Medium sand; fresh	40	1958	1963 1968 1973 1978 (1983)	20	0.1	Merchantable Selection thinning, low and crown. Only trees with dbh over 4" were removed.	Control, no thinning - 4 plots Thinned: Heavy low 4 plots Light low 4 plots Heavy crown 4 plots Light crown 4 plots
4	Sandi-lands Forest Res., Man.	a. Sand, fresh	9	1964	1965 1968 1973 1978	15	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots Thinned 2-way: 5 plots
		b. Sand, fresh	11	1967	1969 1976 (1981)	5	.002 - .007	Mechanical Strip-thinning	Thinned 1-way: 5 plots

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE,

1980 (Continued)

Study No.	Location	Soil and Site	Stand age at establishment	Date of	Date of remeas.*	No. of plots	Plot size (acres)	Thinning Method	Thinning Intensity
4	Sandilands Forest Reserve, Man.	c. Sand, moist	9	1964	1965 1968 1973 1978	15	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots Thinned 2-way: 5 plots
		d. Sand, moist	11	1967	1969 1976 (1981)	5	.002 - .007	Mechanical Stip-thinning	Thinned 1-way: 5 plots
		e. Sandy till, fresh	13	1965	1967 1970 1974 1979	10	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots
		f. Sandy till, fresh	17	1966	1968 1970 1975 (1980A)	10	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots
		g. Sand, dry	13	1965	1967 1970 1974 1979	10	.002- .007	Mechanical strip-thinning	Control: 5 plots Thinned 1-way: 5 plots

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE,

1980 (Continued)

Study No.	Location	Soil and Site	Stand age at establishment	Date of establishment	Date of remeas.*	No. of plots	Plot size (acres)	Thinning: Method	Thinning: Intensity
5	Duck Mtns.		11	1948	1968 1978	5	.25	Selection & Strip	Control: 2, Strip: 1, 7 x 7: 1; 5 x 5: 1
6	Bow River Forest, Alta.	Till, fresh to moist	30	1971	1976 (1981)	20	.002 - .007	Mechanical Strip-thinning	Control: 6 plots Thinned 1-way: 14 plots
7	Hinton, Alta.	Till, fresh	16	1973	1978	18 3 plots only	.025	Selective thinning with a brush saw	Thinned: 6-7 ft spacing
8	Edson Forest	Silty till, fresh	20	1977	(1982)	18	3.4- 289 m^2	Mechanical strip thinned - Selective thinned	10 plots Control: 5 plots Thinned: 3 plots
	Rocky-Clearwater Forest	Silty till, fresh	9	1977	(1982)	15	12- 196 m^2	Mechanical	1-way 2-way Discs 2 plots 2 plots Barrels 2 " 2 " Chains 2 " 2 " Control 3 plots

* Bracketed dates denote planned remeasurement.

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Yields of managed stands.

2. Title: Mathematical stand growth model for aspen.

3. New: Cont.: X 4. No.: NOR-4-075

5. Study Leader: I.E. Bella

6. Key Words: *Populus tremuloides*, tree and stand growth, stand development density-competition effects, clonal structure, yield, stocking, site, ecological systems, models, simulation.

7. Location of Work: Manitoba and Saskatchewan, some of the analysis at University of British Columbia.

8. Problem:

A general method is needed to forecast growth and yield of aspen for a variety of stand conditions. Of primary interest now is the effect of stand density on merchantable yield both in treated and in untreated stands. Predicting response to fertilization is likely to be a problem in the near future. Such information is a prerequisite to more efficient forest management. Even partial success and preliminary results would be valuable and would be used as became available.

The complexity of this problem, arising largely from the clonal habits of the species, makes it impractical to attempt a solution using conventional techniques only, i.e., sampling and experimentation. Systems modelling and computer simulation is an approach that may provide answers at a reasonable cost in a relatively short time and is used in this study.

9. Study Objectives:

To forecast growth and yield of aspen stands growing under a range of site and density conditions using a stand growth model developed for this purpose.

10. Resources:

a. Starting date: 1968
b. Estimated year of completion: Continuing Revised: Most of these studies generally extend over the life of the stand.
c. Estimated total Prof. man-years required: N/A
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.4	(I.E. Bella)
Supp.	0.5	(J.P. De Franceschi)
Casual	-	
Total	0.9	

11. Progress to Date:

1. Identified major components of tree growth and mortality and developed appropriate mathematical descriptions. Major features of this model are: (a) a new (hopefully improved) method of evaluating competition and description of tree spatial pattern, (b) introduction of a random component in growth (and mortality) and (c) prediction of dry matter weight production.

2. Analyzed growth-competition relations and developed a new competition model from appropriate tree growth data (various thinning and spacing studies) that also included information on spatial pattern of trees in the sample stands.

3. Studied the effect of clonal differences on diameter growth.

4. Pooled information from previous thinning studies (in stands over 10 years old) on stand development in terms of tree growth and size distributions (living and dead), and conducted a study to define the effect of initial sucker density on tree growth and stand development.

5. Developed a computer program for an aspen stand model and conducted initial test runs.

6. An assessment of another stand model (by Stage, USFS), somewhat simpler in principle, was conducted to find out if that model could be easily adopted for immediate use in this region. It was found that this model also required much further refinement, testing and additional local data before it could be applied in forest management practice.

7. Incorporated all previous aspen thinning trials (previously under NOR-4-072) into this study.

8. Some 20 reports and journal articles, and a thesis have been published on aspen growth, yield, thinning response, clonal habits, component weights of aspen trees (biomass), effect of logging practices on initial density, and on intertree competition and simulation modeling by Bella, Bella and De Franceschi, and G.A. Steneker.

12. Goals for 1979-80:

1. Complete the analysis of aspen biomass data and publish appropriate biomass yield tables for young aspen stands as an information report.

2. Using aspen Height/Age data from stem analysis of dominant trees provided by the Aspenite Div. of M & B, Hudson Bay, Sask., also using SI curves by Kirby for Sask., McLeod for Alberta, and other dominant H/A data available from various growth, yield and thinning studies in the region, develop a set of generalized SI predicting functions for this region.

3. Review available growth and yield data for aspen in the region and assess their suitability as input into a forest management decision model.

4. As scientific authority, contribute to the supervision of ENFOR contract P-102 "Development of a stand growth model for trembling aspen in the Prairie Provinces", by Profs. Higginbotham, Heidt, Titus, Dep. Forest Science, University of Alberta.

13. Accomplishments in 1979-80:

1. Completed the analysis of aspen biomass data and prepared an Information Report for publication.

2. Developed a set of generalized SI functions for the region for publication as a Forest Management Note.

3. Initiated a review of available growth and yield data for aspen in the region to assess their suitability as input into a forest management decision model.

4. As scientific authority, supervised ENFOR contract P-102.

14. Goals for 1980-81:

1. Publish generalized SI function for aspen as a Forest Management Note.

2. Analyze juvenile aspen development data and if warranted by the results, define initial density objectives for this species.

3. Participate in the development of a computerized growth and yield data bank for the region; and in the development, testing and refinement of growth prediction model(s) for regional application.

4. As scientific authority, continue the supervision of ENFOR contract P-102 "Development of a stand growth model for trembling aspen in the Prairie Provinces".

15. Publications:

1978-79

Nil

1979-80

Bella, I. E. and J. P. De Franceschi. 1980. Biomass productivity of young aspen stands in western Canada. CFS, Information Report. NOR-X-219.

16. Signatures:

Investigator

Program Manager

Director

SUMMARY OF ACTIVE THINNING AND OTHER GROWTH STUDIES IN ASPEN

1978

Study No.	Location	Soil and site	Stand age at establishment	Date of establishment	Date of remeas.*	No. of plots	Plot size (acres)	Thinning Methods	Thinning Intensity
1 (MS133)	Turtle Mtn. For. Res.	Non telluric mesic clay loam till	11	1948	1953 1960 1965 1971 1976 (1981)	5	0.2	Regular spacing and alternate Strips	Control, no thinning - 2 plots Thinned: 5' x 5', 7' x 7', and 20' alternate strips - 1 plot each
2 (MS155)	Pelly, Sask.	Non telluric mesic clay loam till	14	1951	1957 1962 1967 1972 1977	14	0.2	Thinned to fixed SDI every 5-years	Control, no thinning - 2 plots Thinned: to 120, 100, 80, 70, 60, and 50% of SDI of control in 1951 - 2 plots each intensity
3 (MS146)	Riding Mountain	Non telluric mesic clay loam till	14	1950	1960 1965 1971 1976 (1981)	4	0.1	Regular spacing	Control, no thinning - 1 plot Thinned: 8' x 8', 10' x 10', 12' x 12' - 1 plot each
	National Park	Telluric mesic silty clay loam till	23	1950	1960 1965 1971 1976 (1981)	8	0.2	Regular spacing	Control, no thinning - 2 plots Thinned: 8' x 8', 10' x 10', 12' x 12' - 2 plots each
4 (MS232)	Porcupine Mtn. Swan River, Manitoba	Non telluric mesic clay loam till	15	1964	1969	24	0.1	Thinning to regular spacing and pruning	Control, no thinning - 12 plots Thinned and Pruned: 12' x 12' sp. with 5 pruning treatments

* Planned measurement in the coming year are in brackets

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Yields of managed stands.

2. Title: Transformation and movement of applied fertilizer elements (N, P, S) in selected lodgepole pine stands.

3. New: Cont.: X 4. No.: NOR-4-102

5. Study Leader: J. Baker

6. Key Words: Ammonium-nitrogen, nitrate-nitrogen, amino sugar-nitrogen, amino acid-nitrogen, humin nitrogen, soil horizon, moisture tension, aluminum- & iron phosphate, sulfate-S, total-S.

7. Location of Work: Edmonton, Hinton, Alberta (Edson map sheet 83F)

8. Problem:

Nature of Study:

This is principally a study to determine soils response to applied N, P & S. It emphasizes the influence of soil properties on the transformation, movement, immobilization, and distribution of soil N, P & S. It also seeks to evaluate the modificaitons brought about within the several soil N, P & S fractions as a result of artificially applied fertilizer.

Benefits expected:

In conjunction with the growth measurements obtained in study NOR-4-122, it is expected that information gained in this phase of the project will provide a base for interpretation of stand performance and growth response. In addition, results obtained in this trial will provide information important in deciding the profitability of artificial fertilization of forested areas dominated by these and similar soil types.

Probability of Success:

Initial results, so far as soil responses to fertilizer applications are concerned, suggest that these and similar soil would profit from such applications. Growth and foliar analyses results will have to be considered also before any judgement can be made regarding the likelihood of success.

Probability of Practical Application of Results:

Should both stand and soil responses indicate the probability of success, it would seem reasonable that forest operations (logging and lumber industry) and forest managers (parks and recreation) would be keenly interested in the practical application of results to increase productivity, especially so in view of the decreasing land base available to them.

Method Used:

This is essentially a field oriented study. In the field various installations on treated and untreated plots (Study NOR-4-122) have been carried out. Sampling of soils, vegetation and the various installations will be done on an annual basis to monitor effects of nitrogen applications on soil N, P & S distributions, foliar composition and stand growth - initial (first growing season) and residual (subsequent growing seasons) effects are to be studied.

9. Study Objectives:

To determine the influence of soil properties on the transformation, distribution and accumulation of the various soil N, P & S fractions, amonium-nitrogen, nitrate-nitrogen, humin-nitrogen, or the phosphate, sulfate sulfur, etc. from soil fertilizer applications within selected lodgepole pine stands.

10. Resources:

a. Starting date: 1972
b. Estimated year of completion: 1980 (originally)
c. Estimated total Prof. man-years required: 0.9
d. Essential new major equipment items for 1980-81 with costs:
   Spectrophotometer - $4,500 - 5,000.
   (If the air pollution group obtains such an instrument, this would suffice.)
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

1980-81 man-years	Prof.	0.5	(J. Baker)
	Supp.	0.5	
	Casual	-	
	Total	1.0	

11. Progress to Date:

Soil and foliar analyses have been done on two different occasions since fertilization. Two reports on N-status and two on P-status in Coalspur and Mercoal soil types have been completed. Both soil and foliar samples were taken in November 1977 (5-years after fertilization) and these have been kept in cold storage pending study review decisions. Soil analyses are approaching completion and vegetation analyses for N, P & S will also be undertaken to give an estimation of uptake of nutrients by the stand.

12. Goals for 1979-80:

To complete:

1. Analyses of soil samples.

2. Report of results.

13. Accomplishments in 1979-80:

All soil analyses N, P & S have been completed.

Foliar samples taken at the same time as soils were sampled (added) are not yet complete. Needle and twig tissues are being analyzed separately for N, P & S.

Soil N analyses showed:

a. While the two luvisolic soils responded similarly to the added fertilizers, concentrations (ppm) and contents (kg) were considerably higher in all fractions examined in the orthic luvisol (Coalspur).

b. Both soils (Coalspur and Mercoal) showed a N deficit in the litter layer and in the upper mineral horizons as a 5-yr residual effect; this was especially noticable in the high-N and high-P treatments. The high-S combination showed an N gain.

c. Despite treatment and regardless of N-magnitudes in the various fractions examined, on a percentage basis soil N distributed itself in a common pattern--suggesting the occurrence of an equilibrium between the N-fractions.

Soil P analyses:

a. Generally all P combinations showed slight P gains as a 5-yr residual effect.

b. Greater total soil-P was found in the Coalspur than that in the Mercoal.

c. As in the case of N, plots receiving P in combination with the highest S application showed highest P concentrations.

d. Percentage distribution of P within the P-fractions differed considerably from those for control samples. This was true of both soils.

Soil S analyses:

a. All sulfur combinations showed a marked increase in soil-S status over that in the untreated plots as a 5-yr response.

b. Coalspur again showed greater available as well as total S contents throughout the sampling depths than those found in the Mercoal.

c. In both soils, plots receiving highest S treatment showed higher soil S values throughout.

d. As a result of S applications available soil-S levels increased to a greater extent than corresponding total soil S values.

Foliar analyses:

Coalspur samples:

Phosphorus Trees receiving the highest N application combinations gave a foliar P mean less than that for the control trees.
Trees receiving the highest S application combinations had the highest P mean.
The highest P application combinations gave P means only slightly higher than those found for control trees.

Nitrogen Highest N application combinations produced foliage with lowest mean N values.
Again highest S application combinations were associated with foliage with highest mean N levels.
Highest P application combinations produced foliar N means virtually identical with those from controls.

Sulfur Not completed.

Mercoal samples: - not completed.

14. Goals for 1980-81:

1. Completion of soils and vegetative analyses with a report of results.

2. Terminate study.

15. Publications:

1977-78

Baker, J. 1977. The reaction of two luvisolic forest soils to phosphate applications. Can. J. Soil Sci. 57:385-395.

1978-79

Nil

1979-80

Nil

16. Signatures:

Joseph Baker
Investigator

Program Manager

Director G. T. Silver

PROJECT NOR-5

Fire management systems and guidelines

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Fire retardant and airtanker evaluations and application.

3. New: Cont.: X 4. No.: NOR-5-037

5. Study Leader: R. G. Newstead

6. Key Words: Airtankers, helitankers, retardants, aerial suppression, airtanker accuracy, effectiveness, drop patterns, static testing, tank and gating systems, simulation models, wildfires.

7. Location of Work: Throughout region.

8. Problem:

This operational research study is oriented towards the immediate needs and requests of client agencies, namely Provincial and Territorial Forest Services. The intent is to improve aerial suppression methods by optimizing the use and effectiveness of available airtankers, helitankers and retardants. Results from this study complement those of NOR-128, 131 and 130. Benefits accruing will include reductions in fire suppression costs, and areas burned as well as limiting damage to the forest resource by enhancing operational effectiveness in the control of wildfires by fire control agencies.

Through continuous cooperative effort and liaison with client agencies, the probability of application of study results will be high in the long run, although technological and financial considerations may somewhat affect the degree of utilization in the short run.

Results from this study will see almost immediate use because they will be aligned with present client policies, needs and objectives. Past experience supports this assessment.

Methods:

The methods associated with this study involve the use of a wide variety of fixed and rotary-wing airtankers normally employed in fire suppression operations within the region. Similarly there are a variety of fire retardants, both long-term and short-term which form an integral part of this study. Retardant drop pattern tests, airtanker effectiveness evaluations, and fire retardant mixing, quality control and effectiveness investigations all involve closely integrated field and laboratory study procedures. Air drop grids are established and calibrated to determine drop patterns under controlled conditions and may involve the preparation and supervision of contractual arrangements. Airtanker and helicopter retardant delivery systems are evaluated under controlled test conditions on the air drop grid and on wildfire operations. Retardant mixing and application criteria are observed and evaluated in the combustion laboratory and during field operations for both existing and new retardant products. Much related data is accumulated and disseminated through cooperation with other fire operations and research agencies and through communication with client agencies.

9. Study Objectives:

1. To measure and evaluate the drop characteristics of various airtanker/fire retardant combinations, including helitankers.

2. To evaluate fire retardants and determine the optimum application required to slow and/or stop fires burning in different fuels under varying burning conditions.

3. To observe and evaluate the effectiveness of airtankers and helitankers and other fireline construction resources during fire suppression operations.

4. To evaluate new retardant mixing systems and their role on wildfire operations.

5. To analyze and disseminate information concerning resource use optimization to fire management agencies through technical assistance, consultation, and training.

10. Resources:

a. Starting date: 1968
b. Estimated year of completion: 1978 Revised: 1981
c. Estimated total Prof. man-years required: 0.5
d. Essential new major equipment items for 1980-81 with costs: Four (4) pressure sensitive transducers and digital output recorder - estimated total cost - $6,000.00
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1980-81 man-years

Prof.	0.5	(R. G. Newstead)
Supp.	1.0	(R. J. Lieskovsky)
Casual	-	
Total	1.5	

11. Progress to Date:

Fire retardants and other water modifying additives are in common use throughout the northern region. Investigations concerning retardant properties and quality control, airtanker delivery systems, retardant mixing and storage facilities, pilot accuracy and airtanker and helitanker drop patterns have resulted in more effective aerial fire control by user agencies.

Evaluation of on-site effectiveness of selected fire retardants on wildfires and prescribed fires has led to a better understanding of their role in fire control operations. Laboratory analyses and field trials concerning the chemical, physical and rheological properties of retardants and water thickening compounds and associated mixing equipment have provided necessary technical information to manufacturers and users alike. The results of these tests have enabled these organizations to make qualified decisions on the development and utilization of several commercial products. Guidelines on the selection and application of fire retardant and suppression compounds are being drafted in an effort to enhance this process.

The liaison and development functions of this study have effectively transferred technological achievements to regional, national and international forest fire research and suppression organizations.

Progress in the development of a computerized airtanker allocation model, the synthesis of ten years of airtanker drop pattern data, and three years of airtanker performance data is reported in the fire management systems Study NOR-5-174.

12. Goals for 1979-80:

1. Continue experimental burns at the Slave Lake black spruce plots as weather, logistics and Alberta Forest Service support permit. The effects of various durations of drying time on retardant effectiveness will be the primary variable under investigation. Up to six plots could be involved during this phase of the study.

2. Provide technical assistance to regional fire control agencies, specifically:

   a) Respond to a request from the Department of Northern Saskatchewan concerning factors affecting quality control, mixing and application of long-term retardants.

   b) At the request of the NWL & F Service, evaluate the Avalon Aviation on-board injection system proposed for use with Chemonics Ind. water thickening polymer.

c) In conjunction with the AFS, conduct static drop tests on the delivery systems of modified PBY and B-26 airtankers soon to be introduced to Alberta.

d) Provide additional training and consultation as requested.

3. Conduct retardant drop tests with Chemonics Ind. short-term liquid polymer water thickening compound with the B-26 airtanker to compensate for unsatisfactory results obtained in the 1978 Alberta tests.

4. Pending the availability of equipment development and technical assistance, complete construction and calibration of a retardant spray apparatus. Conduct initial tests on coating and penetration effects of different retardant rheological properties.

5. Prepare draft of development criteria and selection guidelines for short-term retardant products.

6. Complete final thesis manuscript and convocate from U of A masters program.

7. Review pre-1977 retardant drop test results and retardant chemicals summary sheet, convert all values to metric (SI) equivalents and prepare same for release and/or publication.

8. Publish:

Hodgson, M. J. and R. G. Newstead. 1978. "Wildfire and Airtanker Allocation," Annals, Ass'n of American Geographers (in review).

Goals Added:

9. Evaluate physical and rheological attributes of a synthetic liquid polymer water thickening compound as submitted for analysis by the Sanitek Corporation, Los Angeles, California.

10. Attend and/or serve on the following:

- Coast Fire Control Course sponsored by the Canadian Forestry Association, at Abbotsford, B. C., April 2 - 6, 1979.

- Fire retardant workshop sponsored by Chemonics Industries (Canada) Ltd. at Kamloops, B. C., April 17 - 20, 1979.

- National Air Attack workshop sponsored by the Canadian Committee on Forest Fire Control at Ottawa, November 5 - 9, 1979.

- AFS Forest Protection Officers annual meeting at Devon, Alberta, December 12 - 13, 1979.

11. Meet with B. C. Forest Service air attack and operations research personnel regarding co-operative research programs in these fields.

12. Publish:

    Lane, E. D. and R. G. Newstead. 1980. "Three-Dimensional Computer Mapping of Lakes". The Progressive Fish Culturist. Vol. 42 #1, 2, or 3.

13. Accomplishments in 1979-80:

    1. Owing to inclement weather and an abnormally high water table in the vicinity of the Slave Lake black spruce experimental burn plots, prescription minima could not be met and none of the six plots could be treated or burned.

    2. Provided technical assistance as follows:

        a) Assisted Department of Northern Saskatchewan personnel in evaluating and monitoring modified retardant mixing and loading facilities at the Prince Albert and La Ronge tanker bases. These trials resulted in improved retardant quality and flow control throughout the DNS tanker base network.

        b) Evaluated two existing on-board injection systems in conjunction with Poly-trol 200, a liquid polymer water thickening compound marketed by Chemonics Ind. (Canada) Ltd. These tests were conducted at Red Deer and Yellowknife in co-operation with Avalon Aviation Ltd. and the NWL & F Service with the Field conversion Canso. Similar tests were also conducted at Slave Lake, Alberta, in co-operation with the Flying Fireman Ltd. and the Alberta Forest Service with the Fairey conversion Canso. Subsequent file reports indicate that to date neither system affords uniform or consistent mixture quality during water skooping and pick-up.

        c) Static tests were not conducted with AFS contracted B-26 and Super PBY Canso airtankers since proposed modifications were not forthcoming.

        d) Provided additional training and consultation as follows:

            (i) Reviewed and reported on loading and venting characteristics of DNS Tracker airtankers. This assessment could result in system modifications designed to increase tank, gating, and venting efficiency.

            (ii) Prepared comments on the pros and cons of continued use of water thickening compounds with skimmer aircraft in northwestern Ontario. In light of existing mixing equipment and product limitations, the abundance of available water and present water-bombing techniques, the cost-effectiveness of water thickners is questionable in this region of Ontario.

(iii) Presented a lecture to graduating students at the Hinton Forest Technology School on the subject of aerial fire suppression research.

(iv) Participated in the Saskatchewan Department of Tourism and Renewable Resources annual spring fire control meeting at Meadow Lake and presented a talk on aerial attack systems.

3. The B-26 airtanker drop tests were repeated with Poly-trol 200 as scheduled; however, a combination of airtanker malfunction and poor pilot accuracy are likely to invalidate the data collected.

4. Basic construction of the retardant spray apparatus and combustion table is well underway and will be completed upon acquisition of suitable transducers and readout equipment.

5. A preliminary draft of development and selection guidelines for water thickening compounds was submitted to and approved in principle by the CCFFC training subcommittee members in attendance at the national air attack workshop. Baseline rheological information is pending from the Kelco Corporation in San Diego, California, and additional product drying rates under investigation at the PNFI are required prior to preparation of a more comprehensive publication.

6. A completed first draft of thesis manuscript has been reviewed by graduate advisory committee. A revised draft is well underway in anticipation of an early spring oral exam and subsequent convocation.

7. Good progress is being made in revising the retardant chemicals summary for publication. Similarly the past 10 years of airtanker drop patterns are under analysis, having been coded and submitted to the NFRC computer for various determinations. CALCOMP plotting will follow shortly.

8. Publications:

Hodgson, M. J. and R. G. Newstead. 1978. "Wildfire and Airtanker Allocation," Annals, Ass'n of American Geographers (in review).

This article is still in the review stage, having undergone additional revisions.

Accomplishments Added:

9. The physical and rheological properties of a synthetic liquid polymer under development by the Sanitek Corporation of Los Angeles, California, were assessed under lab conditions. Based upon preliminary results, this product is at present unsuitable for use as a water thickener in Canadian skimmer operations.

10. Attended and/or served on the following:

    - Coast Fire Control Course, Abbotsford, B. C.

    - Fire retardant workshop, Kamloops, B. C. (R. J. Lieskovsky - attendee).

    - National Air Attack Workshop, Ottawa, Ontario.

    - AFS Forest Protection Officers Meeting, Devon, Alberta.

11. Research technician Lieskovsky visited air attack personnel and airtanker bases in central B. C. and Victoria to discuss the possibilities of future co-operative research projects with the B. C. Forest Service. A meeting with B.C.F.S. operations research personnel was also held in Edmonton to further consider the role of NFRC fire management systems studies in B.C.F.S. fire operations planning.

12. Publications:

    Lane, E. D. and R. G. Newstead. 1980. "Three-Dimensional Computer Mapping of Lakes". The Progressive Fish Culturist. Vol. 42 #1, 2 or 3 (in press).

14. Goals for 1980-81:

1. Complete thesis manuscript and convocate from U of A masters program.

2. Complete guidelines for development and selection of water thickening compounds, and publish same.

3. Complete revision of fire retardant chemicals summary, and publish same as a Forest Management Note.

4. Complete construction and calibration of fire retardant spray apparatus pending receipt of capital equipment requirements.

5. In co-operation with the AFS, conduct prescribed burns at Slave Lake black spruce plots in a continuing effort to assess the relative effectiveness of various fire retardants over time - as permitted by a predefined weather prescription.

6. In co-operation with the B.C.F.S., conduct static and drop tests with the recently modified Tracker Firecat aerial tanker, at Abbotsford, B. C.

7. Provide technical assistance, training, and technology transfer to regional and other national and international fire control agencies and industrial organizations as requested.

8. Assess future intentions of present study format, make recommendations regarding future objectives, and accordingly modify or terminate study as appropriate.

9. Publish articles in forthcoming Forestry Report as follows:

   "Interim results of retardant effectiveness on two prescribed burns in black spruce".

   "Liquid polymer water thickener - a review of test results to date".

10. Prepare a slide-tape presentation on the role of airtankers and fire retardants in wildfire control.

15. Publications:

Reports and articles published prior to 1978-79

21 in total

1978-79

Hodgson, M. J. and R. G. Newstead. 1978a. "A model for allocating airtanker groups to airbases," Proceedings of the Fifth Pacific Regional Science Conference, Vancouver, B. C.

1979-80

Lane, E. D. and R. G. Newstead. 1980. "Three-Dimensional Computer Mapping of Lakes". The Progressive Fish Culturist. Vol. 42 #1, 2, or 3 (in press).

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Fire behavior in boreal forest fuels.

3. New: Cont.: X   4. No.: NOR-5-086

5. Study Leader: Z. Chrosciewicz

6. Key Words: Canadian Forest Fire Weather Index, fire behavior, fire effects, danger rating.

7. Location of Work: Various areas within the western and northern region.

8. Problem:

Intensive fire control management requires improved methods of assessing and forecasting fire danger for all major fuel types over a wide range of weather and site conditions. Although such methods would not prevent fires from occurring, they would undoubtedly result in substantial reduction of losses through better planning and implementation of various fire control measures all the way from preventation to suppression.

A good start in the development of such methods was made with the publication of the new Canadian Forest Fire Weather Index tables in 1970. The main index as well as the component codes are designed to summarize and rate the important weather variables that affect the ignition and spread of forest fires. The entire system provides means for daily rating of fire danger across the country. However, as the system uses primarily weather-dependent scales, it does not provide means for rating fire behavior in specific fuels.

The second phase, then, would be the development of fire spread and intensity tables for important fuel types by major sites and climates within the Region. Studies of moisture relationships in different fuels will help to determine the degrees of deviation from the standard curves as originally used in working out the Fire Weather Index. Experimental ground burns and observations of natural crown fires will provide data on fire behavior over a wide range of weather and site conditions for each of the fuels. The resulting tables will then relate some of the main characteristics of ground and crown fires to the Fire Weather Index and its component codes. This in turn will provide means for a more precise rating and forecasting of fire danger and fire effects for major fuel types within the Region.

9. Study Objectives:

1. To develop fire spread and intensity tables for major fuel complexes.

2. To assess fire effects in terms of fuel reduction and plant succession over a range of burning conditions.

3. To establish guidelines for rational uses of fire in manipulation of various fuel combinations.

4. To assist fire control agencies in application of the resulting tables and guidelines.

10. Resources:

a. Starting date: 1970
b. Estimated year of completion: 1983
c. Estimated total Prof. man-years required: 8.0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.9	(Chrosciewicz)
Supp.	-	
Casual	-	
Total	0.9	

11. Progress to Date:

The new Canadian Fire Weather Index was introduced to the Region in 1970 through a series of training sessions for the user agencies. Since then, fire behavior and fire effects were studied by means of experimental burning on a number of cutover sites and in uncut stands. Varying in area from 0.16 to 33.35 ha, the tests included 2 burns of black spruce slash, plus 17 burns of jack pine slash in Manitoba, 31 burns of jack pine slash in Saskatchewan, and 22 burns of lodgepole pine slash plus 2 burns of undisturbed black spruce in Alberta. Results are being published as they become available.

While this work was nearing completion, variations in moisture content and heat content of green conifer foliage (jack pine, black spruce, white spruce and balsam fir) were studied in Alberta to determine their seasonal lows (moisture) and highs (heat) that may contribute substantially to the incidence and the spread of crown fires. The foliage data, along with the associated weather information, are now being prepared for publication.

To study further fire behavior under undisturbed forest canopies, a series of 0.09-ha experimental plots were established in each of four mature stands in Alberta (jack pine, black spruce, white spruce-aspen, and aspen). In preparation for the burning tests, inventories of dead fuels and live vegetation were recently completed on 16 jack pine plots. Burning and fire behavior studies were carried out on 12 of the plots in 1978 and 1979.

Associated studies in the major forest cover types of Alberta are aimed at fuel appraisal for improved fire behavior predictions at the operational level.

12. Goals for 1979-80:

1. Publication of reports on (1) "Jack pine and other forest regeneration following postcut burning and seeding treatments in central Saskatchewan," and (2) "Foliar moisture variations in major conifers of central Alberta".

2. Preparation of a report on "Foliar calorific variations in major conifers of central Alberta".

3. Experimental burning and fire behavior studies on the remaining jack pine plots in central Alberta.

4. Based on current work in jack pine, completion of data processing on total biomass, weather, fuel moisture, fire behavior, fire effects, and fuel depletion.

5. Development of fuel and fire behavior relationships over a range of weather conditions for use in the "decision-aid models" (NOR-5-174).

6. Regeneration surveys of postburn plantations and seeded areas in central Saskatchewan.

7. Continuation of providing consultative services as required.

Goals Added:

8. Freeze-drying foliar samples of major conifers in central Alberta.

9. Field review of "Fire Hazard Ratings" for forest ecosystems in central Saskatchewan.

10. Critical review of manuscripts by other scientists prior to publication.

11. Preparation of an invited report on "Some practical methods for securing adequate postcut forest reproduction in Canada".

12. Preparation of several illustrated lectures with topics ranging from fire behavior and fire use to forest regeneration.

13. Attendance at various meetings as needs arise.

14. Participation in a University of Alberta Graduate Committee as an outside member.

15. Participation in an Ontario coroner's inquest as an expert witness re. controlled burning.

13. <u>Accomplishments in 1979-80</u>:

1. The manuscript of a report on "Jack pine and other forest regeneration following postcut burning and seeding treatments in central Saskatchewan" is completed and ready for internal review. All figures, tables and other supporting material for a report on "Foliar moisture variations in major conifers of central Alberta" are now in their final format, and the manuscript will be completed in about two months.

2. Additional data for a report on "Foliar calorific variations in major conifers of central Alberta" are now available from a series of 1979 freeze-drying tests (see item 8), and the final manuscript will be prepared during the next fiscal year.

3. Experimental burning, fire behavior studies, plus detailed preburn and postburn fuel assessments were completed on a total of 12 jack pine plots in central Alberta. The burns now cover the intended range of weather conditions up to the outset of sustained crown fire and, therefore, no further tests in this pine type will be required.

4. Field data on total biomass, weather, fuel moisture, fire effects and, to some degree, fuel depletion were processed as they became available. However, additional computer time, and particularly the reinstatement of lost technical support, will be required to complete the analyses.

5. Delineation of the relationships between fuels, fire behavior and weather had to be postponed until the basic analyses are completed (see item 4).

6. Large-scale postburn jack pine plantations and seeded areas were surveyed in central Saskatchewan at the stand age of about 8 years. In terms of pine re-establishment and its stocking, the treatments were highly successful, very much so after planting and, to a somewhat lesser degree, after seeding. Generally, spring treatments produced better results than autumn treatments, and the rates of height growth varied with site quality.

7. Consultative services were provided to senior forestry officials from Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Alaska, Arizona, and three Scandinavian countries, namely Norway, Sweden and Finland.

Accomplishments Added:

8. Freeze-drying of some 480 foliar samples from central Alberta was done (a) to provide explanation for the existing foliar moisture variations (see item 1), and (b) to secure better controls for the existing foliar calorific variations (see item 2).

9. The "Fire Hazard Ratings" that were previously formulated for some 23 forest ecosystems in central Saskatchewan were progressively field adjusted after viewing and discussing examples of each of the systems. Among participants in this task were provincial forest officials and fire researchers from the Northern Forest Research Centre.

10. Manuscripts for publication by the following authors were critically reviewed: P. L. Fuglem (M. Sc. thesis), H. Zalasky (two reports), I. K. Edwards and L. M. Carlson (one report), plus J. H. Cayford and D. J. McRae (one report).

11. A report entitled "Some practical methods for securing adequate postcut forest reproduction in Canada" was prepared and presented during the International Workshop on Forest Regeneration at High Latitudes, Fairbanks, Alaska (November 13 - 15, 1979). This report is now in press.

12. Several illustrated lectures, or talks, were prepared and given as follows:

    (a) "Fire dynamics and effects within a jack pine stand in central Alberta" by Z. Chrosciewicz, Northern Forest Research Centre, Edmonton, Alberta (August 2, 1979).

    (b) "Examples of experimental burning for fire-behavior studies in semimature jack pine stands of varying density" by Z. Chrosciewicz, Northern Forest Research Centre, Edmonton, Alberta (September 27, 1979).

    (c) "Case studies of successful postcut jack pine and black spruce reproduction following burning, both with and without supplementary treatments" by Z. Chrosciewicz, Northern Forest Research Centre, Edmonton, Alberta (September 27, 1979).

    (d) "Controlled burning for postcut conifer reproduction in central and midwestern Canada" by Z. Chrosciewicz, Bureau of Land Management, Fairbanks, Alaska (November 14, 1979).

13. Attendance at meetings included:

    (a) Central Region Fire Weather Committee, Winnipeg, Manitoba (December 11, 1979).

(b) Briefings re. research program and future needs with officials from the Saskatchewan and Alberta Forest Services, Prince Albert, Saskatchewan (August 30, 1979) and Edmonton, Alberta (January 18, 1980), respectively.

14. Jointly with other members of the University of Alberta Graduate Committee, consultative, supervisory and examining functions were performed over a period of two years for a M. Sc. student candidate.

15. On invitation from the Regional Coroner for northwestern Ontario, "expert witness" services were provided during an inquest in Geraldton, Ontario.

14. <u>Goals for 1980-81</u>:

1. Summarization of updated information on the "Fire Hazard Ratings" for all 23 forest ecosystems in the Mixedwood Section B.18e of central Saskatchewan.

2. Submission for publication of reports on (1) "Jack pine and other forest regeneration following postcut burning and seeding treatments in central Saskatchewan," (2) "Foliar moisture variations in major conifers of central Alberta," (3) "Foliar calorific variations in major conifers of central Alberta," and (4) "Failures and successes in jack pine regeneration following postcut burning and seeding treatments in southeastern Manitoba.

3. Continuation of data analysis leading to the determination of basic relationships between fuels, fire behavior and weather for semimature jack pine stands in central Alberta.

4. Continuation of providing consultative services as required.

15. <u>Publications</u>:

1978-79

Chrosciewicz, Z. 1978. Slash and duff reduction by burning on clear-cut jack pine sites in southeastern Manitoba. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-199. 11 p.

Chrosciewicz, Z. 1978. Slash and duff reduction by burning on clear-cut jack pine sites in central Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-200. 12 p.

Chrosciewicz, Z. 1978. Large-scale operational burns for slash disposal and conifer reproduction in central Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-201. 11 p.

Chrosciewicz, Z. 1978. Silvicultural uses of fire in midwestern Canada. Pages 37-46 *in*: Fire ecology in resource management. Workshop proceedings. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-210.

1979-80

Chrosciewicz, Z. 1980. Some practical methods for securing adequate postcut forest reproduction in Canada. *In*: Proceeding of the international workshop on forest regeneration at high latitudes. Univ. Alaska (in press).

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Initial attack strategy and resources in fire suppression operations.

3. New: Cont.: X   4. No.: NOR-5-130

5. Study Leader: Vacant

6. Key Words: Detection, fire behavior, airtankers, simulation modelling, handcrews, helicopters.

7. Location of Work: Northern Forest Research Centre.

8. Problem:

Fire control agencies serviced by the Northern Forest Research Laboratory in Edmonton spend between 10 and 15 millions of dollars annually on fire suppression. At least an equal amount is lost in the form of damage to various resources. In the past, fire control expenditures have been justified on the basis that fire damage must be reduced "at all cost." In the future, fire protection agencies will see greater competition for the fire control dollar.

In the defence of future budget requests fire protection agencies must place a greater emphasis on planning, including resource valuation. Suppression strategy and allocation must then be geared more closely to existing resource values and fire behavior to obtain maximum value of fire control dollar. The fire manager urgently requires guidelines specifically derived for the initial attack stage since benefits are maximized when the fire is controlled in its early growth stage.

The Alberta Forest Service is cooperating in the development of an initial attack simulation model for Whitecourt Forest District. It is designed to provide a relative assessment of initial attack systems and if the model proves satisfactory, it will be introduced as an operational decision-making aid.

9. Study Objectives:

    1. To develop a simulation model for assessing initial attack systems over a range of burning conditions.

    2. To provide guidelines for suppression strategy and optimum combinations of men and equipment to achieve successful initial attack.

    3. To promote and extend research results to client agencies through lectures and training sessions.

10. Resources:

    a. Starting date: 1972
    b. Estimated year of completion: 1973 Revised: 1978
    c. Estimated total Prof. man-years required: 3.4
    d. Essential new major equipment items for 1979-80 with costs: Nil
    e. Essential new major equipment items beyond 1980 with costs: Nil
    f. 1979-80 man-years

Prof.	0.0
Supp.	0.0
Casual	-
Total	0.0

11. Progress to Date:

An inter-agency study group was formed to develop a simulation model for three initial attack methods, i.e. helicopters, air-tankers, and ground crews. Important variables were documented and ten years of fire and weather data transferred to IBM-360 tapes.

Model development was completed and preliminary runs made for ground and aerial systems. At the request of the Alberta Forest Service, the model was expanded to include: (1) a B-26 airtanker, (2) both land-based and amphibious PBY Canso's and (3) a 204B helicopter W/235 gal. bucket.

A statistical analysis of 2000 individual AFS forest fire reports and 35 000 fire weather observations has been completed. Results indicate that the Fire Weather Index and components accurately reflect key aspects of fire behavior and fire-fighting difficulty, particularly during the early or initial attack phase.

The growth model has been re-designed and dispatch logic for simultaneous operation of helitankers and handcrews is complete.

12. Goals for 1979-80:

    1. Continue membership on the following committees:

        a) Western Fire Weather Committee.

        b) Central Fire Weather Committee.

c) AES/CFS Development Committee.

d) Regional Fire Research Committee.

e) Intermountain Fire Research Council.

f) Fire Danger Rating Working Group.

2. Continue joint AFS/CFS fire behavior/retardant evaluation study in Slave Lake Forest.

3. Report contract results.

ENFOR - Sampling forest floor fuels.
ASPEN - Fuel loading in regional aspen stands.

13. Accomplishments in 1979-80:

1. Continued membership on the following committees:

a) Western Fire Weather Committee - no meeting.

b) Central Fire Weather Committee - attended by Z. Chrosciewicz.

c) AES/CFS Development Committee - did not meet.

d) Regional Fire Research Committee - did not meet.

e) Intermountain Fire Research Council - attended by D. Quintilio as member of Steering Committee.

f) Fire Danger Rating Working Group - attended by D. Quintilio.

2. Project was continued but no burns were conducted in summer of 1979 owing to unsuitable burning conditions. Future burning to be covered under NOR-5-037.

3. Data analysis continued and a draft report has been completed (ENFOR). No progress was made on the aspen fuel loading data owing to resignation of study leader in October, 1979.

14. Goals for 1980-81:

1. Terminate study - unfinished goals transferred to NOR-5-174.

15. Publications:

1978-79

Nil

1979-80

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Evaluation and planning of fire detection, surveillance and communications systems and methods.

3. New: Cont.: X 4. No.: NOR-5-131

5. Study Leader: C. J. Ogilvie

6. Key Words: Aerial patrols, lookouts, forestry communications, weather data collection, storm tracking, wildfire smoke emission, wildfire mapping, remote sensing.

7. Location of Work: Alberta, National Parks, Yukon and Northwest Territories, Saskatchewan, Manitoba

8. Problem:

The study consists of an analysis of fire records as well as of on-site evaluations of existing wildfire detection - mapping and communication systems.

Research is done on factors influencing the performance and efficiency of such systems.

The results of the study will enable user agencies to increase the efficiency of their fire surveillance systems thereby reducing total fire losses and minimizing fire suppression costs.

Since some of the user agencies in the region are, at this time, not operating a fully developed fire surveillance system, the study is bound to meet with a certain measure of success.

Much of the results achieved in this study so far are already being implemented, and the prospects of further findings being put to practical use are excellent since most phases of the study are based upon user requests.

The following general course of action is being followed:

1. Discussion with respective user agencies to define and outline the problems to be solved.

2. On-site evaluations of existing installation and systems as well as analysis of available data.

3. Formulation of objectives and arbitrary financial constraints to be considered with designing the new system.

4. Design of new systems or modifications of existing systems in order to achieve optimal returns under given local conditions and accepted constraints.

5. Assistance to user agency during implementation as well as research through short-term projects solving day-to-day problems that have a bearing on systems design and operation.

9. Study Objectives:

1. Develop plans for wildfire surveillance and communications systems for the Northwest Territories, and other clients, on request.

2. Identify the most advantageous detection medium (alternative) for given conditions.

3. Define and identify factors influencing the design of wildfire detection and communication systems.

4. Develop effective wildfire mapping and surveillance techniques.

10. Resources:

a. Starting date: 1971
b. Estimated year of completion: 1983
c. Estimated total Prof. man-years required: Nil
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.0	(Vacant)
Supp.	0.8	(C. Ogilvie)
Casual	-	
Total	0.8	

11. Progress to Date:

Reports on communications and fire detection plans have been prepared for the Yukon, N.W.T. and Wood Buffalo National Park. These regions are all making use of their respective reports.

The "Barnes Airborne Fire Spotter" was tested and found to be unreliable under actual field conditions.

Experiments started in 1974 have resulted in the widespread use across Canada of the AGA 750 infra-red scanner for detecting holdover fires. NFRC's Sony vidicon was successfully adapted to record the thermovision imagery. A power pack was constructed at NFRC to be used to run the AGA, the vidicon and other instruments.

A simple sighting device to aid air observers in estimating distances on the ground was designed and built.

A device known as a "scan extender" that will allow the AGA 750 thermovision to be used for systematic searches of large areas from a fixed wing aircraft has been developed and tested to a limited degree. A "scan extender" is presently being utilized in fire detection programs in Alberta and Saskatchewan.

The field work for a detection system evaluation in Saskatchewan has been completed. This included taking panoramic photographs, making a sketch of the seen area, and making notes on the safety and efficiency of each of 75 Saskatchewan towers, 7 interacting Manitoba towers and 6 Prince Albert National Park towers.

Data compilation related to the Saskatchewan detection system evaluation is completed. This includes profiles, photographs and seen-area maps for 88 towers.

12. Goals for 1979-80:

1. Process field information on 48 lookout sites collected in Saskatchewan and Manitoba as follows:

   a) Process and interpret remaining 12 sets of panoramic photographs.

   b) Compile seen area maps for each of 38 remaining lookouts based on panoramic photographs, field sketches and profiles.

   c) Construct a composite seen area map of the province.

   d) Compile all information, prepare a final report, and submit with all maps to the client agency.

2. Do the seen area mapping for 6 towers in Prince Albert National Park using the same methods used in Saskatchewan and submit a report to the Parks people.

3. Complete construction and test in co-operation with the Alberta Forest Service an improved version of the AGA scan extender and:

   a) Demonstrate as requested to fire control personnel in Saskatchewan.

   b) Prepare report on construction and use of scan extender.

4. Participate in fuel inventory studies that will provide background for fire prediction models.

5. Continue to appraise Lightning Location and Protection System for regional agencies.

13. Accomplishments in 1979-80:

1. Using standardized CFS procedures, completed field work and data collection on 48 lookout sites in Saskatchewan including 7 interacting Manitoba towers as follows:

   a) Processed and interpreted remaining 12 sets of panoramic photographs.

   b) Compiled seen-area maps for each of 38 remaining lookouts based on panoramic photographs, field sketches and profiles.

   c) Constructed a composite seen-area map of Saskatchewan fixed detection network.

   d) Prepared a partial draft report to be submitted to the client agency when completed.

2. Completed the seen-area maps for 6 towers in Prince Albert National Park. Final reporting on how these towers and the Saskatchewan towers interact along with a composite visible-area map to follow.

3. Continued development of the AGA scan extender by constructing a model that is designed for use outside the aircraft. One version of this new design was mounted on an Alberta Forest Service Cessna 337. Another scan extender was built and, in co-operation with the Department of Northern Saskatchewan, was adapted for helicopter use by mounting it where the cargo hook is normally located on a Bell 206. A first draft report on the construction and use of the scan extender was prepared for publication in Forestry Report.

4. Participated in fuel inventory studies in Wood Buffalo National Park in conjunction with NOR-5-168.

5. Continued to appraise Lightning Location and Protection system for regional agencies by assimilating background information and technical knowledge to prepare a framework for field evaluation of operational units.

14. Goals for 1980-81:

1. Finish report on Saskatchewan detection system and submit it along with the maps and photographs to the Department

of Northern Saskatchewan, and assist in the implementation of the recommendations made in the report.

2. Complete work for Prince Albert National Park.

    a) Prepare composite visible-area map.

    b) Submit a report along with maps and photographs to Prince Albert National Park.

3. Begin a co-operative study with the Department of Northern Saskatchewan to investigate the feasibility of using the AGA scan extender in conjunction with their Lightning Location and Protection System to locate incipient lightning fires. In addition, localized fuel and weather data will be gathered at lightning fire locations discovered. This source of specific information is expected to support assessment of the correlation between lightning fire incidence and fuel and weather parameters.

4. Monitor effectiveness and level of use by Alberta Forest Service of the AGA scan extender and provide technical assistance upon request.

5. Develop a user manual for the operational use of the AGA thermovision and scan extender as applied to forest fire detection.

6. Provide liaison and technical services among client agencies making use of the Lightning Location and Protection System.

15. <u>Publications</u>:

1978-79

Niederleitner, J. 1978. Got a fire mapping job? Photography with infra-red film may be your best bet. Forest Fire News 1978.

1979-80

Nil.

16. <u>Signatures</u>:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Evaluation of the role of fire in forest and intermingled vegetation in the Prairie Provinces, Rocky Mountains and far north.

3. New: Cont.: X

4. No.: NOR-5-168

5. Study Leader: D. E. Dubé

6. Key Words: Fire ecology, fire history, fire cycle, fire type, fire climax, fire scar rating.

7. Location of Work: Region Wide.

8. Problem:

Within broad climatic limitations, fire has been the most important single, natural influence on vegetation throughout the region for about the past 10,000 years. Areal and temporal patterns of burning have varied along with fire intensity. Fire has played a significant role in influencing the physical-chemical environment; in regulating dry-matter accumulation; in controlling plant species and communities, in determining wildlife habitat patterns and populations; in controlling forest insects, parasites, fungi, etc.; in controlling major ecosystem processes and characteristics such as nutrient cycles and energy flow, succession, diversity, productivity and stability. The "natural" fire regime has been obscured by man's intervention and the long-term consequences of fire suppression are now becoming clear.

Resource management problems are developing which require an understanding of the historical role of fire, the effects of fire on a variety of landscapes, the alternatives available to resource managers and approaches required to implement alternatives.

9. Study Objectives:

   1. To develop and implement fire management programs in designated National Parks.

   2. To define the needs and priorities of client agencies in the area of fire impact assessments.

3. To describe and elucidate the natural role of fire.

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: 1984
c. Estimated total Prof. man-years required: 10
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1980-81 man-years

Prof.	0.5	(D. Dubé)
Supp.	0.5	(M. A. Walters)
Casual	-	
Total	1.0	

11. Progress to Date:

Programs in National Parks aimed at integrating fire management into resource management plans are nearing completion.

12. Goals for 1979-80:

1. Publish as Information Report "Early plant succession following wildfire, Kootenay National Park".

2. Submit operational fire management plan for Nahanni National Park.

3. Complete field work and analysis of data for operational fire management plan for Wood Buffalo National Park.

4. Provide consultation and advice for fire management planning in Western and Prairie National Parks.

5. Prepare paper for "Fire in Northern Circumpolar Ecosystems: A Workshop".

6. Participate in training sessions of client agencies and meetings relevant to study content.

13. Accomplishments in 1979-80:

1. Information Report, "Early plant succession following wildfire in Kootenay National Park" is in review process.

2. Operational fire management plan for Nahanni National Park to be completed by February 15, 1980.

3. Field work completed and data has been analyzed for operational fire management plan for Wood Buffalo National Park.

4. Prescribed burning was conducted in Elk Island National Park in May, 1979 and a finished report presented to the Park titled "Prescribed burning in Elk Island National Park".

5. Completed and presented, at the Fire in Northern Circumpolar Ecosystems Conference, a paper titled, "Fire in Wilderness Areas, Parks and other Nature Reserves".

6. Participated in training sessions of client agencies and meetings relevant to study content including the following:

   a) March 5, 1979 - Fire ecology lecture at Hinton Forest Technology School.

   b) March 15, 1979 - Meeting with Alberta Forest Service to discuss program.

   c) March 20, 1979 - Meeting with Northwest Lands and Forest to discuss program.

   d) April 18, 1979 - Meeting in Fort McMurray with A.F.S./ W.B.N.P. to discuss study proposal.

   e) April 30, 1979 - Meeting with Park personnel from Elk Island National Park to discuss prescribed burn.

   f) May 2, 1979 - Lecture at Westlock High School on fire ecology.

   g) May 28, 1979 - Discussion of fire modelling programs with Gradient Modelling Ltd.

   h) June 22, 1979 - Meeting with M. Alexander, GLFRC, to finalize New Brunswick symposium paper.

   i) September 27, 1979 - Presentation to delegation from People's Republic of China.

   j) October 22 - 26, 1979 - Attended "Fire in Northern Circumpolar Ecosystems Symposium," in Fredericton, New Brunswick.

   k) October 29 - November 1, 1979 - Attended Intermountain Fire Research Council Meeting in Missoula, Montana.

   l) November 27, 1979 - Presented Parks work to EMS/Parks Canada meeting.

   m) December 12 - 13, 1979 - Attended Alberta Forest Service, Fire Control Meeting in Devon, Alberta.

   n) January 4, 1980 - Meeting with A.F.S./U.A./F&W to discuss prescribed burning for Bighorn Sheep range improvement.

14. Goals for 1980-81:

1. Publish as Information Report: "Early plant succession following wildfire, Kootenay National Park".
2. Publish in Forestry Report: "Prescribed burning in Elk Island National Park".
3. Publish paper: "Fire management in Wilderness Areas, Parks and other Nature Reserves," *in* Fire in Northern Circumpolar Ecosystems Proceedings, University of New Brunswick.
4. Complete and submit fire management study for Nahanni National Park.
5. Complete and submit fire management study for Wood Buffalo National Park.
6. Provide advice and consultation for fire management planning in Western and Prairie National Parks.
7. Participate in training sessions of client agencies and meetings relevant to study content.

15. Publications:

1978-79

Dubé, D. E. 1978. (Compiler). Fire ecology in resource management. Workshop Proceedings. Northern Forest Research Centre. Information Report NOR-X-210.

Dubé, D. E. 1978. Prescribed fire on Henry House Prairie, Jasper National Park. Fire Ecology in Resource Management, Workshop Proceedings. Information Report NOR-X-210. pp. 20-22.

Dubé, D. E. 1978. Guidelines and operational plan for prescribed burning in Elk Island National Park. File Report. North. For. Res. Cent., 7 pages. Study #168.

Dubé, D. E. 1978. Considerations in the use of prescribed burning. *In*: Fire and Range Management Workshop, Regina, Saskatchewan. pp. 29-31.

1979-80

Dubé, D. E. 1979. Fire Management in National Parks. *In*: Proceedings of the International Fire Management Workshop. pp. 78-79. Information Rept. NOR-X-215. Compiled by Quintilio, D., NFRC, CFS. Edmonton, Alberta.

Dubé, D. E. 1979. Prescribed burning in Elk Island National Park. File Report. NFRC. CFS. Edmonton, Alberta. Study #168.

16. Signatures:

Dennis Dubé
Investigator

G. D. Hunt
Program Manager

G. T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 22, 1980

1. Project: Fire management systems and guidelines.

2. Title: Decision-aid models for use in fire management.

3. New: Cont.: X No.: NOR-5-174

5. Study Leader: D. Dubé, R. G. Newstead, Z. Chrosciewicz

6. Key Words: Fire behavior, fuels, fireline production fire statistics, fire effects, decision models, fire management, computer systems.

7. Location of Work: Regional.

8. Problem:

The economic impact of forest fires in Canada is significant; in this region alone 2,000 fires burn 0.6 million ha annually and associated fire-fighting costs total $20 million. The protection role of regional fire management agencies is complicated by the extreme variability of the occurrence and behavior of wildland fires. The traditional solution to the wildfire problem is similar in all parts of Canada where climate and fuel situations support wildfire conflagrations. Seasonal suppression forces are annually hired by each fire management organization to meet the demands of an "average" fire-season. The fire management resource demand, however, varies considerably over relatively short time spans and is largely unpredictable.

During low and moderate hazards the often excessive expenditure is difficult to justify and there is a tendency to "overkill" many fires. During very serious fire situations, resources are inadequate and the whole fire management process becomes less efficient. This dilemma will exist in Canada until the information required to accurately predict the demand function over time and space becomes available in a systemized form. The requirement of all fire management agencies, then, is decision-aids geared to providing an improved response to individual fire situations. These decision-aids (models) would integrate data on fuel inventory, fire behavior, fire effects and fireline production and much of this information is currently being generated at the NFRC.

Historically the fire research group at the NFRC has focused its resources on the short-term needs of fire management agencies. This effort has contributed to (1) a strong client-research relationship and a credible advisory program, and (2) accessibility to agency data in all operational areas. Output has been service-directed in response to immediate needs, and given the experience of the fire group, this information flow can continue, albeit with a reduced manpower commitment. This new thrust in the area of systematized data processing will add a new dimension to the fire program.

9. Study Objectives:

1. To identify the key factors relating to the occurrence, behavior, and effect of wildfires to the cost-effectiveness of fire control decisions.

2. To build, test, and operate relevant decision-aid models designed to assist fire management agencies in optimizing the allocation and use of available resources during demanding or multiple fire occurrence situations.

10. Resources:

a. Starting date: 1978
b. Estimated year of completion: 1985
c. Estimated total Prof. man-years required: 10
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: $3,000.00 (computer terminal similar to LANPAR Scope Mod. 100)
f. 1980-81 man-years

f. 1980-81 man-years	Prof.	1.0	(Vacant)
		0.5	(R. G. Newstead)
		0.5	(D. Dubé)
		0.1	(Z. Chrosciewicz)
	Supp.	1.0	(M. Maffey)
		0.2	(C. Ogilvie)
		0.5	(M. Walters)
	Total	3.8	

11. Progress to Date:

As is common with any new research undertaking, the initial phase is concerned with gathering the resource and data bases upon which a comprehensive program can be developed. During the two years since its inception, this study has acquired much of the necessary data management hardware and software in the form of the mini-computing system and programs now established at the NFRC. Systems analysis, computing and other related support staff functions have also become available to this study. Data files have been created using regional fire and weather statistics. Pertinent simulation modelling routines have been brought on stream and "regionalization" and modification of these are underway. Contracts have also been let to various specialists to introduce specific aspects of fire modelling to the program, e.g. instructional seminars, fuels inventory requirements and gradient modelling (FORPLAN), etc.

12. Goals for 1979-80:

1. Continue to collate and classify existing relevant data from regional inventories, i.e. biophysical, biogeoclimatic, AFS Phase III.

2. In cooperation with the AFS and NWLF, designate operational test areas to utilize remote sensing technology for fuel inventory processing. Introduce concepts of fire behavior prediction in relation to fuel inventories through discussion with regional agencies.

3. Continue validation of airtanker resource model.

4. Modify the interactive Whitecourt elliptical fire growth model.

13. Accomplishments in 1979-80:

1. A preliminary inquiry was undertaken to determine the feasibility of using existing biophysical, biogeoclimatic, and forest inventories as means of identifying, and quantifying fuel measurements. Correlations among various inventory and presently quantifiable fuel parameters will determine whether or not these data bases can be used to advantage on a broader regional scale.

2. In co-operation with the NWL&F Service, a contract was let to conduct a fuels appraisal survey in the Fort Smith district. Raw data from this inventory is on file at the NFRC. Initial data compilation by Timmerlin Woodland Services Limited, the survey contractor, is in progress. Compilation of the data collected from the aerial photography and line-intersect surveys conducted in northeastern Alberta in co-operation with the AFS is also underway. This goal was achieved in conjunction with Study NOR-22-142.

3. To date there has been no attempt to modify or validate the airtanker allocation model. Only following completion of the affiliated masters program can this model be introduced to the AFS for validation and/or operationalization.

4. The Whitecourt interactive elliptical fire growth model is presently undergoing modification and refinement of its performance abilities is expected. This model was further demonstrated to AFS fire control personnel as a decision-making aid.

14. Goals for 1980-81:

1. Refine, calibrate and field test the elliptical fire growth model. In conjunction with two AFS remote computer terminals located in separate forest protection jurisdictions, interactive model performance will be assessed relative to actual fire growth circumstances.

2. Continue synthesis of regional fuels data base and assess feasibility of integrating fuels data from other inventory and survey criteria (e.g. AFS Phase III, biophysical, biogeoclimatic). These data should provide the framework for the future development of a regional fire behavior model.

3. Analyze and synthesize relevant fire line production data (e.g. airtankers, dozers, and hand lines). These data can then be used in fire behavior modelling where fire containment parameters are required.

4. Assess the feasibility of conducting a fire history and fire effects study in the Swan Hills region of the Slave Lake Forest.

5. Collate 1979 fire statistics from Department of Northern Saskatchewan records. Transfer previous four years' statistics from FFRI computer files to NFRC files. These data can be used in conjunction with study NOR-5-131 goals concerning lightning fire detection and related measurement of fuels and weather parameters in northern Saskatchewan.

6. Complete analysis and compilation of accumulated fixed-wing airtanker drop pattern information initiated under Study NOR-5-037, and publish same.

7. Analyze airtanker effectiveness data collected by AFS aerial observers during the past four-year survey period.

15. Publications:

Nil.

16. Signatures:

Study Leader

Program Manager

Study Leader

Director G. T. Silver

Study Leader

PROJECT NOR-7

Reduction of damage from pollutants
in the atmosphere

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

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: S. S. Malhotra, P. A. Addison, and G. Hogan

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 programs, 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 as they are removed from the atmosphere by settlement, by precipitation and by assimilation. (Hogan, 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, Hogan)

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

4. Test the Federal Air Quality objectives for air quality under defined environmental conditions. (Hogan, Addison, Malhotra)

10. <u>Resources</u>:

a. Starting date: 1971
b. Estimated year of completion: 1985
c. Estimated total Prof. man-years required: 1.0
d. Essential new major equipment items for 1980-81 with costs:
   Peristaltic pump for autoanalyzer $5,000.00
   Auto-sampler for autoanalyzer $5,000.00
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

1980-81 man-years	Prof.	0.3	(Malhotra)
		0.6	(Addison)
		0.2	(Hogan)
		1.1	Total Prof.
	Supp.	0.3	(Radford)
		0.5	(Ridgway)
		0.4	(Fenn)
		1.2	Total Supp.
	Total	2.3	

11. Progress to Date:

In addition to the environmental impact of the smelter plume (Flin Flon) in Manitoba, a study of effects has been initiated in Saskatchewan. Preliminary results (incomplete) have been compiled and are to be used by the program managers and project leaders in meetings with the Saskatchewan authorities as a basis for possible cooperative work similar to that in Manitoba.

Preliminary experiments have been carried out on the effect of metals on jack pine physiology. Plant growth has been examined as an indicator of metal toxicity and effects on nutrient composition are currently being examined.

12. Goals for 1979-80:

1. To conduct a preliminary survey on forest condition around Cold Lake (Prior to the Oil Sands development). Baker, Malhotra)

2. To complete elemental analyses on samples from the study on "The effect of aqueous SO_2 on nutrient levels in soils and lodgepole pine". (Baker)

3. To study the effect of SO_2 on biochemical changes in lichen membranes. (Malhotra, Addison)

4. To study the metal phytotoxicity symptoms and physiological effects of metals on native vegetation. (Hogan)

5. To screen native species from the Flin Flon area for tolerance to metals present in the vicinity of the smelting complex. (Hogan)

6. Depending upon the availability of funds, determine the impact of pollutant deposition via stem flow, foliar drip and direct atmospheric exposure on a standard soil introduced in trenches at varying distances from the pollutant source. (Baker, Malhotra)

7. Write up and report a methodology paper entitled "A precipitation collection for pollutant deposition studies in remote areas. (Hogan, Addison)

Additional Goals:

8. Submit the handbook entitled "Symptomology of Air Pollutant and Natural Stresses on Forest Vegetation in the Canadian Prairie Region" for NFRC and external review, revise it according to reviewers comments and submit for publication. (Malhotra)

9. Examine the impact of sulphur dust from elemental sulphur crushing operations (Aquitaine-Ram River Plant) on surrounding forest vegetation and soils. (Baker and Malhotra)

10. Write up a File Report on the impact of emissions from Hudson Bay Mining & Smelting operations on forest vegetation and soils in Saskatchewan. (Baker)

13. Accomplishments in 1979-80:

1. An exploratory survey of the Cold Lake area was conducted to assess the impact of emissions from current heavy oil upgrading pilot plants on forest vegetation and soils. Since the emission levels are fairly low, no damage to forest or soils could be detected. Monitoring this area will be difficult so far as soils are concerned because of the heterogenious nature of both soil types and land forms.

2. The addition of aqueous SO_2 to soils supporting lodgepole pine had the effect of solubilizing soil nutrients so that uptake of calcium, magnesium, aluminum, etc. was increased. Generally the light SO_2 concentrations added promoted the greater uptake of these nutrients from the two soils used (both luvisolic soils). Regression analysis showed some interesting relationships between S-Mg-Ca seedling uptake. A file report was prepared.

3. Lichens because of their extreme sensitivity to air pollutants provide an excellent biomonitoring tool for atmospheric purity. Fumigation of *Evernia* sp. (epiphytic lichens) with SO_2 produced marked reduction in its photosynthetic rate. Chlorophyll content, acid phosphatase activity and lipid and protein biosyntheses also showed a severe decline. SO_2 treatment also stimulated potassium and magnesium efflux from the membranes. These responses were observed even at very low SO_2 concentrations (0.1 ppm for 24-48 hours) long before any visual injury was detected. It is suggested that lichen membranes are considerably more sensitive to SO_2 than those of vascular species.

4. Experiments on the effects of metals in solution culture and from contaminated soils on the growth of jack pine are being carried out. The results to date indicate that regeneration of jack pine will be problematic within several kilometers of the Thompson smelter. The experiments are continuing but their extreme duration (in excess of 4-6 months) means that the results are slow in forthcoming. This goal shall be extended into the new year.

5. Stocks of native grasses from Flin Flon are being maintained in the greenhouse. We hope to run metal tolerance tests on these grasses as soon as adequate growthroom space is available.

6. No funds were made available to achieve this goal.

7. It has not been possible to report on the development of the precipitation collector. Problems associated with the physical and chemical decomposition of the exchange resins when placed in the field situation has rendered the technique impracticable. Selection of more suitable resins has been attempted without much success, however, it is felt that the technique has merit and that developmental work should continue.

Additional Accomplishments:

8. The symptomology handbook has been reviewed by 14 NFRC and external reviewers; most of their comments have been considered and the final draft is almost ready for publication.

9. Soils and vegetation samples in a gradient eastward from a S-block being reworked by the Aquitaine-Ram River Plant in a S slaking operation were collected to assess the effects of air and ground water borne elemental S on lodgepole pine and soils. Soil analyses showed extremely low soil pH values (high acidities) particularly at the near sampling sites. Available aluminum, calcium, magnesium sulfate-S soil acidity etc. were also extremely high suggesting the effects of elemental S oxidation. Soluble salts were also detected in the ground water

of the closest sampling site suggesting a possibility of a seepage problem.

10. The file report has been prepared.

14. Goals for 1980-81:

1. Write a journal article on the pattern of pollutant deposition in the Athabasca Oil Sands area as measured by lichen element content. (Addison)

2. Write a journal article on the quantification of branch dwelling lichen communities for the detection of air pollution impact. (Addison)

3. Write a final report to the Alberta Oil Sands Environmental Research Program on ecological benchmarking and biomonitoring for the detection of airborne pollutant effects on vegetation and soil. (Addison)

4. Write a final report to the Alberta Oil Sands Environmental Research Program on symptomology and threshold levels of air pollutant injury to vegetation. (Malhotra, Addison)

5. Quantify the differences in the response of lichens between aqueous and gaseous SO_2 and define the mechanisms responsible for these differences. (Addison)

6. Represent Canadian Forestry Service as a member of the Regional Hydrocarbon Committee. (Addison)

7. Participate in the planning and operation of the Sixth North American Forest Biology Workshop. (Addison)

8. Continue studies on metal phytotoxicity symptoms and physiological effects of metal on native vegetation. (Hogan)

9. Continue studies on the impact of air-borne emissions on epiphytic lichens -- goal transferred from NOR-24-159. (Malhotra)

10. Continue studies on the impact of air pollution mixtures on higher plant metabolism -- goal transferred from NOR-24-159. (Malhotra and Khan)

11. Write up and report the following: (Malhotra)

    (a) Effects of SO_2 and other air pollutants on acid phosphatase activity in pine seedlings.

    (b) Final AOSERP reports on NOR-24-157 and NOR-24-159.

(c) Handbook on symptomology of air pollutants and natural stresses on forest vegetation in the Canadian Prairie region.

15. Publications:

1977-78

Hogan, G. D., S. S. Malhotra and D. Wotton. 1977. Heavy metal associated with forest decline near the nickel smelter at Thompson, Manitoba. File Report NOR-7-170 (submitted at the Manitoba Clean Environment Commission Public Hearings).

Hogan, G. D. and S. S. Malhotra. 1977. The effects of emissions from INCO smelter on forest vegetation and soils around Thompson, Manitoba. Transcripts Manitoba Clean Environment Commission Hearing H-17-77 held at Thompson, Manitoba on December 12, 1977.

Blauel, R. A. 1977. Forest vegetation examination around Thompson smelter. File Report NOR-114.

Malhotra, S. S. and R. A. Blauel. 1978. Effects of SO_2 on the forest ecosystem pp.714-719. *In*: The Oil Sands of Canada - Venezuela 1977. The Canadian Institute of Mining and Metallurgy pp. 782.

Baker, J. 1978. Compositional changes in soils and foliar runoff as apparently influenced by distance from a zinc-copper smelter. File Report NOR-144.

Malhotra, S. S. and G. D. Hogan. 1978. Preliminary examination of hydrocarbon release affected area near Lodgepole, Alberta. File Report NOR-114.

Hogan, G. D. and S. S. Malhotra. 1978. Impact on forest of condensate spray and sulphur gases caused by an Amoco gas well blowout near Lodgepole, Alberta. File Report NOR-114.

1979-80

Malhotra, S. S. and R. A. Blauel. 1979. Symptomology of air pollutant and natural stresses on forest vegetation in the Canadian Prairie region. Final draft copy complete.

Malhotra, S. S. and G. D. Hogan. 1979. Impact on plant nutrient status of condensate spray and sulphur gases caused by Amoco Gas Well Blowout near Lodgepole, Alberta. File Report NOR-7-114.

Addison, P. A. and S. S. Malhotra. 1979. Interim report of symptomology and threshold levels of air pollutant injury to vegetation, 1978-79. AOSERP report - in press.

Baker, J. 1979. Heavy metal and sulphur concentration of soils and jack pine foliage at sites in a west northwest gradient from the Hudson Bay Mining and Smelting Operation -- Flin Flon, Manitoba. File Report NOR-7-114.

Baker, J. 1979. Effects of aqueous SO_2 on the concentration and uptake of soluble nutrients in lodgepole pine tissues. File Report NOR-7-114.

16. Signatures:

Investigator

Program Manager

Investigator

Director G. T. Silver

Investigator

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

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

2. Title: Effects of atmospheric effluents from mining and smelting industries on forest vegetation and soils.

3. New: Cont: Terminated 4. No.: NOR-7-170

5. Study Leader: G. Hogan

6. Key Words: Heavy metals, sulphur gases, mining and smelting industries, forest vegetation and soils.

7. Location of Work: Thompson--Flin Flon, Manitoba and Northern Forest Research Centre, Edmonton, Alberta.

8. Problem:

Air-borne pollutants such as heavy metals and sulphur gases emitted by the mining and smelting industries in northern Manitoba have a real, imagined, and/or potentially deleterious effect on the forest vegetation and soils. Government agencies and the general public at all levels are expressing concern. Little is known of the real impact. The industry is apprehensive of the environmental restrictions that may be applied. The major problem is lack of scientific information for (a) early detection of air pollutant injury to vegetation. (b) prediction of long-term effects of air pollutants on forest vegetation and soils, and (c) establishing fair and effective ambient air quality standards. In order to obtain such information, the provincial government agencies, industry and the public request participation of the Canadian Forestry Service in the form of co-operative research and survey programs. The Province of Manitoba is providing operating funds not to exceed 15K for studies within Manitoba.

9. Study Objectives:

   1. To carry out site specific vegetation inventory in suitable forested areas around smelter operation (base line information).

2. To establish benchmark and air pollution biomonitoring system utilizing selected vegetation within the forested communities.

3. To determine the impact of air-borne pollutants (heavy metals and sulphur gases) on forest soil chemistry.

4. To develop diagnostic techniques based on specific symptoms under controlled environmental conditions. This information will be utilized to confirm the existing ambient air quality standards or to establish new and more effective ones.

10. Resources:

a. Starting date: 1977
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: Nil (Study terminated)
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1980-81 with costs: Nil
f. 1980-81 man-years: Nil (Study terminated)

11. Progress to Date:

A network of permanent biomonitoring sites has been established in the vicinity of smelters in Flin Flon and Thompson, Manitoba. Studies are being undertaken to determine the effects of smelter effluents on the quality of rainfall, on forest species and on soil processes. Reports are currently underway on different facets of the research carried out to date. These reports will be submitted to scientific journals for publication.

12. Goals for 1979-80:

Transferred to NOR-32-178.

13. Accomplishments for 1979-80:

Transferred to NOR-32-178

14. Goals for 1980-81:

Nil. Study terminated.

15. Publications:

1977-78

Hogan, G. D. and S. S. Malhotra. 1977. Semiannual progress report. File Report NOR-7-170.

Hogan, G. D., S. S. Malhotra and D. Wotton. 1977. Heavy metal accumulations associated with forest decline near the nickel smelter at Thompson, Manitoba. File Report NOR-7-170 (submitted at the Manitoba Clean Environment Commission Public Hearings).

Hogan, G. D. and S. S. Malhotra. 1977. The effects of emissions from INCO smelter on forest vegetation and soils around Thompson, Manitoba. Transcripts Manitoba Clean Environment Commission Hearing H-17-77 held at Thompson, Manitoba on December 12, 1977.

1978-79

Hogan, G. D. Annual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines Res. Env. Man., Province of Manitoba.

Hogan, G. D. Semi-annual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines Res. Env. Man., Province of Manitoba.

16. Signatures:

G D Hogan
Investigator

Program Manager

G T Silver
Director G. T. Silver

NOR-7-182

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 11, 1980

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

2. Title: Impact of air pollutant mixtures on forest vegetation and soils.

3. New: X Cont.: 4. No.: NOR-7-182

5. Study Leaders: S. S. Malhotra, P. A. Addison and J. Baker

6. Key Words: Sulphur dioxide (SO_2), nitrogen oxides (NO_x), vanadium, nickel, synergistic, additive, antagonistic.

7. Location of Work: Oil sand areas of Alberta, Northern Forest Research Centre.

8. Problem:

Industrial emissions may have actual or potentially deleterious effects upon forest vegetation and soils in the area. A major portion of our earlier research on the impact of air-borne pollutants on forest vegetation has been limited to individual pollutants. We now have the necessary background information on several major individual pollutants in relation to the native vegetation. This information has a direct application in many instances. However, since the pollutant impact on vegetation under field conditions is a reflection of total emissions from a source, government agencies and general public are all expressing concern about the potentially dangerous mixtures of emission elements such as SO_2, nitrogen oxides (NO_x), vanadium and nickel. The effects of these pollutants in mixtures may be additive, antagonistic or synergistic in nature. Presently there is a lack of essential scientific information on response of native forest vegetation and soils to various pollutant mixtures. In order to provide information which will permit regulatory agencies to assess impacts and institute actions as appropriate, detailed research studies on biological impacts of pollutant mixtures must be undertaken. Such studies must be conducted both under controlled environment "pollution chamber" and field conditions. Information arising from such research will provide techniques for early diagnosis of air pollution injury to vegetation and will also aid in the designing of restorative procedures.

9. Study Objectives:

   1. Conduct both controlled and field environmental research to describe and measure the physiological and visual impact of pollutant mixtures on forest vegetation species.

   2. Determine the impact of pollutant mixtures on native soils and their ability to support vegetation (effects on seed germination, growth and physiological processes).

   3. Develop predictive capability as to the fate of forest soils and vegetation at the current or predicted rates of pollutant deposition from major industrial operations.

10. Resources:

   a. Starting date: 1980
   b. Estimated year of completion: 1985
   c. Estimated total Prof. man-years required: 1.0
   d. Essential new major equipment items for 1980-81 with costs: Nil
   e. Essential new major equipment items beyond 1981 with costs: Nil
   f. 1980-81 man-years

Prof.	0.2	(Baker)
	0.4	(Malhotra)
	0.4	(Addison)
	1.0	Total Prof.
Supp.	0.5	(Radford)
	0.5	(Ridgway)
	1.0	Total Supp.
Total	2.0	

11. Progress to Date:

   Nil (new study)

12. Goals for 1979-80:

   Nil (new study)

13. Accomplishments in 1979-80:

   Nil (new study)

14. Goals for 1980-81:

   1. Initiate a study on the impact of air pollution mixtures on higher plant metabolism.

2. Initiate a study on the impact of air pollution mixtures on epiphytic lichens.

3. Collect soil profiles from "air pollution impingement" and "clean" areas (Athabasca Oil Sands) for air pollutant enrichment studies and determine its impact on seed germination growth and physiological processes.

15. <u>Publications</u>:

Nil (new study)

16. <u>Signatures</u>:

Investigator

Program Manager

Investigator

Director G. T. Silver

Investigator

PROJECT NOR-9

Insect and disease management systems

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Insect and disease management systems.

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 dimidatus*, 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, saw timber, 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, Ontario and Minnesota, and consideration is being given to making releases in British Columbia.

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: 1980
c. Estimated total Prof. man-years required: 0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years Prof. 0
Supp. 0
Total 0

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 then 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 co-operation 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 4.0 miles in 1967, 9.5 miles in 1968, 54 miles in 1969 and 65 miles in 1970. In 1971 a spectacular apparent increase in dispersal was found: *O. benefactor* 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*, e.g. 94% at Elma in 1974; 51% at South Junction and 96% at McMunn. Encapsulated *O. benefactor* larvae were found in 60% of 38 larch sawfly larvae from McMunn that had been attacked by this parasite in 1975. In 1976 parasitism by *O. benefactor* was 19% with 12% of these being encapsulated. The attack rate by *M. dimidiatus* on the *O. benefactor* was 76%. In 1978 *O. benefactor* was still at a low level at McMunn (22%); encapsulation was 20% and parasitism of 34 *O. benefactor* larvae by *M. dimidiatus* was 100%.

O. benefactor was released near The Pas, Manitoba, in 1968, and showed rapid establishment; 6% attack in 1968, 50% in 1969 and 83% in 1970. Detected dispersal was 1 mile by 1970, 12 miles by 1973 and 41 miles by 1975. A mass collection of larch sawflies (10,000 for B.C. and 4,000 for Ontario) was made in "The Bog," 45 miles south of the release point, in 1977. About 13% of the larvae were parasitized by *O. benefactor* and host populations here were heavy. In 1978 *M. dimidiatus* was found attacking 62% of the *O. benefactor* in a sample of 45 dissected from larch sawfly larvae collected in the bog. It severely reduced the expected number of *O. benefactor* in the cocoons sent to B.C. and Ontario.

The annual increase in maximum distance at dispersal increased exponentially over the period 1965 to 1971 according to the relationship $Y = .0137e^{1.04x}$ where x = the number of years from release in 1961. The accelerating rate of spread of the parasites as they became more abundant indicated that mutual interference between the parasites was causing an increase in their rate of dispersal. Crude estimates of the absolute number of *O. benefactor* in the region during 1965 to 1969 also showed an exponential increase; the relationship being $Y = 988e^{1.98x}$ where x = the number of years from release in 1961. These estimates are based on known rates of parasitism at various distances from the release point and assumed populations of larch sawfly in the regions occupied. The mean increase per year during this period was 7.2 fold. Using the equation to extrapolate back to 1961, we deduce that the 158 females released would have to have parasitized 50 hosts each to account for the 7,700 first-instar larvae estimated to have been attacked by *O. benefactor* in 1961. This figure is not unreasonable considering that the released parasites were in a weakened condition due to handling.

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 1979-80:

    1. Final revision and publication 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. Collection and analysis of material from Obed Lake, Alberta, for percentage attack by parasites and dispersal of *O. benefactor* from this release point.

    3. Summarize current status of larch sawfly in Manitoba and make recommendations on the need for periodic surveys, as appropriate.

    4. Terminate study.

13. Accomplishments in 1979-80:

    1. The final revision of this paper is being completed. This study is now terminated and this goal transferred to NOR-9-150.

    2. *O. benefactor* appears to have entered a phase of rapid increase in the Lake Obed region. Parasitism in several collections based on size of cocoons was as follows:

Location	Date of collection	No. of cocoons reared	% parasitism
1.1 km west	July 31	923	87
1.1 km west	Aug. 7	383	90
1.1 km east	Aug. 7	268	90
2.1 km west	Aug. 7	131	80

    A total of 40 *O. benefactor* larvae (10 from each collection) were dissected and none were found to contain larvae of the hyperparasite *M. dimidiatus*. A small collection of larch sawfly larvae made 19.3 km east of the release point showed no parasitism by *O. benefactor*.

    3. Information on the current status of the larch sawfly in Manitoba and recommendations on the need for surveys was made in a report by Ives and Muldrew, dated December 14, 1979.

14. <u>Goals for 1980-81</u>:

None. Study terminated. Goal covering the publication of the paper, "Dispersal and impact of the introduced larch sawfly parasites, *Olesicampe benefactor* and *Mesoleius tenthredinis* from 1966 to 1974 in central Canada," transferred to NOR-9-150.

15. <u>Publications</u>:

1978-79

Nil

1979-80

A paper on the biological control program against the larch sawfly in Canada was prepared and sent to Dr. K. P. Carl of the C.I.B.C., in Switzerland, to be included in a "Biological Control Successes" pamphlet to be published in 1980.

16. <u>Signatures</u>:

J. Muldrew
Investigator

Program Manager

GTSilver
Director G. T. Silver

NOR-9-089

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Insect and disease management systems.

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

3. New: Cont.: X   4. No.: NOR-9-089

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 analysis, 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 was 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: 1981
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.4	(W. G. H. Ives)
Supp.	-	
Casual	-	
Total	0.4	

11. Progress to Date:

The historic FIDS data for Manitoba and Saskatchewan have been summarized and plotted. Weather data have also been summarized and plotted. Twenty-one species of defoliating insects have been considered, as well as 11 weather variables, each for 7 geographical areas: SE Manitoba; Interlake area; Riding and Duck mountains, NW Manitoba; Hudson Bay area; Prince Albert area; and Meadow Lake area. Insufficient data were available for northern areas or agricultural areas. Most of the pertinent literature has been reviewed and computer manipulation of data completed.

12. Goals for 1979-80:

Complete the examination of insect population and weather data and prepare a draft copy of an information report. A tentative title is "Infestations and interrelationships of 21 species of forest insect defoliators collected in Manitoba and Saskatchewan by the Forest Insect and Disease Survey during the period 1945 to 1969".

13. Accomplishments in 1979-80:

Most of the pertinent literature has been reviewed. Most of the statistical analyses have been completed. Preparation of the first draft of the report is currently underway. At the time of review, somewhat more than one-half of the manuscript has been drafted.

14. Goals for 1980-81:

Complete revision of manuscript tentatively entitled "Infestations and interrelationships of 21 species of forest insect defoliators collected in Manitoba and Saskatchewan by the Forest Insect and Disease Survey during the period 1945 to 1969".

15. Publications:

1978-79

Nil.

1979-80

Nil.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Insect and disease management systems.

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.

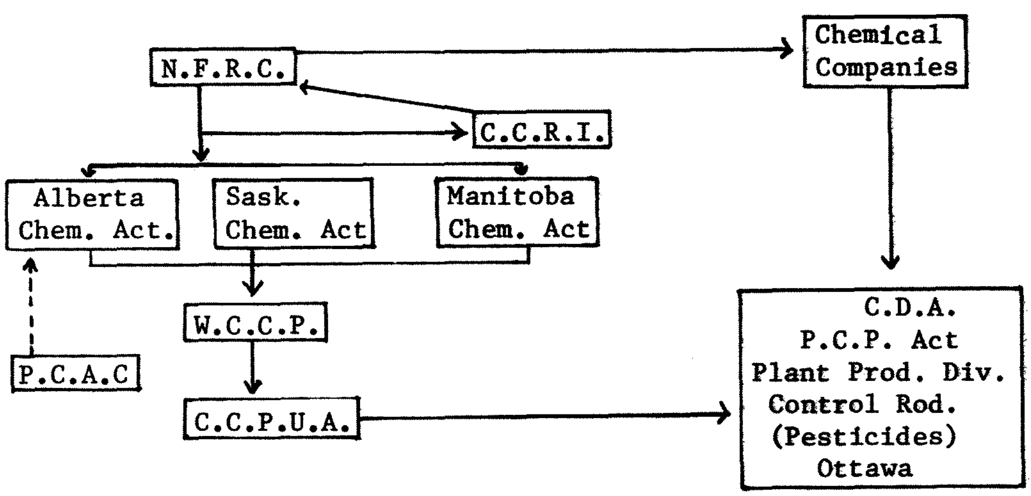
Where controls are not feasible, or economically or biologically justified, such will be reported and included in Canadian Forestry Service control recommendations to the chemical firms.

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 trials 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 phytoxicity.

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

10. Resources:

    a. Starting date: 1972
    b. Estimated year of completion: 1980
    c. Estimated total Prof. man-years required: 0
    d. Essential new major equipment items for 1980-81 with costs: Nil
    e. Essential new major equipment items beyond 1981 with costs: Nil
    f. 1980-81 man years

Prof.	-
Supp.	.5
Casual	-
Total	.5

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 insect species requiring controls.

From 1972 to 1977, conducted efficacy tests using mist blower, hydraulic,soil drench, bark paints and ultra low volume application methods. As part of an ongoing program at NFRC, emphasis was on completing data requirements with the numerous insecticides to obtain registrations. These tests with suitable recommendations were submitted, on completion, to the Plant Products Division, Control Products Section of the Department of Agriculture, Ottawa. As a result of six years of trials, sufficient data has been submitted for registration review of 11 chemical products for the control of 33 insect pests attacking 22 species of trees and shrubs. These Canadian registrations are now included on several labels of insecticides.

In 1978, 22 insecticides, a nucleopolyhedrosis virus and an adjuvant were tested against 13 insect species for a total of 78 separate evaluations using 6 application methods. Forty-nine foliar spray treatments were applied with a mistblower to control birch leaf miners, sawflies, forest tent caterpillar, insects attacking the fruit of saskatoon and chokecherry, the large aspen tortrix and a willow sawfly. Eighteen soil drenches were conducted to control the birch leaf miners, the northern pitch twig moth and open feeding aphids.

Analysed data and submitted performance reports to 11 chemical companies; summary of 78 evaluations to the Pesticide Research Report (ECPUA), Ottawa; prepared an Information Report, NOR-X-213; submitted manuscript on chemical control of the Box-Elder Twig Borer in Alberta; presented paper to Ent. Soc. Alta. on biology and control of the insects attacking the fruit of saskatoon in Alberta; reviewed, edited and illustrated pest leaflet on herbicides and sterilants; problem analysis on chemical controls and herbicidal activities 1979; illustrated Forestry Report (Manitoba) and front covers for Info. Rpt. NOR-X-217.

12. Goals for 1979-80:

1. Complete evaluations of established insecticides previously tested and showing promise including the new synthetic pyrethroids with a view to completing 2-3 year data required for registration; Basudin, Dutox, Ambush, Nem-A-Tak, Dacamox, Ripcord (WL 43467) 40, Belmark (43775) 30, Orthene.

2. Continue nucleopolyhedrosis virus spray application for Ives at Buford and Obed (20 acres) aerial spray application, at Partridge Hill and Flatbush on second instar, fourth instar and eggs respectively.

3. Complete extensive spray program and life history studies on *Contarinia* and a complex of sawflies and one *lepidoptera* attacking chokecherry and saskatoon. Manuscript on chemical controls of these species submitted to Bi-Monthly Report for publication in late 1979.

4. Complete extensive birch leaf mining sawfly field tests and biology. Publish results as "Notes on biology and chemical control of birch leaf mining sawflies in Alberta, 1978".

5. Preparation of manuscript with final report on chemical control of tree pests.

6. Conduct a problem analysis of chemical control needs in the region and redefine future needs.

7. Evaluate the use of herbicides for weed and brush control in plantations, locate suitable sites, screen and test a variety of suitable candidate chemicals for timing, phytotoxicity, efficacy.

8. Write pest leaflet on Herbicides and Sterilants--review, edit, illustrate pest leaflets: birch leaf miners, borers, gall rusts, silverleaf.

13. Accomplishments in 1979-80:

1. Continued evaluations, with emphasis on the new pyrethroids, submitted updated new and modified uses on 19 chemicals for the control of 15 insect species. Products submitted to the Pest Control Products Division, Ottawa, for registration under new and modified uses as a result of additional data obtained from 1973 to 1979.

2. NPV sprays applied as planned for W. G. H. Ives at locations indicated; see Ive's report re: NPV trials 1979.

3. Continued intensive spray trials and life history studies on insects attacking the fruit of saskatoon. Extensive sampling on fruit. Sawflies (4) and weevils are the major pests. All species bore into and hollow the fruit. Sawflies were the most numerous and these Hoplocampa spp. cause up to 46% damage to chokecherry and 29% to saskatoon. Two weevils, the apple curculio, *Tachypterellus quadrigibbus* Say and *Pseudanthonomus cratagi* Walsh. occuring in 1% and 2% of the fruit respectively. File report to follow.

4. Completed the birch leaf mining sawfly-field tests and biology. Results on the control and an analysis of the species complex involved will be published as a file report.

5. Final report on the chemical control of tree pests has been deferred.

6. A problem analysis of chemical controls on the Prairies Region with future needs and concerns was prepared.

7. Herbicide activites in 1979 and future projections.

8. A pest leaflet on Herbicides and Sterilants was prepared with the front cover illustration and submitted to the editors. Illustrations for the Forestry Report (Manitoba), also front covers for Inf. Rep. NOR-X-217 and a design for Resource Management masthead.

Accomplishment Added:

9. CFS representation, reporting, handling requests, surveys, consultation, talks and papers were provided to the following:

   a) Western Committee on Crop Pesticides (ECPUA);
   b) New and modified uses, Plant Products Division, CDA;
   c) Plant Industry Lab., Alberta Agriculture, clients, general public;
   d) Survey in Medicine Hills small fruit orchard, Carstairs.
   e) Presented paper to Alberta Ent. Soc. on insects attacking saskatoon fruit.

f) Presented paper to Peace R. Small Fruit Growers Association on "Insects attacking the fruit of saskatoon, residues and controls".

14. Goals for 1980-81:

1. Prepare step study plan on the use of herbicides as a tool in forest management; assess needs; development of control methods; determine and select techniques and equipment; conduct efficacy tests; obtain data requirements and submit suitable recommendations with a view to registration.

2. Participate in a study to determine importance of seed and cone insects in Prairies Region for seed orchard management; investigate means of minimizing these losses through chemical and cultural controls where needed (integrate with NOR-9-181).

3. Assist W. G. H. Ives in nucleopolyhedrosis virus aerial spray application on forest tent caterpillar with heavy concentration.

4. Review, edit, illustrate pest leaflets, Information Reports and Forestry Reports.

15. Publications:

1978-79

Drouin, J. A. and D. S. Kush. 1978. Pesticide field trials on shade and shelterbelt trees in Alberta, 1977. Environ. Canada, Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-205.

Drouin, J. A. and D. S. Kusch. 1978. Summary of field tests, 1977. Pesticide Research Report, Canada Agric., Canada Committee on Pesticide Use in Agriculture, Ottawa, Ontario.

Drouin, J. A. 1978. Pest Leaflet Series. White pine weevil, PL 25-78. A willow-shoot boring sawfly, PL 24-78.

Drouin, J. A. and D. S. Kush. 1978. Chemical control of a seed-boring sawfly and a midge damaging chokecherry in Alberta. Bi-Mon. Vol. 34, No. 6, November-December 1978.

1979-80

Drouin, J. A. and D. S. Kusch. 1979. Pesticide field trials on shade and shelterbelt trees in Alberta, 1978. Environ. Canada, Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-213.

Drouin, J. A. and D. S. Kusch. 1979. Summary of field tests. 1978. Pesticide Research Report, Canada Agric., Expert Committee on Pesticide Use in Agriculture, Ottawa.

Drouin, J. A. and D. S. Kusch. 1979. Chemical Control Trials on the Box Elder Twig Borer in Alberta. Bi-Mon. Vol. 35, No. 4, July - Aug. 1979.

Drouin, J. A. and D. S. Kusch. 1979. Chemical Control Trials on the Northern Pitch Twig Moth in Alberta. Environ. Canada, Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. App. 11, Info. Rep. NOR-X-

Drouin, J. A. 1979. Annual revision of insect pests and controls on Berry Crops. In W.C.C.P. Report (1979). 5 pp.

Cerezke, H. F. and J. A. Drouin. 1979. Annual revision of insect pests and controls on shelterbelts, ornamental trees and shrubs. In W.C.C.P. Report (1979). 14 pp.

Philip, H. and J. A. Drouin. 1979. Annual revision of insect pests and controls on houseplants and on greenhouse woody ornamentals. In W.C.C.P. Report (1979). 4 pp.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Insect and disease management systems.

2. Title: Integrated control of the forest tent caterpillar.

3. New: Cont.: X 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 alone or in combinations. Unfortunately, both the dipterous 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 artifical 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 nuclear polyhedrosis virus, augmented where necessary by chemical or bacteriological control measures.

10. Resources:

a. Starting date: 1977
b. Estimated year of completion: 1981
c. Estimated total Prof. man-years required: 6.5
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years Prof. 0.4 (J. A. Muldrew)
0.4 (W. G. H. Ives)
Supp. 0.2 (R. M. Smith)
Total 1.0

11. Progress to Date:

Development of techniques for rearing *Sarcophaga aldrichi* Parker on artificial media has been halted, due to lack of progress, hence any further work with the flies has been discontinued and efforts concentrated on tests with the virus.

Preliminary ground spraying of aspen stands with virus suspensions gave encouraging results, as did sprays with Dipel. Virus sprayed on larvae in 1976 gave almost complete mortality in one 1/2 acre plot and exceeded 95% in another. Dipel, when supplemented by 1 oz. or less of Sevin per 50 gals. of spray, gave 85 to 75% mortality in 1-acre plots. Various concentrations of virus were applied in 1977 before the larvae hatched. The two heaviest concentrations of polyhedra (1×10^8/mL and 1×10^7/mL) caused mortality approaching 100%, while a concentration of 1×10^6 polyhedra/mL caused about 75% mortality.

Aerial spraying of virus in 1978 was done under adverse conditions. Weather was unsettled, with frequent showers, some of them heavy, and synchronization between foliage and larval development was very poor. The larvae hatched early, then mined the buds. Consequently, some of the late-flushing trees were partially defoliated before the leaves flushed. In addition, the spray plots were heavily infested with forest tent caterpillar, and larval mortality due to starvation was heavy on some plots, and natural virus also caused a considerable amount of mortality. Nevertheless, the two heaviest concentrations (1×10^7 and 1.5×10^7 polyhedrol inclusion bodies per ml) increased total mortality by about 10% and 20% respectively.

12. Goals for 1979-80:

1. Apply and assess the effect of the same concentration of virus (probably 1×10^7 polyhedra/mL) applied by helicopter against three stages (eggs, II-instar larvae and IV-instar larvae) of the forest tent caterpillar, to determine if the virus can be introduced effectively during a longer time period.

2. Continue to monitor forest tent caterpillar populations in the Joussard and Sundance areas to determine the amount of virus present.

3. Prepare a progress report on interim results of forest tent caterpillar virus spray trials.

4. If a supply of virus is available, make small-scale field test of NPV against the Bruce spanworm in the Obed area.

13. Accomplishments in 1979-80:

1. Virus was applied as planned; weather conditions were nearly ideal. Assessment of mortality showed that application to the eggs increased mortality by about 15%. Spray applied to first-instar larvae increased mortality by about 20%. Larvae sprayed during the third- and fourth-instar did not appear to suffer increased mortality, but there may have been an increase in sub-lethal mortality and a consequent increase in the carry-over of virus.

2. Populations in the Joussard and Sundance areas were monitored to determine the incidence of virus. In the Joussard area, the so-called "Railroad-Crossing" plot showed an increased incidence of virus over surrounding areas, although mortality was less than last year. Spread of virus from the spray area could not be demonstrated. In the Sundance area, there appeared to be no difference in the incidence of virus between areas that were sprayed in 1978 and adjacent unsprayed areas.

3. A file report summarizing above results was prepared.

4. Small-scale field trials of an NPV of the Bruce spanworm were made in the Obed area. The trials indicated that this is a virulent NPV. A note has been prepared, in co-operation with Dr. J. C. Cunningham, Forest Pest Management Institute, for submission to the Canadian Entomologist.

14. Goals for 1980-81:

1. Test heavy aerial applications of forest tent caterpillar NPV to determine if the amount of additional mortality can be increased sufficiently to give satisfactory control. The actual concentrations will depend on the amount of virus on hand. Provisional values are 10^9, $2x10^8$ and 10^8 polyhedral bodies per millilitre.

2. Conduct limited follow-up sampling to determine if incidence of virus infection has increased in Partridge Hill plot, as a result of spraying in 1979.

3. Prepare an information report summarizing the results of aerial spraying conducted during 1978-80.

4. Collect late-instar larch sawfly larvae in the vicinity of the Pine Falls, Rennie, and Seddon's Corner to determine the current rates of parasitism by *Olesicampe benefactor* and

Mesochorus dimidiatus. At the same time, take note of current rate of defoliation, or make egg population estimates. If time permits, evaluate rates of larch sawfly parasitism in Obed Lake area of Alberta.

5. Complete revision of manuscript on *Olesicampe dispersal* and publish results as an information report.

15. Publications:

1978-79

Ives, W. G. H. and J. A. Muldrew. 1978. Preliminary evaluations of the effectiveness of nucleopolyhedrosis virus sprays to control the forest tent caterpillar in Alberta. Inf. Rep. NOR-X-204.

Ives, W. G. H. 1978. Evaluations of effectiveness of nucleo-polyhedrosis virus sprays to control the forest tent caterpillar in Alberta - 1978 trials. File Report. 2 pp. (plus 1 table and 1 figure).

1979-80

Ives, W. G. H., J. A. Muldrew and R. M. Smith. 1979. Evaluation of effectiveness of nucleopolyhedrosis virus sprays applied in 1979 to control the forest tent caterpillar in Alberta with a follow-up assessment of 1976 and 1978 applications. 3 pp. (plus 2 tables and 1 figure).

16. Signatures:

Investigator

Program Manager

Investigator

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Insect and disease management system.

2. Title: Evaluation of pest impact on plantations.

3. New: X Cont.: 4. No.: NOR-9-181

5. Study Leader: W. G. H. Ives, J. A. Muldrew, J. A. Drouin.

6. Key Words: Seed production, seed and cone insects, plantations, pest impact, growth loss, tree mortality, data management, white spruce, *Picea glauca*, Jack pine, *Pinus banksiana*, Lodgepole pine, *Pinus contorta*, Tamarack, *Larix laricina*, Black spruce, *Picea mariana*, Red pine, *Pinus resinosa*, Balsam fir, *Abies balsamea*, Tembling aspen, *Populus tremuloides*, seed orchards, chemical control.

7. Location of Work: Prairie Provinces and Edmonton.

8. Problem:

The anticipated increase in the intensity of management of forest stands in the Prairie Provinces in the foreseeable future will demand an increase in the amount of information that is available to the forest manager in a form that he can use. During the past 30 or 40 years, the research conducted by the Canadian Forestry Service in the region has produced a large body of information on the effects of various pests upon different tree species. Much of this information cannot be used by the forest manager because it is not in a suitable format. The proliferation of computer technology in recent years has now made synthesis of this data into usable format feasible, but the data must first be screened, processed and re-assembled.

Past studies on mortality and growth of planted trees have yielded part of the data referred to above. However, these same plantations provide a potential source of additional information, and by re-examination can provide data on the current (and recent) effects of insect and disease attack.

The increased amount of reforestation that is taking place in the Prairie Provinces in recent years, particularly in Alberta, has focused attention on the amount and quality of seed available, particularly for white spruce. At the moment, white spruce seed is collected primarily during cutting operations and from squirrel caches. However, as reforestation progresses, and the intensity of management increases, this procedure will probably be replaced by a more selective one, either using selected stands or plantations as a source of seeds. This change will be desirable, from the point of view of tree improvement, but will also mean that the source of seed becomes more restricted.

Seed production and quality are known to fluctuate markedly from year to year. As far as this study is concerned, this has to be accepted as a fact. If, however, the amount of this seed that is damaged by insects also fluctuates, the problem of obtaining a reliable source of seed on a continuing basis will be further compounded.

An opportunity, therefore, exists to make an assessment of the severity of the problem and to determine potential lines of study before forest management intensifies and before the use of seed orchards becomes a common practice. This would permit research to be done, and remedies to problems devised, before the seed-collection agencies encounter major problems and before forest managers encounter problems demanding immediate answers.

9. Study Objectives:

    1. To examine the usefulness of historical data and current information from plantations in the Prairie Provinces as sources for establishment of a regional data base on insect impacts on plantations.

    2. Determine the species and abundance of cone and seed insects and their importance in the production of coniferous seed, primarily white spruce.

    3. Develop and maintain a computerized data bank on tree losses attributable to insects and diseases.

    4. Develop guidelines and related information packages to enable resource managers in incorporating insect and disease impact considerations into resource management strategies.

10. Resources:

    a. Starting date: 1980
    b. Estimated year of completion: 1985
    c. Estimated total Prof. man-years required:
    d. Essential new major equipment items for 1980-81 with costs:
    e. Essential new major equipment items beyond 1981 with costs:
    f. 1980-81 man-years

Prof.	0.2	(W.G.H. Ives)
	0.6	(J. A. Muldrew)
Supp.	0.5	(J. A. Drouin)
	0.8	(R. M. Smith)
Total	2.1	

11. Progress to Date:

    Nil.

12. Goals for 1979-80:

    N/A.

13. Accomplishments in 1979-80:

    N/A.

14. Goals for 1980-81:

    1. Conduct a preliminary survey of seed production plants, by means of personal interviews and examination of cone samples, in order to determine the importance of seed and cone insects in the production of coniferous seed, particularly white spruce.

    2. Conduct preliminary surveys of a number of established plantations in the Prairie Provinces to determine the amount of current pest damage and to determine the feasibility of obtaining quantitative estimates of its effect on tree mortality and growth loss.

    3. Conduct a preliminary evaluation of the available data on losses attributable to insect and disease attack of trees in the region in order to determine the feasibility of incorporating this information into a Regional Data Bank on forest production.

15. Publications:

    N/A.

16. Signatures:

Investigator

Program Manager

Investigator

Director G. T. Silver

Investigator

PROJECT NOR-10

Silvicultural prescriptions

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Silvicultural prescriptions.

2. Title: Nursery operations.

3. New: Cont.: X 4. No.: NOR-10-039

5. Study Leader: R.F. Huber

6. Key Words: Root pruning, storage and packing, storage mold, disease control, *Septoria, Marssonina,* seedling mortality, *Populus, Pinus, Picea,* conifer seedbed culture, containerized seedling rearing, quality control.

7. Location of Work: Northern Forest Research Centre, Edmonton, Alberta; Provincial Tree Nursery, Oliver; Alberta Forest Service Nurseries, Smoky Lake, Rocky Mountain House, Peace River; Alberta Horticultural Research Centre, Brooks; Saskatchewan Department of Tourism and Renewable Resources Nurseries, Big River, Chitek Lake, MacDowall, Prince Albert; PFRA Tree Nursery, Indian Head, Saskatchewan; Pineland Nursery, Hadashville, Manitoba; Northwest Pulp & Paper, Hinton; Simpson Timber, Whitecourt, Alberta and Hudson Bay, Saskatchewan.

8. Problem:

Nature of Study:

Every year an increasing area of the more productive forest lands is being harvested for wood products and must be reforested to ensure supplies for future generations. Tree planting is an essential part of today's program of more intensive timber culture. Prompt tree planting and scarification saves years that are often lost while waiting for natural regeneration. There is a large backlog of poorly stocked or unstocked forest land in need of planting, consisting of hundreds of hectares throughout the region. Trees and shrubs are also planted to protect soil from erosion by wind or water and to improve wildlife habitat. In urban areas, plantings improve the human environment by protecting man from the effects of heat, wind, dust, and noise; by screening objectionable sites; and by beautifying the urban landscape. Tree nurseries are essential for the production of the seedlings needed in all of these applications.

The prairie region has 16 nurseries and tree-rearing facilities either in production or coming on stream in 1980. The production from these nurseries by 1980 will be about 45 million trees annually, of which 75% will be used for reforestation. The present cost of producing a seedling of plantable size is in excess of 6 cents. The operating costs of nurseries in the region is probably close to 4 million dollars. Recent surveys indicate a poor survival of outplantings of white spruce and lodgepole pine (NOR-X-031). There is evidence in many cases that mortality was related to problems in the nursery system and they appear to be both cultural and pathological. Solving these problems and others like them could possibly prevent similar losses in the future.

Two large government nurseries in the Northern Forest Region are involved in the production of shelterbelt and parks nursery stock. The problems of rearing are mainly cultural and require some attention. As with coniferous stock, storage, packing and shipping present the major problem.

Demands on the nursery for production are high. With limited amount of space and money they are expected to produce certain numbers of trees at a certain quality. There is need for information that will help cut costs, increase the effective use of land, and maintain quality.

Probability of Success: Excellent.

Probability of results being put into practice: Good.

Method Used:

Definition of problems

Consultation with nursery managers
Through information from nursery monitoring

Determine priority of problem--relating to demands for the crop.

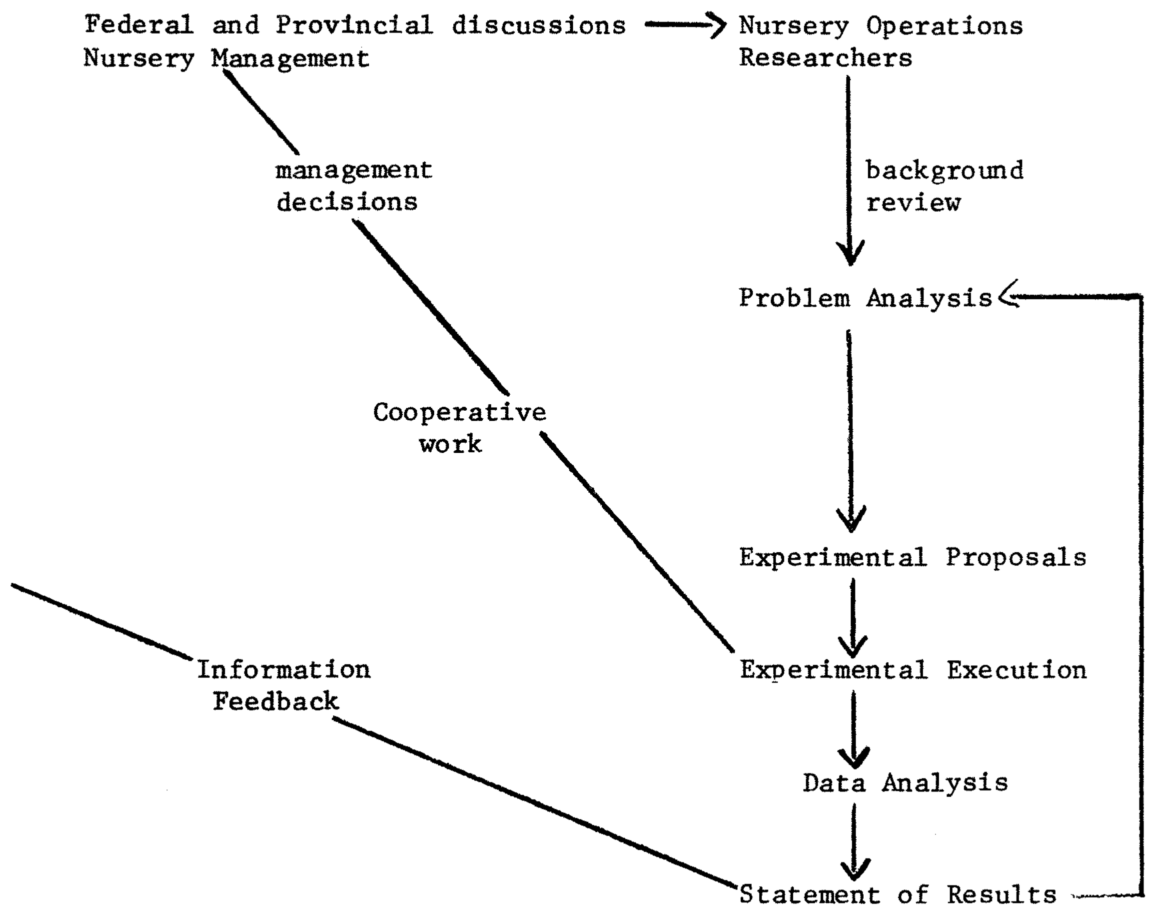
Scientific investigation of the problem

Experiments set with proper consideration for statistical analysis.

Results to be fed back to the nursery system as soon as possible.

Problem analysis flow chart:

Client Responsibilities | Departmental Responsibilities



9. <u>Study Objectives</u>:

   1. To improve general nursery practices, including seedling handling, disease control, weed control, cultural operations, and innovations for seedbed treatments.

   2. To advise on container production of seedlings.

10. <u>Resources</u>:

   a. Starting date: 1968
   b. Estimated year of completion: 1978 Revised: Ongoing
   c. Estimated total Prof. man-years required:

d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	-	
Supp.	1.0	(R.F. Huber)
Casual	-	
Total	1.0	

11. Progress to Date:

- Root deformities in some container grown jack pine in south-eastern Manitoba was reported on.

- An inventory and monitoring program for nursery stock was developed.

- Eight sources of Western Canadian peat were evaluated.

- Seedling storage was studied and reported on.

- Site investigations for nurseries in Alberta and Saskatchewan were carried out.

- Control of poplar leaf spot was established with the use of fungicides.

- Advice was given to Parks Canada on regeneration and reclamation.

- Simpson Timber (Alta.) Ltd. was given cultural advice on the start-up of their container program.

- Two workshops, one in Edmonton and one in Prince Albert, on Basics of Fertilization, Insects and Diseases Common to Nurseries and Greenhouses were organized. They were both well received.

12. Goals for 1979-80:

1. To survey regional nurseries for problem assessment and to perform related liaison functions.

2. To obtain 7th and 5th year data on spacing trials in poplar cutting beds at Alberta Provincial Tree Nursery and Prince Albert Forest Nursery respectively.

3. To continue the second phase of the study on special cropping schedules for increasing the organic matter content of Prince Albert Nursery soils. Pine seedlings will be harvested and monitored in October 1979. Spruce seedlings will grow for one more year.

4. Continue the study on the control of western gall rust of lodgepole and jack pine at Pine Ridge Nursery. Final data will be taken in the fall of 1979.

5. Publish Information Report, "Guidelines for rearing containerized seedlings".

6. Organize a meeting of regional government nurserymen to discuss operation problems. Meeting to be held at Pine Ridge Forest Nursery, Smoky Lake.

7. Organize a workshop on forest seed. Subjects such as seed evaluation, seed damage, germination tests, seed quality in relationship to sowing, and seed handling to be discussed.

8. Do a regional seed survey and report on inventories. Processing methods, seed quality (methods used for testing and upgrading), amounts of seed used in nursery and direct seeding, and costs.

9. Do a study on the effects of magnetism in relation to germination of pine and spruce seed and growth of seedlings.

10. To start an inventory of seedlings produced for reforestation in the region by species, type, quality, age and costs. To be updated yearly.

11. Complete study on native plants for Parks Canada.

Added Goals:

12. Present a paper "Nursery Scene in Western Canada" at the 1979 Intermountain Nurseryman's Meeting, Aspen, Colorado.

13. Co-Chairman for 1981 Intermountain Nurseryman's Meeting to be held in Edmonton, August 1981.

13. Accomplishments in 1979-80:

1. All regional nurseries were visited in 1979. Examples of problems encountered are: soil fertility at Hadashville, Man.; overwintering at St. Regis; overwintering and fertilizer at Rocky Mountain House; survival of Simpson Timber (Alta.) outplantings; numerous calls from private individuals on how to grow conifers, both container and bareroot, and problems asscoiated with growing; co-operated with PFRA Tree Nursery to use hydro-mulch for seedbed covering and oscilloscope for depicting dormancy. Co-operated with N.W.T. forest resources on a cone study by cleaning seed and doing germination tests. Initial tests completed and reported.

2. Yield data from 7th and 5th year cuttings from poplar spacing trials at Provincial Tree Nursery, Oliver and Prince Albert Forest Nursery has been taken. No trend has developed at either location. A short report will be written on Oliver and that part of the study dropped. They want to utilize the land for other purposes.

3. All seedlings will be harvested and monitored, Spring 1980. Initial plan was to harvest pine, Fall 1979 and spruce, Fall 1980. Both species have now reach plantable size, therefore seedling samples will be taken during the nursery lifting.

4. All sampling on the plots for the control of western gall rust on jackpine at Pine Ridge Nursery has been completed. No significant differences were found. A short report will be sent to Investigations Section at Pine Ridge.

5. "Guidelines for Rearing Container Conifer Seedlings in the Prairie Provinces" was published.

6. The Regional Nurseryman's meeting was dropped on account of nursery personnel attending seed workshop and tour of Pine Ridge Nursery.

7. A workshop on Forest Seed was held at NFRC and Pine Ridge Forest Nursery. Seventy-nine people registered. Subjects covered were: seed source--genetic quality, provenance and certification; cone collection and processing--effects on seed quality and yield; seed release in lodgepole pine and white spruce; the effects on seed production by insects and diseases; measuring seed quality; and benefits of high quality seed.

8. A questionnaire on seed was distributed through the Regional Silviculture Committee. The questionnaire indicated that records on seed are vague and follow-up by personal contact is necessary.

9. Dropped.

10. An inventory of all nurseries producing seedlings for reforestation and agricultural planting was completed. This served two purposes:
    a) Provided data for a national directory of forest nurseries;
    b) Gave us an up-to-date indication of reforestation within the region.

    Cost/seedling for 1979 was not attained because of cost accounting not completed for 1979.

11. The study for Parks Canada on government facilities willing to co-operate with them on their Native Plant Program was completed. A file report was sent to Parks Canada.

12. Presented a paper, "Nursery Scene in Western Canada," at the 1979 Intermountain Nurseryman's Meeting.

13. This goal started in September/79 and to date has involved making room and meeting room reservations, as well as a mailing list involving some 285 nursery personnel.

14. Goals for 1980-81:

1. To survey regional nurseries for problem assessment and to perform related liaison functions, such as: continue cooperative study with N.W.T. on cone and seed study, contact regional nursery personnel to obtain input into a regional meeting to discuss problems and developments, cooperate with Pine Ridge Nursery on monitoring outside overwintered container seedling and storage for temperature variations.

2. To obtain 6th year data on spacing in poplar cutting beds at Prince Albert Forest Nursery and report on seven years at the Provincial Tree Nursery, Oliver.

3. Monitor jack pine and white spruce seedlings from the study on special cropping schedules for increasing organic matter content of Prince Albert Forest Nursery soils and report. (File Report.)

4. Organize a workshop with the objective of presenting information to technicians and foresters who plan and supervise reforestation activities. The Regional Silviculture Committee will be asked for topic and location. In progress.

5. Continue on Regional Seed Survey (by personal interview) to get as much data as possible. Make information available to NOR-9.

6. Update seedling inventory for reforestation in the region.

7. Act as co-chairman for the 1981 Intermountain Nurseryman's Meeting to be held in Edmonton in August 1981.

8. Publish proceedings from seed workshop.

15. Publications:

Up to 1979-80

Huber, R. F. and Carlson, L. W. 1977. Jack pine storage molds. p. 274. *In*: C. W. Averre (Ed.), Fungicide-Nematicide Tests, Results of 1976. A.P.S. Vol. 32.

Carlson, L. W. and Nairn, L. D. 1977. Root deformities in some container grown jack pine in southeastern Manitoba. The For. Chron. Vol. 53, No. 3. June 1977. pp. 147.

1979-80

Carlson, L. W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can., Can. For. Ser., North. For. Res. Cent., Edmonton, Alberta. Info. Rep. NOR-X-214.

Huber, R. F. 1979. Report for a background study on government research facilities and nurseries in the western and northern region. Environ. Can., Can. For. Ser., North. For. Res. Cent., Edmonton, Alberta. File Report NOR-10-039.

Huber, R. F. 1980. Nursery scene in Western Canada. In Proc. Intermountain Nurseryman's Association. In press.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Silvicultural prescriptions.

2. Title: Nursery soil fertility and seedling growth.

3. New: Cont.: X 4. No.: NOR-10-135

5. Study Leader: I. K. Edwards

6. Key Words: Nutrient uptake, plant nutrition, *Pinus contorta, Pinus banksiana, Picea glauca.*

7. Location of Work: Oliver, Alberta and Prince Albert, Saskatchewan.

8. Problem:

Nature of Study:

Growing bare root and containerized coniferous stock under different fertilizer regimes and cultural practices in provincial nurseries in order to optimize production.

Benefits to be expected from the solution:

1. Higher quality of seedlings in terms of height, weight, top/root ratio and higher survival in stand establishment.

2. Reduced growing cycle in the nursery thus affording more efficient use of resources.

Probability of Success:

High but progress will be slow. Seedlings are grown in nurseries for three years before being field-planted. Besides, subsidiary work may be necessary to establish firm conclusions about certain treatments either in the nursery or at field sites.

Probability of results being put into practice:

Potentially high but decision rests entirely with provincial nursery management. Demonstration plots may be necessary to accomplish implementation.

Method Used:

Seedlings are grown in the nurseries in the presence of different combinations of N, P and K fertilizers. The optimum combination will be selected according to seedling quality in the nursery and on field survival. Support studies of cultural practices will provide data on such aspects as best nutrient source, time and method of fertilization.

9. Study Objectives:

1. To determine the nutrient requirements of coniferous species being produced in the nurseries and greenhouse.

2. To determine the effects of seedling density, fertilizer type, time and method of placement on seedling growth.

3. To determine the effect of irrigation on the loss of nutrient ions from the soil.

4. To determine the effect of soil amendments on the availability of nutrient ions.

10. Resources:

a. Starting date: 1971
b. Estimated year of completion: 1978 Revised: 1982
c. Estimated total Prof. man-years required: 9.7
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	1.0	(I. K. Edwards)
Supp.	1.0	(J. J. Van Dyk)
Casual	-	
Total	2.0	

11. Progress to Date:

Experiments to determine optimum fertilization and cultural practices for bare root and container seedlings have been completed and documented. Recommendations have enabled nursery managers to use fertilizers more effectively, use land resources more efficiently, and improve stock quality.

Nurseries have expanded their operations and advisory service has been provided accordingly. Assessment of soil fertility of cleared, uncultivated land has been made and operational problems related to large-scale fertilization of container seedlings have been solved.

12. Goals for 1979-80:

1. To publish the report, "Effect of N, P, and K on growth of lodgepole pine and white spruce in peat culture". This will be a journal publication.

2. To complete a soil fertility assessment of the Big River Nursery and prepare a report. This will be a File Report.

3. To prepare a paper, "Chloride determination and levels in the soil-plant environment," for journal publication. It was presented at the International Soil Science Congress in June 1978.

4. To review published and unpublished data, assess the soil fertility requirements of seed production areas, and prepare a report.

5. To develop an Erodibility Rating for the 1979-80 progress report on the Biogeoclimatic Classification of Alberta. This relates to the Silvicultural Prescriptions program.

6. To provide advisory service as required by industry and government agencies.

Added Goal:

7. To act as scientific authority for a contract to appraise overwintering procedures for containerized seedlings at four locations in the region.

13. Accomplishments in 1979-80:

1. The manuscript was completed and submitted to "Canadian Journal of Forest Research." It was not accepted by the editor on the grounds that the seedlings described in the paper were not at a "plantable" stage. The manuscript will be submitted to "Canadian Journal of Plant Science."

2. The report was completed and submitted to the client, Saskatchewan Department of Tourism and Renewable Resources. It is entitled, "Soil Analysis of the Big River Forest Nursery, Saskatchewan".

3. The manuscript was completed and given to the Editor, as required, for submission to the journal, "Environmental Pollution."

4. The report was completed. It is entitled, "Fertilization and Soil Fertility in Conifer Seed Production".

5. The report is incomplete. A literature review of soil erosion indicated that the agricultural context of most of the previous work make the results inapplicable to forest soils in the boreal region. The profile for a computer search of relevant bibliography had to be changed.

6. Advisory service was provided to industry and government agencies as required:

   a) Investigated uneven growth of container seedlings in greenhouse at Pineland nursery. Problem due to: i) uneven distribution of water and fertilizer solution by the irrigation system and ii) incorrect nutrient regimes.

   b) Analyzed soil from Pineland nursery and made fertilizer recommendations for bareroot stock.

   c) Investigated precipitation problem in concentrated nutrient solution at Prince Albert nursery. Problem due to phosphorus compound present. Preparation of more dilute stock solution recommended.

   d) Identified severe salt damage in amenity plantings along Edmonton streets. City Parks and Recreation Department advised re: harmful effects of deicing salt and suitable tree species for high-risk areas.

   e) Provided fertilizer recommendations for red pine plantations in southeastern Manitoba.

   f) Investigated chlorosis of 25 year old ponderosa pine in a city park. Highly alkaline soil, manganese deficiency, and restricted rooting contributed to the problem. Provided recommendations.

<u>Added Accomplishment</u>:

7. Functioned as scientific authority for overwintering contract. Along with John Powell and Harry Zalasky, met with contractor to discuss preliminary as well as final report. Contractor agreed to revise the report, giving more details of his appraisal. Completion date is still March 10 as scheduled.

14. <u>Goals for 1980-81</u>:

1. To review literature including infiltration data for the Hinton area, and develop a Soil Erodibility Index for application to the Biogeoclimatic Classification of Alberta.

2. To publish, "Guidelines on fertility requirements for seed production areas".

3. To review forest soil studies and investigate opportunities for integrating soil characteristics with site productivity ratings in support of performance trials in silviculture.

4. To provide advisory service in soil fertility and tree nutrition as required by industry and government agencies.

5. To prepare a paper on phosphorus extraction and uptake for possible presentation at the Tree Nursery Soil Management Workshop to be held July 28 - August 1 at Syracuse, New York.

15. Publications:

Up to 1979-80

Edwards, I. K. 1978. Effect of wet-weather logging on certain soil properties in the Grande Prairie forest. File Report NOR-10-135.

Edwards, I. K. 1978. Effect of nutrient regime on drought tolerance in lodgepole pine and white spruce seedlings. File Report NOR-10-135.

Edwards, I. K. 1978. A short course for nursery personnel: the basics of soils and fertilizers. File Report NOR-10-135.

Edwards, I. K. 1978. Discoloration of white spruce and balsam fir at Candle Lake, Saskatchewan. File Report NOR-10-135.

Edwards, I. K. 1978. Report on foliar concentration data for Procter and Gamble fertilization project. File Report NOR-10-135.

Edwards, I. K. 1978. Root pruning of conifer seedlings. File Report NOR-10-135.

Brace, L. G., I. K. Edwards, and W. D. Johnstone. 1978. Report on methods for stimulating cone and seed production in the Maloneck plantations. File Report NOR-10-039.

Cerezke, H. F. and I. K. Edwards. 1978. Canadian Forestry Service report to the Environmental Subcommittee of the Alberta Horticultural Advisory Committee. File Report NOR-143/135.

1979-80

Edwards, I. K. 1979. Soil analysis of the Big River Forest Nursery, Saskatchewan. File Report NOR-10-135.

Edwards, I. K. 1979. Fertilization and soil fertility in conifer seed production. File Report NOR-10-135.

Edwards, I. K. 1979. Growth of paperpot container seedlings at Pinelands tree nursery. File Report NOR-10-135.

Edwards, I. K. 1979. Chlorosis of ponderosa pine at Winston Churchill park, Edmonton. File Report NOR-10-135.

Cerezke, H. F. and I. K. Edwards. 1979. Canadian Forestry Service report to the Environmental Subcommittee of the Alberta Horticultural Advisory Committee. File Report NOR-143/135.

16. Signatures:

I. K. Edwards
Investigator

G. D. Hunt
Program Manager

G. T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Silvicultural prescriptions.

2. Title: Conditioning, winter storage and initial field performance of containerized conifer seedlings.

3. New: Cont.: X 4. No.: NOR-10-155

5. Study Leader: H. Zalasky

6. Key Words: Conditioning, winter storage, *Pinus* sp., *Picea* sp., container seedlings, dormancy, field performance.

7. Location of Work: Northern Forest Research Centre, Edmonton, various locations in Prairie Provinces.

8. Problem:

The increased demand for conifer seedlings for reforestation has led to the rearing (or demand for rearing) of containerized seedlings throughout the year. Seedlings reared in spring and summer but not planted in the year of production present a problem of storage if they are to be used during the following planting season. At present there are limited methods for storing these seedlings during the cold northern latitude winter months. Indoor storage space is limited and expensive. An economical and efficient outdoor method should be assessed.

Outside storage of containerized seedlings that were sufficiently hardened-off before the onset of winter has been carried on for a number of years with variable success. Depending on the snow cover and the winter conditions the seedlings have been subject to frost injury and dessication or have come through without injury. Regulating outside winter storage of containerized conifer seedlings is therefore important in insuring that more seedlings will be available for reforestation. Such a program should then provide 1) flexibility and safer storage of seedlings; 2) ease of handling of containerized seedlings; 3) an increased capacity for seedling production; and 4) protection against frost injury and dessication.

Plan of attack:

1. Test risk factors and effectiveness of outside winter storage using the current cold frame method, or of cold storage facilities similar to that used for bare root stock.

2. Determine the length of time for initiation and completion of dormancy in roots and tops.

3. Manipulate the container system to bring about dormancy by reduction of photoperiod, reduction of temperature, or combining both treatments when seedlings can receive the greatest benefit.

4. Monitor early performance after outplanting in the field.

9. Study Objectives:

1. To develop a method for winter storage of containerized conifer seedlings and monitor early field performance.

2. Develop overwintering guidelines for containerized seedlings.

3. To develop a method to bring about dormancy in containerized conifer seedlings.

10. Resources:

a. Starting date: 1977
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 2.0
d. Essential new major equipment items for 1979-80 with costs:
e. Essential new major equipment items beyond 1980 with costs: Unknown
f. 1979-80 man-years

Prof.	0.8	
Supp.	0.5	(F. Dendwick)
Casual	-	
Total	1.3	

11. Progress to Date:

A new storage facility was constructed in the fall of 1978 to accomodate two storage treatment areas. Straw was used as insulation material for the outer walls and roof. The facility was a marked improvement over plastic structures of 1977-78 overwintering period. Storage results were good and gave a new direction in further development to improve the insulation materials and their R values, narrow the range of temperature fluctuation and slow down the warming and cooling more closely to operational levels.

Two age groups of pine and spruce seedlings have been tested during 1977-78. The implication appears to be that roots of white spruce require less post-conditioning time than lodgepole pine in the first few weeks after storage. Root conditioning investigation now should provide an answer why spruce behaves differently from pine in overnight storage than under field conditions after outplanting.

A manuscript was published and a field photoguidelines with brief notes was prepared for technician use. Literature Retrieval services were used to help search for research information on conditioning, storage and storage damage. Nursery contacts were made with government and private agencies to consult on matters pertaining to storage and examine seedlings for pre-wintering frost damage.

12. Goals for 1979-80:

1. Outplant 3000 NFRC and 2000 provincial and industrial overwintered conifer seedlings and monitor their rootability, survival and suitability over a period of 2 or 3 months at NFRC nursery.

2. Organize a work shop for provincial and industrial nursery managers in the fall of 1979 on the performance of overwintered pine and spruce seedlings test planted at NFRC.

3. Rear and precondition a new set of pine and spruce seedlings for 1979-80 storage.

4. If necessary re-inforce the temperature barrier with available materials to narrow down radiation gains and losses in the seedling storage area.

5. Review all data including those in goal No. 1 and report on factors affecting overwintering storage of conifer seedlings with the view of establishing operational guidelines.

6. To publish a manuscript on "Shoot abnormalities from frost injury in lodgepole pine".

13. Accomplishments in 1979-80:

1. Jack pine and lodgepole pine as well as black and white spruce containerized seedlings overwintered by NFRC, provincial and industrial nurseries were field tested and used as demonstration plots; and are being overwintered for final field assessment of frost heave damage in poorly rooted ones in the spring of 1980. They have been assessed for mortality before and after outplanting, flushing and growth habit, bud formation, and rootability which affects height growth and diameter.

2. A successful workshop attended by 32 foresters, nurserymen, and AFS silviculturists from Alberta and Saskatchewan was held in September to assess and promote requirements for operational guidelines in proper conditioning, overwintering, storage facilities and seedling viability before and after outplanting. This workshop

featured a paper and slide show presented indoors, a field demonstration and advice and a discussion of the condition and viability of seedling after pre- and post-winter storage, and after planting and one season's growth. Participants endorsed the need for guidelines in storage of containerized seedlings and methods (the state of the art).

3. Newly reared and preconditioned pine and spruce seedlings have been stored outside and inside at three storage intervals for 1979-80 test period. Rearing and preconditioning parallels that of 1978-79, but the inside storage condition is much improved.

4. Fiberglass wool now lines the inside walls and ceiling, as well as the roof previously covered by bailed straw which lost its insulation quality from excessive weathering. The outside walls insulated with bailed straw would have to be replaced with fiberglass in 1980 now that we have some measure of R rating requirements. The success of such storage structure should be invaluable for on-site storage facilities because they are relatively cheap and easy to construct and they serve as an excellent shelter to container seedlings against severe cold and wind chill.

5. My own data, and that of published field information available from B.C., Ontario, U. S. and Sweden have been reviewed for Section 1 of the operational guidelines. This covers the conditioning requirements as it affects the tops and roots; the present cultural practices that may favorably or unfavorably affect conditioning; frost damage prior to storage and ensuing deterioration in outside or inside storage; types of storage facilities available and usefulness under our Interior Plains winter conditions; the temperature of snow, and the availability of snow cover for proper outside storage in Ontario, B. C., U. S. and Sweden as compared to that in our Interior Plains.

6. Final review, editing and retyping of the manuscript has been delayed late into 1979 because of a low priority rating.

14. Goals for 1980-81:

1. Complete publication of "Shoot abnormalities from frost injury in lodgepole pine".

2. Complete manuscript on "Guidelines to overwintering container stock". These guidelines will include a section on the detection of frost damage to coniferous seedlings.

3. Outplant 3000 NFRC overwintered conifer seedlings and monitor their rootability, survival and suitability over a period of 3 months at NFRC nursery.

4. Rear and condition a new set of pine and spruce seedlings for 1980-81 storage and test post-conditioning requirements of NFRC pine and spruce roots.

5. Upgrade present storage for insulation R-rating.

15. Publications:

1977-79

Zalasky, H. 1978. Stem and leaf spot infections caused by *Septoria musiva* and *S. populicola* on poplar seedlings. Phytoprotection 59, 43-50.

Zalasky, H. 1978. Variation in fascicles, primordia and phyllotaxy of lodgepole pine *Pinus contorta* Dougl. var *latifolia* seedlings after frost damage. Bi-Mon. Res. Notes 34, 26-27.

Zalasky, H. 1978. Silvicultural studies related to overwintering, bud-setting and dormancy of containerized nursery stock. File Report.

Zalasky, H. 1979. Preplanting conditioning and overwintering in nurseries. Forestry Report (in press).

1979-80

Nil

16. Signatures:

Harry Zalasky
Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Silvicultural prescriptions.

2. Title: Preplanting conditioning of containerized conifer seedlings and field performance.

3. New: Cont.: X 4. No.: NOR-10-156

5. Study Leader: H. Zalasky

6. Key Words: Container seedlings, field performance, growth survival, pre-plant conditioning.

7. Location of Work: Northern Forest Research Centre, Edmonton and Grande Prairie.

8. Problem:

Results of research into the development of the container planting system of regenerating forest land, initiated in the early sixties, has been generally encouraging (North American Containerized Tree Seedling Symposium, Denver, 1974). The system is now in use by all provincial forest management agencies and a number of forest industries in the region, and is providing strong competition to the more traditional bare-root planting methods.

In the research conducted to date very little effort has gone into determining the negative or positive effects of accelerated growth, and other rearing practices on field performance of the seedlings. Identification of those effects will provide a better biological basis for the design of rearing and planting schedules that will allow utilization of the full potential of the container planting system.

Presumably, containerized seedlings should have morphological development and ecological stability similar to that of natural seedlings. They would then be ready to adapt to seasonal growth patterns imposed by the field environment and deviate from them as little as possible even though nature may at times be harsh. Control experiments have to be designed to find how stock conditioning influences performance in the field. The aspects of preplanting conditioning that can be assessed include: 1) light regimes and means of attaining prescribed light regimes, 2) temperature regimes, 3) nutrient regimes, 4) practices utilized to "harden-off", "toughen" or otherwise condition the seedling before planting, 5) chemical treatments utilized to adjust seedling morphology and growth patterns.

In addition, seedling condition as determined by rearing practices must presumably be matched to the field environment to achieve the best possible field performance. The main aspects of the field environment that can be assessed are microclimate as influenced by location and site condition, and season of planting.

Any effort to relate preplant condition to field performance will have to consider some of the transitional stages of conifer seedlings. This is all the more important when nursery practice thus far places emphasis on continuous growth arrested artificially. Arrested growth leaves the shoots at the soft stage of tissue and organ development. To understand the silvicultural implications of this practice, the basic morphological phases of seedling development in conifers should be reviewed.

During growth, conifer seedlings go through 3 phases of morphological development 1) plumule phase; 2) soft-bud phase; 3) hard-bud phase. Plumule phase lasts 2 to 3 wk after germination and is terminated with an epicotyl above the cotyledon. The soft seedling phase is a period of slow growth which may last 2 to 10 years depending upon the conditions of the microclimate, especially temperature. These seedlings characteristically lack branching or have an intermittent cambial activity (growth periods alternating with rest). The latter results in atypical, late growth patterns, suppressed apical dominance and subapical etiolation. Shoots with intermittent growth have primary and secondary needles and specific bud features. The central root tip discontinues growth early and develops adventitious and lateral roots. In current practice, it appears that the majority of containerized plants are in this phase when planted. Plants terminate this transitional phase randomly, accelerate their shoot growth and develop a hard-bud phase. Thereafter, plants form a whorl of internodal-branches in a regular annual pattern.

The preplanting seedlings must be characterized for seedling development of buds, needles, shoots and roots. Daily examination of seed germinants and seedlings should identify any abnormalities whether caused by conditioning treatment or by damage during seed set. Chilling is the last conditioning treatment. Observations for damage are then recorded before plants are sent to the field. Similar characterization is also made after planting and first year's establishment because of idigenous frost damage and ensuing changes in form and height, in organ and tissue morphogenesis, and in growth patterns.

Late summer leaders resulting from intermittent cambial activity are susceptible to frost injury and subsequently to forking, multistem formation, dieback, and cankers. Discolored areas in the bark that are bridged by frost ribs and frost burls are also noted. These anomalies which have been fully described (Zalasky 1972-1975) may be measured visually or with the aid of the oscilloscope. Such data may be useful in both characterization and in statistical analysis of seedling performance in the field. The techniques can be applied also to damage by tolerable and non-tolerable levels of chemicals applied to conditioned seedlings.

Plan of attack:

1. First year 1976-77

    1. Select site for field studies in Alberta.

    2. Obtain containerized material from each production run at Oliver and Hinton.

        - two species at each nursery
        - complete histories obtained, plus physical data
        - NFRC container material from rearing study also to be used: lodgepole pine

    3. Plant seedlings into site on 2 planting dates.

    4. Observe and collect data on field performance.

        - could extend over 3 years

2. Second year 1977-78

    1. Use same site as in 1976-77

    2. Seedlings prepared by NFRC for experimental work will be used.

        - experimental design and treatments to be determined at end of first year data collection 1976-77

    3. Plant seedlings into site.

    4. Observe and collect data as before.

3. Third year 1978-79

    Same as second year 1977-78

    - vary rearing regimes at NFRC as needed to elucidate field performance.

9. <u>Study Objectives</u>:

To determine what types of preplanting conditioning have significant effects on conifer seedlings field performance.

10. <u>Resources</u>:

a. Starting date: 1976
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 2.5
d. Essential new major equipment items for 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

Prof.	0.2	
Supp.	0.5	(F. Dendwick)
Casual	-	
Total	0.7	

11. <u>Progress to Date</u>:

Seedlings reared for 20 wk under two sets of conditions were outplanted for field testing at Wapiti near Grande Prairie on Proctor and Gamble property. A third group of seedlings was reared for 14 wk and the lypocotyl growth was terminated with needle buds. The third group of seedlings were tested for bud flushing in the greenhouse. The results suggested that seedlings conditioned at 10°C flushed better and were more suited for spring planting; those conditioned at 15°C were better for fall planting because they remained dormant longer. The same conditioning treatments were used for seedlings in project 155 but the differences between 10°C and 15°C conditioned seedlings is primarily in the ability of the root system to survive winter conditions.

Seasons climatic and seedlings' performance data have been computerized.

Two manuscripts have been published concerning low temperature effects on tissues, organs and phyllotaxy.

Literature on TOK-E effects on pine seedlings was reviewed using literature made available from our own and outside libraries and by using the literature retrieval services.

12. <u>Goals for 1979-80</u>:

1. To publish a subjective manuscript on "Shoot abnormalities from frost injury in lodgepole pine", (Bi-Mon.).

2. To publish a manuscript on "Influence of splash cones on outplanted containerized conifer seedlings", (Bi-Mon.).

3. To complete a file report on effects of TOK-E-25 on containerized conifer seedlings (Information Report or Can. J. F. Res.).

4. Prepare a guidelines report on "Detection of frost damage to conifer seedlings," (Information Report).

5. Supervise tallies of 1977 and 1978 outplanted seedlings for frost damage, survival, rootability after frost heave, cyclical growth, habit, measurements and splash cone effects at Grande Prairie.

6. To determine if preconditioning is correlated to spring- and fall-frost hardiness by examining seasonal outplanting data from this study.

13. <u>Accomplishments in 1979-80</u>:

1. & 2. Both manuscripts are in final editing, and retyping delayed late into 1979 because of low priority rating.

3. Have not been able to devote more time to TOK-E manuscript after a rewrite and literature search earlier in the year.

4. The report material was incorporated into a slide show for the nurserymen (Project 155) and is in rough form.

5. One field trip was made to satisfy tally requirements and to take some black and white photos.

6. The first computer trial run of preconditioning effects, frost heave and splash cone effects is scheduled in early 1980.

14. <u>Goals for 1980-81</u>:

1. Continue to monitor stock on Grande Prairie site.

2. Terminate study.

15. <u>Publications</u>:

1978-79

Zalasky, H. 1978. Variation in fascicles, primordia and phyllotaxy of lodgepole pine, *Pinus contorta* Dougl. var. *latifolia* seedlings after frost damage. Bi-Mon. Res. Notes, 34(4), 26-27.

Zalasky, H. 1978. Silvicultural studies related to overwintering, bud-setting and dormancy of containerized nursery stock. File Report.

Zalasky, H. 1978. Outplanted jack pine seedlings from Lythe, Saskatchewan. File Report.

Zalasky, H. 1979. Tracheids of boreal and treeline tamarack (*Larix laricina*). Bi-Mon. Res. Notes, 34(6):38.

1979-80

Zalasky, H. 1980. Influence of splash cones in outplanted containerized conifer seedlings. Accepted for publication in Bi-Mon. Res. Notes.

16. Signatures:

Harry Zalasky

Investigator

G. D. Hunt

Program Manager

G. Silver

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Silvicultural Prescriptions

2. Title: Development of Silvicultural Prescriptions and Management Tools for Forest Resource Planners.

3. New: X Cont.: 4. No.: NOR-10-176

5. Study Leader: L. G. Brace and W. J. Ball

6. Key Words: Silvicultural prescriptions, models, guidelines, planning, computer data bank.

7. Location of Work: N.F.R.C.

8. Problem:

Forest regeneration following harvesting and wildfire has recently been identified as a major problem area and a limiting factor in achieving sustained yield forest management in the region and throughout Canada (see results of Canadian Forestry Association meeting in Quebec City in October, 1977). On a region-wide basis the problem is most acute in the Mixedwood forest. In Alberta, the Foothills and Subalpine forests, which contain over 50 percent of the provincial allowable cut of softwoods, are estimated to have a 20 percent shortfall in reforestation of the annual cutover, using existing management practices.

The Canadian Forestry Service suggests that much of the information needed to upgrade silvicultural practices in the region is already available, but must be located, assessed and coded before it can be utilized in the formulation of guidelines and other management tools for use by forest management decision makers to upgrade the practice of silviculture.

9. Study Objectives:

   1. To promote the development of silvicultural prescriptions, as part of the forest management options program. This includes work with regional and local committees, development of data bank criteria, and establishment of the silviculture component of a data bank.

2. To catalogue, develop, assess and adopt management tools such as guidelines and computer models for use by forest management planners in the area of silviculture.

3. To publish reports of a regional overview nature related to silvicultural concerns such as planting stock performance and reports on and demonstration of computer models for application in planning of silvicultural operations.

10. Resources:

a. Starting date: April 1, 1979
b. Estimated year of completion: Continuing
c. Estimated total man-years required:
d. Essential new major equipment items required 1979-80: Nil
e. Essential new major equipment items required beyond 1980: Nil
f. 1978-79 man-years

Prof.	3.0	(Brace, Ball, Vacant)
Supp.	1.0	(Walker)
Casual	-	
Total	4.0	

11. Progress to Date:

Actual data bank entries have not been made for silvicultural data. Samples of data from a variety of sources, including research studies and reports and operational plot records, were assessed for codability, and data on equipment specifications (site treatment and planting) and on stock performance were coded and used in reports. Progress has been made in assessing data reliability and in setting up standard codes. Bank entries await agreement amongst project leaders on standard site codes. These must be related to a common assessment framework such as the bio-geoclimatic.

Efforts to obtain agreement with provincial governments to obtain silvicultural data are still in progress. The Regional Reforestation Technical Committee is addressing the area of interest as well as providing technology transfer through meetings and workshops.

A reforestation planning model using integer programming techniques was adapted to regional data for use in the National CIF displays at Jasper in September - October, 1979. This proved useful in pointing out weaknesses in the integer programming approach.

A stock performance contract has been set up with the Alberta Forest Service to provide CFS staff with further stock performance information--on a cost-shared basis. This will run for at least five years on a yearly contract basis.

12. Goals for 1979-80:

(Brace)

1. Co-ordinate establishment stages of silviculture data bank, including standardization of codes, criteria for judging utility and reliability of data, preliminary entry of stock performance data and entry of data for use in a nursery stock allocation model.

2. Act as project leader in other NOR-10 studies, with specific objective of aligning goals with requirement of the forest resources research.

3. Initiate development of a catalogue of silvicultural management tools such as stock performance guidelines and computer models which can be adapted for use by forest management planners in silviculture.

4. Assess and test a specific nursery stock allocation model (A Seasonal Reforestation Planning Model).

5. Function as chairman of:

   a) Regional Reforestation Technical Committee;

   b) CFS Ad Hoc Committee for computerized technology transfer display at the National CIF Meeting in 1979;

      - Develop statement of feasibility by April 30, 1979.

   Act as member of:

   c) Alberta Technical Committee on Forestry;

   d) Task Force for Kananaskis Country.

6. Publish silviculture issue of Forestry Report.

Goal Added:

7. a) Serve on EMS Evaluation Team for the Interpretation Program.

(Ball)

8. Complete work carried over from Prince Albert sub-office:

   a) NSR Study Report (Information Report);

   b) Finn Plow Trial Establishment Report (File Report).

9. Locate, assess and initiate coding of survival and juvenile growth data from federal, provincial and industrial sources in Saskatchewan, for use in silviculture data bank.

10. Initiate similar action in Alberta and Manitoba and combine with data from Goal 2. for use in preparing a region-wide report on survival and initial growth of major species. Recommend additional data requirements, if any.

11. Initiate a survey of methods, costs and results for Seed Production Areas (SPA) established to date from B. C. to Ontario, for species of regional interest, and set up codes for inclusion in silviculture data bank (in co-operation with Edwards, Huber, Klein, Cerezke and Ondro).

12. Co-ordinate initial phases of field performance trials for lodgepole pine and white spruce in Alberta, sponsored by the Alberta Technical Committee on Forestry.

Goal added:

13. Participate in Forest Economic Survey with B. Ondro's group. Complete industrial questionnaires for wood-using industries in Rocky-Clearwater and Whitecourt Forest Districts.

13. Accomplishments in 1979-80:

(Brace)

1. Data bank concept developed to point where entries can be made for field performance data and for equipment production and limitation data (site preparation and planting) once standard codes for site description are agreed upon amongst project leaders in CORE program.

2. Objectives and goals are now aligned with those of management options program except for completion of some longer term goals in two studies. These will be combined in 1980/81 to focus directly on new priorities.

3. Not achieved in the form of a catalogue. Work was begun on stock performance guidelines by Walker and Ball, and on an equipment catalogue (by updating and extending the FMI catalogue) by Wambold.

4. The Seasonal Reforestation Planing Model was adapted to regional data and used in CIF National Meeting at Jasper as part of the CFS computer technology display.

5. a) The Regional Reforestation Technical Committee held its scheduled meeting at The Pas, Manitoba, in 1979 and was used as a vehicle for developing workshop themes, obtaining material for overwintering assessment by Zalasky, expediting the overwintering contract by

Longley and initiating assessment and proposal for CFS involvement in data bank development using silviculture data from DTRR (Saskatchewan).

b) Acted as chairman of Ad Hoc Committee until June 1979 for the CFS display at the Jasper CIF meeting. Feasibility statement of April, 1979, drew together commitements for computer displays from Ottawa to Victoria and detailed plans were developed. In June 1979, chairmanship was passed to Ross Waldron and work began on computer display for silviculture (see Accomplishment 4.).

c) Contract was developed with Alberta for CFS participation in a stock performance experiment. The work was then passed to Jim Ball for execution.

d) The Task Force for Kananaskis Country completed its work as far as federal input was concerned when the Kananaskis property was transferred to provincial ownership in mid-1979. The main work of the CFS member was in integrating the CFS resource management interpretation program with ongoing and planned provincial programs in Kananaskis Country.

6. Not achieved due to work load on EMS Committee (see below).

Accomplishment Added:

7. Served on a three member team from August 1979 to the present. First draft of report completed on December 23, 1979. Second draft submission for this member completed and submitted on January 24, 1979. This assignment required travel across the country and a large number of meetings. Final reporting is still required.

(Ball)

8. Completed work carried over from Prince Albert sub-office as follows:

a) Published Information Report NOR-X-216. An aerial reconnaissance of softwood regeneration on mixedwood sites in Saskatchewan.

b) Finn Plough Trial outplanting was completed; after planting heights and moisture regimes have been taken on individual seedlings and this information is now being recorded on 80-column forms.

9. Reviewed the Saskatchewan Silvicultural Data Base proposal and suggested modifications and assisted in adaption of regional data to reforestation planning model used in Jasper display.

10. Some plantation performance data from Saskatchewan and Alberta have been assembled and two Forest Management Notes are currently at the review stage:

    a) Plantation performance in perspective by Ball;

    b) Cavity size and rearing time affect container seedling field performance by Walker and Ball.

11. Nil. This survey may best be made a goal of a different study or dropped for the present time.

12. Goals and objectives have been refined through a series of meetings held with AFS. Initial trials at Pine Ridge in 1979 indicated that the range of seedling sizes desired can be produced at Pine Ridge.

Accomplishment Added:

13. Forest economic survey questionnaires were completed on industries in Rocky-Clearwater and Whitecourt forest districts.

14. Goals for 1980-81:

(Brace)

1. Complete assignment on EMS Evaluation Team, with final report submission and presentation by April 30, 1980.

2. Publish Silviculture issue of forestry report.

3. Co-ordinate development of the Silviculture Prescriptions Project (NOR-10) with other projects in the Forest Resources Research Program by:

    a) Agreeing upon and implementing standard codes for data bank use, relating specifically to land inventory and site description codes, to implement initial data bank entries for silviculture.

    b) Set priorities and procedures for silviculture data bank development and provide interface with other banks in CORE program.

4. Continue as Chairman of Regional Reforestation Technical Committee. Organize 1980 field meeting and follow-up.

5. Obtain and assess additional resource management models of silvicultural application on the reforestation field, with emphasis on initial development of a model suitable for developing silvicultural prescriptions on an interactive basis, using the silviculture data bank and standardized site data for CORE program.

(Ball)

6. To select (with P & G) candidate areas for field performance trials, monitor container stock (with Pine Ridge) and provide liaison with Alberta Technical Committee on Forestry.

7. To publish plantation performance data from Saskatchewan and Alberta, two Forest Management Notes:

   a) Plantation performance in perspective (by Ball);

   b) Cavity size and rearing time affect container seedling field performance (by Walker and Ball).

8. To commence a modified bibliography on information sources using key words specific to computer use. This would include standardized codes for a low cost data bank:

   i) authors, title, year;
   ii) geographic location of work;
   iii) species;
   iv) cover type;
   v) research or other approach in work;
   vi) size of area used in study;
   vii) reliability index.

   This bibliography will be limited to native conifers in the region.

9. Obtain ten-year height and survival data for both container and bare-root plantings available from regional CFS trials and deemed reliable for use in performance data bank. Report significant results in the Forest Management Note series.

15. Publications:

Up to 1978-79

Nil

1978-79 (Published)

Whitney, R. D. and L. G. Brace. 1978. Internal defect resulting from logging wounds in residual white pine trees. 16 pp. For. Chron. Dec. 12, 1978.

1978-79 (Unpublished)

Annon. 1978. Interpretive planning options, Kananaskis Country. 56 pp.

A report prepared for the Interpretive Task Force for Kananaskis Country, by J. Christensen, D. Clark and

W. Pearce, for presentation to the Kananaskis Country Interdepartmental Planning/Standards/Review/Approval Committee.

Brace, L. G., I. K. Edwards and W. D. Johnstone. 1978. Report on methods for stimulating cone and seed production on the Maloneck Plantation. File Report, NOR-10-039.

Report for use by Saskatchewan government in planning work for the Maloneck Seed Production area.

1979 (Published)

Ball, W. J. and V. S. Kolabinski. 1979. An aerial reconnaissance of softwood regeneration on mixedwood sites in Saskatchewan. N.F.R.C. Inf. Rep. NOR-X-216. 14 pp.

16. Signatures:

Investigator	Program Manager
W. J. Ball Investigator	Director G. T. Silver

PROJECT NOR-12

Genetic improvement of commercial forest species

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1980

1. Project: Genetic improvement of commercial forest species.

2. Title: Provenance tests for coniferous species.

   Experiment a. (Formerly MS 187) Provenance experiments with the white spruces of Manitoba and Saskatchewan.
   Experiment b. (Formerly MS 089) Red pine *(Pinus resinosa)* provenance experiment.
   Experiment c. (Formerly MS 088) Scots pine *(Pinus sylvestris)* provenance experiment.
   Experiment d. (Formerly MS 234) A test of twelve Norway spruce provenances from northern Europe and Siberia -- Riding Mountain Research Area.
   Experiment e. (Formerly MS 019) All-range jack pine provenance experiment, Manitoba-Saskatchewan sub-experiment.
   Experiment f. (new) Geographic variation in black spruce, Northern Region component.

3. New: Cont.: X 4. No.: NOR-12-050

5. Study Leader: J.I. Klein

6. Key Words: Geographic variation, seed sources, seed zones, Alberta, Manitoba, Saskatchewan, exotic species, *Picea abies*, *Picea glauca*, *Picea mariana*, *Pinus banksiana*, *Pinus resinosa*, *Pinus sylvestris*.

7. Location of Work: Wasagaming, Vassar, Piney, Mafeking, Sundown and Carberry, Manitoba; Holbein, Indian Head, and P.A. Pulp Camp 6, Saskatchewan; Reno, Alberta.

8. Problem:

This study comprises provenance experiments with six conifer species. Five are sub-experiments of cooperative investigations initiated by Petawawa Forest Experiment Station. The white spruce experiment was undertaken by the District Forest Officer stationed in Winnipeg.

Each experiment involves establishment of plantations containing populations of varying geographic origin, and comparison of performance among populations over an extended number of years.

Application of the results of this experiment is expected to lead to improved productivity of forest plantations, in consequence of increasing genetic suitability of seed source. All of the component experiments are capable of yielding some progress toward this goal. None is capable of disposing of the provenance question as a research problem for an important plantation species in this Region.

Operational application of the results will depend upon their inherent practical value, and on availability of seed from the desired sources. Interest of provincial foresters in using improved seed seems assured. Prospects for practical application appear relatively good for the Scots pine experiment, but immediately available seed is limited to that produced in the test plantations. Probable usefulness of the white spruce and red pine experiments is limited by the small number of provenances tested in relation to their geographic range. The jack pine and black spruce experiments are likely to offer greater practical benefits east of this Region. Early growth in the Norway spruce test appears to offer little promise of immediate practical usefulness, but this prospect may improve in the years to come.

All six experiments share the familiar general procedure for provenance testing. Planting stock is grown from seed of known and varying geographic origin. Seed is usually collected from several to many trees of each souree population. Replicated plantations are established in one or more locations. The experimental unit is a plot containing some number of trees from one source. Performance of the trees from each source is observed and scored periodically for as long as the test is deemed worthy of maintenance. Inferences are drawn from the performance scores, about expected performance of trees that might be grown from seed originating in some area about the tested provenances, when planted on sites similar to the experimental plantation site.

9. Study Objectives:

1. To screen populations of conifer species for possible usefulness for planting in various areas within the Northern Region.

2. To obtain an indication of the probable usefulness of further provenance testing or similar research with the species under trial and to guide the planning of such research.

3. To obtain information on patterns of geographic variation in the species under trial.

4. To identify adapted genotypes among the introduced populations for further breeding use.

10. Resources:

a. Starting date: white spruce, 1955; red pine, 1958; Scots pine, 1960; Norway spruce, 1960; jack pine, 1968; black spruce, 1971.
b. Estimated year of completion: indefinite and various.
c. Estimated total Prof. man-years required: 8.8
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.1	(J. Klein)
Supp.	0.1	(A. Nanka)
Total	0.2	

11. Progress to Date:

White Spruce

In May, 1959 a plantation was established near Wasagaming, Manitoba, with transplants of 14 Ontario and Quebec populations, plus one each from Manitoba and Saskatchewan. Ontario and Quebec stock had been sown at Petawawa Forest Experiment Station. All planting stock except for the Saskatchewan population had been lined out, without replication, at the Riding Mountain National Park nursery since spring, 1956. The plantation is in random block design with 4 replicates and 49-tree square plots. Transplants of 13 Manitoba and Saskatchewan populations plus one Ontario population were planted near Wasagaming in September, 1959. Several provenances were represented by one single-tree progeny. Plantations lacking three of the western populations were established near Big River, Saskatchewan and Vassar, Manitoba in September and October, 1959. Planting stock production for the three latter plantations was carried out in nurseries near the respective planting sites in unreplicated plots. Each of these three plantations has three replicates with 25-tree square plots. The Big River plantation is spaced 4 x 4 feet, the others 6 x 6 feet. Dead seedlings were replaced in the western origin plantations in 1960. Chemical and mechanical weed control was done in some years.

Height measurements, morphological descriptions, and phenology were recorded during the nursery phase for all populations. Survival and condition for all plantations were recorded in 1960. Height, survival, and condition were recorded for all plantations in 1961. The Big River plantation was remeasured in 1965, then written off in 1973 owing to severe browsing. The Wasagaming plantations were remeasured in 1966, 1970, and 1976, and the Vassar plantation in 1976. Three unpublished establishment reports are on file, and the 1970 measurement was reported in the Proceedings of the Committee on Forest Tree Breeding in Canada.

Red Pine

A plantation was established near Piney, Manitoba, in May, 1958, with four-year-old transplants produced at Petawawa Forest Experiment Station. Nine populations from Ontario, Quebec, Michigan, New Brunswick and Nova Scotia were arranged in five randomized blocks, with 49-tree square plots at 4 x 4 foot spacing. Red pine of local origin was planted in single rows between plots, and in two rows surrounding the planting. The plantation has been measured three times, most recently in June, 1973. Results have been published in Bi-Monthly Research Notes (1968) and an Information Report.

Scots pine

Planting of this test was accomplished in May, 1960, near Carberry and Piney, Manitoba. The three-year-old transplants (2+1) were produced at Petawawa Forest Experiment Station. The plantations contain 10 populations from the U.S.S.R. and one from Finland. A four-replicate, randomized block design was used, with 49-tree square plots at 6 x 6 foot spacing. Scots pine transplants (2+2) grown from Manitoba seed collections of unknown origin were planted in single rows between plots and as a two-row surround. The two Manitoba plantations, plus two plantations in Saskatchewan of the same age and having the same populations, were measured in September 1974. Height and diameter were measured in all four plantations. Stem defects, insect attacks, and cone production were scored as warranted. The Saskatchewan plantations are located near Holbein and Indian Head. An Information Report dealing with the Manitoba plantations was published in 1971, and a report on the Manitoba and Saskatchewan plantations was published in Bi-Monthly Research Notes in 1979.

Norway Spruce

Three-year-old transplants of 12 populations were received from Petawawa Forest Experiment Station in May, 1960, and lined out promptly in the Riding Mountain National Park nursery near Wasagaming. Seven of the populations were of U.S.S.R. or Poland provenance, three from Swedish stands of German origin, and two were collections from adapted trees at Petawawa. In May, 1962, 400 trees of each population were planted without replication near Wasagaming. In May, 1963, a plantation was established in the same locality, using trees left in the nursery from the 1962 plantation, supplemented with trees of two populations supplied by Petawawa Forest Experiment Station. The 1963 plantation is in random block design with eight replicates and 9-tree square plots at 8 x 8 foot spacing. Two rows of planted white spruce form an outer perimeter for each portion of the 1963 plantation. The 1963 plantation has been measured five times, most recently in September, 1976. The 1962 plantation was examined in October, 1973, for assessment of its possible usefulness as a source of hardy breeding material. An unpublished establishment report is on file. Results have been published in Bi-Monthly Research Notes in 1971, and in an Information Report in 1977.

Jack Pine

Seed of 81 populations of range-wide provenance was sown at Birds Hill Research Nursery near Oakbank, Manitoba in 1960. Seedlings from two spring-sown replicates were planted near Sundown, Manitoba in May, 1972. Seedlings from the two fall-sown replicates were planted near Smeaton, Saskatchewan in June, 1972. The Smeaton plantation was unsuccessful, for reasons not readily apparent. The Sundown plantation has 5 replicates in lattice-square design, 4-tree row plots, at a spacing of 6 x 6 feet. Survival and condition of the planted seedlings at Sundown were recorded in June, 1973, and 5-yr height in September, 1976. An establishment report is on file.

Black spruce

Selected black spruce populations of range-wide origin were planted in spring 1975 on prepared sites in Alberta, Saskatchewan, and Manitoba. The Alberta plantation, near Reno, has 30 populations mainly from the northwestern portion of the range, in rectangular lattice design with 3 replicates. The Saskatchewan and Manitoba plantations have 49 populations in lattice-square design with 4 replicates each. The Saskatchewan plantation is north of Nipawin Provincial Park. The Manitoba plantation, with fewer northern and more eastern populations, has 3 replicates west of Mafeking at about 700 m elevation, and 1 replicate north of Mafeking at 300 m. All plantations have 9-tree square plots, at a nominal spacing of 1.8 m.

Most of the planted trees were grown in extruded peat cylinders in 1972, then lined out at the Alberta Provincial Tree Nursery near Edmonton in May 1973, and lifted in November 1974. Other trees were sown at the nursery in 1971 and lifted November 1974, or reared entirely in containers. The rearing history of each seedling is entered as a code number on the permanent performance record form for the experiment.

Survival and initial height were recorded in all three plantations during or after the 1975 growing season, and height was measured in fall 1979.

12. Goals for 1979-80:

White Spruce

Nil for 1979-80. Plot means from the plantation of Ontario and Quebec sources were provided to Dr. C.C. Ying at Petawawa, for analysis and joint publication. The remaining data barely merit reporting.

Red pine

Nil for 1979-80.

Scots pine

Publish the manuscript now under review, entitled "Height growth of Russian Scots pine populations in Saskatchewan and Manitoba 15 years after planting".

Norway spruce

Nil for 1979-80.

Jack Pine

Nil for 1979-80.

Black spruce

1. Draft a file report entitled, "Establishment of black spruce provenance test plantations in Alberta, Saskatchewan and Manitoba, 1975".

2. Carry out required plantation maintenance.

3. Measure the plantations following the fifth growing season from planting.

13. Accomplishments in 1979-80:

Scots pine

"Height growth of Russian Scots pine populations in Saskatchewan and Manitoba 15 years after planting" was published in the May-June 1979 issue of Bi-Monthly Research Notes.

Black spruce

1. A file report entitled, "Establishment of black spruce provenance test plantations in Alberta, Saskatchewan, and Manitoba" was not completed owing to lack of sufficient time.

2. Plantation maintenance was not carried out owing to lack of sufficient time.

3. The plantations were measured following the fifth growing season from planting.

14. Goals for 1980-81:

White spruce

Nil for 1980-81. The data provided to Dr. Ying may be used after the vacant white spruce genetics position at Petawawa is filled.

Red pine

Nil for 1980-81. A report has been published on the 1973 measurements. The next remeasurement may be in 1982.

Scots pine

Nil for 1980-81. A report has been published on the 1974 measurement. Remeasurement is recommended for 1984, 25 years after planting.

Norway spruce

Nil for 1980-81. A report has been published on the 1976 measurement. There are no firm plans for further remeasurement. The plantations have potential value for selection of hardy Norway spruce genotypes.

Jack pine

Nil for 1980-81. A five-year measurement was done in 1976, and the plantation is scheduled for remeasurement in fall 1981. A combined report on the 5- and 10-year measurements may be more useful than a report on the 5-year measurement.

Black spruce

1. Complete the file report entitled, "Establishment of black spruce geographic variation plantations in the prairie provinces, 1975".

15. Publications:

1978-79

Nil

1979-80

Klein, J. I. 1979. Height growth of Russian Scots pine populations in Saskatchewan and Manitoba 15 years after planting. Bi-Monthly Research Notes, 35(3):14-15.

16. Signatures:

J I Klein
Investigator

G. D Hunt
Program Manager

GTSilver
Director G. T. Silver

Appendix A. Location, design, and years of planting, measurement, and reported measurement for provenance experiments in study NOR-10-050.

Species	Location	Design[1]; nos. of populations-replicates-trees per plot	Month and year planted	Years measured	Latest measurement reported	Year of next measurement
white spruce, Man.-Sask.	Riding Mountain N.P., Man.	RB; 14-3-25	Sept. 1959	1961 1966 1970 1976	1970	1984 or none
same as above	Vassar, Man.	RB; 10-3-25	Oct. 1959	1961 1976	none	1984 or none
white spruce, Ont.-Quebec	Riding Mountain N.P., Man.	RB; 16-4-49	May 1959	1961 1966 1970 1976	1970	1984 or none
red pine	Piney, Man.	RB; 10-5-49	May 1958	1963 1967 1973	1973	1982
Scots pine, USSR	Piney, Man.	RB; 11-4-49	May 1960	1965 1969 1974	1974	1984
Scots pine, USSR	Carberry, Man.	RB; 11-4-49	May 1960	1965 1969 1974	1974	1984
Scots pine, USSR	Holbein, Sask.	RB; 9+ jack pine-4-100	May 1960	1968 1974 earlier by Sask. DNR	1974	1984
Scots pine, USSR	Indian Head, Sask.	CR; 9-3-50 some rows cut	May 1960	1968 1974 earlier by PFRA Nursery	1974	1984
Norway spruce	Riding Mountain N.P., Man.	RB; 12-8-9	May 1963	1963 1965 1970 1976	1976	none planned

Species	Location	Design[1]; nos. of populations-replicates-trees per plot	Month and year planted			
jack pine	Sundown, Man.	LS; 81-5-4	May 1972			
black spruce	Mafeking, Man.	LS; 49-4-9	June 1975			1984
black spruce	10 km NE of Nipawin PP, Sask.	LS; 49-4-9	June 1975	1976 1979	none	1984
black spruce	Reno, Alta.	RL; 30-3-9	June 1975	1976 1979	none	1984

[1] RB - randomized blocks, CR - completely random, LS - lattice square, RL - rectangular lattice.

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

February 21, 1980

1. Project: Genetic improvement of commercial forest species.

2. Title: Breeding jack pine for the Northern Region. I. First selection cycle.

3. New: Cont.: X 4. No.: NOR-12-051

5. Study Leader: J. I. Klein

6. Key Words: *Pinus banksiana*, progeny test, family test, seed orchard, forest genetics, tree breeding, artificial selection, grafting, clone bank, Saskatchewan, Manitoba, Alberta.

7. Location of Work: Sundown, Marchand, Stead, Oakbank, Boggy Creek, and Birch River, Manitoba; Smeaton, Meadow Lake, and Hudson Bay, Saskatchewan; Whitecourt and Wildwood, Alberta.

8. Problem:

This study is the first step in an applied breeding program, aiming to identify superior genotypes within a gene pool assembled from the wild base population. Genotypes identified as superior will then be propagated by provincial forestry agencies for establishment of seed orchards. Seedlings grown from seed produced in the orchards, or produced in source stands identified as superior, will form stands expected to be more productive than either plantations from unimproved seed or natural regeneration.

The design of the study virtually assures that most of the available genetic variation in the base population will be effectively exploited as genetic gain. The magnitude of this variation in the base population, hence the actual amount of genetic gain to be expected, will not be known until study results are analyzed. Only preliminary results have been reported from similar studies with this species.

Application of the study's results will involve establishment and management of seed orchards by provincial forestry agencies, and establishment of plantations using the seed produced in them. An additional application, compatible with that above, would involve management for seed production of natural stands identified as being genetically superior by the study results. Forestry officials in Saskatchewan and Manitoba have expressed interest in the study. Their willingness to invest resources in production of improved seed will doubtless be influenced by the magnitude of genetic gain achieved, and the importance of artificial regeneration of jack pine at the time improved genotypes are identified.

The area of jack pine planting interest in the Region was divided into three breeding districts, e.g., eastern Manitoba, western Manitoba and eastern Saskatchewan, and central Saskatchewan west to eastern Alberta. In each breeding district, family tests are established on representative sites, using open-pollinated progenies of parent trees selected primarily within each district. Each family test includes 216 entries in cubic lattice design, of which one or two are controls. The eastern district test has 15 replicates and 4 tree plots, hence 60 trees per family and nearly 13,000 plot trees. The central and western district tests have 12 replicates with the same plot size distributed on four sites in each district, hence 48 trees per family and 10,368 total plot trees per district. The total number of plot trees for the three breeding districts is thus nearly 35,000.

Clone banks will be developed to preserve the parental genotypes. Family performance, in terms of productivity and stem quality, will be scored periodically for ranking of parental genotypes, identification of superior progeny genotypes, and estimation of genetic gain. Whenever estimated genetic gain appears adequate for the purpose, scoring results will be supplied to provincial forestry agencies for establishment of seed orchards or designation of natural stands for seed production management. Successive measurements of the progeny test plantations may lead to establishment of additional seed orchard acreage having different composition from the earlier ones, to reflect change in performance scores.

9. Study Objectives:

To produce jack pine seed genetically improved in terms of economic yield.

10. Resources:

a. Starting date: 1966
b. Estimated year of completion: 2001
c. Estimated total Prof. man-years required: 11.0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

1980-81 man-years	Prof.	0.9	(J. Klein)
	Supp.	0.9	(A. Nanka)
	Total	1.8	

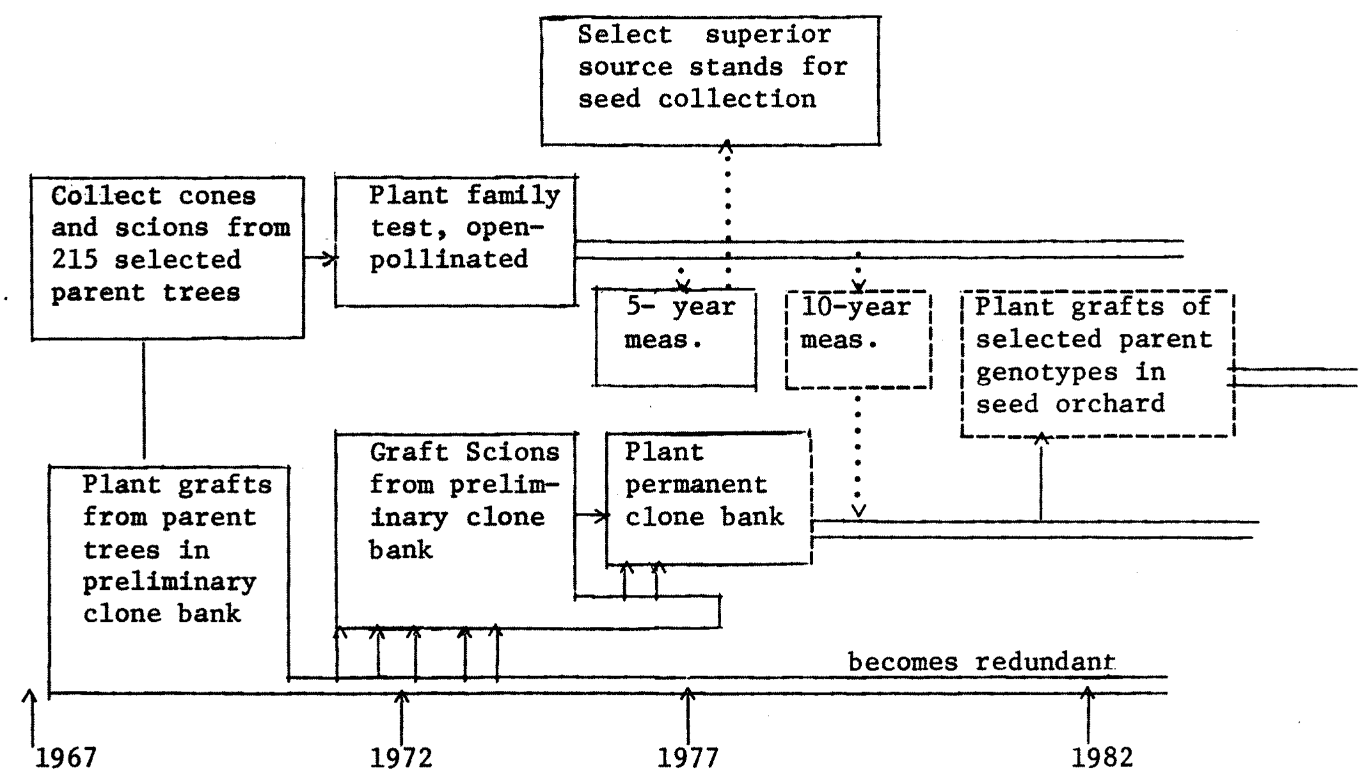
11. Progress to Date:

Collection of breeding materials, seed processing, grafting of scions from parent trees, and planting of primary grafted ramets in preliminary clone banks was begun in 1967 and completed in 1972. Family tests for the eastern, western and central breeding districts were planted in 1972, 1974, and 1976. All three tests have 216 entries which are nearly all open-pollinated progenies of parent trees selected within the breeding district of the test, are in cubic lattice design with 4-tree row-plots and 12 or 15 replicates on four sites, and are fenced. Approximately 2,000 ramets, grafted from 1974 to 1978, are planted in the clone bank at Chip Lake, of 3,185 required to fill it.

The eastern and western district family tests were measured after the fifth growing season from planting. Superior parent clones have been selected on the basis of progeny mean height, providing genetic gain on the order 12% for 5-year height. Results for the eastern breeding district were reported to a meeting of the I.U.F.R.O. working party on progeny testing.

The first selection thinning has been done in an experimental seedling seed orchard containing 220 eastern district families planted at Birds Hill Research Nursery in 1972.

Progress from program inception toward initial practical benefits is diagrammed in the following flow chart for the eastern breeding district. Continuation of a plantation is shown by a double line, transfer of plant materials by a solid single line, transfer of information by a dotted line, and projected events by a broken line.



Narrative reports on biennial progress have been published in the Proceedings of the Canadian Tree Improvement Association and its predecessor. Proposals for advanced-generation breeding, and a description of the seedling seed orchard, have been published.

12. Goals for 1979-80:

1. Promote application of 5-year family test results by cooperators.

2. Write an article on the genetics program for the Forestry Report issue on silviculture.

3. Prepare a file report entitled, "Establishment of jack pine family test plantations in eastern Saskatchewan and western Manitoba, 1976".

4. Begin preparation of a file report entitled, "The Chip Lake Research Planting Area, near Wildwood, Alberta," covering establishment of the jack pine clone bank and other development progress.

5. Submit a biennial progress report to the 17th meeting of the Canadian Tree Improvement Association.

6. Prepare a first draft of an Information Report entitled, "Strategy, establishment, and first results of a genetic improvement program for jack pine in western Canada".

7. Carry out required plantation maintenance for the eastern and central breeding district family tests.

8. Graft 1,500 scions, including about 420 from selected eastern district progeny trees lacking a parental clone, and not successfully grafted in 1978.

9. Transplant slow-growing ramets from preliminary clone bank near Whitecourt to regional clone bank at Chip Lake.

10. Maintain regional clone bank as required, and increase stocking from the present 2,102 grafts to 2,700 grafts, of a total of 3,185 positions.

11. At Chip Lake Research Planting Area, complete establishment of trailer camp, complete access road improvements delayed by rain in 1978, continue site preparation on the new area cleared in 1978, and map current development.

12. Write a brief background paper on the program for the Regional Reforestation Committee.

13. Contribute information on costs and benefits of tree improvement

procedures to the integrated core forestry program, as required.

14. Act as Tree Seed Inspector under the Canada Seeds Act as required.

13. Accomplishments in 1979-80:

1. One hundred and five grafted ramets of 18 superior progeny-tested western district clones were provided to Prince Albert Pulpwood Ltd. These ramets have been planted in a seed orchard. Agreement was reached with the Manitoba government for grafting of superior clones and planting of seed orchards in 1980 and 1981, and with the Saskatchewan government for grafting of superior clones in 1980.

2. An article on the genetics program was written for Forestry Report, but the silviculture issue was not published.

3. The central district establishment report has not been completed, owing to lack of sufficient time.

4. A file report entitled "Acquisition and Initial Development of the Chip Lake Research Planting Area near Wildwood, Alberta" has been completed.

5. A report entitled "Genetic Improvement of Jack Pine for the Prairie Provinces, 1977-79" was submitted and pre-printed for the 17th meeting of the Canadian Tree Improvement Association.

6. No work was done on an Information Report entitled "Strategy, Establishment, and First Results of a Genetic Improvement Program for Jack Pine in Western Canada". Time available for reporting was instead allocated to three establishment reports.

7. Brushing, mowing, protective spraying, and fence repair were done as required in one eastern district and four central district test plantations.

8. 1,571 scions were grafted, including 143 for a seed orchard and 404 from selected eastern breeding district progeny trees. About 600 clone bank grafts and 105 orchard grafts were successful.

9. Slow-growing ramets in the preliminary clone bank at Whitecourt were not transplanted to the Chip Lake clone bank owing to lack of sufficient manpower. Maintenance work and a new inventory were done in the Whitecourt plantation.

10. Partial stump removal, graft tending, weed control, inventory update, and protective spraying were done in the regional clone bank. Planting of 1979 grafts could not be done owing to in-

sufficient casual support. Stocking declined to 1,809 ramets in good condition plus 170 damaged but living ramets, in consequence of moderately high mortality among ramets grafted in 1977 and 1978.

11. The trailer camp at Chip Lake now has two trailers fully serviced. Lack of sufficient manpower prevented completion of nonessential work. Access road improvement by the Alberta government is in progress. Manpower was not available for site preparation of a new planting area. A development map is included in the file report on the Chip Lake area.

12. A memorandum to L.G. Brace, dated 19 July 1979, described the rationale, progress, and plantation maintenance needs of the jack pine breeding study, for the information of the Regional Reforestation Technical Committee.

13. There was no requirement to contribute tree improvement information to the integrated core forestry program.

14. There was no requirement to act as Tree Seed Inspector under the Canada Seeds Act.

14. Goals for 1980-81:

1. Continue to promote application of 5-year family test results by cooperation.

2. Complete the file report entitled "Establishment of Jack Pine Family Test Plantations in Eastern Saskatchewan and Western Manitoba, 1976".

3. Remove volunteer jack pine seedlings from test plantations near Smeaton, Saskatchewan and Birch River, Manitoba.

4. Graft 1,500 scions, for Manitoba and Saskatchewan government seed orchards, and for the clone bank. Goals for the clone bank grafting are to eliminate the need for further scion collection in Manitoba, and to produce successful grafts from most of the 28 parent clones which have yielded no successful grafts in previous attempts.

5. Transplant slow-growing ramets from preliminary clone bank near Whitecourt to Chip Lake clone bank.

6. Maintain clone bank as required and plant vigorous 1979 grafts.

7. Rear rootstocks for 1981 and 1982 grafting, modifying procedures to reduce manpower requirements for tending.

8. Select progeny ortets for western breeding district families lacking a parent clone, or having a parent clone which cannot

be grafted successfully. Collect scions from these ortets and commence grafting them.

9. Burn remaining brush piles at Chip Lake.

10. Contribute information on costs and benefits of tree improvement procedures to the integrated core forestry program, as required.

11. Act as Tree Seed Inspector under the Canada Seeds Act, as required.

12. Publish an Information Report entitled, "Strategy, Establishment, and First Results of a Genetic Improvement Program for Jack Pine in Western Canada".

13. Measure the central breeding district family test following the fifth growing season after planting.

14. Thin the seedling seed orchard plantation at Birds Hill.

15. <u>Publications</u>:

1978-79

Klein, J. I. 1979. Selection programs and genetic parameters. Proc. Workshop on Tree Seed Production and Improvement in Canada; R & D Needs, 1977-87. Inf. Rep. PS-X-74. p. 73-79.

Klein, J. I. 1978. Preliminary report on height growth in a jack pine family test five years after planting. Int. Union For. Res. Org., Working Party S2.04.03 (Progeny Testing).

Nanka, A. M. and J. I. Klein. 1978. Establishment of jack pine family test plantations in central and western Saskatchewan, 1974. Can. Dep. Fish. Environ., Can. For. Serv., North. For. Res. Ctr. File Report NOR-051.

1979-80

Klein, J. I. 1979. Genetic improvement of jack pine for the prairie provinces, 1977-1979. 17th Meet. Can. Tree Improve. Assn. Members Reports.

Klein, J. I. 1980. Acquisition and initial development of the Chip Lake Research Planting Area near Wildwood, Alberta. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. File Report NOR-051.

16. Signatures:

J J Klein

Investigator

Program Manager

G.T. Silver

Director G.T. Silver

PROJECT NOR-13

Maintenance and improvement of water yield and quality

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1980

1. Project: Maintenance and improvement of water yield and quality

2. Title: Research coordination in the Alberta Watershed Research Program; Marmot, Streeter, Deer Creek, Tri Creeks, Cache Percotte, Spring Creek Experimental Basins.

3. New: Cont.: X   4. No.: NOR-13-017

5. Study Leader: R. H. Swanson

6. Key Words: Hydrology, forest climate, gauged basin

7. Location of Work:

Marmot Basin	115°09'05"W	50°56'57"N
Streeter Basin	114°03'48"W	50°06'59"N
Cache Percotte	117°30'00"W	52°23'00"N
Tri-Creeks	117°15'00"W	53°09'00"N
Spring Creek	117°51'11"W	54°55'06"N

8. Problem:

The principal need for this study is to clearly identify the role of the Canadian Forestry Service in the coordination of research activities within the Alberta Watershed Research Program. Since the inception of the Alberta (East Slopes) Watershed Research Program in 1960, the Canadian Forestry Service has supplied the research coordinator. His role historically has been to suggest projects, deal with cooperators in furthering their research within Marmot, Streeter and Deer Creek experimental basins, and to provide a focal point for information exchange. He was also responsible for bringing numerous cooperating agencies together to form working groups to plan and carry out joint research projects.

In 1969 this role was changed. A sharp distinction between cooperative and coordinated research was defined and the program was expanded to include all of Alberta. Two programs were recognized: a cooperative effort with little or no coordination; and a problem oriented effort with a research-management coordinator in charge.

In the cooperative program, each cooperator was more or less placed on his own initiative to conduct any research as long as it did not conflict unduly with other cooperators, and did not involve a vegetative or topographic treatment that would significantly alter the natural hydrologic regime of any basin or subbasin. Within each experimental basin, a large number of independent research studies are being conducted both by members of the Canadian Forestry Service, and by the cooperating agencies. Those conducted by the Canadian Forestry Service are covered separately as studies in themselves.

The problem oriented phase became the coordinated effort. Each basin has a treatment phase during which it no longer is used merely as a place to do research, but becomes in itself a research project. Each basin when established had a problem oriented treatment phase.

Marmot:

1. Are the present high altitude spruce-fir forest timber harvesting guidelines effective in maintaining watershed condition and suitable water quality?

2. How can non-commercial spruce-fir stands be harvested to improve water supplies?

Streeter:

Does aspen-brush removal and subsequent grazing deteriorate range land-watershed quality?

Tri-Creeks:

Will a change in operating procedures to allow large block or continuous clearcut from the present forty-acre strips be detrimental to watershed condition and water quality as fish habitat?

Spring Creek:

Are high flood peaks associated with the farm lands in the vicinity a result of agricultural clearing and operations?

Cache Percotte:

What is the influence of various harvesting techniques and systems on watershed condition, water quality and yield?

These problems require carefully designed and executed experiments to insure that the results satisfy the objective. Thus coordination now involves planning research projects and/or demonstrations aimed at solving specific watershed problems and enlisting the aid of cooperating agencies in carrying out these plans. This coordination role has been divided between management and research with the Alberta Forest Service furnishing the management coordination. This is a significant step as prior to 1969, no person or persons were specifically charged with planning a coordinated research program. Relevant research was more a fortunate happenstance than the result of planned activity.

9. Study Objectives:

To coordinate the efforts of cooperating agencies toward fulfilling the following:

1. To learn how to manage forested public lands for the protection of existing water supplies and the enhancement of future supply by alteration of regimes or yield through timber harvesting.

2. To broaden the overall knowledge base in hydrology of range lands, forest land and alpine areas.

3. To propose and to test specific land management practices designed to increase annual water yield, retard flood peaks or improve on-site watershed condition.

4. To evaluate and test existing land management practices with respect to their influence on the hydrologic regime of specified test areas.

5. To act as consultant and adviser in proposing and evaluating the influence of various land management practice on the local and regional surface and groundwater hydrology.

10. Resources:

a. Starting date: 1960
b. Estimated year of completion: 1984
c. Estimated total Prof. man-years required: 0.5 per year
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.4	(Swanson
Supp.	1.0	(Fisera 1.0)
Casual	-	
	1.4	

11. Progress to Date:

(Coordination aspect only. Research covered under appropriate study statement.)

Marmot:

1. Data has been collected from the various networks describing climate, ground and surface water hydrology. Such data collection is scheduled to continue through 1983-84 to evaluate the effects of the two timber harvests on streamflow.

2. Harvest roads were constructed on Cabin Subbasin in 1971 and evaluated for erosion and sediment production during 1972-73. No increases in suspended sediment occurred. Harvest blocks ranging from 12 to 29 acres were clearcut in 1974 by Spray Lakes Lumber Company. All standing material on the blocks was laid flat. Scarification for regeneration took place in the fall of 1978.

   Data to date indicates no change in sediment in Cabin Creek. This result has been confirmed by samples taken from the Spray Lakes area too. The lack of sediment has been mainly due to extremely stable soils on the slopes in these areas.

3. Twin subbasin treatment commenced in 1978. Approximately 2,100 1-tree height clearings were completed by December 1979. Some timber extraction is planned in the lower portion of the basin where large trees and relatively good topography favor removal. Most of the cost of clearing has been under-written by the Technical Services Branch, Alberta Environment, the Alberta Forest Service, or the Alberta Research Secretariat.

Streeter:

1. Streamflow data collection from the three subbasins was reduced from continuous recording to periodic manual reading. Data collection continued from the main stream as part of the Water Survey of Canada's regional inventory network.

2. A treatment has been designed and carried out for improving the range quality for wildlife and domestic livestock. Preliminary results indicate substantial increases in flow from springs affected by the treatment. Wildlife and domestic livestock use of the tree-cleared areas has increased. Evaluations are to continue through 1983.

Dear Creek:

All operations have ceased in Deer Creek. It has been released back to the Province and its research basin status terminated.

Tri-Creeks:

Tri-Creeks data has been compiled and the annual compilation for 1967-75 are available upon request from the Alberta Forest Service.

The treatment plan has been revised from a summer logging to a winter operation. Harvest began in 1978, and is to continue through 1980.

Spring Creek:

Treatment on this basin is planned and an appeal for more on-site evaluation has been received from the Alberta Water Resources Coordinator.

Cache Percotte:

The AWRP has offered its services as a 'vehicle' for watershed management applications in Alberta. There has been a good deal of interest in a 100 square mile pilot test of some practice specifically designed to increase water yield.

12. Goals for 1979-80:

1. Continue evaluation of Marmot and Streeter treatments under appropriate studies. (Swanson)

2. Finish remaining clearing on Marmot-Twin. (Swanson)

3. Publish Forestry Report on watershed management and preliminary results of Marmot-Cabin harvest. (Swanson)

4. Continue as alternate for Director General on NRC Associate committee on Hydrology. (Swanson)

5. Pursue forest-watershed management application with Alberta Forest Service and Technical Services Division, Alberta Environment. (Swanson and Stevens)

6. Publish information report on results of Streeter treatment. (Swanson and section)

Added Goals 1979-80:

7. Prepare literature review on forest management for water for chapter in Canada water yearbook. (Swanson)

8. Prepare forest hydrology display for National CIF meeting. (Swanson)

9. Review science subvention "Nashwaak" project in New Brunswick for CFS headquarters. (Swanson)

13. Accomplishments 1979-80:

1. Snow course data was taken as normal but the intensive snow survey was discontinued until the Twin harvest is complete. Some preliminary analysis of the streeter basin data were conducted. These indicate a 48% increase in spring flow volume and an increase in soil moisture in the clearing of approximately 4 cm over the forest sites.

2. The Marmot-Twin clearing has been completed. All but 51 small clearings that we had marked for felling were done by 15 December. There are no plans to clear these 51 openings as their area would not affect the final result. In all, 737 "large" clearings (.031 ha each, total area 23.2 ha) and 1366 "small" clearings (0.014 ha each, total area 18.7 ha) have been created. Approximate cost of clearing only was $116,000.00 of which the Province of Alberta furnished all but $10,000.00.

3. Deferred due to added commitments of goals 7 and 8.

4. Appointed as member, NRC Associate Committee on Hydrology.

5. Several meetings to discuss the need for and feasibility of a pilot watershed management area have taken place. There is general agreement that such a pilot project should be undertaken. The Alberta Forest Service has indicated its preference for a 118 sq. mi. area in the upper Oldman drainage in southwestern Alberta. The probable water yield increases resulting from several types of treatments are being simulated so that water resources can prepare a benefit-cost comparison. The AFS is pondering the date of several timber licenses already allocated to this area.

6. Preliminary reports on snow accumulation, soil moisture alteration and springflow increases have been written. CWS personnel are preparing a similar document for wildlife and domestic livestock use. These will be combined into one report for publication during 1980.

7. Prepared a comprehensive review of forest management research applicable to water yield improvement in Canada. Submitted as requested to IWD water yearbook editor.

8. Prepared and manned display on watershed management and computer simulation modeling at National CIF meeting, Jasper.

9. Reviewed Nashwaak project with Dr. W.B.G. Denyer from Ottawa headquarters. Filed report with Ottawa.

14. Goals for 1980-81:

1. Continue evaluation of Marmot and Streeter treatments under appropriate studies. (Swanson)

2. Publish information and/or forestry report on results of Marmot Cabin subbasin harvest. (Swanson, et al)

3. Publish information report on preliminary results of streeter basin watershed-wildlife treatment. (Swanson, Golding, Hillman, Telfer)

4. Publish information report on review of forest management for water yield in Canada. (Swanson)

5. Continue cooperation with Alberta Forest Service and water Resources toward establishment of watershed management pilot project.

6. Continue as member NRC Associate Committee on Hydrology.

15. Publications:

1977-79

Swanson, R. H. 1977. The Alberta Watershed Research Program 1959-1977. Pages 4-20 in: Swanson, R. H. and Logan, P. A., compilers. Alberta Watershed Research Program Symposium Proceedings, 1977, Northern Forest Research Centre Information Report NOR-X-176.

Swanson, R. H. and P. A. Logan, compilers. 1977. Alberta Watershed Research Program Symposium Proceedings, 1977. Northern Forest Research Centre Information Report NOR-X-176. 342 pp.

Golding, D. L. 1977. Forests and water. Environment Canada, Forestry Service, Ottawa, Fact Sheet. 4 pp.

Golding, D. L. 1977. Forest hydrology. Proc. First Meet. Work. Group on Land/Water Integration. Can. Comm. on Ecological (Biophysical Land Classification, Environment Canada, Lands Directorate, Ottawa. p. 43.

Swanson, R. H. 1978. Increasing water supply through watershed management. Can. Water Resources Jour. 3(1): 85-93.

1979-80

None

16. Signatures:

Investigator

Program Manager

Director

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1980

1. Project: Maintenance and improvement of water yield and quality.

2. Title: Disposition of water in forest soils.

3. New: Cont.: X 4. No.: NOR-13-083

5. Study Leader: G.R. Hillman

6. Key Words: Unsaturated flow, evapotranspiration, infiltration, redistribution, modelling.

7. Location of Work: Southwestern and west central Alberta.

8. Problem:

Nature of study - this study is designed to evaluate saturated and/or unsaturated transient flow through nonhomogeneous, anisotropic porous media i.e., through typical forest soils, in response to the forces of drainage, transpiration and evaporation.

Benefits of the study - the results can be applied in the development of a watershed model based on physically derived, rather than on empirically derived relationships. Such a model can theoretically be applied to entire or parts of watersheds both before and after treatment. Thus where vegetation is manipulated for increasing water yield, the model can contribute significantly to determining which type of sites should be logged to obtain the best timing of the resulting increase in water yield as streamflow.

The results can be used in environmental quality studies to ascertain the rates at which biocides are transported by water through the soil system and into groundwater reservoirs and stream channels.

In forest management, the results will be of benefit in determining optimal stand densities when thinning is considered. They may also be useful for evaluating the regeneration potential of a site, and for consumptive use studies of forest tree species.

Probability of success - recent literature on the subject of saturated and unsaturated flow through porous media indicates that a physically-based mathematical model for three-dimensional, transient, saturated-unsaturated flow is now available (Freeze 1971, 1972). Solutions for the model have been found and a computer program for the model is available. Some progress has been made to incorporate this model into a physically-based synthesis of the hydrologic cycle.

Certain problems associated with soil freezing and with variability in both bedrock and surficial materials remain. However, the probability of completing the study successfully is high, particularly if the model is applied over small areas.

Freeze, R. Allan 1971. Three-dimensional, transient, saturated-unsaturated flow in a groundwater basin. Water Resources Research 7(2): 347-366.

Freeze, R. Allan 1972. Role of subsurface flow in generating surface runoff. 1. Base flow contributions to channel flow. Water Resources Research 8(3): 609-623.

Probability of results being applied - the probability is very high that the results will be used in the hydrologic model for Marmot Creek basin, and subsequently, for other watersheds as well.

In order for the results to be useful to forest management agencies directly, it would be necessary to carry out further research so that subsurface flow (saturated and unsaturated) patterns are correlated, for example, with stand vigor and densities, with and without thinning, with establishment and survival of regeneration and with consumptive use by different tree species.

Method used - the equation of flow developed for subsurface water movement requires measurement of pressure head (h), hydraulic conductivity (K), volumetric moisture content (θ), and porosity (n). These measurements are used to develop basic functional model inputs k (h), θ (h), and n (h), where k is the specific permeability derived from hydraulic conductivity (K).

Although the model accommodates three-dimensional flow, only two-dimensional flow will be considered initially. Measurements will be made on Cabin Creek basin (sub-basin of Marmot Creek) along transects oriented downslope between the watershed divide and the stream channel, and also along transects that lie within, outside and across boundaries of blocks of timber earmarked for cutting.

Thermocouple psychrometers and tensiometers will be used to measure pressure heads less than atmospheric pressure. Pressure heads in the saturated zone will be measured with piezometers. Hydraulic conductivities and porosities will be determined by standard laboratory procedures, but attempts will be made to obtain *in situ* values also. Water table fluctuations will be monitored by means of water table observation wells and recorders.

Output from the model is in the form of the pressure head, total head, and moisture content fields at any time step. From the output it is possible to develop quantitative hydrographs of surface infiltration, groundwater recharge, water table depth and stream base flow. These hydrographs will be the main tools used to evaluate the effects of logging on infiltration and redistribution of water in the saturated-unsaturated flow system.

9. Study Objectives:

1. To develop from Darcy's Law and the continuity equation a mathematical model of two dimensional transient unsaturated and saturated flow through porous media applicable under natural conditions.

2. To incorporate the mathematical model as part of a physically-based synthesis of the hydrologic cycle.

An approximate time table to meet these objectives follows:

1. 1977 Preliminary model with flow chart, form of mathematical functions, statement of assumption and trial runs using existing Marmot data.

2. 1978 Specification and collection of additional or new data required to verify assumption.

3. 1979 Final groundwater flux model.

4. 1980 Incorporation of groundwater flux model into overall Marmot model.

10. Resources:

a. Starting date: 1976
b. Estimated year of completion: 1980 Revised: 1983
c. Estimated total Prof. man-years required: 5
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.8	(Hillman)
Supp.	0.8	(Robson)
Casual	-	
Total	1.6	

11. Progress to Date:

A literature search revealed that very few watershed models exist which could possibly be used to evaluate the effects of logging on quantity and timing of streamflow. Many watershed models are unsuitable because they do not adequately or realistically simulate the subsurface flow component of the watershed system.

The Freeze subsurface flow model which incorporates the equations of flow through porous media, appears best to simulate real watershed conditions. It is extremely complex, however, and is not suitable for general application. The concept of the model is scientifically sound and will provide the framework for developing a similar, but more practical subsurface flow model.

Marmot Creek Basin provides the setting in which the proposed subsurface flow model will be tested. Established as a research basin in 1962, it has since been subjected to commercial-type logging--in Cabin Creek subbasin, and is currently (1979) undergoing a watershed management prescription treatment--in Twin Creek subbasin.

The surficial geology, bedrock geology, soils and vegetation of the basin are now well documented, and there is also a comprehensive record of hydrometeorological data. Groundwater table observation wells, piezometer nests, and soil moisture/soil temperature sensors were established on the basin by 1966. Since that time some of the old installations have been discontinued, and new ones installed. Thus four new groundwater table observation wells and 39 soil moisture measuring sites were established on Cabin Creek subbasin in 1972. A snow pillow was installed on Cabin Creek subbasin in 1978.

The wells have been monitored continuously and soil moisture periodically since the installations were completed. The 1972-76 Cabin Creek soil moisture data have been compiled and processed by computer. The information is tabulated in six arrays for 39 sampling sites and four depths. Supplementary information on the soil and shallow rock layers was obtained in 1973, using a portable refraction seismograph with manually operated hammer.

A conceptual hydrologic model showing inputs and outputs to the subsurface flow system is illustrated in Fig. 1. Water additions to, and losses from the subsurface system are indicated by plus and minus signs respectively. Further elaboration is given in Fig. 2 where the subsurface flow system serves as the core to the hydrologic model. The basic premise for the model is that imposition of a watershed management or forest harvest prescription on the system results in modification to infiltration and exfiltration components.

The proposed model for the subsurface flow system routes water from the upper boundary (ground-air interface) through the porous media to the stream channel. The finite element method has been selected, largely on the basis of spatial simulation considerations, as the means of solving the equations of flow through porous media.

Upper boundary conditions are controlled by the infiltration and evaporation processes. The influence of vegetation will be simulated through a series of sinks imposed on near-surface nodes contained in the nodal mesh used in the subsurface flow model. Enough flexibility will be incorporated in the model so that it can be updated or modified as necessary.

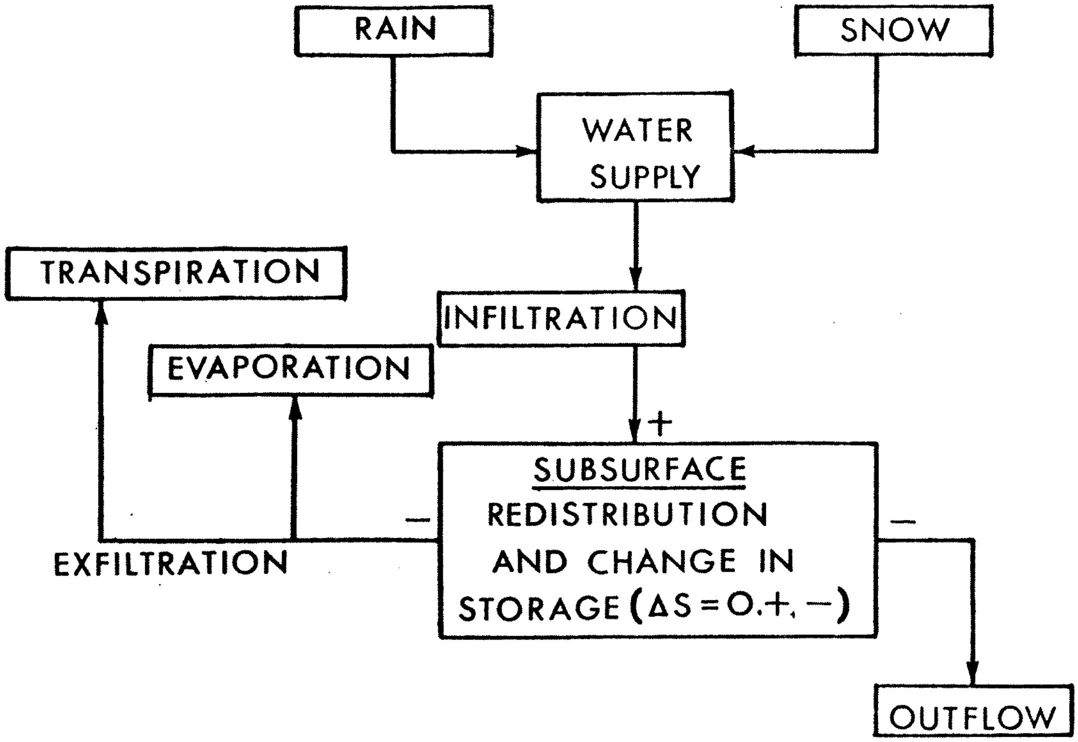


Figure 1. Conceptual hydrologic model

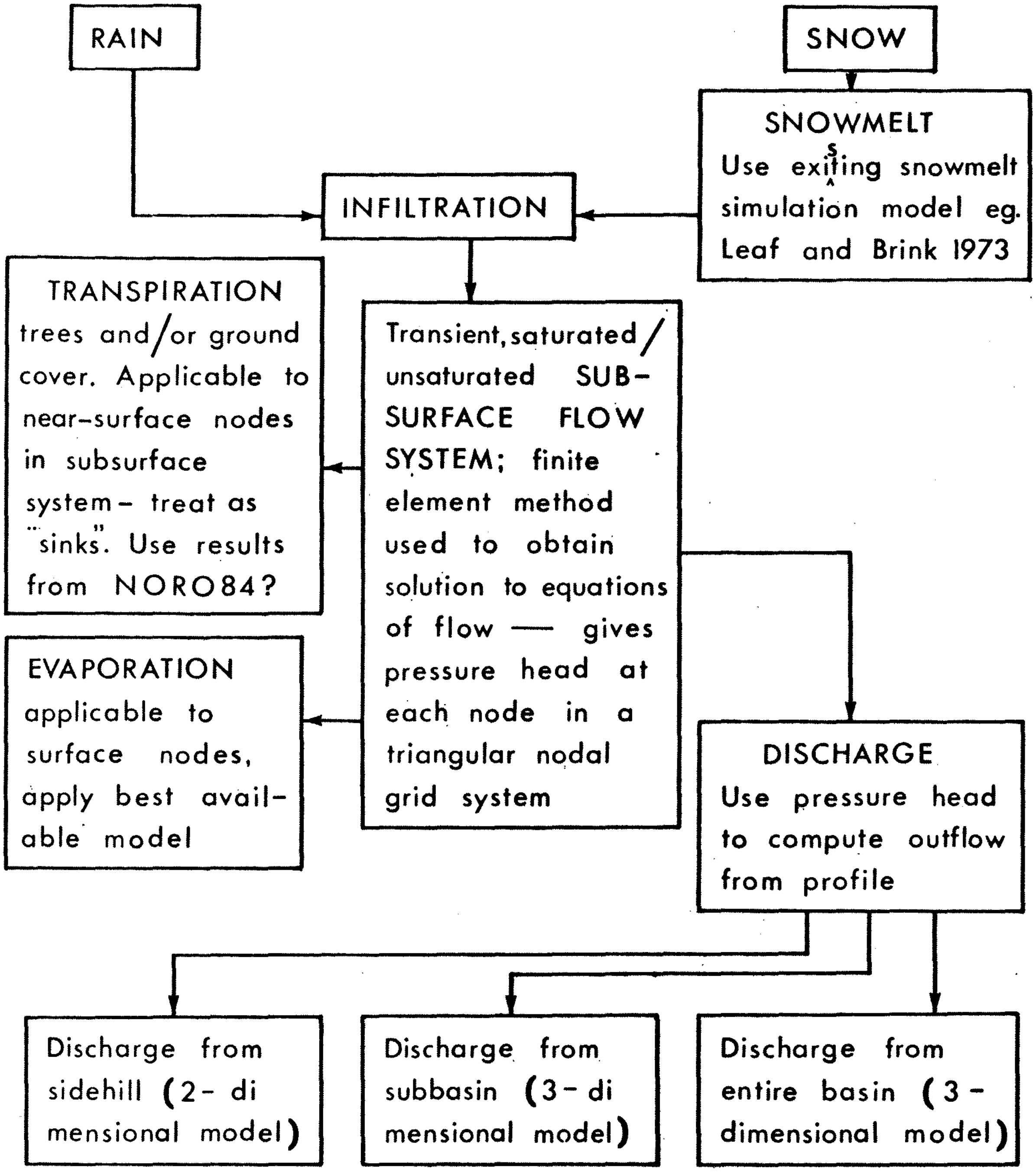


Figure 2. Conceptual hydrologic model applied to vegetated basin.

The assumptions associated with the model are:

1. in the saturated region, flow is laminar and Darcian; inertia forces, velocity heads, temperature gradients, osmotic gradients, chemical concentration gradients are all negligible. Water, the soils and geologic formations are assumed to be incompressible,

2. in the unsaturated zone, it is assumed that the soils are non-swelling and that the air phase is continuous and always in connection with constant external atmospheric pressure,

3. there is no leakage from the basin, inflow to the subsurface system occurs at the upper boundary (ground surface) only, the topographic divide coincides with the phreatic divide,

4. each soil type or geologic stratum is homogeneous,

5. trees on the basin can be simulated by sinks applied to a number of nodal points near the upper boundary. The sinks become redundant when trees are harvested.

The basis for the subsurface model, taking into account the assumptions listed above is the two dimensional form of the equation for transient, saturated-unsaturated flow:

$$\frac{\partial}{\partial x}\left[K_{xx}(F,h)\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial z}\left[K_{zz(F,h)}\left(\frac{\partial h}{\partial z}+1\right)\right] = C(F,h)\frac{\partial h}{\partial t} \qquad (1)$$

where

x, z coordinate directions, m;
z elevation head, m of water;
K_{ii} hydraulic conductivity (m/day) as a function of geologic formation or soil type (F) and pressure head (h):
h pressure head, m of water;
$C=\frac{\partial\theta}{\partial h}$ specific moisture capacity, m^{-1} of water;
θ volumetric moisture content, decimal fraction;
t time, days.

The finite element method was used together with this equation to produce the final working equation:

$$\int_A P \left(Kxx(F,h)\frac{\partial\phi j}{\partial x}\frac{\partial\phi i}{\partial x} + Kzz(F,h)\frac{\partial\phi j}{\partial z}\frac{\partial\phi i}{\partial z}\right) dA \; +$$

$$\int_A \frac{dP}{dt} C(F,h)\phi_j\phi_i dA = \int_\Gamma q_n\phi_i \, ds \qquad (2)$$

where ϕ_i and ϕ_j are the basis functions used to approximate the pressure head (h). The terms on the left hand side are integrated over the element area, while the term on the right hand side is integrated over the element boundary, if applicable. Equation (2) represents a set of simultaneous equations which can be expressed in matrix form as

$$[A]\ \{P\}\ + [B]\ \left\{\frac{dP}{dt}\right\} = \{F\}$$

The correspondence between the mathematical terms and the physical situation is illustrated in Fig. 3.

A computer program entitled SUBFEM (subsurface finite element model) has been developed. Input data requirements for SUBFEM include: profile geometry, properties of porous medium, and definition of sinks and boundary conditions. Output information includes: element and nodal point data, pressure head field, and outflow from the seepage face.

Some preliminary studies and evaluations have been completed:

1. soil moisture redistribution about a single tree,

2. water-holding capacity of the forest floor,

3. analysis of pre- and post-treatment groundwater data for Cabin Creek.

In case 3), examination of 1972-76 groundwater data showed that a difference exists between the pre- and post-treatment data. Slightly, but consistently higher groundwater levels were sustained in the wells during recession in the post-treatment period.

Some of the information contained in this section has been incorporated into Study Progress Report -13-083, dated January 1978.

12. <u>Goals for 1979-80</u>:

1. Restructure the subsurface flow problem and program it so that a given watershed profile can be partitioned into a number of subsystems, or large elements. Equations for the entire system are solved first, then those for each subsystem are solved as required. Derivation of an equation solver forms an integral part of this development.

   This modification should produce a marked reduction in computer core storage requirements.

   Also incorporate further programming techniques that will enhance this result.

2. Complete the subsurface model as originally conceived, i.e. for transient, saturated-unsaturated flow conditions, by introducing the time variable. Solve the resulting equations using a combination of the finite element method, and an appropriate finite difference scheme for time discretization and iteration.

Transient problem: $[A]\{P\} + [B]\left\{\frac{dP}{dt}\right\} = \{F\}$

Steady state problem: $[A]\{P\}=\{F\}$

Elements of $[A]$ $[B]$ and $\{F\}$ are:

$$a_{i,j} = \int_A \left(Kxx(F,h)\ \frac{\partial \phi_j}{\partial x}\frac{\partial \phi_i}{\partial x} + Kzz(F,h)\ \frac{\partial \phi_j}{\partial z}\frac{\partial \phi_i}{\partial z} \right) dA$$

$$b_{i,j} = \int_A C\ \phi_j\ \phi_i\, dA$$

$$f_i = \int_\Gamma q_n \phi_i\, ds$$

$$h \sim \hat{h} = \sum_{j=1}^{N} P_j(t)\, \phi_j\,(x,z)$$

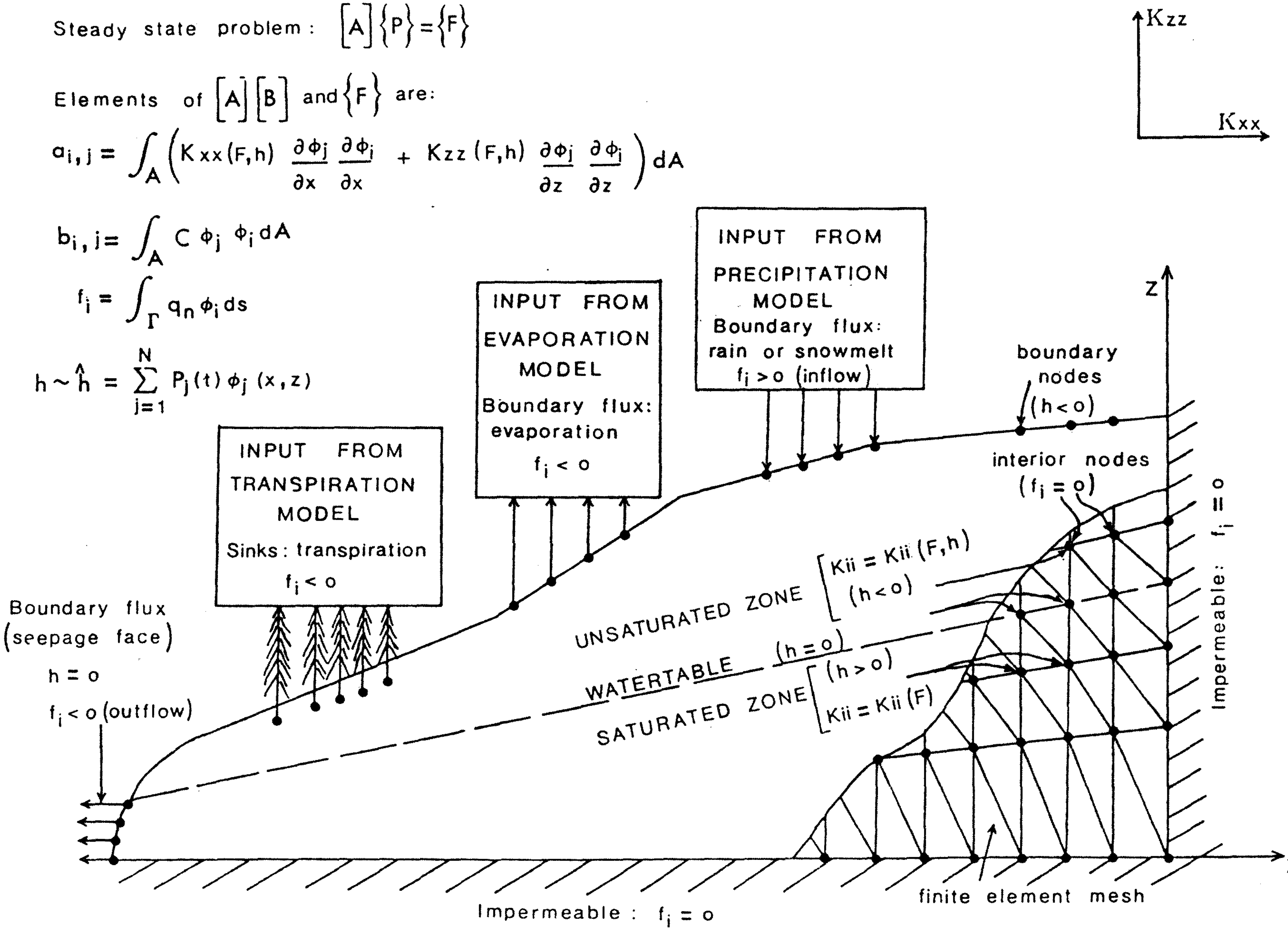


Figure 3. Application of mathematical terms to physical system (watershed profile).

3. Prepare geologic (profile) maps of Marmot Creek subbasins and use them together with soils and vegetation data and a suitable finite element mesh, as a basis for the first Marmot simulation runs.

4. Run model to physically simulate profiles of Marmot Creek Basin. The main factors to be considered are:

   1. initial conditions: water content, groundwater table position and boundary fluxes,
   2. flux boundary conditions: seepage face, inflow and evaporation,
   3. sources and sinks: transpiration and treatment effects.

   The objectives of these first simulations are to determine:

   1. the "active" depth of the profile,
   2. how changes in the vegetation cover affect water redistribution in the profile, and alter outflow at the seepage face.

5. Develop lumped system empirical subsurface flow routing technique based on recession flow analysis. Test model using Marmot Basin, Streeter Basin and St. Regis lease area data.

6. Continue writing Ph.D. dissertation. Complete chapters as follows:

   Description of finite element method
   Model development
   Programming details and user's guide

   The computer will be used (TEXTFORM program) to facilitate editing and copying, and to reduce costs.

7. Monitor soil moisture content during snowmelt and the fall. Also complete neutron count vs. soil moisture calibration for Streeter Basin sites.

8. Monitor groundwater table levels throughout the year.

9. Process and interpret seismic data obtained on Marmot Basin during 1973.

<u>Goals added--1979-80</u>:

10. Process and analyze soil moisture data from clearcut blocks and leave strips on Streeter Basin.

11. Prepare internal report on the effect of cutting on soil water, for incorporation into a multi-authored Information Report describing the effects of the Streeter Basin treatment (see goals 1 and 6) under study NOR-13-017).

13. Accomplishments in 1979-80:

1. About 75% complete. The program was rewritten to provide the model with a built-in equation solver that would solve the partitioned watershed profile problem. When a large system (82 nodes, 124 elements) was simulated, numerical instability occurred, and no solution was obtained. After reverting to a non-partitioned watershed profile, a solution was obtained for a simulation of a small, simple system (15 nodes, 16 elements). Flow diagrams were developed from the results.

2. Not done. This goal is dependent on the completion of goal 1.

3. Completed. Ten geologic profile maps of Marmot Creek Basin were prepared.

4. Not done. This goal is dependent on the completion of goals 1 and 2.

5. The possibility of using empirical relationships between subsurface water storage and streamflow on Marmot Creek Basin (Storr, 1974) as a basis for a lumped subsurface flow model was investigated. The relationships, which are applicable to streamflow recession only, indicate that maximum subsurface storage capacity corresponds to a flow through the main weir of about 20 cfs. This value marks the upper limit of delayed flow. Recession flow in excess of 20 cfs can be regarded as quick flow, which must be simulated differently from delayed flow. Storr derived the relationships using pre-treatment data, therefore it is necessary to determine if the relations still hold for the post-treatment (1974-on) data.

   Storr's equations have been rewritten so that streamflow becomes the dependent variable and is a function of subsurface water storage. The subsurface water storage in turn must interface with the output from the hydrologic vegetation manipulation models, e.g. PROSPER (study NOR-13-177).

   Storr, D. 1974. Relating subsurface water storage to streamflow in a mountainous watershed. Canadian Meteorological Research Report 4/74. 14 p.

   A literature review on subsurface flow routing techniques and recession flow analysis was completed. A working knowledge of the hydrologic vegetation manipulation models SNOW, CON, and PROSPER (study NOR-13-177) was also obtained.

6. The proposed chapters as shown were not completed. Instead, the Introduction was rewritten and an extensive literature review chapter, consisting of five subsections, was included. The completed chapters have been stored on the computer.

7. Soil moisture measurements were taken on Marmot Creek Basin periodically between 25 May and 27 June, and on 25-26 September, 1979. Calibration of neutron depth moisture gauges was completed for two sites on Streeter Basin and for one site on Marmot Creek Basin.

8. Groundwater levels were monitored throughout the year by means of water level recorders.

9. Completed. Marmot Basin seismic data were processed to obtain thicknesses of surficial material at points along the soil moisture transects.

10. Completed. Analysis of soil moisture data for the year following treatment of Streeter Basin showed that soil moisture was nearly always higher for cleared sites than for aspen sites. The differences were significant during the summer and fall months, and amounted to about 8 cm at the end of the growing season.

11. Report entitled "Effects of 1976 treatment of Streeter Basin on soil moisture" was prepared.

14. <u>Goals for 1980-81</u>:

1. Complete development of simplified subsurface flow routing model (SIMSUB) to interface with existing hydrologic vegetation manipulation models.

2. Test SIMSUB by interfacing with existing hydrologic vegetation manipulation models, using Marmot or Hinton area data (see goal 1, NOR-13-177). Write internal report on feasibility of using SIMSUB for prediction purposes.

3. Analyze Cabin Creek (Marmot) basin soil moisture/groundwater data for the period 1972-76.

4. Prepare section on the effect of cutting on soil moisture, in an Information Report describing the effects of the Streeter Basin treatment (see goal 3, NOR-13-017).

5. Check and report on longevity of the effects of Streeter Basin treatment on soil moisture by:

   a) measuring soil moisture on Streeter Basin once a month during the period April through November, 1980;

   b) processing and analyzing 1978 and 1980 soil moisture data;

   c) starting to write a report for publication in the Journal of Range Management.

6. Complete development of SUBFEM by:

   a) debugging program for the partitioned watershed profile problem and providing for simulation of outflow at the seepage face (stream channel).

   b) introducing the time variable, and solving the resulting equations using the finite element method and an appropriate finite difference technique.

7. Run SUBFEM to physically simulate profiles of Marmot Creek Basin.

8. Continue writing Ph.D. dissertation. Target completion date is spring, 1981.

9. Monitor groundwater table levels on Marmot Creek Basin throughout the year.

10. Meet with British hydrologists and discuss common hydrologic problems during visit to U. K.

15. Publications:

1978-79

Nil

1979-80

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1980

1. Project: Maintenance and improvement of water yield and quality.

2. Title: Measuring transpiration of individual trees *in situ*.

3. New: Cont.: X

4. No.: NOR-13-084

5. Study Leader: R.H. Swanson

6. Key Words: Heat pulse velocity, conducting xylem, sap velocity, sap flow, moisture content, lodgepole pine, Radiata pine

7. Location of Work: Kananaskis Forest Experimental Station; Marmot, Streeter, Deer Creek Experimental Basins.

8. Problem:

Transpiration is the process whereby water is evaporated from the soil via a plant water conducting system. The amount of water thus vaporized is a considerable quantity, up to that which falls as annual precipitation. From the hydrologist's point of view such vaporization represents a loss in the water budget of a land area. From a physiologist's point of view, transpiration is closely related to stomatal opening which in turn controls gaseous exchange in photosynthesis and/or respiration. Transpiration measurements are therefore indicative of a tree's ability to function in its current environment. No practical, reliable field method exists for evaluation *in situ* transpiration.

It has been suggested that there are differences in transpiration volumes between and among species. This has been demonstrated by lysimeter and potted seedling experiments. The most notable example of a within species difference is New Zealand Forest Research Institute's clone 457 which transpires roughly 30 to 50% more than "normal" clones of the same species. However, it still remains to be proven in field trials of stands that differing transpiration can account for either growth or streamflow changes.

Field trials require in situ transpiration estimates. The technique being tested and developed in this study utilizes in stem sensors to detect the flow of heat as influenced by upward sap movement. This movement, which is analogous to the "V" of the continuity equation for fluid flow-Q = AV, when coupled with an estimate of the sap conducting wood area, directly quantifies transpiration rate. Practical instrumentation for detecting sap movement (heat pulse velocity) have been developed by the author.

9. Study Objectives:

For the commercial tree species of Alberta:

1. To determine if heat pulse speed is distributed across the sap conducting xylem in a regular pattern that can be closely approximated by a mathematical function.

2. To determine if the magnitude of heat pulse velocity measurement within a given tree is indicative of the magnitude of the transpiration from that tree.

3. To develop and refine a technique for estimating, with precision, the water consumption of individual trees in situ.

10. Resources:

a. Starting date: 1969
b. Estimated year of completion: 1975 Revised: 1983
c. Estimated total Prof. man-years required: 2.5
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1980-81 man-years

Prof.	0.5	(Swanson)
Supp.	0.5	(Hurdle)
Casual		
Total	1.0	

11. Progress to Date:

Reliable and simple to use field instrumentation has been developed for determining heat pulse velocities. Sensing probes consists of two readily available thermistors and a hand-constructed nichrome wire heater. These sensors can be permanently installed for repeated readings at desired intervals. The sensors cause some damage to the tree which in turn creates callus tissue that affects the heat pulse velocity readings. Callus appears to be fully formed after one growing season. If the callus development is small compared to the tree cross section then the installations have no discernible effect on tree function. In general trees or stems greater than 30 mm diameter can be instrumented without harm.

Objective one has been satisfied by work to date. The direct answer to this objective is that there isn't any single mathematical function that can be used to describe the heat pulse velocity distribution across the sapwood in even lodgepole pine. However, the sapwood depth in lodgepole pine, Engelmann spruce and Douglas-fir in Alberta is sufficiently shallow that heat pulse velocities can be determined directly for any given depth. A useful approximation to the sapwood area can be determined from increment borings or from heat pulse probes placed deeper than the sapwood depth (likely unknown at time of installation).

Objective two has also been partially satisfied. The magnitude of a heat pulse velocity measurement is proportional to the transpiration, but the same constant of proportionality does not continue. Heat pulse velocities will show a decline with time due to wound reaction. Either new probes must be installed at each determination date, or some wound correction factor must be applied.

The final attack on objective three consists principally of theoretical work to remove empirical constants for both initial installation wounding and subsequent physiological wound reaction from the transpiration estimation equations. Also a means of recording heat pulse velocities for routine application in catchment water balance studies is desired.

12. Goals for 1979-80:

1. Publish Journal article on numerical and experimental analysis of heat pulse velocity theory and practice.

2. Publish information report and/or New Zealand Forest Research Institute internal report on models to estimate transpiration in selected New Zealand and Canadian conifers.

3. Publish Journal report on transpiration of New Zealand Mountain Beech.

4. Continue to work on digitizing and up-dating heat pulse velocity instrumentation.

13. Accomplishments 1979-80:

1. Article has been written and received first reviews. It is now being revised and shortened before submission to Journal of Experimental Botany.

2. Deferred to 1980-81 due to added work committments in NOR-017 during 1979.

3. Report has been accepted by N.Z. Journal For Science and Galley proof returned. Expect publication to appear during 1980.

4. Designed digital heat pulse meter based on results of numerical analysis of theory. Constructed a prototype and have conducted preliminary operational tests.

14. Goals 1980-81:

1. Complete growth room and field tests to verify numerical analysis of heat pulse velocity theory. Write first draft of thesis. (Swanson)

2. Publish "A numerical analysis of heat pulse velocity theory and practice." [Swanson - Whitfield (U of A thesis supervisor)]

3. Prepare and publish information report of NZFS internal report on preliminary models for measuring transpiration using heat pulse velocity techniques. (Swanson)

4. Design and construct digital heat pulse velocity indicating and recording equipment for use in growth room and field studies. (Hurdle)

15. Publications:

1979 - 1980

Swanson, R.H., U. Benecke and W.M. Hauranck (In Press, 1980). Transpiration in mountain beech estimated simultaneously by heat pulse velocity and climatized cuvette. New Zealand Journal Forest Science.

16. Signatures:

Robert H. Swanson
Investigator

Program Manager

Director

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1980

1. Project: Maintenance and improvement of water yield and quality.

2. Title: Runoff patterns resulting from differential snow accumulation and ablation as influenced by mass and energy relationships in small forest openings.

3. New: Cont.: X 4. No.: NOR-13-103

5. Study Leader: R.H. Swanson

6. Key Words: Snow melt, radiation, wind, lodgepole pine, aspen, Deer Creek, Marmot, Streeter Basin.

7. Location of Work: Alberta East Slopes

8. Problem:

The hydrologic influence of large, clearcut blocks (10-100 acres), particularly with reference to snow accumulation and melt, is fairly well known. The leeward edge produces a sharp discontinutiy in wind streamlines flowing over the forest, causing more snow to be deposited in the first 2-5H (tree height) distance within the opening, than under the treed edge or further out into the opening. Beyond 4-5H from the leeward edge, wind streamlines are again fairly uniform, often resulting in less snow than within the adjacent stand.

At the windward edge another discontinuity occurs. Streamlines may rise above the canopy or may penetrate 1-2H and dissipate their energy against the interior canopy. More snow is usually deposited under the canopy on the windward edge than in the open or the forested area. The development of the leeward eddy and windward penetration of streamlines depends on speed and structure of the wind, horizontal and vertical structure of the forest, and opening geometry.

In general, snow melts faster in large openings than under the canopy, resulting in greater streamflow occurring earlier than from areas of continuous forest. The volume of water in the rising limb of the snow melt hydrograph is always greater from areas harvested in large clear-cut blocks than from uncut areas. This may create problems in Alberta where rivers flow east or north, because of ice breakup and snow melt occurring simultaneously.

No watershed studies have been conducted using small forest openings. Relevant runoff data is not available for snow accumulation and melt relationships in small openings. Very little real data exists on snow accumulation, melt, or wind-radiation patterns in small openings. What there is, is mainly observational and qualitative. However, observations do indicate that small openings contain more snow than surrounding forest, and melt rates are not dissimilar. These observations need quantitative statistical support to provide the basis for influencing snow accumulation, melt and associated runoff patterns.

The solution to this problem will permit forest logging patterns to be designed to regulate streamflow regime to influence such parameters as snow melt floods and low flows.

9. Study Objectives:

To determine the influence of small forest openings on snow accumulation amounts, melt rates and snow melt runoff paterns through:

1. Development of a physically-based conceptual hydrologic model incorporating differential areal precipitation input to predict the snow manipulative aspects of timber harvest schemes applied to experimental watersheds, on the resultant outflow hydrographs, and to test these models on experimental watersheds.

2. Quantitative determination and theoretical process description of differential snow accumulation amounts in a 10 treatment block of circular openings from 1/4 to 6 tree heights in diameter.

3. Quantitative determination and theoretical process description of differential snow ablation rates within the above 10 treatment blocks.

4. Small scale pilot testing of proposed harvesting patterns to ascertain their general effect on snow melt runoff.

10. Resources:

a. Starting date: 1970
b. Estimated year of completion: 1983
c. Estimated total Prof. man-years required: 2.7
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	Swanson	.1
Supp.	Hurdle	0.5
Casual		0.3
Total		0.6

11. Progress to Date:

Ten replications of 10 opening sizes have been established. Snow Surveys have been carried out on three uncut areas within the study area and it has been determined that the snowpack is homogeneous across the study area. Snow surveys have been carried out in the openings during early spring since 1973. Five snow pillows were installed on Marmot basin to record snow accumulation and ablation throughout the snow season and data are available since November 1972.

Four 100-ft towers have been erected and directional anemometers installed at the top. Stations have been established at each of the tower sites, instrumented for temperature, humidity, and precipitation. Data has been obtained since December 1971.

Two 100-ft towers were erected in the uncut forest and instrumented at three levels. Short-term energy balances were conducted using the data-acquisition and analysis system.

Baseline data from meteorological stations have been transferred to punch-cards. Data have been analyzed showing the variation in snow-accumulation and melt.

Fourteen 1H openings were cut at 1H spacing to determine snow accumulation in small openings at close spacing. Sample openings were created on Marmot to substantiate applicability of James results to the Marmot-Twin treatment.

A harvest treatment designed to increase snow accumulation in 1H tree height openings and to retard its melt rate was proposed for Marmot-Twin sub basin based on research results of this study. This proposal was accepted by the Alberta Watershed Research Program and clearing commenced in 1977 with a target date for completion of 1979.

12. Goals for 1979-80:

1. Measure wind, air temperature, relative humidity (if possible) in range of small clearings at James River snow study site. (one month's data needed). Analyse and prepare estimates of potential evapotranspiration from clearings as influenced by horizontal dimensions.

2. All other snow measurements will be temporarily suspended pending replacement of technical help.

13. Accomplishments 1979-80:

1. Thirteen climatic stations measuring wind speed, air temperature and relative humidity were established in clearings ranging from 1 to 20 tree heights. The wind and air temperature data for

selected periods have been analysed. A report regarding the modification of wind speed and thus evaporation potential in small clearings has been prepared for presentation at the 1980 Western Snow Conference.

Much of the data was unusable due to recorder malfunctions. It would be desirable to repeat some aspects of this study in the future when better integrating instrumentation has been prepared to record wind data.

2. All instrumentation and all but one living trailer have been removed from the James River site. The data taken to date has been reduced from the charts and key punched for computer handling.

   The intensive snow survey on Marmot was not conducted because the clearing was not complete.

14. Goals for 1980-81:

1. Design and construct digital integrators to record data from bi-directional propeller wind speed transducers. Conduct operational tests. (Swanson - Hurdle)

2. Initiate work to design microproscessor based data package for recording microclimate data for replicate energy balance studies in small clearings. (Hurdle - Swanson)

3. Resume Marmot intensive snow survey on Twin experimental clearings and middle control. (Swanson, Hurdle, Hillman, Robson plus NRC contract to Golding - UBC)

4. Publish "Surface wind structure in small clearings during chinook activities." (Swanson)

15. Publications:

1978-79

Golding, D.L. 1978. Studies using climate data collected by hydrology section, Northern Forest Research Centre. 71 p. In. J.M. Powell, editor, Climatic Networks. Northern Forest Research Centre Information Report NOR-X-209.

1979-80 Nil

16. **Signatures:**

Investigator

Program Manager

Director

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1980

1. Project: Maintenance and improvement of water yield and quality.

2. Title: Vegetation manipulation-hydrologic modelling.

3. New: X Cont.: 4. No.: NOR-13-177

5. Study Leader: (Vice Stevens), Hillman

6. Key Words: Hydrologic modelling, snowmelt, evapotranspiration.

7. Location of Work: Alberta

8. Problem:

Forest land managers and hydrologists in Canada lack the ability to predict accurately what changes in streamflow occur as a result of vegetation manipulation. Without this capability managers are forced to use inaccurate or incomplete information in decision making. Hydrologic modelling is a tool that is capable of filling this gap in knowledge.

Through modelling, research results can be extended to watersheds with various kinds of soil, climate and physiography. Hydrologic modelling is also of value to the researcher; models can be used to study and interpret the processes that govern water movement. Both the manager and the researcher can also learn where to place emphasis in data collection.

The number of hydrologic models that are capable of simulating a forest and changes within that forest is relatively small. Even so, a large variation in model complexity and applicability exists within this group of forest hydrology models. This means careful evaluation of a given model is necessary before it can be applied to a different region.

The probability of developing and using a forest hydrology model to predict various hydrologic components is very high. Forest hydrology models are now in use in several areas in the United States. The probability of the results of this study being applied both as a research tool and a management tool is also very high. The Watershed Management Section of the Alberta Forest Service realizes the value of modelling in predicting the effect of forest cover manipulation on basin hydrology. They are cooperating in a trial application of a hydrologic model now and are eager to use modelling on a more routine basis. As well, modelling will undoubtedly play a major role in the evaluation of the potential for watershed management to increase water yield in the Oldman River basin.

9. Study Objectives:

1. Develop vegetation manipulation-hydrologic models applicable to the Saskatchewan River headwaters.

2. Incorporate the results of other NFRC studies dealing with individual components of the hydrologic cycle into the watershed model.

3. Communicate the models to forest-water resource managers in provincial and federal governments.

10. Resources:

a. Starting date: 1979
b. Estimated year of completion: 1983
c. Estimated total Prof. man-years: 4.5
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1980-81 man-years:

Prof.	1.2	(1.0 Vice Stevens, 0.2 Hillman)
Supp.:	0.2	(Robson)
Casual		
Total	1.4	

11. Progress to Date:

Work on this study has been previously carried out and reported under NOR-13-017. Several hydrologic models were obtained in order to evaluate the usefulness of them. The models that were examined include:

1. WATBAL (Leaf, C.F. and G.E. Brink. 1973. Hydrologic Simulation Model of Colorado Subalpine Forest. Rocky Mtn. For. & Ran. Expt. Sta., Res. Pap. RM-107).

2. MELTMOD (Solomon, R.M., P.F. Ffolliott, M.B. Baker, Jr. and J.R. Thompson. 1976. Computer Simulation of Snowmelt. Rocky Mtn. For. & Ran. Expt. Sta., Res. Paper. RM-174).

3. PROSPER (2 versions) (Goldstein, R.A., J.B. Mankin and R.J. Luxmoore. 1974. Documentation of PROSPER: a model of atmosphere-soil-plant water flow. EDFB-IBP73-9, Oak Ridge Nat. Lab, Oak Ridge, Tenn.).

4. MARMOT MODEL (Dickinson, W.T. Theoretical mathematical models for streamflow from a forested mountain watershed. Report to the Northern Forest Research Centre).

The sucess of the trial simulations has been reported in more detail in NOR-13-017. In summary difficulties were encountered with both WATBAL and MELTMOD; insufficient flexibility existed within these models to allow good simulations for Marmot Creek basin. The simulations tried with the MARMOT MODEL were not extensive since it was soon apparent that this model was unsuitable for evaluating the effects of changes in forest cover. Both the model structure and the method of determining parameter values severely limit this model. PROSPER is essentially an evapotranspiration model. Success to date in using PROSPER has been encouraging. It requires more detailed information than some ET models but it is capable of simulating more than just water loss. It was designed so that it could be coupled to a primary production model as well as a sub-surface flow model. Snowmelt is not simulated by PROSPER so a routine based on several in use by the U.S. Forest Service has been coupled to it. Simulation with this combination have been good and it appears as though it will be flexible enough to be applied in different regions.

By combining PROSPER and the snowmelt model, simulation of generated run-off is possible. Data requirements include daily values for solar radiation, temperature, relative humidity and precipitation. Mean slope and aspect of the land surface, leaf area index, crown cover density and several soil and plant hydraulic properties are also required.

12. <u>Goals for 1979-80</u>:

1. Continue development of the watershed model so that vegetation manipulation can be more fully simulated and with greater ease. This would include incorporating results from local research into the model.

2. Continue applying the watershed model (tentatively PROSPER and the snowmelt model).

   a. Complete trial simulations on Cabin Creek,

   b. Do simulations on Tri-Creek watershed in the pretreatment phase. Prepare simulations for Wampus Creek for the post-treatment phase,

   c. Prepare simulations for Twin Creek for the post-treatment phase,

   d. Do simulations (in cooperation with AFS) on the proposed watershed management pilot project if the project proceeds. This would include developing or obtaining a program to generate climatic variables needed by the hydrologic model.

3. Prepare a paper on the results of the trial simulations on Cabin Creek for the Canadian Hydrology Symposium.

4. Work with G. Hillman to interface routing procedure and/or subsurface flow model to the watershed model.

5. Assist interested users in implementing the model.

13. Accomplishments 1979-80:

Note: The principal investigator on this project resigned in August 1979 to take up a position in the watershed management section of the Alberta Forest Service.

1. The combined snowmelt-evapotranspiration model was adapted to both the University of Alberta (Amdahl) and NFRC (PDP) computers. Routines to input local snow accumulation and snowmelt relationships derived from James River (NOR-103) data were incorporated.

2. a. Not done prior to resignation.

   b. Simulations were done and furnished to the Alberta Forest Service to assist them in the evaluation of the Tri Creeks harvest. Internal report available.

   c. Some simulation of the effects of the clearings on snowmelt on various topographic aspects were prepared to assist the coordinator in specifying clearing priorities on the basin in the event that the entire harvest could not be done. No simulations were done for the post-treatment water yield.

   d. Some simulations of proposed harvesting patterns were carried out after the investigator had joined the Alberta Forest Service. Further cooperation in the use of the NFRC-derived model is expected within this watershed management pilot program.

3. Not done prior to resignation.

4. Not done prior to resignation.

5. Assistance rendered to Alberta Forest Service Watershed Management Personnel.

14. Goals for 1980-81:

1. Interface simplified sub-surface routing model with PROSPER and snowmelt models for complete hydrograph simulation. (Hillman)

2. Become familiar with model operation as programmed on NFRC (PDP) computer. (Vice Stevens)

15. Publications:

Nil

16. Signatures:

R.H. Swanson for Vies.
Investigator

Program Manager

Director

PROJECT NOR-17

Liaison and technical advisory services in forest management

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

1. Project: Liaison and technical advisory services in forest management.

2. Title: Liaison and technical advisory services in the Western and Northern Region.

3. New: Cont.: X 4. No.: NOR-17-118

5. Study Leader: H. J. Johnson and K. Froning

6. Key Words: Silviculture, appraisals, demonstrations, photogrammetry, mensuration, insects, disease.

7. Location of Work: Manitoba, Saskatchewan, Alberta and the Northwest Territories.

8. Problem:

The solution to many forest management problems in the Western and Northern Region do not require long term research. Often the answer lies in the application of existing knowledge. In some cases, it is necessary for the Canadian Forestry Service to assist in putting dimensions on problems. By working closely with provincial and industrial forest management agencies in the determination of problems and recommending and testing promising forest management techniques, it is possible to rapidly upgrade forestry practices in the region. This can be done by appraisal of existing practices, trials and demonstrations of various techniques, the preparation of practical reports and brochures, workshops, seminars and good contact.

9. Study Objectives:

To establish strong lines of communication with various forest management agencies, to ensure that the results of departmental research are known and utilized, and to advise the Program Management Committee on forest management problems.

10. Resources:

a. Starting date: 1965
b. Estimated year of completion: Continuing

c. Estimated total Prof. man-years required: N/A
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	2.0	(H. J. Johnson, K. Froning)
Supp.	3.0	(Gorman 1.0, Rentz 1.0, Kolabinski 1.0)
Casual	-	
Total	5.0	

11. Progress to Date:

1. Established cooperative reforestation demonstrations of container planting, seeding and conventional planting for use by Alberta Forest Service and quota holders.

2. Establishment and maintenance of interprovincial forest fertilizer trials in Slave Lake Forest (three installations).

3. Coordination and preparation of a literature review and interpretation of the effects of large-scale clearcutting in Alberta.

4. Evaluation of reforestation practices in Alberta, Saskatchewan and Manitoba. Two information reports prepared.

5. Silvicultural advisory services in Alberta and the Territories.

6. Assistance to several projects in collection of special survey data, compilation and preliminary analyses.

7. Prepared a report on regeneration following strip-cutting in Alberta.

12. Goals for 1979-80:

1. Goals for the appraisal crew will be determined after project reviews.

2. Maintain effective contact with forestry officials in Manitoba and Saskatchewan. The purpose of this contact is to keep well informed of forestry activities, to transfer technology and to keep the NFRC program committee informed of opportunities and requirements for research.

3. To actively participate in the accumulation of information for the proposed data bank on silvicultural information. The first task will be to locate sources of data to establish reforestation peformance.

4. To conduct liaison on specific NFRC programs in Manitoba and Saskatchewan, e.g. core forestry program, Insect and Disease Survey, etc., DREE obligations, ENFOR, National Forestry Statistics, etc.

5. To continue maintenance of small-scale NFRC cooperative trials in Manitoba and Saskatchewan involving less than 0.1 m/y.

13. Accomplishments in 1979-80:

1. Appraisal crew assignments accomplished:

	Assignment	Man Months
a.	Specific gravities of various forest fuels (Quintilio).	2.5
b.	NOR-5. Test burns (Chrosciewicz).	4.0
	Fuel loading survey (Quintilio).	2.0
	Test drops, Slave Lake (Newstead).	2.0
	Survival and growth of seedlings after prescribed burning (Chrosciewicz).	3.0
c.	NOR-17. Finn Plow Planting trials (Ball).	2.0
	Inter-provincial fertilizer trial, Saskatchewan (Johnson).	1.0
d.	NOR-9. Forest tent caterpillar sampling and collection (Ives).	1.0
e.	NOR-173. Biomass Study (Johnstone) (incomplete).	9.0
f.	Miscellaneous assignments.	3.0
	Tanker air drop maps (Lieskovsky).	
	Mailing lists (Waldron).	
	Closure K.F.E.S. (Oaks).	

2. Effective contact has been maintained with Manitoba and Saskatchewan forestry officials through the appointment of Mr. K. Froning as liaison specialist subsequent to the closure of the Winnipeg and Prince Albert sub-offices.

In addition to numerous contacts by telephone and letter, the following liaison trips were made:

I - April 18 - 25 Prince Albert, The Pas, Winnipeg, Birds Hill

Agency	Principal Contact	Title	Major Topic
Sask. DTRR	W. Bailey	Director	Courtesy, general
	J. Benson	Section Head	Visiting Scientist
	F. Flavelle	Section Head	Silviculture
Man. DNR	W. MacLean	North. Reg. Manager	Courtesy
	D. Lamb	North. Reg. Forester	Silviculture, protection
	D. Rannard	Chief, For. Mgmt.	Research, general
	C. K. Smith	South. Reg. Manager	General
	A. Jardine	East. Reg. Manager	General
	S. Segaran	Head, For. Research	Tree Improvement

II - May 17 - June 1 Winnipeg, Hadashville, Sandilands, Dauphin, Prince Albert

Agency	Principal Contact	Title	Major Topic
Man. DNR	H. Laws	Director	DREE, policy
	D. Rannard	Chief For. Mgmt.	Various project related
	A. Jeffrey	Chief For. Prot.	I&D surveys
	R. Lamont	Chief For. Invent.	Remote sensing
	S. Williamson	West. Reg. Manager	General
	G. McColm	West. Reg. Forester	Budworm, silviculture
	K. Vogel	South. Reg. Forester	Project related
	L. Yarn	East. Reg. Forester	Silviculture
City of Wpg.	M. Bennum	Parks & Rec. Direc.	DED program
	J. Hreno	Parks, Forester	Nursery takeover
Man. Mines, Res. & Envir. Mgmt.	M. Kaye	A/Director	SO_2 program
Man. Dep. Agric.	Dr. Platford	Prov. Pathologist	Nursery rust problems
Man. Parks Br.	D. Moffat	Director	General, Ins. & Dis.
Parks Canada	D. MacMillan	Chief	I&D survey
	B. Lee	Veget. specialist	Spruce budworm
Sask. DTRR	F. Flavelle	Section Head	Silviculture, DREE
	S. Price	Silviculturist	Nursery & silviculture
	J. Benson	Section Head	Inventory
P.A. Pulpwood Co.	J. Perkins	Woodlands Manager	ENFOR
P.A. Pulpwood Co.	S. Smith	Forester	Reforest. & Tree Improvement

III - June 13 - 25 Winnipeg, Hadashville, Birds Hill, The Pas, Sandilands, Saskatoon

Man. DNR	D. Rannard	Chief For. Mgmt.	Manuscript
	S. Segaran	Head, For. Res.	Tree Imp. Project
	L. Yarn	East. Reg. Forester	Container trials
	W. Trowsdale	Nursery Superint.	Growing problems
	D. Lamb	North. Reg. Forester	Extension
	K. Vogel	South. Reg. Forester	rp thinning study
City of Wpg.	J. Hreno	City Forester	CIF program, nursery
	V. Hildahl	Co-ordinator	DED
Alta., Sask., Man.	Reps.	Reg. Tech. Refor. Comm.	Ann. Meeting, The Pas

IV - July 9 - 23 Meadow Lake, Big River, Prince Albert, Hudson Bay, Sawn River, Riding Mountain, Winnipeg

Agency	Principal Contact	Title	Major Topic
Sask. DTRR	M. Pandila	Reg. Forester	Silvic. & industry
	McCatchum	Nursery Manager	General production
	V. Stuart	Sen. Resource Tech.	Silvic. equipment
	D. Henlin	Resource Tech.	Silvic. equipment
	J. Ives	Park Superint.	Candle Lk field stn.
	L. Rempel	Nursery Manager	Container production
	D. Hunter	(H.B. Reg.) Supt.	Courtesy
	V. Begrand	(H.B. Reg.) Forester	Reforest. projects
P.A. Pulpwood Co.	S. Smith	Forester	Silvic. equipment
	A. Kabzems	Consultant	Site classification
	R. Orinek	Forester	Genetic program
M&B, Hud. Bay	N. Anderson	Woodlands Manager	Study proposal
	R. Brooks	Senior Technician	Site location
Simpson Co.	J. Gorman	Woodlands Manager	Statistics
	P. Wearmouth	Forester	Silvic. equipment
Man. DNR	S. Kaczanowsky	West Reg. Forester	Silviculture
	K. Vogel	South Reg. Forester	General
	L. Yarn	East Reg. Forester	Herbicides
	A. Jardine	East Reg. Manager	Courtesy
	C.K. Smith	South Reg. Manager	Courtesy
City of Wpg.	M. Benum	Parks & Rec. Direc.	Courtesy
	J. Hreno	City Forester	DED & nursery
	V. Hildahl	Co-ordinator	DED
Parks Canada	J. Campbell	Chief Warden	Courtesy
	B. Lee	Veget. Specialist	Silviculture, spruce budworm, CFS plot locations

V - August 12 - Sept. 9 Prince Albert, The Pas, Dauphin, Winnipeg, Pine Falls, Hadashville, Riverton

Sask. DTRR	W. Bailey	Director	Courtesy
	F. Flavelle	Section Head	Silviculture
	J. Benson	Section Head	Visiting scientist
	S. Price	Silviculturist	Provenance study
	R. Berezowsky	Forester	Aerial photography
	F. Wilson	Forester	CIF meeting
	A. Kosowan	Soils specialist	Site classification

Agency	Principal Contact	Title	Major Topic
Man. DNR	D. Lamb	North.Reg. Forester	Regen. survey, I&D extension, silvic. equipment
	G. McColm	West. Reg. Forester	Silviculture, spruce budworm
	R. Mackenzie	Resource Technician	I&D surveys
	L. Yarn	Interlake Reg. For.	Herb. spray program
	K. Vogel	South.Reg. Forester	Seed prod. area, herbicide program
	S. Segaran	Head, For. Research	Provenance study
	W. Trowsdale	Nursery Superint.	Production
	W. Middlebro	Forester	Forest products
	D. Becalla	Forester	Cone collection, container planting
Man. Mines, Res. & Envir. Mgmt.	D. Wotton	Env. Research specialist	Environ. program
City of Wpg.	J. Hreno	City Forester	Nursery & CIF meeting
	V. Hildahl	Co-ordinator	DED & surveys
Parks Canada	B. Lee	Veget. Specialist	I&D survey
Abitibi Co.	H. Peacock	Forester	Herbicide program

Man. For. Assoc. Host Ann. Meeting of CFA Managers - partial program participation

Man. Sect. CIF Ann. Meeting - full participation - 40 members contacted

VI - October 1 - 7 Jasper, Grande Prairie, Hinton

Participated in CIF National Meeting and kept in close touch with six Saskatchewan and two Manitoba representatives. Guided Mr. Yarn (Man. DNR) on a three-day silvicultural project tour in Grande Prairie and Hinton, Alberta, areas.

VII - October 12 - 19 Prince Albert, Hudson Bay, The Pas

Trip primarily field work oriented. Contacted:

Sask. DTRR	J. Benson	Sect. Head	Inventory data
	J. Thompson	Forester	Study plots
	V. Begrand	H.B. Region, For.	Courtesy
Man. DNR	D. Lamb	North.Reg. Forester	Regen. survey
	W. McLean	Director	Courtesy
	W. Rugg	Forester	Regen. survey

VIII - Oct. 28 - Nov. 12 Hudson Bay, Winnipeg, Hadashville, Pine Falls

Agency	Principal Contact	Title	Major Topic
M&B Hudson Bay	N. Anderson	Woodlands Manager	Logging study, manuscript
	R. Brooks	Senior Technician	Plot establishment
Sask. DTRR	V. Begrand	H.B. Reg. Forester	Logging study
Simpson Co.	J. Gorman	Woodlands Manager	Logging study, manuscript
Man. DNR	H. Laws	Director	General & policy
	D. Rannard	Chief, For. Mgmt.	General
	W. Middlebro	Forester	Products
	B. Sepalla	Special Proj. For.	General
	W. Trowsdale	Nursery manager	Soil samples
	S. Segaran	Head, For. Research	Silvic. projects
	C. K. Smith	Industrial Liaison Officer	General
	A. Jardine	Regional Manager	Silv. prescr. project
	J. Nespor	Regional Manager	Courtesy
	K. Vogel	Regional Forester	Silv. prescr. project
	L. Yarn	Regional Forester	Silviculture
Man. For. Assoc.	D. Beaven	Manager	Extension program
Man. MREM	M. Kaye	A/Director	Courtesy
	D. Wotton	Env. Research Specialist	Spruce budworm control project
City of Wpg.	M. Bennum	Parks & Rec. Direc.	Policy
	J. Hreno	City Forester	DED research
	V. Hildahl	Co-ordinator	Award presentation
Abitibi Co.	B. Bartlett	Woods Manager	Courtesy
	H. Peacock	Forester	Silviculture

IX - December 3 - 6 Hudson Bay, Prince Albert

M&B Hudson Bay	N. Anderson	Woodlands Manager	Logging study
	R. Brooks	Senior Technician	Plot establishment
Simpson Co.	P. Wearmouth	Forester	Logging study
	P. Heffernan	Technician	General
Sask. DTRR	V. Begrand	Regional Forester	Logging study
	W. Bailey	Director	General
	J. Benson	Section Head	General

X - December 20 - January 4/80 Winnipeg, Pine Falls

Agency	Principal Contact	Title	Major Topic
Man. DNR	H. Laws	Director	Organization
	S. Segaran	Head For. Research	General
	K. Vogel	Regional Forester	Data acquisition
	L. Yarn	Regional Forester	General
Abitibi Co.	B. Bartlett	Woods Manager	Remote sensing, technology transfer

Man. Sect. CIF Council Meeting in Pine Falls, 8 participants

3. A plan for the development of prescriptions for the reforestation of jack pine in the Sandilands Forest Reserve, Manitoba, has been developed in consultation with L. G. Brace, Project Leader, Silvicultural Prescriptions Program. Data sources have been identified and permission has been granted by the Manitoba government to use their seedling performance and cost data.

4. While most of the small scale trials received little attention, the co-operative study on logging of aspen to avoid damage to spruce understory in the Hudson Bay Region of Saskatchewan has received significant input. Major revisions to the first draft of a proposed information report are completed. Several recommendations from the report have been brought to the attention of MacMillan Bloedel Ltd. and Saskatchewan D.T.R.R. Some have been implemented and others are under discussion.

14. Goals for 1980-81:

1. Tasks for the appraisal crew will be determined after project reviews.

2. To maintain effective communication with forestry officials in Manitoba and Saskatchewan. The purpose of this contact is to keep well informed of forestry activities in these provinces, to transfer technology and to keep the NFRC management committee informed of opportunities and requirements for research.

3. To prepare silvicultural prescriptions for the reforestation of jack pine in the Sandilands Forest Reserve, Manitoba. These prescriptions will be based on research and operational data available for the area using data bank techniques. Publication of these prescriptions will prove most useful to forest managers and will also serve as a pilot study for the NFRC silvicultural prescriptions program.

4. Publish information report on logging of aspen stands to reduce damage to the spruce understory.

15. Publications:

1978-79

Walker, N. R. 1979. Field performance of Coniferous Spencer-Lemaire container seedlings in west-central Alberta Information Report NOR-X-207.

1979-80

Walker, N. R. and H. J. Johnson. The field performance of coniferous seedlings reared in two types of containers. Information Report NOR-X-218.

16. Signatures:

K. Froning
H J Johnson
Investigator

H J Johnson
Program Manager

G. T. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 24, 1980

1. Project: Reduction of damage from insects.

2. Title: Control and damage impact of insects injurious to trees and shrubs.

3. New: Cont.: X 4. No.: NOR-17-143

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 the insect and its potential damage, and by the wishes of the owner(s) or forest manager. Staff of the FIDS fulfill much of this need as a routine extension function provided in response to client requests throughout the Prairie Provinces.

Other entomological problems arise which are usually localized and require more comprehensive examination or 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, or with use of cultural techniques, biological agents, and insect pheromones. Opportunity may also exist to undertake field trial demonstrations for testing control procedure and long-term effectiveness. NOR-143 study is specifically concerned with these kinds of problems.

A prime function of this study also is to maintain up-to-date expertise and knowledge of all major forest entomological implications reflected in the wise management of forest resources by federal, provincial, and industrial agencies and the general public. Major benefits from this study will therefore be in complementing the services offered under NOR-033 and to other studies related to forest resource management such as regeneration stocking standards, forest inventory losses, seed and cone losses, and in silvicultural applications. Benefits will also extend to various federal and provincial committees which regularly review pesticide legislation, use, and application, and in the dispersal of information on insect pests of trees and shrubs generally throughout the prairies region.

9. Study Objectives:

1. To maintain up-to-date information and provide technical and advisory services 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, damage impact and depletion losses in areas of concern to various clients.

10. Resources:

a. Starting date: 1973
b. Estimated year of completion: Continuing
c. Estimated total Prof. man-years required: Ongoing
d. Essential new major equipment items for 1980-81 with costs:
e. Essential new major equipment items beyond 1981 with costs:
f. 1980-81 man-years

Prof.	0.7	(0.3 in -033)
Supp.	0.8	(0.2 in -033)
Casual	-	
Total	1.5	

11. Progress to Date:

Reporting and CFS representation have been provided on the various federal, regional and provincial committees listed under 12. A variety of consultory, editorial and identification services were provided within CFS. Various contributions were made on entomological problems within the region through TV, radio and newspaper media, by direct consultation with clients and through lecture and workshops. Special field surveys involving data collection, analyses and reporting were made on woodborers, spruce budworm, seed and cone insects, jack-pine budworm, nursery pests and other problems.

12. Goals for 1979-80:

1. Work toward completing first draft of "Common insects of trees and shrubs of the Prairies" as time provides.

2. Provide CFS representation on various regional and provincial committees as follows:

   (a) Western Committee on Crop Pests.

   (b) Alberta Pest Control Advisory Committee.

   (c) Saskatchewan Advisory Council on Insect Control.

   (d) Shelterbelt Committee of Western Canadian Society for Horticulture.

   (e) Contact Officer for CDA Pest Control Products Act and Trade Memorandum 104.

   (f) Alberta Horticultural Advisory Committee and Environmental Sub-Committee of AHAC.

   (g) Steering Committee for Alberta Plant Protection Act proposal.

   (h) Eastern Spruce Budworm Committee, Bt Committee, CAN/USA.

3. Prepare report on damage impact of jack pine budworm, Nisbet Provincial Forest.

4. If requested, assist Parks Canada (Riding Mt. National Park) in pre- and post-spray larval sampling during their proposed spray program with Bt against spruce budworm.

5. Provide consultory and identification service, and workshop-seminars on forest insect pests to provincial and industrial agencies as requested.

6. Provide editorial reviews as required.

13. Accomplishments in 1979-80:

1. No progress made due to extra commitments in this study and in NOR-033, except for acquiring several new photographs.

2. CFS representation was provided as follows:

   (a) Western Committee on Crop Pests and Western Forum: attended annual meeting in Vancouver and prepared revisions for 1980 update for chapter on insect controls in "Shelterbelts, Ornamental Trees and Shrubs".

   (b) Alberta Pest Control Advisory Committee: attended annual meeting in Edmonton and reported on current insect and disease problems of trees and shrubs in Alberta.

   (c) Saskatchewan Advisory Council for Insect Control: attended annual meeting in Saskatoon and reported on major forest and shade tree pests in Saskatchewan.

   (d) Shelterbelt Committee of Western Canadian Society for Horticulture. No annual meeting held in 1979, but report prepared to update shelterbelt pests. Additional information was provided to the Windbreak Management Task Force of the Great Plains Forestry Committee, USA.

   (e) Contact has been maintained with Plant Products Division, CDA, Ottawa, on matters relating to federal pesticide legislation and registration.

   (f) Environmental Sub-committee of Alberta Horticultural Advisory Committee. A report was prepared jointly with I. Edwards summarizing CFS activity of concern to this committee.

   (g) Steering Committee for Alberta Plant Protection Act proposal: attended two meetings in Red Deer for discussion of this committee.

   (h) Eastern Spruce Budworm Reviews, Bt Committee, CAN/USA: attended meeting in Toronto for annual update of spruce budworm developments in eastern Canada and USA under framework of CAN/USA agreement. Attended meeting for review of 1979 Bt results on spruce budworm.

<u>Accomplishment Added</u>:

   (i) Forest Pest Control Forum: attended annual meeting in Ottawa and reported on major pest conditions for region in 1979.

3. A first draft report has been prepared summarizing the effects of jack-pine budworm defoliation in Nisbet Provincial Forest of Saskatchewan for period 1975-1978. Main findings are: defoliation was highest in 1976 (96%) and 1977 (96%), and declined in 1978 (23%). During 1978, top-kill of 0.2-0.5 m occurred on about 20% of trees, few new shoots were produced,

needle lengths was reduced, no male or female cones were produced, and no tree mortality exclusively caused by defoliation was observed. Radial growth reductions were evident in the upper crown as early as 1973 or 1974, while major reductions throughout the stem were not apparent until 1977 and 1978, resulting in portions of missing rings. Volume losses in 1978 in moderately and severely defoliated areas were 54% and 88% respectively.

4. As requested by Parks Canada in Riding Mountain National Park, assistance was provided in assessing the spruce budworm infestation in high use areas. With co-operation of Parks personnel, foliage samples were collected in eleven plot areas and evaluated for defoliation since 1977, 1979 top-kill, 1980 foliage potential, and crowns of 50 trees/plot were visually rated for defoliation categories by "Benoit visual method." The data are summarized and will be reported to Parks Canada to assist in their decision making in such high use areas as campgrounds, townsite, golf course and scenic locations of high visual interest.

5. A variety of consultory services, short-term studies, talks and workshops were provided as follows:

   (a) Bt information provided to Manitoba Parks for control study of jack-pine budworm.

   (b) Information provided to Plant Quarantine on bark beetle infested logs and for identification of jack-pine cone insects.

   (c) Information to Simpson Timber Co. on important forest insects and disease.

   (d) Dispersal of information on forest tent caterpillar in Saskatchewan and Alberta--through CDA, Saskatoon, several TV, radio and newspaper media, one-day workshop in Saskatoon to over 50 city parks and municipal personnel, illustrated talk to farm and acreage owners near Edmonton and sampling and monitoring information to Prince Albert National Park.

   (e) Identification of insect materials was provided to Alberta Provincial Tree Nursery, information on aphid control and a survey of 3-0 lodgepole pine seedlings for incidence and loss due to tip weevils.

   (f) Fire-scorched spruce in Nipiwin area of Saskatchewan were re-examined for rate of mortality and woodborer risk. Results reported to Department of Northern Saskatchewan. Other information provided to DNS on hazard and control of woodborers in decked logs.

(g) Shoots of young red pine trees in Manitoba examined for organism likely causing bud kill and forked leaders.

(h) Information sent to UBC staff member on *Pissodes* incidence and damage in this region.

(i) Information sent to Parks Canada on wood ticks.

(j) Slide illustrative material on forest insect and dwarf mistletoe damage sent to Alberta Forest Technology School, Head - Alberta Forest Protection and to community college, Prince Albert.

(k) A joint study with Proctor and Gamble Cellulose Ltd. was undertaken to assess the effects of a soil-applied insecticide for control of white spruce seed and cone insects in the Grande Prairie area. A total of 2800 cones were examined from two treatment sites. Data are now being transferred to punch cards for analyses. Preliminary results have indicated seven different insect species, their relative importance in causing seed loss, levels of abundance of each species and incidence of cone rust. One larva per cone of the spruce cone midge caused an average 40% loss of potentially viable seed. Insect control was low or insignificant and appeared to be offset by deleterious effects of the insecticide, affecting both cone length and numbers of potentially viable seed per cone.

(l) Participated in a seed workshop sponsored at NFRC and presented a report on "The effects of insects on seed and cone production." Workshop was attended by over 75 people from Ontario to B. C.

(m) Served as chairman for local arrangements for annual meeting of Entomological Society of Alberta, held in Edmonton.

(n) Provided on-site inspection of provincial campground (Sibbald) west of Calgary and prepared a report summarizing observations and recommendations for site improvement.

6. Several editorial reviews were provided including review of "Symptomatology and recognition of air-borne pollutants on forest vegetation".

14. Goals for 1980-81:

1. Select and assemble photographs for the proposed publication "Common insects of trees and shrubs of the Prairies," and have these mounted onto plates with assistance of CFS photography unit. Complete first draft of text.

2. Provide CFS and NFRC representation on various federal, regional and provincial committees as follows:

   (a) Western Committee for Crop Protection and Western Forum.

   (b) Alberta Pest Control Advisory Committee.

   (c) Saskatchewan Advisory Council for Insect Control.

   (d) Shelterbelt Committee of Western Canadian Society for Horticulture.

   (e) Maintain contact with Plant Products Division, CDA, Ottawa.

   (f) Alberta Horticulture Advisory Committee and Environmental Sub-committee of AHAC.

   (g) Eastern spruce budworm committee, CAN/USA program and Bt committee.

   (h) Forest Pest Control Forum.

3. Finalize jack-pine budworm study into Information Report: "Impact studies of the jack-pine budworm (*Choristoneura pinus pinus* Free.) in the Nisbet Provincial Forest of Saskatchewan.

4. Finalize status report on spruce budworm impact in Riding Mountain National Park for Parks Canada spring planning.

5. Prepare final report summarizing my results of the joint study on control of spruce seed and cone insects for Proctor and Gamble Co. and prepare a publication, possibly for Bi-Monthly Research Notes.

6. Formalize report for seed workshop proceedings as presented earlier at NFRC. Title of report--"The effects of insects on seed and cone production".

7. Provide consultory, editorial and identification service, and workshop--seminars on forest pests to federal, provincial and industrial agencies as requested.

15. <u>Publications</u>:

Up to 1979-80

Cerezke, H. F. 1977. Variation in shoot and needle growth patterns on 46-cm branch tips of healthy white spruce. Bi-Mon. Res. Notes 33:18-19.

Cerezke, H. F. 1977. Characteristics of damage in tree-length white spruce logs caused by the white-spotted sawyer, *Monochamus scutellatus*. Can. J. For. Res. 7:232-240.

Cerezke, H. F. 1978. Jack pine budworm, (*Choristoneura pinus pinus* Free.) in the Nisbet Provincial Forest of Saskatchewan: an anlysis of the current infestation. File Report NOR-143, 17 pp.

Cerezke, H. F., J. A. Drouin and B. Neill. 1978. Annual revision of insect pests and controls on shelterbelts, ornamental trees and shrubs. In WCCP Report (1978): pp. 55-63; 74-79; 82; 89-90.

Cerezke, H. F. 1978. Shelterbelt Protection. Summary presented in 1978 Proceedings of Shelterbelt Committee meeting, pp. 57-58.

Cerezke, H. F. and H. S. Gates. 1978. Woodborer survey in Weyakwin Burn, Saskatchewan. File Report NOR-143: 7 pp.

Cerezke, H. F. and I. K. Edwards. 1978. Canadian Forestry Service Report to the Environmental Sub-Committee of the Alberta Horticultural Advisory Committee. File Report NOR-143/135, 8 pp.

Cerezke, H. F. 1978. The budworms and survey and control advances. Presentation on spruce and jack pine budworm made in Winnipeg. File Rep. NOR-143.

Cerezke, H. F. 1978. (Contributions to NFRC Forestry Report on insects and diseases:)

(a) Spruce budworm - how important is it here in the west?
(b) Jack pine budworm.
(c) Birch leaf-mining sawflies.

1979-80

Cerezke, H. F. 1979. Examination of fire-damaged spruce, Nipiwin Burn, File Rep., 3 p.

Cerezke, H. F. 1979. Report on visit to Sibbald Flats, Campground, Alberta, File Rep., 3 p.

Cerezke, H. F. and I. K. Edwards. 1979. Canadian Forestry Service Report to the Environmental Sub-committee of the Alberta Horticultural Advisory Committee. File Rep. 143/135, 6 pp.

Cerezke, H. F. 1979. Report on Protection Section of Prairie Shelterbelt Committee, File Rep., 2 p.

Cerezke, H. F. 1979. Canadian Forestry Service Report to the Alberta Pest Control Advisory Committee. File Rep., 3 p.

Cerezke, H. F., J. A. Drouin. 1979. Annual revision of insect pests and controls on shelterbelts, ornamental trees and shrubs. In WCCP Report (1979): 14 p.

Cerezke, H. F. 1979. Effects of insects on seed and cone production. Slide-illustrated talk presented at Seed Workshop, Northern Forest Research Centre, Edmonton, November 14 - 15, 1979, 6 p.

Cerezke, H. F. 1979. Report on spruce budworm and other major forest insect pests of Western - Northern Region for Seventh Ann. Meeting Forest Pest Control Forum, Ottawa, 3 pp.

16. Signatures:

Herbert F Cerezke
Investigator

K J Johnson
Program Manager

G.T. Silver
Director G. T. Silver

PROJECT NOR-22

Remote sensing application

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 12, 1980

1. Project: Remote Sensing Applicaiton.

2. Title: Remote sensing and technical advisory services.

3. New: Cont.: X 4. No.: NOR-22-142

5. Study Leader: C.L. Kirby

6. Key Words: Assessment, environment, forest regeneration, forest growth and yield, inventory, aerial photography, satellite imagery.

7. Location of Work: Alberta, Saskatchewan, Manitoba and Northwest Territories.

8. Problem:

   Rapid developments in remote sensing and increased concern with the environment have increased the demand for baseline information. New sensors in aircraft and satellites require development of applications and education of users on new technology.

9. Study Objectives:

   1. To develop and apply new remote sensing techniques and sampling designs for forest inventories and environmental management in cooperation with industry, provincial governments and other federal agencies.

   2. To provide advisory services in survey design, interpretation and analysis.

   3. To maintain an image acquisition and analysis laboratory for cooperative studies.

   4. To develop improved forest management information systems.

10. Resources:

a. Starting date: 1973
b. Estimated year of completion: Continuing
c. Estimated total Prof. Man-years required: 1.0
d. Essential new major equipment items for 1980-81 with costs:
e. Essential new major equipment items beyond 1980 with costs:

Camera and Radar Pod $30,000.00

f. 1979-80 man-years Prof. 1.0
Supp. 1.0
Total 2.0

11. Progress to Date:

1. An efficient low-cost 70 mm camera system with radar altimeter has been developed for sampling of forest stands and regeneration. Tests and applications have been done in the Yukon, NWT, Alberta, Saskatchewan and Manitoba. The system may be operated from fixed or rotary wing aircraft. It has the only radar presently available that is suitable for sampling of forest regeneration where flying heights of 70 to 150 m above ground are used.

2. Computer programs for large-scale photo sampling and ground plot compilation into average stand and stock tables, and a map information system have been developed for use in the region. These programs are being used increasingly by industry and government agencies and reducing their forest inventory costs significantly.

3. A multistage sampling design applicable to forest appraisals utilizing measures from ground sampling, aerial photography and satellites has been developed and tested in the Boreal and Sub-alpine forest region. Applications of the highly efficient forest inventory design have been completed by Simpson Timber Co., NWT and Yukon Forest Services.

4. Advisory services in remote sensing has been provided to clients in this region.

5. Aerial photography at various scales has been obtained with in-house equipment or through contracts as required for specific projects.

6. Serve as member of the Canadian Advisory Committee on Remote Sensing (CACRS) working group for forestry, wildlife and wildlands remote sensing applications, and the Alberta Remote Sensing working group which provides an annual (past eight years) one week training session in remote sensing.

7. Serve as chairman of the Canadian Institute of Forestry Remote Sensing working group which sponsored a two day workshop on remote sensing forestry in November, 1977, and as chairman of a 2nd workshop on practical applications of remote sensing in forest inventory. (Sept. 26-28, 1979) This 2nd workshop was sponsored by N.F.R.C., Alberta Remote Sensing Centre, Alberta Energy and Natural Resources and the Canada Centre for Remote Sensing. It was attended by approximately 100 delegates from across Canada and with some delegates from the U. S. A.

12. Goals for 1979-80:

1. To enter into a cooperative cost sharing project with N.W.T., McKenzie Forest Service. The objective will be to develop applications and assist in transfer of existing technology to a resource inventory and map information system for their timber management and fire control purposes.

2. To act as chairman of a three day workshop on Remote Sensing and Forest Inventory to be held prior to C.I.F. meeting in Jasper and to present two papers at the workshop: Large-scale Photo Sampling; Multistage Forest Inventory.

3. To present a paper on large-scale photo sampling at an international workshop to be held at the University of Idaho, September 10 to 14.

4. To assist in a technology transfer display at the Jasper C.I.F. meeting illustrating mini computer applications for map information system and large-scale photo sampling programs.

5. To obtain a controlled test of large-scale photo sampling with and without measurement of tip and tilt in cooperation with the provinces of Alberta and Saskatchewan.

6. To obtain DOT approval of our helicopter camera mount.

14. Accomplishments in 1979-80:

1. A cooperative cost sharing project between the N.W.T. Forest Service and Northern Forest Research Centre was initiated. The N.W.T. provided $36,000.00 for contract and operating funds. The objective of the project is to develop a resource inventory and map information system for fire and timber management on a 1 1/2 million ha pilot area. The Northern Forest Research Centre is supervising contracts and providing aerial photography, computer programming and coordination to accomplish the objective of the project.

2. Chairman of a workshop on "Remote Sensing and Timber Inventory". This was a three day workshop held at the Chateau Lacombe, September 26-28 sponsored by: Alberta Energy and Natural Resources (Forest Service), Alberta Environment (Remote Sensing Centre), Canada Centre for Remote Sensing and the Northern Forest Research Centre. One hundred delegates from across North America attended and 26 papers were presented.

3. Participated in 5-day workshop on forest inventory held at Fort Collins, Collorado. Did not present paper at International Symposium of Remote Sensing because of time required to chair workshop in Edmonton (Item 2 of accomplishments).

3. Assisted in CFS technology transfer display showing computer mapping applications and large-scale photo measurement and compilation with a desk top computer.

5. Obtained a comparative test of FMI and NFRC large-scale photo sampling systems with photography at Simpson Timber Company lease near Whitecourt, Alberta. The results are being analyzed under contract supervised by Dr. P. Gimbarzeusky of the National Forestry Institute.

6. DOT approval not obtained for large-scale photo sampling helicopter mount. Estimates indicate that $30,000.00 will be required to construct a camera and radar antenna pod that may be safely and speedily mounted on helicopters to provide a portable photo sampling system for National needs. This could provide a service for the CFS in Canada.

7. Aerial photo contract for detection and mapping of mountain pine beetle in southern Alberta was supervised.

14. <u>Goals for 1980-81</u>:

1. To enter into a cooperative project with the Pacific Forest Research Centre (PC-48-370) and the Yukon Forest Service, to assess forest regeneration 20 cm and taller and forest habitats. The Northern Forest Service will provide assistance in sampling design and analysis techniques and will supervise the obtaining of aerial photography for the project.

2. To develop a request for proposal and development of an interactive resource data base for estimates of forest biomass for regional and national needs (NOR-34-180). This will involve a computerized mapping and data base management. Other applications of the system may be for the National Forest Statistics program.

3. To develop a cooperative project with the Manitoba Forest Service and Abitibi - Price Co. at Pine Falls to transfer

technology in large-scale photo sampling and computer mapping and information system for improved selection of areas for silvicultural treatment and prescription.

4. To obtain aerial photography for:
   a. assessment of mountain pine beetles damage (in house project).
   b. assessment of habitat damage on Banff Park Trails in the Sunshine area (University of Calgary & Parks Canada project).

5. To assist other regional establishments of the CFS requiring large-scale photo sampling applications.

15. <u>Publications</u>:

Up to 1979

Van Eck, P.I. and Bihuniak, P. 1977. A two-camera intervalometer with a sampling option. Photogram. Eng. Remote Sensing. 44 (3): 285-287.

Kirby, C.L. and P.I. Van Eck. 1977. A Basis for Multistage Forest Inventory in the Boreal Forest Region. *In*: Proceedings of Fourth Canadian Remote Sensing Symposium).

Kirby, C.L. and P.I. Van Eck. 1977. An aerial photography and interpretation service at the Northern Forest Research Centre. File Report.

1979-80

Kirby, C.L. and R.J. Hall. 1979. The estimation of logging residues using large-scale aerial photographs. p.57-62. *In* Proc. International Fire Management Workshop. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-215.

Kirby, C.1. and R.J. Hall. 1979. The large-scale photo sampling system at the Northern Forest Research Centre. presented at the Practical Applications of Remote Sensing to Timber Inventory Workshop. Edmonton, Alta. *In* proceedings.

Kirby, C.1. 1979. Applications of multistaged and multiphased timber inventories. presented at the Practical Applications of Remote Sensing to Timber Inventory Workshop. Edmonton, Alberta. *In* proceedings.

Kirby, C.L. and R.J. Hall. 1980. Description and accuracy evaluation of the Honeywell radar altimeter (In press as an Informaiton Report NOR-X-222).

Kirby, C.L. 1980. A camera and interpretation system for assessment of forest regeneration. (In press as an Information Report NOR-X-221).

16. Signatures:

Investigator

Program Manager

Director

PROJECT NOR-23

Land and vegetation resource inventory of Banff and Jasper national parks

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1980

1. Project: Land and vegetation resource inventory of Banff and Jasper National Parks.

2. Title: Land and vegetation resource inventory of Banff and Jasper National Parks.

3. New: Cont.: X   4. No.: NOR-23-148

5. Study Leader: W. D. Holland

6. Key Words: Resource inventory, land inventory, biophysical mapping, vegetation inventory, land use interpretation guides

7. Location of Work: Banff and Jasper National Parks and Northern Forest Research Centre, Edmonton

8. Problem:

The National Parks Service have requested assistance to meet a number of objectives of the National Parks Inventory Program. The request indicates a need for knowledge of the kinds of soil and vegetation and their distribution in the National Parks system. The knowledge will be used for such purposes as:

1. determining soil limitations for certain land uses, e.g. soils subject to flooding, landslides, droughtiness; load bearing ability for access roads, trails, buildings; slope, drainage, permeability; soil depth, texture, stoniness; productivity for vegetation of different kinds, fertility levels, etc.

2. providing background information for impact assessments and environmental monitoring.

3. providing the Parks personnel, wardens, planners, and managers with interpretative guidelines for use of land for various purposes. Knowledge pertaining to soil characteristics and how they affect soil quality will assist in evaluation of the degree and kind of risk or hazard (soil limitations) that a certain soil may have for specific, selected National Park uses.

4. provision of information on forest cover and vegetative communities. Such knowledge assists in fuel-type mapping, establishment fragility ratings, determining productivity of alpine and winter ranges, successional stages and advance growth, and understory components.

5. assisting, if necessary, with interpretation of the information for Parks personnel preparing master plans of the Parks.

9. Study Objectives:

To provide a land, soil, and vegetation inventory of Banff and Jasper National Parks, including maps and report, and research studies, plus interpretation of data for land use planning and management within the Parks.

10. Resources:

a. Starting date: April 1974
b. Estimated year of completion: March 31, 1981
c. Estimated total Prof. man-years required: 30
d. Essential new major equipment for 1980-81 with costs: Nil
e. Essential new major equipment beyond 1981 with costs: Nil
f. 1980-81 man-years: Canadian Forestry Service

Prof.	2.0	W. D. Holland, Ian G. W. Corns
Supp.	2.0	D. T. Allan, J. Dyck
Casual	0	
Total	4.0	

Alberta Institute of Pedology and Land Resource Research Institute

Prof.	4.0	G. M. Coen, B. D. Walker, W. S. Taylor, P. L. Achuff
Supp.	4.5	Janet Marsh, Bev. Berteau Tom Hilborn, Goldwyn McEwen Soils Lab at U.or A.

11. Progress to Date:

Summary of field work progress since 1974:

VEGETATION AND SOIL SAMPLING

	Banff	Jasper
No. of vegetation plots	2138	1877
No. of vegetation types	93	93
Bryophytes and lichens collected	≃9000	≃9800
Vascular plants collected	≃5000	≃7500

	Banff	Jasper
Soil observation points (daily & notebook)	2541	3748
Soil laboratory samples	780	891
Notebook records	686	1853
CanSIS soil description sheets:		
Daily forms	1832	1870
Semi-detail	1	18
Detailed (sampling sites)	132	131
Approximate total area	2565	4200
Approximate area completed:		
Square miles	2565	4200
% of total	100	100

The project is on schedule except for backlogs of identifications of vascular plants from the 1979 season and soil analyses from 1978 and 1979 samples.

Interim reports have been submitted annually, but are not required for 1979-80.

12. Goals for 1979-80:

1. Completion of Progress Report No. 5 for Banff. Because the final report will commence in the fall of 1979, this year's interim will be abbreviated to annotated Itek air photos, legend, and descriptions of new map units encountered in the 1978 map area.

2. Completion of Progress Report No. 4 for Jasper.

3. Completion of any sampling and/or correlation of map units for Banff. The field work in Banff is essentially complete, thus the time commitment is short for any clean-up work in Banff.

4. Completion of the soil and vegetation inventory in Jasper; approximately 1330 square miles in the northern portion of the Park.

5. Continued cooperation with the Land Resource Research Institute (SRI) development of the CanSIS data bank.

6. Continuation of committee meetings, seminars, workshops, assistance with site specific problems as requested by National Parks, or others.

*7. Continuation of phytosociological investigation of Banff and Jasper.

*8. Continuation of floristic investigations of Banff and Jasper.

9. Supervision of contract with Dr. D. Vitt for identification and report on bryophytes and lichens collected in Banff and Jasper.

10. To continue developing a method of obtaining better integration of the wildlife resource component with the soil and vegetation component.

*11. To develop a method of computer-plotting plant species distributions or ranges on a small scale map, with the help of CFS, Edmonton.

*12. To further develop vegetation classification programs to facilitate comparison of plot data from many plots, with help of CFS (Bill Chow).

*13. To submit thesis manuscript(s) for publications.

* I.G.W. Corns

13. <u>Accomplishments in 1979-80</u>:

1. Walker, B. D., P. L. Achuff, W. S. Taylor, J. R. Dyck, and J. E. Marsh. 1979. Biophysical land classification of Banff National Park, Progress Report No. 5, 1979-80. G. M. Coen, W. D. Holland, Eds. Northern Forest Research Centre, Edmonton. 24 pp. plus 5 appendices.

2. Wells, R. E., I.G.W. Corns, and D. T. Allan. 1979. Biophysical land classification of Jasper National Park, Progress Report No. 4 1979-80. G. M. Coen, W. D. Holland, Eds. Northern Forest Research Centre, Edmonton. 41 pp. plus 5 appendices.

3. Project field work is complete in Banff. An instrumented Cryosol (permanently frozen soil) is being serviced monthly in the Red Deer valley. Permanently frozen soils occurring under forest vegetation have not previously been known to the Canadian Rocky Mountains. A total of 25-30 such locales, each usually less than 200 ha in extent, are known along the eastern mountain ranges of Banff and Jasper Parks.

4. Field work is complete in Jasper. No further field work is anticipated.

5. Cooperation continued with the Land Resource Research Institute (formerly SRI) development of the CanSIS data bank. May and December meetings were in Calgary and Winnipeg.

6. Project liaison activities involved interaction of biophysical team personnel with people and agencies within and outside of Parks Canada, reflecting an increased awareness of the accomplishments of the biophysical team. Included are:

   a. Interim report presentations to Parks Managers in Jasper and Banff, May 1979.

   b. Biophysical data management, including pilot project meetings with CanSIS personnel, Calgary, May 1979, Winnipeg, Dec. 1979.

   c. Advice to Parks Canada WRO re:
      - environmental impact at upper terminus of Jasper sky tram at Whistler Mountain.

      - environmental impact of proposed ski development expansion at Marmot Basin, Jasper.

      - twinning of Trans Canada highway in the eastern part of Banff.

      - interpretive service queries.

      - review of IEE for proposed Lake Louise village expansion.

      - preparation of IEE for Whitehorn Mountain ski area development, Banff.

   d. Advice to Parks Canada PRO re: means of best "salvaging" information from the Kluane National Park biophysical, which was not done to the satisfaction of Parks Canada.

   e. Consultations to CWS personnel not participating in the Banff-Jasper biophysical:

      - determination of vegetation types of wildlife exclosures in Jasper and Banff Parks for G. Trottier.

      - identification of plant collections for H. Reynolds (Jasper Bison Study) and for J. McGillis.

   f. Two lectures to forest-soils students at University of Alberta dealing with the importance of soils to forest recreation facility development.

g. Seminar presentation to U. of A. Botany Department staff and students - "Vegetation-Soil Relationships in Banff and Jasper National Parks"

h. Seminar presentation to U. of A. Dept. Soil Science staff and students - "An Integrated Resource Inventory in the Rocky Mountains".

i. Presentation of methodology paper to the American Society of Agronomy meetings, Fort Collins, August 1979.

j. Submission of manuscript dealing with Cryosolic soils in Banff and Jasper National Parks to Canadian Journal of Soil Science.

k. Participation in the development of Ecoregions map of Alberta and Canada through the provision of data and participation in committee meetings of Ecoregions Working Group - C-C-E-L-C.

l. Liaison with individuals involved with the preservation of Alberta natural areas.

m. Consultation to private consultants using biophysical data re:

  - proposed Trans Canada highway twinning through Banff Park, G. Rogers, Thurber Consultants.

  - vegetation on ski slopes at Lake Louise and Mt. Norquay, D. Walker, reclamation consultant.

  - location of Wilcox Pass - Tangle Creek trail, Dr. D. Pattie, consultant to Parks Canada.

n. Consultation to J. Benson, Supervisor, Forest Inventory, Saskatchewan Tourism and Renewable Resources, regarding applicability of Banff-Jasper biophysical inventory methodology to Saskatchewan forest inventory and mapping.

o. Consultation to U. of A. Forest Science graduate students regarding their thesis research.

  - ecology of burned subalpine forests in Kananaskis Park and their similarity to adjoining burned forests in Banff Park - B. Hawkes.

  - ecology of nitrogen-fixing shrubs and their potential for revegetating oil sand spoils at Fort McMurray - J. McLean.

p. Advice to Cliffe White, graduate student and Banff Park warden re his plans to prepare a fire management plan for Banff Park using the biophysical inventory as the base.

q. Consultation to CFS and forest industry colleagues regarding their respective research interests.

- use of stem analysis for dendrochronology, J. Powell (NFRC), M. Parker, L. Jozsa, Western Forest Products Lab (FORINTEK)

- determination of forest types in H. Zalasky's plot areas south of Grande Prairie

7. General phytosociological investigation was extended into the northwest portion of Jasper National Park into the upper Snaring, Snake Indian, Smoky and Miette River valleys. Three new vegetation types were added to the integrated Jasper-Banff vegetation descriptions, bringing the total to 93 for both Parks.

8. General floristic investigation was continued in the field survey areas listed above. Approximately 100 new species, mostly lichens and mosses, were added to the previous collections for Jasper and Banff. Range extensions of several species were noted. Checklists of vacsular and non-vascular plants are being updated.

9. Identification of approximately 3,000 bryophyte specimens collected in Jasper and Banff during 1979 has been completed by Dr. Dale Vitt, Dept. of Botany, U. of A.

10. Work has continued towards better integration of the wildlife resource with the physical and vegetation components, through the efforts of Geoff Holroyd, CWS wildlife biologist and of the soils-vegetation team who have tested various suggestions as to how the soils-vegetation information might be enhanced to reflect meaningful relationships to wildlife. Future resource inventory work in Kootenay, Glacier and Mount Revelstoke Parks will likely earlier involve the participation of wildlife biologists on the field survey teams.

11. We now have the capability of computer-plotting plant species distributions and ranges on a small scale map of Banff and Jasper Parks. This development should have application in the final report and in a journal publication dealing with rare and unusual species in Jasper and Banff.

12. A computer program has been prepared which facilitates tabular comparisons of data from many plots. A complementary program to this is currently being developed to retrieve data from the computer files and to tabulate soil and site information for these plots. Cluster analysis and ordination programs are being adapted to our data format.

13. Two manuscripts from I. Corns' Ph.D. thesis are still in preparation.

14. <u>Goals for 1980-81</u>:

1. Completion and publication of final reports for Banff and Jasper Parks. Both parks are included in one report but are planned in 4 volumes:

Vol. I	General description and summary
Vol. II	Detailed soil and vegetation descriptions
Vol. III	Wildlife description and ecological relationships
Vol. IV	Interpretative Field Guide (A committee of Parks Canada, CFS, and AIP is currently being established to outline the format of this volume.)

2. Continued cooperation with the Land Resource Research Institute.

3. Initiation of the Biophysical (Ecological land classification) agreement with Parks Canada for Kootenay, Mount Revelstoke, and Glacier National Parks and commencement of field reconnaissance work.

4. Continuation of committee meetings, seminars, workshops, and assistance with site specific problems as requested by Parks Canada or others.

5. As time permits, preparation of thesis manuscripts for publication.

   a. Vegetation Indicators as Independent Variables in Forest Growth Prediction Equations

   b. Forest Types of Western Alberta Foothills in Relation to Environmental Factors

6. As time permits preparation of manuscript(s) for journal publication dealing with vegetation of Banff and Jasper National Parks.

   a. Vegetation-habitat relationships in Banff and Jasper National Parks.

   b. Rare and unusual vascular plants collected in Jasper and Banff National Parks.

c. Rare and unusual lichens collected in Jasper and Banff National Parks.

d. Rare and unusual mosses collected in Jasper and Banff National Parks.

e. Preparation of brochure - "Applications of the Banff-Jasper Resource Inventory".

f. Podzolic soils with deep Ae horizons in Jasper National Park.

7. Further explore ways and means by which the Banff-Jasper data bank can be used to further develop our understanding of soil/site-vegetation relationships in forest and non-forest environments.

15. <u>Publications</u>:

Twardy, A. G. and I.G.W. Corns. 1980. Soil survey of the Wapiti map area, Alberta. Alberta Institute of Pedology Report No. 39. In press.

Walker, B. D., S. Kojima, W. D. Holland, and G. M. Coen. 1978. Land classification of Lake Louise study area, Banff National Park. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-160.

Walker, B. D., P. L. Achuff, W. S. Taylor, and J. R. Dyck. 1978. Biophysical land classification of Banff National Park. Progress Report No. 4 (1977-78). Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta.

Walker, B. D., P. L. Achuff, W. S. Taylor, J. R. Dyck and J. E. Marsh. 1979. Biophysical land classification of Banff National Park. Progress Report No. 5 (1978-79). Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta.

Wells, R. E., I.G.W. Corns, D. T. Allan, and J. R. Cuddeford. 1978. Biophysical land classification of Jasper National Park. Progress Report No. 3 (1977-78). Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta.

Wells, R. E., I.G.W. Corns, and D. T. Allan. 1979. Biophysical land classification of Jasper National Park. Progress Report No. 4 (1978-79). Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta.

16. Signatures:

W. D. Holland
Investigator

Rev Reid
Program Manager

for G. W. Comer
Investigator

GTSilver
Director G. T. Silver

APPENDIX A

CanSIS Meeting with Parks Canada, Winnipeg

Current Status of Banff-Jasper Biophysical Computer Files--Data and Programs

A. DATA

1. Vegetation

All Banff and Jasper 1975-78 plot data (3230 plots) keypunched, edited and stored on magnetic tape. Plot data from 1979 season are keypunched and stored on magnetic tape but are not yet edited or updated with plant collection identifications.

2. Soils

a. Daily

- all 1974-76 Banff and Jasper daily (green) forms keypunched, edited and stored on magnetic tape in Edmonton

- All 1977-78 Jasper green forms keypunched and edited

- 1977-78 Banff green forms currently being keypunched, editing to follow

- 1979 Jasper dailies being updated with map units etc. prior to keypunching.

b. Detailed

- all 1974-76 Banff and Jasper detailed descriptions (green) and analytical data (gold) keypunched

- all 1977 Banff and Jasper detailed descriptions and analytical data sent to CanSIS but not yet returned

- 1978-79 sample data to be sent for keypunching when laboratory work done

- 1974-76 Sample data edited on printout (computer file not yet edited)

Daily forms keypunched at CFS Edmonton, detailed forms sent to LRRI for keypunching.

B. PROGRAMS

1. Vegetation

   a. Vegetation data edit program functional.

   b. Ceska-Röemer stand classification program functional.

   c. Cluster analysis and ordination programs being adapted to our data format.

   d. Have interface of vegetation and soils files.

   e. Plot locations on small scale map (species distribution) program functional.

   f. Vegetation table program.

2. Soils

   a. Soils edit program functional as soon as tables prepared.

   b. Soils sort program functional as soon as tables prepared. Input is tabular summary data for each plot including landform, drainage, calcareousness, soil subgroup, texture, vegetation type, elevation and map unit.

December 11, 1979

I.G.W. Corns

PROJECT NOR-24

AOSERP: Effects of SO_2 on vegetation

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

1. Project: AOSERP: Effects of SO_2 on vegetation.

2. Title: Symptomology and threshold levels of air pollutant injury to vegetation.

3. New: Cont.: X 4. No.: NOR-24-157

5. Study Leaders: S. S. Malhotra, P. A. Addison

6. Key Words: Sulfur dioxide, plants, symptomology, injury thresholds, tolerance.

7. Location of Work: Alberta oil sands area and Northern Forest Research Centre.

8. Problem:

Delineation of SO_2 effects on vegetation in the field requires rapid diagnosis of symptoms of injury that may be due to any of a variety of causes. Since symptom expression and threshold levels of pollutant injury to vegetation is dependent upon a number of plant and environmental factors, it is absolutely necessary that such studies be carried out under controlled fumigation and environmental conditions. The present air quality standards lack adequate experimental support. It is therefore highly desirable that in the light of Alberta species and climate, new air quality standards be established.

9. Study Objectives:

   1. Describe visible and microscopic effects of air pollutants on selected vegetation from the oil sands area in order to develop techniques to identify and assess the impact of air pollutants on vegetation.

   2. Determine in quantitative terms, the threshold levels of air pollutant injury to species native to the oil sands region.

3. Screen candidate revegetation species for tolerance to air-borne pollutants under climatic stress conditions.

10. Resources:

a. Starting date: 1975
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: Nil
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years: Nil (Study terminated)

11. Progress to Date:

A fumigation chamber has been designed, constructed and further modified to provide a 4 x 8 foot plant growing area with controlled temperature, humidity, light and pollutant concentration (SO_2 and NO_x). Several boreal plant species have been fumigated at 0.34 ppm SO_2 (one of the ambient air quality standards) for up to 60 days during which CO_2 gas exchange and physical condition of the individuals were monitored. A species sensitivity list has been created based upon the rate of decline of CO_2 gas exchange and visual symptom development with time after 0.34 ppm SO_2 was added to the environment. Results indicate a distinct separation between conifer and broad-leaf species as well as some differences among species in each group. In order of physiological tolerance and visual symptom development, the species studied are willow, paper birch, trembling aspen, green alder, labrador tea, white spruce, black spruce and jack pine.

A group of plant species (jack pine, white and black spruce, willow, aspen and caragana) that were planted on the Suncor Inc. tailings dike several years ago were collected in their soil, brought into the laboratory, fumigated with 0.34 ppm of SO_2 and compared where possible with the same species in natural soil. Results are currently being synthesized.

12. Goals for 1979-80:

1. Test revegetation species (to be supplied by Alberta Forestry and/or Alberta Agriculture) as to their tolerance to SO_2 under controlled conditions in the laboratory. Tolerance will be determined in physiological terms using CO_2 gas exchange rates and in visual terms using photographic observations. (Malhotra, Addison)

2. Complete the stomatal resistance study as outlined in 1978-79 goals. (Addison, Malhotra)

3. Write up and report the final AOSERP report. (Malhotra, Addison)

Added Goal

4. Write up and submit to AOSERP the Interim Report of Symptomology and threshold levels of Air Pollutant Injury to Vegetation, 1978-79 (Addison, Malhotra).

13. Accomplishments in 1979-80:

1. Plant material was not provided by Alberta Forestry or by Alberta Agriculture but a trip was made to the tailings dike at Suncor and collections of plants that have survived both transplanting and the tailings dike environment were made. These revegetation species were grown in the laboratory for a short time and then fumigated with 0.34 ppm SO_2. Results are currently being synthesized.

2. The stomatal resistance study was terminated before completion owing to time constraints caused by heavy involvement in departmental and interdepartmental committees by the researchers. Aspects of this study will be transferred to NOR-7-114.

3. Data from the fumigation chamber experiments is being synthesized and a paper that compares the plants in tailings sand with those in native soil will be submitted to AOSERP prior to March 31, 1980.

Added Accomplishment

4. The Interim Report of Symptomology and threshold levels of Air Pollutant Injury to Vegetation, 1978-79 is in press.

14. Goals for 1980-81:

The study was designed to meet its overall objectives by 1980 and was financially supported by the Province of Alberta to that date. The majority of the goals of this study have been accomplished and the remaining ones have been transferred to NOR-7-114. The study has been terminated.

15. Publications:

Up to 1979-80

Malhotra, S. S., P. Addison, R. Blauel, and S. K. Sarkar. 1977. Symptomology and threshold levels of air pollutant injury to vegetation and species tolerance. Pages 1-2 *in*: Malhotra, S. S. (ed.) The Effect of SO_2 on forest vegetation and soils of Alberta Oil Sands area. Annual Report (1976-77), Vegetation Technical Research Committee, AOSERP, Edmonton. 46 pp.

Malhotra, S. S. and P. A. Addison. 1978. Interim report of symptomology and threshold levels of air pollutant injury to vegetation, 1975 to 1978. *In*: Alberta Oil Sands Environmental Research Program Land System Report, L.S.3.1, Edmonton, Alberta. 18 pp.

1979-80

Addison, P. A. and S. S. Malhotra. 1979. Interim report of symptomology and threshold levels of air pollution injury to vegetation, 1978-79. Prep. for the Alberta Oil Sands Environmental Research Program by Canadian Forestry Service, Environment Canada. 17 pp.

16. Signatures:

Investigator	Program Manager
Investigator	Director G. T. Silver

NOR-24-159

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

1. Project: AOSERP: Effects of SO_2 on vegetation.
2. Title: Physiology and mechanisms of SO_2 injury.
3. New: Cont.: X   4. No.: NOR-24-159
5. Study Leader: S. S. Malhotra
6. Key Words: Sulphur dioxide, plants, injury mechanisms, physiology.
7. Location of Work: Alberta Oil Sands area, Northern Forest Research Centre.
8. Problem:

   Full understanding of plant injury thresholds requires a knowledge of the types of injury to be expected at different exposures and conditions, because injury development is a continuum, not a "yes" or "no" situation.

9. Study Objectives:

   1. Determine effects of SO_2 on central biochemical processes in forest species.

   2. Determine effects of SO_2 on subcellular organization and relate these results to Objective 1.

10. Resources:

    a. Starting date: 1975
    b. Estimated year of completion: 1980
    c. Estimated total Prof. man-years required: Nil
    d. Essential new major equipment items for 1980-81 with costs: Nil
    e. Essential new major equipment items beyond 1981 with costs: Nil
    f. 1980-81 man-years: Nil (Study terminated)

11. Progress to Date:

Biochemical and physiological research on the impact of SO_2 on forest species has shown that aqueous and gaseous SO_2 produce similar effects on plant metabolism. A number of techniques such as chlorophyll/phaeophytin ratios, peroxidase, acid phosphatase, ribulose 1, 5-diphosphate carboxylase, glycollate oxidase and malate dehydrogenase activities and changes in lipid and protein synthesis have been developed to detect air pollution injury to vegetation prior to visual symptom development.

Experiments conducted with pollution mixtures showed that in jack pine, SO_2 and NO_2 mixtures produced either additive or synergistic response.

Epaphytic lichens exposed to SO_2 exhibited a considerable inhibition in various biochemical functions even at very low concentrations of the pollutant.

This study has helped us understand the mechanisms of air pollutants (SO_2, NO_2 and heavy metals) action on selected forest vegetation and to develop several diagnostic techniques to detect air pollution injury to vegetation prior to visual symptom development.

12. Goals for 1979-80:

1. Study the effect of air pollutants on lichen membrane biochemistry (Malhotra, Khan)

2. Complete study on the effect of air pollution mixtures on plant metabolism. (Malhotra, Khan)

3. Utilizing the physiological and biochemical techniques developed in our lab, determine the impact of pollutants on forest vegetation from the "maximum impingement" and "control" sites in the Oil Sands area. (Malhotra, Khan)

4. Prepare and publish the following scientific papers:

   (a) The effect of SO_2 and other pollutants on peroxidase activity. (Malhotra, Khan)

   (b) The effect of SO_2 on organic acid content and malate dehydrogenase activity in jack pine needles. (Malhotra)

Additional Goals

5. Initiate a study on the biochemical and physiological responses of epiphytic lichens exposed to pollutants under field condition (Malhotra, Khan and Addison).

6. Write up and submit to AOSERP the Interim Report of Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1978-79. (Malhotra and Khan)

7. Write up and report in a scientific journal the manuscript entitled "Gas Liquid Chromatographic Method for Separation of Organic Acids and its Application to Pine Needle Extracts. (Malhotra)

13. <u>Accomplishments in 1979-80</u>:

1. Lichens because of their extreme sensitivity to air pollutants provide an excellent biomonitoring tool for atmospheric purity. Some of the biochemical changes that are brought about prior to visual injury by air pollutants were therefore studied. The experiments initiated with highly sensitive epiphytic *Evernia* sp. showed that 24-48 have exposure to SO_2 at 0.1 ppm concentration severely affected some of the important metabolic functions (photosynthesis, protein synthesis, acid phosphatase activity, lipid biosynthesis, chlorophyll content and potassium and magnesium efflux). These effects became progressively more severe and irreversible as the fumigation was continued. These results strongly support our earlier work with vascular plants. It is suggested that lichen membranes are considerably more sensitive to SO_2 than those of vascular species.

2. <u>Metals and SO_2 Studies</u>

   Exposure of pine seedlings to oil sands emission elements such as vanadium and nickel alone or in combination with gaseous SO_2 produced visual and metabolic changes. The visual changes were early browning of root hairs, root caps and later, the entire root surface. The foliage of these seedlings showed mild to severe dessication, wilting, tissue chlorosis leading to necrosis. Metals in the presence of SO_2 produced more severe visual symptoms.

   Physiological and biochemical techniques that were developed in previous years were utilized to detect air pollution injury to vegetation prior to visual symptom development. Metal treated plants showed marked differences from control plants in several key metabolic functions. These differences were evident even at very low concentrations. In general combined treatments with SO_2 and heavy metals produced increased metabolic injury. These studies indicate that there is a potential for heavy metal SO_2 injury to vegetation in the Oil Sands area. The concentrations of heavy metals found in Ft. McMurray soils are, however, fairly low to cause any problem at the present time.

NO$_2$ and SO$_2$ Studies

Plants exposed to different concentrations of NO_2 (0.2-2 ppm) showed very little or no visual symptoms even upon long exposures. However, exposure to SO_2 (0.34 ppm) for the same or shorter lengths produced characteristic chlorotic symptoms in pine and deciduous plants. Fumigation of pine and birch foliage with a mixture of SO_2 (0.34 ppm) and NO_2 (0.2 ppm) produced chlorotic symptoms which were not as severe as SO_2 alone, but in alder the mixture caused a more rapid appearance of these symptoms than SO_2 alone.

Physiological and biochemical analyses of the foliage exposed to these gases showed marked effects on the metabolic processes by either gas. These effects became either partially additive or synergistic in foliage exposed to a mixture of both SO_2 and NO_2. The differences in metabolic activities were evident even in the foliage showing no visual injury. These results are of a considerable significance in view of high rates of nitrogen oxide emissions from the Syncrude plant.

Since this study is being terminated this year as per our agreement with AOSERP, further work on pollutant mixtures will be continued under NOR-7-114.

3. Branches of jack pine were collected from the "maximum impingement" and "clean" areas around the oil sands operation and analyzed for several biochemical and physiological responses. No appreciable differences were found between the various sites indicating that to date no detectable injury to jack pine has taken place that can be attributed to emissions from the oil sands industry.

4. (a) The manuscript entitled "The effect of SO_2 and other pollutants on peroxidase activity" is in preparation.

   (b) The manuscript entitled "The effect of SO_2 on organic acid content and malate dehydrogenase activity in jack pine needles" has been published in Biochem. Physiol. Pflanzen.

Additional Goals:

5. Epiphytic lichen samples have been collected from 5 different locations around Suncor operation. These samples are currently being analyzed for various biochemical and physiological responses and pollutant content.

6. The Interim Report of Physiology and Mechanisms of Air Pollutant Injury to Vegetation, 1978-79 is in press.

7. The manuscript entitled "Gas-Liquid Chromatographic Method for Separation of Organic Acids and its Application to Pine Needle Extracts" has been published.

14. Goals for 1980-81:

The study was designed to meet its overall objectives by 1980 and was financially supported by the Province of Alberta to that date. The majority of the goals of this study have been accomplished and remaining ones have been transferred to NOR-7-114. The study has been terminated.

15. Publications:

Up to 1979-80

Hocking, D., S. S. Malhotra and R. Blauel. 1975. Environmental stress in the forest. Environ. Can., North, For. Res. Cent. For. Rep. 4(2).

Malhotra, S. S. and D. Hocking. 1976. Biochemical and cytological effects of sulphur dioxide on plant metabolosm. New Phytol. 76:227-237.

Malhotra, S. S. 1976. Effects of sulphur dioxide on biochemical activity and ultrastructural organization of pine needle chloroplasts. New Phytol. 76:239-245.

Malhotra, S. S. 1976. Physiology and mechanisms of air pollutant injury to vegetation. Proceedings of the First Annual Workshop of the Vegetation Technical Research Committee, AOSERP, Oct. 14 and 15, 1976. pp. 19-30.

Khan, A. A. and S. S. Malhotra. 1977. Effects of aqueous sulphur dioxide on pine needle glycolipids. Phytochemistry 16:539-543.

Malhotra, S. S. 1977. Effects of aqueous sulphur dioxide on chlorophyll destruction in *Pinus contorta*. New Phytol. 78:101-109.

Malhotra, S. S. and S. K. Sarkar. 1977. Physiology and mechanism of air pollutant injury to vegetation. Pages 2-23 *in*: Malhotra, S. S. (ed.) The effect of sulphur dioxide on forest vegetation and soils of Alberta oil sands area. Annual Report (1976-77), Vegetation Technical Research Committee, AOSERP, Edmonton. 46 pp.

Khan, A. A. and S. S. Malhotra. 1978. Biosynthesis of lipids in chloroplasts isolated from jack pine needle tissues. Phytochemistry 17:1107-1110.

Malhotra, S. S. and A. A. Khan. 1978. Effects of SO_2 fumigation on lipid biosynthesis in pine needles. Phytochemistry 17:241-244.

Malhotra, S. S. and R. A. Blauel. 1978. Effects of SO_2 on the forest ecosystem. Proceedings Canada-Venezuela Oil Sands Symposium 77. Canadian Institute of Mining Special Volume 17:714-719.

1979-80

Sarkar, S. K. and S. S. Malhotra. 1979. Gas-liquid chromatographic separation of common amino acids in pine needle extracts J. Chromatography. 170:371-378.

Sarkar, S. K. and S. S. Malhotra. 1979. Gas liquid chromatographic method for separation of organic acids and its application to pine needles. J. Chromat. 171:227-232.

Sarker, S. K. and S. S. Malhotra. 1979. Effects of SO_2 on organic acid content and malate dehydrogenase activity in jack pine needles. Biochem. Physiol. Pflanzen. 174:438-445.

Malhotra, S. S. 1979. Interim report of physiology and mechanisms of air-borne pollutant injury to vegetation, 1978-79. AOSERP report - in press.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

1. Project: AOSERP: Effects of air pollution on vegetation.

2. Title: Ecological benchmarking and biomonitoring for the detection of air pollution effects on vegetation and soils.

3. New: Cont.: X 4. No.: NOR-24-160

5. Study Leader: P. A. Addison and S. S. Malhotra

6. Key Words: Sulphur dioxide, boreal forest, air pollution, biomonitoring, soil nutrition, lichen communities.

7. Location of Work: Athabasca Oil Sands area and Northern Forest Research Centre.

8. Problem:

Long-term exposure to air pollution (especially SO_2) at low concentrations may result in dramatic changes in composition of plant communities and soils leading to forest decline. Early detection of such decline is critical to maintain environmental quality and to provide a basis for emission standards and controls review.

9. Study Objectives:

    1. Locate and inventory suitable vegetation reserve areas in the vicinity of oil sands leases; establish permanent benchmark plots.

    2. Establish a biomonitoring network through vegetation response units.

    3. Under controlled environmental and field conditions, determine the influence of air pollutants characteristic of oil sands operations on soil chemistry.

10. Resources:

    a. Starting date: 1975
    b. Estimated year of completion: 1980
    c. Estimated total Prof. man-years required: Nil
    d. Essential new major equipment items for 1980-81 with costs: Nil
    e. Essential new major equipment items beyond 1981 with costs: Nil
    f. 1980-81 man-years: Nil (Study being terminated.)

11. Progress to Date:

Biomonitoring plots were established at 13 locations at various distances and directions from the oil sands operations. Sites were described with respect to vascular and cryptogam species lists, stand age and density, cones and frequency of understory plant species, soil type and characteristics, and condition of vegetation. Vegetation samples were collected from six species and analyzed for S, Fe and Al. Five sites were established and described (as above) in a gradient SW of GCOS. In addition to site description, pine and spruce material was collected, brought to NFRC and analyzed for biochemical and physiological characteristics. Lichen transplants were used to determine the impact of GCOS emissions on community structure and composition and on factors such as available K^+ and Mg^{++} and general physical condition. Soils both under a canopy and in the open were sampled in detail and analyzed at two sites. A complete reexamination of all biomonitoring sites was done in 1979 and the results were compared with the baseline state of the sites (1976) with respect to the factors described above. In addition, both total deposition and gaseous sorption at all sites were measured throughout the growing season.

12. Goals for 1979-80:

    1. Determine the pattern of pollutant deposition at biomonitoring sites in the Athabasca Oil Sands area by:

        a. Collection and analysis of precipitation.
        b. Entrapment of SO_2 by sulphation plates.

    2. In order to determine changes in air pollutant effects on forest vegetation and soil, reexamine all biomonitoring plots (13) in the Athabasca Oil Sands area by determining:

        a. Stand age and density.
        b. Vascular species composition and cover.
        c. Lichen species composition and cover.
        d. Soil characteristics.
        e. Pollutant content of vegetation and soils.
        f. Crown condition of dominant tree species.

3. Reexamine lichen transplants (physiological and community) at the gradient sites to assess the biomonitoring methods as to its future usefulness.

4. Write information report on "The pattern of pollutant deposition in the Athabasca Oil Sands area as determined by a survey of lichens".

5. Write final report to AOSERP on "Changes in biomonitoring plots from 1976 to 1979 in the Athabasca Oil Sands area".

13. Accomplishments in 1979-80:

1. Both total and gaseous deposition were measured at all biomonitoring sites in the Athabasca Oil Sands area throughout the growing period. Total deposition collectors were placed on the top of three trees at each site and sulphation plates were located, in duplicate, in three microenvironments of each stand.

2. Each of the 13 biomonitoring sites in the Athabasca Oil Sands area was described with respect to stand age and density, vascular and cryptogamic species composition and cover, soil physical characteristics, chemical content of selected species and all soil horizons and the condition of the crown of the stand. Data are currently being compared with baseline measurements made in 1976.

3a. Lichen transplant communities at the 5 gradient sites were sampled photographically and the cover and frequency of four species groups were compared with data collected when the branches were installed at the sites. A paper describing the changes in lichen communities from 1977 to 1979 is in the initial stages of preparation for publication.

b. Lichen material (*Evernia mesomorpha*) was collected from the transplanted branches installed in 1977. Potassium and magnesium efflux in water and sulphur content have been determined. Results indicated that there has been continued degradation of the lichen material (increased K and Mg efflux) but that it was unrelated to sulphur uptake or to tissue concentration.

4. A paper entitled "Deposition of atmospheric pollutants as measured by lichen element content in the Athabasca Oil Sands area" has been written in conjunction with Dr. K. J. Puckett (AES) and is currently under review at NFRC.

5. Data from the 1979 field and laboratory analyses of the biomonitoring plots have been synthesized and will be compared with 1976 data. A paper describing the changes in the biomonitoring plots will be submitted to AOSERP prior to March 31, 1980.

14. Goals for 1980-81:

The study was designed to meet its overall objectives by 1980 and was financially supported by the Province of Alberta to that date. The goals of this study have been accomplished and the study terminated.

15. Publications:

Up to 1979-80

Blauel, R. A. 1975. Inventory Design Comments (AOSERP Vegetation Committee). File Report.

Addison, P. A. 1976. Ecological benchmarking and biomonitoring for detection of SO_2 effects on vegetation and soils. p. 31-37. *In*: Proceedings of the Vegetation Research and Technical Committee meeting, October, 1976. AOSERP, Edmonton. 182 pp.

Addison, P. A. 1976. Soils of the air pollution benchmark sites in the Athabasca Oil Sands Area. Canadian Forest Service. File Report NOR-7-160.

Blauel, R. and D. Hocking. 1976. Forest condition as benchmarked in the Alberta Oil Sands Area prior to 1976 by Northern Forest Research Centre. File Report NOR-7-160.

Addison, P. A. and J. Baker. 1977. Ecological benchmarking and biomonitoring for detection of SO_2 effects on vegetation and soils. Pages 22-46 *in*: Malhotra, S. S. (ed.), The effect of sulphur dioxide on forest vegetation and soils of Alberta Oil Sands area. Annual Report (1976-77), Vegetation Research and Technical Committee, AOSERP, Edmonton. 46 pp.

Baker, J. 1977. Nutrient levels in rainfall, pine foliage and soils of the Oil Sands area of Alberta. File Report NOR-24-160.

1979-80

Addison, P. A. 1979. Baseline condition of jack pine biomonitoring plots in the Athabasca Oil Sands area, 1976-77. Inf. Rep. NOR-X-215.

Addison, P. A. and J. Baker. 1979a. Interim report of ecological benchmarking and biomonitoring for detection of airborne pollutant effect on vegetation and soils, 1975 to 1978. Prep. for Alberta Oil Sands Environmental Research Program by Canadian Forestry Service, Environment Canada. AOSERP Report No. 46. 38 pp.

Baker, J. 1979. Soil and foliar composition as influenced by cover and distance from a pollutant source. Inf. Rep. NOR-X-300. 27 pp.

Addison, P. A. and J. Baker. 1979b. Interim report on ecological benchmarking and biomonitoring for detection of airborne pollutant effects on vegetation and soils, 1978-79. Prep. for the Alberta Oil Sands Environmental Research Program by Canadian Forestry Service, Canada Dept. of Environment. 17 pp.

16. Signatures:

P.A. Addison
Investigator

Program Manager

Investigator

Director G. T. Silver

PROJECT NOR-27

Biogeoclimatic ecosystem classification of the Province of Alberta

NOR-27-169

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1980

1. Project: Biogeoclimatic ecosystem classification of the Province of Alberta.

2. Title: Biogeoclimatic ecosystem classification of the Province of Alberta.

3. New: Cont.: X 4. No.: NOR-27-169

5. Study Leader: G. J. Krumlik, J. D. Johnson

6. Key Words: Ecosystem classification, biogeoclimatic zone, forest vegetation classification, vegetation-environment relationships, forest site classification

7. Location of Work: The Province of Alberta

8. Problem:

In order to develop ecologically-sound forest management and practices, a necessity to obtain basic information on forest ecosystems at a generalized as well as detailed level has been strongly recognized in the Province of Alberta.

In 1976, the Alberta Forest Service and the Canadian Forestry Service have reached an agreement of the Northern Forest Research Centre to undertake a research project, on cost-sharing basis, to meet this demand.

The goal of the project is to develop an ecological classification of the forested part of the province at the level of biogeoclimatic zone, subzone and forest ecosystem type. It was understood that the study would follow basically the concept and approach of biogeo-climatology developed by V. J. Krajina of the University of British Columbia

Such a classification system will provide useful ecological guidelines and rationale to formulate forest management and practices at a regional as well as operational levels. Incidentally it also enumerates ecological assets of the province.

During the course of the project biogeoclimatic zones will be identified, described, and mapped at a scale of 1:1 million. A biogeoclimatic zone represents a high level of generalization of ecosystems at a regional level. It is a geographical area characterized by the same macroclimate, predominant soil forming processes, and climatic climax vegetation. It serves, therefore, as an ecological framework of the province for developing strategic forest management plans at a regional level such as land use allocation, design and development of tree improvement programs, establishment of seed collection and breeding zones, prescription of reforestation and harvesting techniques, and design of the future ecological research programs. For the forested zones, plant associations will be identified and described. A plant association is a basic unit of the ecosystem classification. It is the smallest unit discriminable floristically as well as environmentally. It will be identified primarily by floristic similarities and environmental affinities of sample plots. It represents the smallest homogeneous unit of forest ecosystems, thus, comparable to "biogeocoenosis" of Sukachev. It will, therefore, serve as a functional unit for forest management and operations such as assessing potential capability of forest ecosystems, selecting best performing trees site-specifically, predicting effects of ecological impacts and treatments, preventing site deterioration, determining fertilization and thinnings, planning prescribed burnings, planning logging operations and deciding harvesting techniques, and identifying ecological problems and correlating research efforts.

9. Study Objectives:

In cooperation with the Province of Alberta

1. To develop and provide an ecological classification of forest ecosystems of Alberta.

2. To provide basic data on structure and characteristics of forest ecosystems.

3. To provide some interpretation as to vegetation-environment relationships of the forest ecosystems.

4. To promote application of the classification in forest management and research programs.

5. To maintain the schedule of the project designed as follows:

1977-78:	to cover northwest of the province
1978-79:	to cover northeast of the province
1979-80:	to cover southwest of the province
1980-81:	to cover southeast of the province and to prepare the final report.

10. Resources:

a. Starting date: October 1976
b. Estimated year of completion: December 1981
c. Estimated total Prof. man-years required: 8.0
d. Estimated new major equipment for 1980-81 with costs: Nil
e. Estimated new major equipment beyond 1981 with costs: Nil
f. 1980-81 man-years:

Canadian Forestry Service
Prof. 2.0 G. J. Krumlik 1.0
J. D. Johnson 1.0
Total 2.0

Alberta Energy and Natural Resources
Prof. 4.0 4 foresters
Casual 1.3 1 summer student, 1 full time assistant
Total 5.3

11. Progress to Date:

Three of the four sections into which the province is divided have been completed, i.e. the NW, NE and SW sections. The remaining SE section contains nonforestry land and therefore detailed sampling will not be conducted. A preliminary classification of the forest ecosystems of northern Alberta was prepared and presented in the form of a progress report.

The biogeoclimatic zones of Alberta have been proposed, described, and presently the second approximation of a map of the Biogeoclimatic zones of Alberta is in preparation.

12. Goals for 1979-80:

1. To continue field survey and to establish sample plots in the southwestern section of the province, comprising Whitecourt, Edson, Clearwater-Rocky, and Bow River-Crowsnest Forest Districts. This area covers the boreal white and black spruce zone, subalpine Engelmann spruce-subalpine fir zone, montane aspen-lodgepole pine-white spruce zone, and interior Douglas-fir zone.

2. To identify plant specimens, to analyze soil samples, and to develop a preliminary classification of the sample plots in the area investigated.

3. To complete a progress report for the fiscal year.

4. To continue with obtaining and analyzing published information on climate, physiography, geology and soils of the province and to continue the literature review as it relates to the goals of biogeoclimatic classification.

13. <u>Accomplishments in 1979-80</u>:

1. During the 1979 field season, the SW part of the province was investigated. The reconnaissance and detailed study of Whitecourt, Edson, Clearwater-Rocky, and Bow River-Crowsnest Forest Districts was undertaken, 152 sample plots were established. However, as it was impossible to cover the entire area, some additional work is needed during 1980 field season.

   Summary of field investigation:

Number of plots established	152
Number of plant specimens collected for identification	
Vascular plants	340
Bryophytes and lichens	3,800
Total number of trees measured	4,956
Average number of trees per plot	33
Total number of tree core samples obtained	1,871
Average tree core samples per plot	12
Number of soil samples collected	630
Number of water samples collected	20
Total mileage driven for reconnaissance and plot setting	28,100

2. Identification of plant specimens and analyses of soil samples from the 1978 field season was completed. The data are stored in computer and are being processed by Forest Planning Systems Ltd. in Vancouver, B. C.

3. Sample plots were tentatively classified into thirteen plant associations. These associations belong in four Biogeoclimatic zones. Boreal white and black spruce, subalpine Engelmann spruce-subalpine fir, interior Douglas fir, and aspen-pine-white spruce zones.

4. A preliminary progress report for the 1979-80 fiscal year was submitted to the Chairman of the Alberta Forest Development Research Trust Fund along with a renewal application for the 1980-81 fiscal year.

5. A preliminary classification of the sample sites in northern Alberta (plots established during the 1977 and 1978 field seasons) was compiled, soil physical and chemical properties are summarized for soil profiles associated with recognized plant associations. This information, together with description of biogeoclimatic zones of Alberta, climatograms depicting representative climatic stations in different biogeoclimatic zones, and literature review on geography, climate, geology and soils and vegetation of NE Alberta was submitted in the form of a detailed progress report for the 1978-79 fiscal year to Chairman of the Alberta Forest Development Research Trust Fund.

Additional Accomplishments:

6. A workshop was organized in July, in the Grande Prairie Forest District, where the Biogeoclimatic forest ecosystem classification was demonstrated to about 60 foresters, who represented industry, governments, and universities.

7. Two lectures and one seminar on the Biogeoclimatic classification of Alberta were prepared for students of the University of Alberta.

8. During July and August close cooperation was maintained with Dr. S. Kojima who worked on zonation of southwestern Alberta. His report is submitted by Western Ecological Services Ltd.

14. Goals for 1980-81:

1. Field investigation -- finish reconnaissance and establish sample plots in areas with insufficient amount of information available for defining biogeoclimatic zones and subzones.

2. Analyze soil samples and increment cores and identify plant materials from 1980 field season before end of December 1980.

* 3. Transfer data from 1979 field season onto computer paper, get them keypunched and recorded on a magnetic tape before the beginning of 1980 field season.

** 4. During summer of 1980, incorporate data from 1979 field season into existing body of data through joint analyses of data from 1977, 78, and 79 field seasons.

5. Finish analyses of all data before end of March 1981.

6. Prepare literature review, introduction and methods sections for the final report during the winter of 1979/80.

7. Prepare a budget application by November 15, 1980.

8. Prepare a progress report by December 1, 1980.

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* To fulfill this objective, analyses of soil and increment cores and identification of plant material from 1979 field season has to be completed prior to March, 1980.

** To fulfill this objective, data from 1977 and 78 field seasons has to be analyzed before the end of March, 1980.

Tentative goals for 1981-82 Fiscal Year

1. Prepare final synthesis tables for zones and subzones by the end of May, 1981.

2. Prepare first draft of the final report by the end of August, 1981.

3. Get the report edited and reviewed by the end of October, 1981.

4. Prepare the final report by the end of December, 1981.

15. Publications:

Up to 1979-80

Kojima, S. 1977. Biogeoclimatic ecosystem classification of Alberta--philosophy, objectives, methodology, and benefits. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton. File Report NOR-27-169. 11 pp.

Kojima, S. and G. J. Krumlik. 1977. Ecological classification of forests in Alberta. Proceedings of the Symposium on Ecological Classification of Forest Land in Canada and Northwestern U.S.A. Pages 199-207.

Kojima, S. and G. J. Krumlik. 1977. Biogeoclimatic ecosystem classification of Alberta -- 1977 Progress Report. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. File Rep. NOR-27-169. 10 pp. plus appendices.

Kojima, S. and G. J. Krumlik. 1978. Biogeoclimatic classification of forests in Alberta. Submitted to Forestry Chronicle.

Krumlik. G. J. and J. D. Johnson. 1978. Biogeoclimatic ecosystem classification of Alberta--1978 Progress Report. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. File Rep. NOR-27-169. 7 pp. plus appendices.

Krumlik, G. J., J. D. Johnson, L. D. Lemmen. 1978. Biogeoclimatic ecosystem classification of Alberta--Progress Report for 1977-78 fiscal year: Forest types in northwestern Alberta--first approximation. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. File Rep. NOR-27-169. 87 pp. plus Appendices.

1979-80

Krumlik, G. J. and J. D. Johnson. Biogeoclimatic ecosystem classification of Alberta -- 1979 Progress Report. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. File Rep. NOR-27-169. 12 p. plus Appendices.

Krumlik, G. J., J. D. Johnson, and L. D. Lemmen. Biogeoclimatic ecosystem classification of Alberta, Progress Report for 1978/79 fiscal year. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. File Rep. NOR-27-169. 216 p. plus Appendices.

Kojima, S. and G. J. Krumlik. Biogeoclimatic classification of forests in Alberta. Forestry Chronicle 55(4):130-132.

16. Signatures:

G. J. Krumlik
Investigator

Program Manager

J. D. Johnson
Investigator

G. T. Silver
Director G. T. Silver

PROJECT NOR-28

Environmental impact assessments

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1980

1. Project: Environmental Impact Assessments

2. Title: Impact of development on terrestrial environment

3. New: Cont.: X 4. No.: NOR-28-171

5. Study Leader: S. C. Zoltai

6. Key Words: Arctic, land use, development, impact, vegetation, terrain

7. Location of Work: Western and Northern Region

8. Problem:

Large scale intensive exploration and development of hydrocarbon resources is currently under way in northern Canada. Two large pipelines to deliver natural gas to southern markets have been proposed. A small diameter oil pipeline from Norman Wells to the south is likely. Shipping of liquefied natural gas and oil through the Northwest Passage to southern markets is proposed. This would entail extensive shore-based support and processing facilities. Mining and hydropower developments have received impetus from high world prices for base metals and power.

The impact of the proposed development on the terrestrial environment is evaluated by the proponents and by government agencies. During the assessment process the expertise of CFS is requested. This may take the form of membership in an assessment panel, or as scientific advisor to the assessing agency. Ancillary developments (roads, ports, gravel sources, timber sources, gas production and treatment facilities, etc.) may have to be assessed separately.

Existing Territorial regulations require the mitigation of environmental impact of smaller development projects, as well as the massive projects. Activities associated with roads, powerlines, or settlements are subject to environmental impact assessment. CFS expertise may be requested by the licensing agency to advise on general or site specific problems associated with such developments.

9. Study Objectives:

   1. To assess the impact of given developments on the terrestrial environment.

   2. To suggest measures minimizing, or mitigating the adverse impact of proposed developments.

   3. To record the total effort of NFRC to specific environmental assessment processes.

10. Resources:

   a. Starting date: 1977
   b. Estimated year of completion: Open
   c. Estimated total prof. man-years required: N.A.
   d. Essential new major equipment items for 1980-81 with costs: Nil
   e. Essential new major equipment items beyond 1981 with costs: Nil
   f. 1980-81 man-years

Prof.	0.5
Supp.	-
Casual	-
Total	0.5

11. Progress to Date:

Served as Chairman, DOE Regional Task Force on Mackenzie Valley Pipeline from 1974 to 1976. Assessed the Canadian Arctic Gas Pipeline Ltd. and Foothills Pipe Lines Ltd. proposals. Participated in the development of environmental guidelines for the Mackenzie Delta gas producing facilities. Participated in the mile-by-mile examination of the Mackenzie Highway proposal. Served as scientific advisor to Mackenzie Valley Pipeline Inquiry counsel (Berger Commission). Served as expert witness to Inquiry on the Impact of proposal on the terrestrial environment.

Contributed to the evaluation of the environment impact by CAGPL, foothills, Alcan, and Polar Gas proposals. Participated in the review of Environmental Code for the proposed Mackenzie Valley pipeline. Assessed the impact of various drilling and gas treatment plans in the Mackenzie Delta.

As member of the Regional Transportation Committee, contributed to the assessment of various highway construction projects.

Since 1979, served as CFS representative on the Regional Screening and Co-ordinating Committee.

12. Goals for 1979-80:

    1. Participate in assessment processes of development proposals as required.

    2. Develop expertise in assessing the impact of development proposals on the terrestrial environment in various parts of the Region.

13. Accomplishments in 1979-80:

    1. As member of the Regional Transportation Committee, contributed to the environmental assessment of the Liard Highway, and Dome-Canmar long range land-based facility requirements.

    2. As member of RSCC, attended 10 regular and 2 information meetings of this body, contributing to the evaluation of impact statements and assessments. Projects considered included uranium mines and processing plants, base metal mines, oil sand and heavy oil developments, hydroelectric dams and transmission lines, pipelines and roads.

    3. Provided advice on environmental impact directly to pipeline companies and licensing agencies of the N.W.T. government.

14. Goals for 1980-81:

    1. Participate in assessment processes of development proposals as required.

    2. Act as CFS representative on the Regional Screening and Co-ordinating Committee.

    3. Develop expertise in assessing the impact of development proposals on the terrestrial environment in various parts of the Region.

15. Publications:

    Up to 1979-80:

Zoltai, S. C. (Chairman), 1975. Report of the DOE Task Force on the Mackenzie Valley pipeline application. Part I. North of 60°, 41 pp.

Zoltai, S. C. 1976. Consideration of impact on the physical environment. Transcr. Mackenzie Valley Pipeline Inquiry. Vol. 101-102, 19 pp.

1979-80:

Nil

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1980

1. Project: Environmental Project Assessments

2. Title: Environmental Assessment - Arctic Regions

3. New: Cont.: X 4. No.: NOR-28-172

5. Study Leader: S. C. Zoltai

6. Key Words: Arctic, land use, permafrost, pipelines, thermal erosion.

7. Location of Work: Arctic Regions

8. Problem:

Explorations for hydrocarbon resources identified commercially exploitable natural gas resources in the Mackenzie Delta adjoining Beaufort Sea areas, and in the Sverdrup Basin. Oil reserves were proven in the Norman Wells area, in the Beaufort Sea and Sverdrup Basin. Exploration is continuing at present in these areas and in a number of other areas, especially in Baffin Bay-Davis Strait.

Exploration for mineral resources and uranium resulted in the identification of economic deposits of base metal, gold, and uranium. The mining industry is applying pressure to explore in federal reserves, such as the Thelon Game Sanctuary. New mines are being planned and old ones expanded throughout the Arctic regions.

Increased energy costs and needs necessitate the development of hydropower. The Liard and Slave rivers are the subject of development proposals.

The above development proposals and the associated ancillary developments (roads, airports, ports, storage, etc.) all involve a demand on land resources at an unprecedented scale. The impact of this demand on the terrestrial environment varies greatly from place to place. Although the proponents are responsible for environmental studies, the assessment of the impact of proposals is a federal responsibility. Assessment cannot be effective without an intimate knowledge of terrain and vegetation conditions in the affected areas.

Recent trends show that assessments of development by CFS must be made without the benefit of on-site vegetation and terrain studies. This necessitates a change in strategy to provide effective evaluation of development pro ects. Development-related expertise must be maintained and augmented in as many different parts of the Arctic regions as possible. By accumulating a store of knowledge of baseline information on resources and interactions, a reasonably reliable assessment of development proposals can be carried out.

The study proposal by the Territorial Wildlife Service and the Canadian Wildlife Service provides an opportunity to expand our experience to a new area. Metal and uranium ore was found in areas outside the Thelon Game Sanctuary and such resources may well occur within the sanctuary. However, exploration and exploitation activities are not compatible with the intended land use in the sanctuary. Portions of the sanctuary may be released if this does not jeopardize the game population. A knowledge of vegetation and forage species is a basic requirement for the recognition of essential and sensitive wildlife areas. Participation in this study would provide baseline information for impact assessment of developments in the area and in the neighbouring regions.

Short-term studies of possible National Parks in the Arctic regions provides further opportunity for acquiring baseline information in diverse areas. Such studies, commissioned by Parks Canada, involve vegetation, landform, soil, and permafrost at a reconnaissance level.

9. Study Objectives:

1. To determine relationships between terrain, vegetation and permafrost in various physiographic and climatic regions of Arctic Canada.

2. To determine the terrain-vegetation relationships in the Thelon Game Sanctuary in co-operation with Territorial and other federal agencies.

3. To investigate the vegetation, soils, and permafrost conditions in potential National Park sites in Arctic Canada.

4. To provide expertise in the development of environmental criteria for the design and rehabilitation of structures associated with piepline, mining or power developments.

10. Resources:

a. Starting date: 1978
b. Estimated year of completion: 1981
c. Estimated prof. man-years required: 1.0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.5
Supp.	1.0
Casual	-
Total	1.5

11. Progress to Date:

In 1978 completed the study of natural resources of the Horton-Anderson rivers area (financed by Parks Canada).

Research proposal for the vegetation-range studies of Thelon Game Sanctuary submitted through Territorial Wildlife Service.

12. Goals for 1979-80:

Using information obtained in the past, supplemented by laboratory studies, prepare scientific publications relating to northern ecosystems.

a. Journal paper in preparation: S. C. Zoltai and C. Tarnocai--Some types of nonsorted patterned ground in northern Canada.

b. Possible journal papers: 1) Influence of soil properties on the arctic tree line, 2) Chemical characteristics of peat in the Mackenzie Valley.

13. Accomplishments for 1979-80:

Journal paper, S. C. Zoltai and C. Tarnocai--Some types of non-sorted patterned ground in northern Canada, is in final stages of editorial review.

Participated in a co-operative study with CWS to assess two areas (Thomsen River area (Banks Island), 8,000 km^2; Bathurst Inlet area, 6,000 km^2) for possible national parks.

Accomplishments not Related to Arctic

As chairman, Ecoregions Working Group, organized a national body of experts. The working group is determining the natural ecosystem regions of Canada that can be used as a framework of ecologically sound information storage and referral system.

As member of the Wetlands working Group, assembled information on the Wetland Regions of Canada.

14. Goals for 1980-81:

1. Participate in the vegetation-muskox range studies in Thelon Game Sanctuary, if project financing is approved by the Territorial Government.

2. Participate in the evaluation of the natural resources of Wager Bay area as a possible National Park.

3. Continue the determination of the ecoregions of Canada.

15. Publications:

Up to 1979-80

Zoltai, S. C., C. Tarnocai, and W. W. Pettapiece. 1978. Age of cryoturbated organic materials in earth hummocks from the Canadian Arctic. Proc. 3rd Int. Conf. Permafrost, Vol. 1. pp. 325-331.

Zoltai, S. C. 1978. Soil productivity in the arctic environments of Canada. Proc. 11th Conf. Int. Soil Sci. Soc., Vol. 3, pp. 348-359.

Tarnocai, C. and S. C. Zoltai. 1978. Earth hummocks of the Canadian Arctic and Subarctic. Arct. Alp. Res. 10:581-594.

Zoltai, S. C. 1978. A portable sampler for perennially frozen stone-free soils. Can. J. Soil. Sci. 58:521-523.

Zoltai, S. C., D. J. Karasiuk, and G. W. Scotter. 1979. A natural resource survey of Horton-Anderson rivers area, N.W.T. 150 pp.

1979-80

Zoltai, S. C. and F. C. Pollett. 1979. Wetlands in Canada: Their classification, distribution, and use. Elsevier Scientific Publishing Co. Amsterdam (In Press). 54 pp.

Zoltai, S. C. and V. Woo. 1978. Sensitive soils of permafrost terrain. 5th North. Am. For. Soil Conf., Ft. Collins CO., pp. 410-424.

Zoltai, S. C. and H. Zalasky. 1979. Postglacial fossil tamarack (Larix laricina) wood from the Mackenzie Delta, N.W.T. Bi-monthly Res. Notes 35:7-8.

Tarnocai, C. and S. C. Zoltai. 1978. Soils of northern Canadian peatlands: their characteristics and stability. 5th N. Am. For. Soils Conf., Ft. Collins CO, pp. 433-448.

16. Signatures:

Investigator

Program Manager

Director G. T. Silver

PROJECT NOR-29

Forest resource data

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Forest resource data.

2. Title: Growth and yield of lodgepole pine in the foothills section of Alberta.

3. New: Cont.: X 4. No.: NOR-29-009

5. Study Leader: W. D. Johnstone

6. Key Words: *Pinus contorta*, stand development, yield tables, management planning, B. 19a, c., thinning and spacing.

7. Location of Work: Foothills section of Alberta.

8. Problem:

Unmanaged Stands --

There are now adequate yield tables for the lodgepole pine type in Alberta. The reduction in stand productivity with high stand density has been documented in Alberta, and the extent of the loss and the relationship between density, site and productivity are known. Yield tables are necessary for rational sustained yield management (through the quota system and pulpwood lease agreements), and silvicultural practice (i.e., for prescribing remedial stand treatments). The effects of site and stand density on the yield of pure lodgepole pine, were determined from 865 measurements of permanent and single examination sample plots.

Managed Stands --

Although growing space has a pronounced effect on the development of individual trees and forest stands, the optimum spacings for Alberta's native spruce and pine have yet to be determined. This situation prevails at a time when planting is being employed at an ever increasing rate, and when serious consideration is being given to the correction of over-stocking of lodgepole pine by pre-commercial thinning. In order to determine the optimum density for lodgepole pine, several spacing and thinning trials were established in young stands.

9. Study Objectives:

   1. To construct a variable-density yield table for use in natural, unmanaged lodgepole pine stands.

   2. To determine how thinning and spacing affects diameter, height and volume growth, and stand development of lodgepole pine.

10. Resources:

   a. Starting date: 1951
   b. Estimated year of completion: Continuing
   c. Estimated total Prof. man-years required: N/A
   d. Essential new major equipment items for 1980-81 with costs: Nil
   e. Essential new major equipment items beyond 1981 with costs: Nil
   f. 1980-81 man-years

Prof.	0.3	(W.D. Johnstone)
Supp.	0.4	(S. Lux)
Casual	0.0	
Total	0.7	

11. Progress to Date:

Objective 1 of this study has been satisfied by the publication of Can. For. Serv. Tech. Rep. 20. Continued remeasurement of permanent sample plots will provide valuable base-line data against which many of our cultural treatments can be compared.

a. Growth and yield plots --

1951, 1952 and 1953 - 141 permanent and 41 single examination plots established.
1954 - preliminary yield table prepared.
1961 - permanent sample plots remeasured.
1964 & 1965 - AFS sample plot data obtained and combined with CFS data.
1969 & 1970 - all data coded and analysis initiated.
1974 - 85 CFS permanent sample plots remeasured and analyzed.
1976 - variable-density yield tables for natural stands of lodgepole pine in Alberta (Can. For. Serv. Tech. Rep. 20) published.

b. McKay Thinning Trial:

1954 - treatments introduced, all trees tagged and measured.
1960 - remeasurement of sample trees.
1969 - trees remeasured, treatment 5 rethinned.
1979 - remeasurement of sample trees.

c. Gregg Burn (Hinton) Espacement Trial:

1963 & 1964 - 5 espacements established in 7-year-old pine on 3 sites.
1966 - initial measurements.
1970 - plot maintenance.
1971 - trees remeasured.
1973 - biological agents affecting growth and survival of each tree identified.
1974 - plot maintenance.
1976 - trees remeasured and aerial photographs taken.

d. Tee-Pee Pole Creek Trials:

1966 & 1967 - initial treatments applied to 25-year-old pine stand.
1972 - plots remeasured.
1977 - plots remeasured.

12. Goals for 1979-80:

1. Remeasure McKay thinning trial.

2. Continue analysis of data from Gregg Burn and Tee-Pee Pole Creek spacing trials as time permits.

13. Accomplishments in 1979-80:

1. McKay thinning trial remeasured and all data coded.

2. Analysis of Gregg Burn data nearly complete.

14. Goals for 1980-81:

1. Complete analysis of Gregg Burn data and report results.

2. Continue analysis of Tee-Pee Pole Ck. data and initiate analysis of McKay Thinning as time permits.
(Gregg Burn trials' remeasurement due 1981).
(Tee-Pee Pole Ck. trials' remeasurement due 1982).
(Permanent sample plot remeasurement, yield study, due 1984).
(McKay thinning trials' remeasurement due 1989).

15. Publications:

1978-79

Nil

1979-80

Nil

16. Signatures:

W.D. Johnstone
Investigator

G. D. Hunt
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Forest resource data.

2. Title: Fertilization of established lodgepole pine stands.

3. New: Cont.: X 4. No.: NOR-29-122

5. Study Leader: W. D. Johnstone

6. Key Words: *Pinus contorta*, B.19a, tree nutrition, nutrient deficiencies, nitrogen, phosphorus, sulphur.

7. Location of Work: Hinton, Alberta

8. Problem:

Considerable interest is being expressed by forest management agencies in the use of fertilization as a means of increasing productivity, particularly in view of the successful commercial applications by the Scandinavians. No published information is presently available in Alberta to indicate the levels of fertilization which will maximize lodgepole pine growth over a range of site and age classes. In order to develop a general prediction relationship between fertilizer input and response, a study was initiated on two soil types and in two age classes (30 and 70 years) in 'normal' density pine stands in the Hinton area. The experimental design chosen was a "central composite rotatable second order" design expanded to include a conventional 2^3 complete factorial. Twenty-four treatment combinations were applied in each of three blocks in each age-soil type, amounting to a total of 288 treatment plots. The fertilizers applied were combinations of the following levels of nitrogen, phosphorus and sulphur specifically required by the response surface design used in the study.

Coded level	Elemental lb/ac applied N	P	S
-1.68	0	0	0
-1.00	68	34	20.4
0	168	84	50.4
1.00	268	134	80.4
1.68	336	168	100.8

Prior to treatment soil and foliar samples were collected from each area by Mr. W.D. Holland, samples of the current year's foliage were collected in each plot, and a complete dbh tally was taken in each plot. The fertilizers were applied before the growing season in 1972 and samples of the current year's foliage were collected after the 1972 and 1973 growing seasons. Greenhouse fertilization trials were initiated in 1975 to provide data to examine the characteristics and best analytical methods for the response surface design used in the field experiments.

9. Study Objectives:

1. To predict the combination of levels of nitrogen, phosphorus, and sulphur fertilization that optimizes the growth response of lodgepole pine on each of a range of site types and age classes in the lower foothills region of Alberta, by means of estimating "a response surface".

2. To examine the possibility of using either foliar content or soil characteristics, or a combination of both as a diagnostic tool for fertilization.

10. Resources:

a. Starting date: 1970
b. Estimated year of completion: 1980 Revised: 1985
c. Estimated total Prof. man-years required: 1.3
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.2	(Johnstone)
Supp.	0.1	(Lux)
Casual	-	
Total	0.3	

11. Progress to Date:

1970 - Plot centres located in field, and soil and foliage samples taken and analyzed by Mr. W.D. Holland.

1971 - Plot boundaries located, tree dbh's tallied for all trees, and heigh-diameter data measured.

Pre-treatment foliage collected and analyzed.

1972 - Fertilizers applied before 1972 growing season.

First post-treatment foliage samples collected and analyzed.

1973 - Second post-treatment foliage samples collected and analyzed. Study Establishment Report Completed.

1974 - Computer program to analyze study design developed in cooperation with CASD.

1975 to 1979 - Series of greenhouse fertilization trials conducted to develop best analytical methods for response surface design.

12. Goals for 1979-80:

    1. Complete seedling measurement and initiate analysis of data.

13. Accomplishments in 1979-80:

    1. Seedling measurements completed and data currently being analyzed in cooperation with CASD.

14. Goals for 1980-81:

    1. Complete analysis of greenhouse fertilization trial data and report findings if appropriate.
    (Field plots to be measured in 1981.)

15. Publications:

    1978-79

    Nil

    1979-80

    Nil

16. Signatures:

W.D. Johnstone
Investigator

C.D. Hunt
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Forest resource data.

2. Title: Forest operations statistics.

3. New: Cont.: X 4. No.: NOR-29-173

5. Study Leader: W. D. Johnstone

6. Key Words: Regional and national forest statistics; growth, depletion and inventory data.

7. Location of Work: Western and Northern Region.

8. Problem:

Regional and national resource managers must have reliable resource data and information upon which to base their decisions. Canada currently lacks the forestry statistics, related to demand, supply, depletion, growth and inventory, required for national and international planning. In addition, there is insufficient data to define national forest research priorities, or to develop a national focus on forestry with respect to forest management, trade and commerce, etc. Regionally, there is a lack of data required to develop regional research programs. Current regional statistics do not permit comparisons between various regional agencies, and a computerized system for data maintenance, retrieval and updating is required. There is also a growing need to coordinate the acquisition and dissemination of data by various regional and national (i.e. PNFI, etc.) agencies. This study will develop and maintain the data and statistics required by regional and national planners and managers.

9. Study Objectives:

   1. To obtain, compile, analyze and publish appropriate forestry statistics to satisfy regional and national requirements.

   2. To provide consultation and advice to provincial, federal and industrial forest management agencies concerning the availability, interpretation and application of forestry data.

3. To contribute to the development of improved resource management guidelines by examining and testing simulation models based on regional research and operational data.

10. Resources:

a. Starting date: 1978
b. Estimated year of completion: Continuing
c. Estimated total Prof. man-years required: N/A
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	2.4	(W.D. Johnstone 0.4, Vacant 1.0, Vacant (Vice Stevenson) 1.0)
Supp.	0.5	(S.J. Lux 0.5)
Casual	-	
Total	2.9	

11. Progress to Date:

Lines of communication have been established with PNFI and the provincial forest services within the region regarding the national forest statistics program. To date the national program has:

1. Published--"Canada's Forest Inventory - 1976" by M.G. Bowen. [Can. Dep. Environ., Can. For. Serv., For. Manag. Inst. Inf. Rep. FMR-X-116 (1978)].

2. Published--"Pilot study for Canadian forest resource data system" by G.M. Bonnor. [Can. Dep. Environ., Can. For. Serv., For. Manag. Inst. Inf. Rep. FMR-X-122 (1978)].

3. Contributed to Statistics Canada (Cat. 25-202), Canada Year Books, and "Canada's Forests 1978".

4. A report "Our Forest Resources - 1976" is currently being prepared.

At the regional level, the PDP 11/60 computer has been acquired and is operating at NFRC. A data management system (DATA-TRIEVE II) has been ordered.

12. Goals for 1979-80:

1. Complete publication of biomass data from *Populus* stands in Alberta.

2. Monitor and participate in the National Forestry Statistics Program.

3. Initiate collection of forest operational statistics to satisfy regional requirements.

4. Supervise ENFOR contract (Proposal No. P92) "Development of biomass production equations for six commercial tree species in the Prairie Provinces".

13. Accomplishments in 1979-80:

1. A second draft of the manuscript entitled "Above-ground component weights in Alberta *Populus* stands" is undergoing local review.

2. Participation in National Forestry Statistics Program by:
   a. Member of CFS Task Force on forestry data.
   b. Member of FRDP Planning Committee.
   c. Reviewing FRDP reports.
   d. Liason with provinces on FRDP data requirements and acquisition.

3. Review of regional data base needs and acquisition of data retrieval system for NFRC's PDP 11/60 computer.

4. Tree component fresh weights and dry-weight conversion subsamples collected under contract (ENFOR Project P-92) from 420 trees of 7 major tree species in the Prairie Provinces.

14. Goals for 1980-81:

1. Complete publication of Alberta *Populus* stand biomass data.

2. Monitor and participate in the National Forestry Statistics Program [now termed the Forest Resource Data Program (FRDP)].

3. Continue development of regional forest resource data program by defining data requirements for regional resource data base and by operating the DATA-TRIEVE II system with Alberta Forest Industry survey data, etc.

4. Publish results of stand-edge effects on the growth and survival of pine and spruce seedlings (former study NOR-14-139).

5. Supervise ENFOR contract P-92 (see Study NOR-34-180).

15. Publications:

1978-79

Nil

1979-80

Nil

16. Signatures:

W.D. Johnstone

Investigator

C.D. Hunt

Program Manager

G.T. Silver

Director G.T. Silver

PROJECT NOR-30

Forest resource management alternatives

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Forest resource management alternatives.

2. Title: Development and application of simulation models and data management systems as decision-aids in forest resource management.

3. New: Cont.: X 4. No.: NOR-30-175

5. Study Leader: C. Lee and T. Singh

6. Key Words: Forest management, alternatives, simulation models, systems analysis, forest statistics, forest renewal, forest depletion.

7. Location of Work: Western and Northern Region.

8. Problem:

The intensification of forest management activities and forest land use by the general public is exerting increasingly greater pressures on the management agencies to develop integrated plans and operational procedures for the wise management of forest, water, recreation and wildlife resources. Fragmentation of resource management responsibilities amongst several agencies is sometimes a deterrent to effective integration and planning of these management activities. Integration of research findings into a systems framework is one way of organizing and demonstrating the usefulness of research findings.

The immediate problem relates to the need to integrate and systematize available relevant data and to package the information in a manner to be most useful to resource managers and researchers. In this way, critical gaps in data will be identified and new studies initiated to gather the required information. It is anticipated that systems analysis techniques and the high-speed data processing capability of electronic computers will contribute substantially to the attainment of study objectives. The end result will be in the form of integrated decision-aids concerning biological, technical and socio-economic considerations of interest to the resource management agency.

There exists a vast quantity of relevant data in the fields of forest economics, forest protection, reforestation, growth and yield, and forest influences. Some of this information has been or is being utilized, but the available data base and application procedures tend to be fragmented and incomplete. Initial emphasis will therefore be placed on the identification of data to satisfy the needs of study objectives. The development of data bases and models will depend on input from other studies and programs, but this study will provide the mechanism and expertise for integrating and systematizing research results within a framework of economic, social and environmental factors.

9. Study Objectives:

1. To identify and systematize all relevant data from other NFRC research projects for use in the development and testing of simulation models.

2. To test and evaluate the applicability of selected simulation models and data systems in support of resource management activities in the Western and Northern Region.

3. To provide advice and guidelines to forest managers and researchers and to promote the use of computerized simulations of selected forest depletion and replacement activities and alternatives.

10. Resources:

a. Starting date: 1978
b. Estimated year of completion: 1983
c. Estimated total Prof. man-years required: 10
d. Essential new major equipment items for 1980-81 with costs: Mini-computer accessories: $30,000
e. Essential new major equipment items beyond 1981 with costs: Computer accessories: $25,000
f. 1980-81 man-years

Prof.	1.3	(C. Lee 0.8, Singh 0.5)
Supp.	0.7	
Casual	-	
Total	2.0	

11. Progress to Date:

A systems analyst was hired in June, 1979. A PDP 11/60 minicomputer and several terminals have been installed at NFRC; software and hardware requirements for future developments of data retrieval systems and simulators have been identified and decisions have been made to purchase DATATRIEVE 11--a database management system and a TEKTRONIX plotter. Advice on systems analysis and statistical methodology have been provided to the staff of NFRC and DTRR (Saskatchewan). Requests have been made to obtain growth and yield simulators for stands and individual trees; evaluation of the FREP (Forest Resources Evaluation Program) simulator is underway. Model building for fire growth has been initiated.

12. Goals for 1979-80:

1. Coordinate the identification, integration, development and/or testing of simulation models as decision-making aids in forest resource management in W & N Region.

2. Provide liaison and consultation with client agencies and program staff concerning systems development methodology, and application of models in support of planning and operational activities.

3. Staff vacant position (Systems Analyst, Biometrician).

4. Participate in development of a framework for a computerized data management system to satisfy NFRC program objectives.

13. Accomplishments in 1979-80:

1. Participated in the evaluation of the FREP growth and yield simulator. Implemented a new version of the elliptical fire growth model on the PDP 11/60.

2. Provided advice on curve fitting and FORTRAN programs to DTRR (Saskatchewan) staff. Provided consultation to the staff of NFRC on such topics as the evaluation of the impact of oil exploration on forest, the application of the Weibull distribution to DBH data and the comparison of aerial to ground measurements of tree heights.

   Completed study on comparisons of various methods for correcting the bias introduced by the loagrithmic transformation in biomass estimated. Provided advice and assistance to the NFRC scientists and technicians, and client agencies, on biometrics, particularly analysis of cubic lattices and incomplete block data, non-linear optimization, cluster analysis, multiple comparisons, and improved prediction models.

3. A systems analyst and a biometrician were hired in June, 1979.

4. Evaluation of requirements and design proposals for the inventory system of DTRR was completed in September 1979. Participated in the development of an economic database of the wood-using industry in Alberta.

14. Goals for 1980-81:

1. Finalize paper "Comparison of correction methods for the bias due to the logarithmic transformation in the estimation of biomass".

2. Provide advice and assistance to the scientists and technicians of NFRC, and client agencies, on biometrics, including improved prediction models in forestry.

3. Test elliptical fire growth model with empirical data (integrate with Study NOR-5-174); estimate parameters of the model for various fuel types.

4. Participate in the evaluation and refinement of the FREP and CSGS tree and stand growth simulators.

5. Participate in the development and operation of an economic data base and the regional Forest Resource Data System.

15. Publications:

Up to 1979-80

Nil

16. Signatures:

Che young Lee
Investigator

G. D. Hurt
Program Manager

T. Singh
Investigator

G. Silver
Director G. T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 23, 1980

1. Project: Forest resource management alternatives.

2. Title: Development of integrated biomass prediction equations for Western and Northern Region.

3. New: X Cont.: 4. No.: NOR-30-183

5. Study Leader: T. Singh and C. Lee
   Co-operators: W. D. Johnstone, C. L. Kirby, I. E. Bella and L. Brace

6. Key Words: Biomass, regional and national forest statistics, energy, inventory, simulation, Prairies Region, prediction equations, mathematical models.

7. Location of Work: Western and Northern Region.

8. Problem:

Rapid depletion of non-renewable resources used for energy requirements in the modern world is a matter of growing concern. Present estimates indicate that about 90 percent of the total known oil reserves are likely to be consumed by the year 1990. Renewable resources provide only 3 1/2 percent of all energy used in Canada at present.

Alternative sources of energy, such as energy from forests, need to be quantitatively assessed to help meet future demands and to supplement existing supply levels from the fossil fuels. Biomass is gaining increased recognition as a potentially viable renewable resource for partial solution to the existing energy problems on the American continent.

Gathering quantitative information on the availability of forestry biomass on a sustained basis is an essential pre-requisite to the future planned use of this resource. At present only very limited data are available to make a reliable estimate of the existing forest biomass in the Prairie Provinces. The great diversity of vegetation occupying widely different sites over a vast geographical area makes such estimations exceedingly difficult. Poplars, for example, have the widest range and largest volume of any of the hardwood genera in Canada, occupying a wide range of site conditions with quite different growth rates. Poplars are the fastest growing species on many sites in the Prairies Region and, along with other tree species, present attractive possibilities for future use as a source of energy from forest lands.

Much information is already available in the regional forest inventories on the merchantable volume of the growing stock, at least for important species. Such inventories are constantly being updated and expanded through modern techniques involving aerial photography and computer technology. It is possible to incorporate biomass estimates by collecting additional information on relatively few parameters. The relevant required data are currently being obtained by the NFRC scientists and ENFOR contracts through studies such as NOR-34-180, NOR-4-075, NOR-29-173, NOR-10-176 and NOR-17-118. Prediction equations for regional application can thus be derived, based on the regional forest volume inventories and biomass weight data when made available from the field studies currently in progress.

9. Study Objectives:

1. To synthesize the available biomass data for the regionally important tree species for predicting biomass in the Western & Northern Region.

2. To develop and test regional biomass equations, for their accuracy and bias, in a pilot-scale demonstration for converting a conventional forest inventory to a biomass inventory.

10. Resources:

a. Starting date: April 1, 1980
b. Estimated year of completion: 1984
c. Estimated total Prof. man-years required: 4.0
   (Singh 2.5, Lee 0.5)
d. Essential new major equipment items for 1980 with costs:
   1. Computer Graphics System .... $ 8,005
   2. Computer terminal with CRT 4,855
   3. Disks and other computer peripheral accessories 1,250
e. Essential new major equipment items beyond 1980 with costs:
   PDP Mini-computer simulator accessories $20,000
f. 1980-81 man-years

Prof.	0.7	(Singh 0.5, Lee 0.2)
Supp.	0.3	
Casual	-	
Total	1.0	

11. Progress to Date:

Preliminary work so far has been:

1. Review of current literature on forest biomass.

2. Meetings with the forest resource group for gaining familiarity with the forest resource inventory and biomass data which would be available for the development of regional biomass equations.

3. Review of mathematical functions commonly used for biomass estimation.

4. Assessment of the computer software, support staff and programming skills needed for the successful completion of the project.

12. Goals for 1979-80:

N/A.

13. Accomplishments in 1979-80:

N/A.

14. Goals for 1980-81:

1. Identify and compile all relevant biomass information for biomass inventory and data synthesis work in the Western & Northern Region.

2. Prepare computer data files for computation and analysis in connection with the development of integrated biomass equations.

3. Make preliminary tests and select the most promising and regionally acceptable mathematical equations for subsequent biomass inventory demonstration on a pilot basis.

15. Publications:

Up to 1979-80

Nil

16. Signatures:

T Singh
Investigator

Program Manager

Investigator

Director G. T. Silver

PROJECT NOR-31

Climatic studies

NOR-31-179

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 8, 1980

1. Project: Climatic Studies

2. Title: Impact of Climatic Variation on Boreal Forest Biomass Production

3. New: Cont.: X No.: NOR-31-179

5. Study Leader: J. M. Powell

6. Key Words: Climatology, climatic change, climatic variation, forest biomass, proxy data, dendrochronology, tree-rings, paleobotany, pollen analysis, X-ray densitometry, isotopic measurements, historical records, forest growth, Boreal Forest Region (B).

7. Location of Work: Edmonton Laboratory, Prairie Provinces, N.W.T.

8. Problem:

Climate has a direct and pronounced effect on forest vegetation, however, there is a need to establish the impact of climate, and especially climatic fluctuations, on forest biomass productivity. Little is known about the effect of climatic parameters on biomass and how climatic fluctuations effect forest growth and yield. Also with the recent renewed interest in the use of forest products and wastes for energy supplements as liquid fuels, and the interest in using certain forest products for food, especially animal fodders and supplements, there is a further demonstrated need to develop long-term inventories of biomass in forested areas and to establish projected annual yields which take climatic factors into account. The rate of biomass renewal under a wide range of conditions of environment, site and growing stock is at present unknown. Climate should also have a direct and pronounced effect on planning and decision making related to present and future use of land and all renewable natural resources. Present day forests and their associated vegetation did not evolve under constant or uniform climatic conditions. Different regions of the boreal and subalpine forests in the Western and Northern Region are subjected to widely contrasting temperature and precipitation regimes. Annual weather patterns are highly variable. Forests in existence today reflect past climates. Their origins over time and space, growth rates, species composition, longevity and total biomass are largely dictated by past and present climates. Predictions relating to future forest vegetation or biomass must take that fact into consideration. Climatologists have recently concluded that the North American climate is unlikely to remain as amenable in the near future as during the past several decades, a period with little climate fluctuations. Some are predicting a significant lowering of temperature, others a warming, but all are predicting a return to increased variation with subsequent detrimental impact on energy, food and other resources. In the past, land use decisions have been made in the boreal forest and adjacent areas with little reference to impact of climate, more specifically climatic change or fluctuations, on long term success of those uses. Continuing to ignore or pay little attention to climatic variations could therefore have severe social and economic implications. There is evidence to indicate that climatic fluctuations of significant magnitude occurred in the recent and distant past. Local climates were warmer or cooler, dryer or wetter than occurs today, and the position of the boreal forest zone and northern tree line has fluctuated over time. The boreal forest presently occupies a zone with a summer temperature range of only 2°C, therefore any long-term temperature decrease, even of 0.5°C, would adversely affect this zone and its resulting biomass productivity. Information relating to climate impact on forest biomass is therefore required in two specific areas; 1) impact of climate on forest biomass production; and 2) past climates in the boreal forest region.

9. Study Objectives:

1. Determine extent and degree of past short- and long-term climate variation in selected regions of the boreal forest for purpose of assessing impact of climatic variation upon tree and forest growth.

2. Determine quantitative and qualitative interrelationships between key climatic parameters/climate variations and measures of forest biomass growth and production in selected regions of the boreal forest.

10. Resources:

a. Starting date: 1979
b. Estimated year of completion: 1984
c. Estimated total Prof. person-years required: 4.0
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 person-years: Prof. 1.0 (Powell)
Supp. 1.0
Total 2.0

11. Progress to Date:

New project.

12. Goals for 1979-80:

1. Initiate a literature gathering and review of information concerning climatic fluctuations and forest biomass productivity, with special emphasis on the boreal forest zone.

2. Locate and gather data sources utilizing instrumented climate data and various proxy records of climate which relates to the boreal forest zone, such as those obtained from dendrochronology, paleobotanical, lake sediments including foraminifera, speleothems, archaeological evidence, and the historical written record.

3. Act as Scientific Authority for possible contracts related to obtaining climate fluctuation, tree-ring chronologies, and forest biomass productivity information.

4. Provice advice on climate input for the Biogeoclimatic ecosystem classification (NOR-27-169) as required, and possibly seek ways in which their tree-ring cores could be used to provide information or correlations with climatic factors thereby providing proxy climate records extending chronologies into the past.

5. Maintain liaison with the Canadian Climate Centre and other agencies, as this project is identified as part of the Department's integrated Canadian Climate Program.

6. Help plan for a Workshop on the "Socioeconomic Impact of Climate"; compile a proceedings of the Workshop for publication; and complete third term as chairman of the Alberta Climatological Association.

7. Continue progress towards summarizing all temperature and other climatic parameter data collected in connection with an earlier study on climate of clearcut forested areas, including input for a report on seedling growth related to stand edge.

8. Continue to fulfil duties of Vice-President of the Canadian Meteorological and Oceanographic Society and begin duties as President in June; also continue other commitments on advisory and other committees.

13. Accomplishments for 1979-80:

1. A survey of the available literature was initiated. Some of the relevant literature for the Canadian boreal forest zone has been reviewed. Information on biomass appears to be scarce.

2. A start was made to locate sources of climate proxy records which relate to the Canadian forest zone and adjacent area. To date these have mainly related to dendrochronological, paleobotanical, and lake core sediment sources. Considerable related information was obtained through attending two meetings of the AES Ad Hoc Committee on Climatic Fluctuations and Man, and a meeting of the NMNS Climatic Change Project. A ms. on regional climatic fluctuations in Canada in the recent past was received minus the maps, while a listing of all long-term (greater than 25 years) stations (approx. 120 locations) in the Prairies and NWT was compiled preparatory to checking for homogeneity of records and further analysis.

3. Late in the year a small contract was given to Forintek Canada Corp., Western Forest Products Laboratory to analyse tree-ring samples collected at the southern end of proposed transects of sites through the boreal forest in Alberta. Ten to 12 white spruce tree samples were collected from the Swan Hills (300 yr.+) and Lac La Biche (100-140 yrs. old) in mid-September. For many of the trees sample disks were obtained at four levels for tree-ring densitometry analysis, otherwise at dbh or close to the stump. In addition samples for other dendroclimatological purposes were obtained from near Banff, Peyto Lake, Kananaskis, South of Highwood Pass, and Cypress Hills. These involved Douglas Fir, Limber Pine in addition to white spruce samples. Contacts were made with forestry personnel to help select other sites in the boreal forest for future sampling. Other dendroclimatological sampling is going on elsewhere in Canada and these boreal transects will help fill a large geographical gap. Climate data for 16 stations was supplied to Forintek for their analysis of the tree-ring samples.

4. Information on year-round and summer-only stations in Alberta were supplied for the biogeoclimatic ecosystem classification. In a closely related area base climatic data from the earlier climate classification for forestry study was supplied to the Resource Evaluation and Planning Division of the Alberta Energy and Natural Resources to assist them in defining "ecoregions" from a climatic viewpoint. Discussions were had with the Project Leader for NOR-27-169 about the desirability of obtaining tree-rings or disks from their study; such samples are already being obtained, but no decision was made about using them for aspects of the present study.

5. Good liaison was maintained with the Canadian Climate Centre (CCC) and various committees associated with the Canadian Climate Program (CCP). I attended two meetings of the Climate Advisory Committee (CAC) representing the Canadian Meteorological and Oceanographic Society and on one occasion reported on the activities of the Alberta Climatological Association which is being used as an example for the establishment of Regional CAC's across the country. I attended the Task Force Committee to help design the CCP, representing the CFS. Have helped plan for the CCP Forestry Sector Workshop which I recently attended giving a background paper on climate related courses given in forestry departments at post-secondary institutions, and chairing a session; attended two planning meetings for the Water Sector Workshop; and attended the two day Agriculture Sector Workshop in November. I also attended the CO_2/Energy issues and impacts workshop in August and have recently been assigned to the Expert Committee on CO_2 as the CFS representative. During the year I attended two meetings of the Ad Hoc Committee on Climatic Fluctuations and Man an AES Committee concerned with palaeoclimatic aspects of the CCP. I also was invited to the National Museum of Natural Sciences Climatic Change Project meeting. Information was supplied for various inventories being undertaken for the CCP concerning NFRC studies and climatic data. Information on the study was supplied at a number of the above meetings, and information was obtained from the CCC on a number of visits to Toronto or through other contact.

6. The Workshop on "Socioeconomic Impact of Climate" was successfully completed last March with a keynote speaker and 20 other speakers in four working group areas: Agriculture and Forestry; Recreation; Industrial Applications - Energy; and Urban and Regional Planning. I also chaired the Annual Meeting of the Alberta Climatological Association, presented two reports, and compiled the proceedings of the workshop and annual meeting including writing the preface and abstract.

7. The summarizing of climatic data collected in connection with an earlier study on climate of clearcut forested areas was continued. Extraction and summarizing of some further wind data and soil and air temperature data associated with the former NOR-139 study was undertaken. Also further extensive quality control procedures were completed on the temperature data and the data keypunched and summarized. Tables were prepared of various climatic parameter data associated with the NOR-139 study and much of the similar data was tabulated in association with the former NOR-138. Data was provided from these and other earlier studies to the Alberta Energy and Natural Resources and two consulting companies for their current projects.

8. Duties as Vice-President of the Canadian Meteorological and Oceanographic Society were completed in May and those of President started at that time. In addition to those committees mentioned under item 5, I continue on the Alberta Agrometeorological Advisory Committee; Alberta Climatological Association (completed term as Chairman in March); Steering Committee for the Climate Inventory Program, Resource Evaluation Division, Alberta Energy and Natural Resources; Alberta Fish and Wildlife Advisory Council; and Alberta Ecological Survey (Secretary/Editor). I recently completed my second 3-year term on the Public Advisory Committee on the Environment of the Environment Council of Alberta (during the year served on the Membership Committee, Nominations Committee, and Environmental Protection Study Group).

14. Goals for 1980-81:

1. Continue a literature gathering and review of information concerning climatic fluctuations and forest biomass productivity, with special emphasis on the Canadian boreal forest zone.

2. Continue to locate and gather data sources utilizing instrumented climate data and various proxy records of climate which relate to the boreal forest zone, such as those obtained from dendrochronology, paleobotany, lake sediments including foraminifera, speleothems, isotopes, archaeological evidence, and the historical written record. Initiate an analysis of climatic variation from the instrumented climate record for the central boreal zone (Yukon to northwest Ontario).

3. Act as Project Leader for Project NOR-31, including acting as Scientific Authority for contracts related to obtaining climate fluctuation, tree-ring chronologies, and forest biomass productivity information. Collection of tree-ring samples will be continued to complete a north-south transect through the boreal zone in the Alberta-NWT area for future analysis by Forintek. Further information will be gathered for a possible second transect in the Saskatchewan-Manitoba area.

4. Provide an internal report on the progress of the Project.

5. Maintain liaison with the Canadian Climate Centre and other agencies as the NOR-31 project is identified as part of the integrated Canadian Climate Program (CCP). Also continue involvement on the Climate Advisory Committee and other committees associated with the CCP, including that on CO_2. An opportunity will also be taken to visit the Climatic Research Unit at Norwich, England during a vacation in that country.

6. Continue involvement with the Forestry-Climate Workshop for the CCP by helping to compile the recommendations and proceedings of the Workshop for publication. This will include completion of the report Climate input in forestry courses at post-secondary institutions.

7. Continue progress towards summarizing all temperature and other climatic parameter data collected in connection with an earlier study on climate of clearcut forested area, with emphasis on data associated with the seedling growth study related to stand edge.

8. Continue to provide climatic advice and information to colleagues and others as requested in my role as Regional Climatology Advisor. This will include advice on climate input for the Biogeoclimatic ecosystem classification (NOR-27-169) as required.

9. Continue to fulfil duties as President of the Canadian Meteorological and Oceanographic Society until June and then those of Past President. Also continue other commitments on advisory groups and other committees.

15. Publications:

Up to 1979-80

Nil

1979-80

[Powell, J. M. 1979]. Canada/Canadian Forestry Service, Northern Forest Research Centre, Environmental Management, Environment Canada. pp. 125-129. In B. M. Barr (compiler and editor). The Canadian Association of Geographers Directory 1978. 182 pp.

Powell, J. M. (compiler). 1980. Socioeconomic Impacts of Climate. Proceedings of the Workshop and Annual Meeting of the Alberta Climatological Association. Environ. Can., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-217. 101 pp.

Powell, J. M. 1980. Northern Forest Research Centre: 1978 studies in Alberta with climatological input. pp. 89-91. In Powell, J. M. (compiler). Socioeconomic Impacts of Climate: Proceedings of the Workshop and Annual Meeting of the Alberta Climatological Association. Environ. Can., North. For. Res. Cent., Edmonton, Alta. Inf. Rep. NOR-X-217. 101 pp.

16. Signatures:

J. M. Powell
Investigator

Rex Reid
Program Manager

G. T. Silver
Director G. T. Silver

PROJECT NOR-32

Long range transport of air pollutants

NOR-32-178

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 5, 1980

1. Project: Long range transport of air pollutants.

2. Title: Impact of air pollutants from major regional sources on forest vegetation and soils.

3. New: X Cont.: No.: NOR-32-178

5. Study Leader: G. Hogan, J. Baker and S. Malhotra

6. Key Words: Pollutant, sulphur, metals, vegetation, soils, diagnosis, impact, restoration.

7. Location of Work: Region wide.

8. Problem:

With the increased industrialization there is concern in Canada as to the distribution, extent of transport and impact of airborne pollutants on natural environment.

Atmospheric motions are known to cause the transport of air pollutants across provincial and international boundaries. For pollution control negotiations with the provinces and the U. S. it will be necessary to quantify the ecosystem.

Major air pollution in this region originates from three sources; fossil fuel processing in Alberta, heavy metal processing in northern Manitoba, Saskatchewan and the Northwest Territories. A departmental co-ordinated program has been developed to provide information with respect to long range transport of air pollutants. The Canadian Forestry Service and the Northern Forest Research Centre specifically have agreed to cover off the forest vegetation and soils aspects.

9. Study Objectives:

   1. To determine the state of representative components of the terrestrial ecosystems; specifically vegetation and soils.

2. To determine the extent to which the long range transport of air pollutants is degrading these systems (relative to other sources of pollution).

3. To determine the origin of these airborne pollutants.

10. Resources:

a. Starting date: April 1, 1979
b. Estimated date of completion: 1985
c. Estimated total Prof. man-years required: 1.6
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1981 with costs: Nil
f. 1980-81 man-years

Prof.	0.8	(Hogan)
	0.4	(Baker)
	0.3	(Malhotra)
	1.5	
Supp.	0.6	(Fenn)
	0.2	(Radford)
	0.8	
Total	2.3	

11. Progress to Date:

A network of permanent biomonitoring sites has been established in the vicinity of smelters in Flin Flon and Thompson, Manitoba. Studies are being undertaken to determine the effects of smelter effluents on the quality of rainfall, on forest species and on soil processes. Reports are currently underway on different facets of the research carried out to date. These reports will be submitted to scientific journals for publication.

12. Goals for 1979-80:

1. Reexamine all study plots in Thompson. This will include sampling of rainfall, soil, lichens and foliage to determine the continued distribution of smelter effluents. These collections will be compared to those made in 1977 to determine the rate of degradation of the forest. (Hogan)

2. Investigate metal toxicity symptoms in native vegetation by studying the physiological effects of metals. (Hogan)

3. Study the germination and growth of forest species in metal contaminated soils. (Hogan)

4. a. Complete information report on Thompson. (Hogan)

   b. Write up and report a methodology paper entitled "A precipitation collector for pollutant deposition studies in remote areas". (Hogan and Addison)

Added Goals:

5. Expand the networks of soil and lichen sampling sites in directions north, east and west of the Thompson smelter stack. Examine lichen condition, collect samples for analysis of nutrients and pollutant content.

6. Initiate a study of soil organic matter decomposition as measured by litter accumulation at all permanent study plots in Thompson.

7. Expand the precipitation sampling in Thompson (Goal 1) to provide monthly estimates of wet and dry deposition of metal particulates and to attempt to provide reliable estimates of rainfall pH.

8. Synthesize moss bag monitoring data from Flin Flon and write a paper on comparisons between soil and moss bag data and present deposition rates.

9. Establish permanent study sites in the heavy impingement areas immediately south and west of the smelter in Thompson. Sample each area for distribution of metals in soils, vegetation and precipitation.

13. Accomplishments in 1979-80:

1 a) Precipitation samplers were erected at each major study site in Thompson and samples were collected over the course of the summer. The samples have been analyzed for pH and are currently being processed to determine metal and sulphur levels.

b) Lichen transplants and natural communities have been examined at all plots. Each lichen microplot was rephotographed. The microplots were examined for lichen condition. An analysis of the transplanted lichen material has been postponed until the 1980 field season. At this time physiological condition and elemental content of the transplanted material will be attempted. The lichen transplants have shown considerable change since 1977, but some of the lichen removal can be attributed to physical removal of the lichens by branch action other than degradation by atmospheric pollutants. This confounding factor tends to complicate the biomonitoring by use of lichen communities.

c) Soils were resampled at all the previously established sites to determine whether or not significant detectable increases in soil metal levels have taken place over the duration of the study. Organic samples and mineral soil samples have been digested and are awaiting analysis.

d) Samples of four species of vegetation were taken at each site, and one half of each sample was subjected to a washing treatment while fresh. The washed and unwashed samples were dried, ground and ashed and are currently being analyzed. The comparison of the two treatments will allow us to determine the amount of surface contamination that is present on foliar material. The surface contamination cannot be considered as part of the foliar material even though it is an important source of contamination from a soil and wildlife standpoint.

e) Moss bags were erected at all study sites and were used to estimate dryfall and wetfall of metal particulates at various sites. These samples are being processed and the results will be available in the next month.

2. a) The effect of copper on tolerant and nontolerant grasses has been examined from a standpoint of nutrient composition. These experiments are continuing and are aimed at finding the cause of copper toxicity and tolerance at a metabolic level. The results obtained in the preliminary experiments are not conclusive.

b) The effects of metals on the root growth of jack pine and white spruce grown under hydroponic conditions are being examined. However, constraints on time and personnel have not allowed us to make much progress in this area.

3. Experiments on the effects of metal contaminated soils from Thompson on the growth of jack pine are being carried out. The results to date indicate that regeneration of jack pine will be problematic within several kilometers of the smelter at Thompson. The experiments are continuing but their extreme duration (in excess of 4-6 months) means that the results are slow in forthcoming. This goal should be extended into the new year.

4. a) Complete information report on Thompson. This goal has not been completed, however, progress towards writing a paper on the Thompson baseline work has been made.

b) It has not been possible to report on the development of the precipitation collector. Problems associated with the physical and chemical decomposition of the exchange resins when placed in the field situation have rendered the technique impracticable. Selection of more suitable resins has been attempted without much success. However, it is felt that the technique has merit and that developmental work should continue.

5. An extended network of lichen and soil sampling locations has been established around Thompson, Manitoba. This will allow us to predict deposition rates and velocities in all directions from the smelter. The samples have been prepared and analyzed and the results are being synthesized.

6. A small study of organic matter accumulation was carried out at all sites around Thompson, Manitoba. The results indicated that no significant accumulation or organic matter had occurred. These results, however, should be interpreted as preliminary. The study has indicated that at any site extreme variations in soil LFH layer occur. Because of this fact extensive sampling (50-100 replicates per site) must be carried out at any given site.

7. The expanded precipitation sampling schedule was implemented to provide monthly rather than seasonal estimates of rainfall pH, and wet and dryfall deposition. The analyses of pH were carried out in the field and indicate that pH gradients do exist. The analysis of elemental composition has not been carried out because of problems with equipment scheduling and manpower.

8. Synthesis of moss bag monitoring data has been completed. The results are currently being used to prepare a paper on metal monitoring in Flin Flon, Manitoba. The paper should be completed in the early part of the new year.

9. Samples of vegetation soils and precipitation from heavily contaminated sites are currently being analyzed for content of pollutant and nutrient elements.

14. <u>Goals for 1980-81</u>:

1. Report on the baseline study carried out in Thompson. (Hogan)

2. Report on the baseline study carried out in Flin Flon. (Hogan)

3. Publish a paper on the use of the moss bag technique and resultant data in Flin Flon. (Hogan)

4. Publish an impact paper on the studies being carried out on the effects of smelter effluents on forest communities. (Hogan)

5. Investigate metal toxicity symptoms in native vegetation by studying the physiological effects of metals. (Hogan)

6. Study the germination and growth of forest species in metal contaminated soils. (Hogan)

7. Continue to monitor the present rates of deposition of pollutants in Flin Flon and Thompson by collection and analysis of precipitation and dryfall. (Hogan)

8. a) Establish 6 permanent biomonitoring sites in areas suspected to be influenced by Cold Lake heavy crude upgrading operations. The sites will be selected on the basis of wind direction and frequency, existing air quality information and consistency in land form, soil type and forest cover (similar age, height and density). Three sites will be located in Alberta and 3 in Saskatchewan. (Baker)

   b) Describe soil profiles at each site and collect soil and vegetation (overstory and understory) samples for pollutant and elemental analyses. (Baker, Malhotra)

15. <u>Publications</u>:

1978-79

Hogan, G. D. 1978. Annual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines Res. Env. Man., Province of Manitoba.

Hogan, G. D. 1978. Semi-annual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines Res. Env. Man., Province of Manitoba.

1979-80

Hogan, G. D. 1979. Semiannual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines, Res. Env. Man., Province of Manitoba. (Sept. 1978).

Hogan, G. D. 1979. Annual Progress Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. NOR-7-170. Submitted to Dept. Mines, Res. Env. Man., Province of Manitoba. (May 1979).

16. Signatures:

Investigator

Program Manager

Investigator

Director G. T. Silver

Investigator

PROJECT NOR-33

Technical and scientific information

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 26, 1980

1. Project: Technical and scientific information.

2. Title: Technical information.

3. New: Cont.: X 4. No.: NOR-33-145

5. Study Leader: R.M. Waldron

6. Key Words: Displays, audio-visuals, publications, resource managers, industrial managers, general public.

7. Location of Work: Region wide.

8. Problem:

The problem of communicating the results of research and development programs to the forest resource and industrial managers has been well documented in issues of professional and trade journals, in reports issued by the Science Council of Canada and by the Senate Committee on Science Policy. A study of CFS publications led a task force of the Department's Management Consulting Service to recommend and the CFS Program Committee to conclude that there is a real need to undertake the production of technically oriented publications specifically aimed at forest resource and industrial managers. Part of the evidence which led to the conculsion was the fact that of a total of approximately 600 articles published annually by the CFS, 80% were written for our scientific audiences and only 20% for our technical audiences; this allocation is based on definitions of our four principal audiences as contained in a policy statement prepared by Dr. M.L. Prebble on October 11, 1970. The need to increase our use of other forms of communications such as seminars, workshops, and audio-visual presentations is also recognized. It is anticipated that with more frequent and more effective use of these media the NFRC can enhance its probability of successfully communicating the results of our R & D program to clients and client agencies.

9. Study Objectives:

To initiate, develop and implement, with the cooperation and active participation of the research staff, a technical information program designed to encourage the application of research findings by forest resource, industrial managers and general public.

10. Resources:

a. Starting date: 1973
b. Estimated year of completion: continuing
c. Estimated total Prof. man-years required: 1.0 annually
d. Essential new major equipment items for 1980-81 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1980-81 man-years

	Prof.	1.0 (R. Waldron)
	Supp.	
	Casual	
	Total	1.0

11. Progress to Date:

Nine technical publications and ten Forestry Reports specifically prepared for our technical audiences have been published. An audio-visual on the Marmot Creek Watershed research program was prepared and shown to a number of technical and public audiences. Twenty-five Pest Leaflets, Trees and Forests of Jasper National Park and the Calgary-Regina Ecotour have been prepared for use by the general public.

12. Goals for 1979-80:

1. Publish 3 Forestry Reports

   (i) Forest Economics in Manitoba -- W. Ondro
   (ii) Silviculture -- L. Brace
   (iii) Program of the Northern Forest Research Centre -- Program Managers

2. Supervise the production of maps for the Regina-Winnipeg Ecotour, make final photograph selection and prepare specifications for printing.

3. Edit and publish "Guidelines for rearing containerized conifer seedlings in the Praire Provinces" -- L. Carlson and "Symptomology of SO_2 damage" -- S. Malhotra.

4. Assume responsibility for the Information Officer's duties until such time as the position is filled or duties reassigned. Duties include responsibility for distribution of publications, responding to requests for information, correspondence and devising an efficient retrieval-storage system.

5. Contribute to CFS-CIF Jasper meeting display.

13. Accomplishments in 1979-80:

1. Two Forestry Reports were published

   (i) "The importance of forestry in Manitoba" by W. Ondro was printed in the spring of 1979.

   (ii) Following technical review the report on Silviculture was returned to L. Brace.

   (iii) "Northern Forest Research Centre - its first decade" initiated by the Program Managers was printed in the fall of 1979.

2. Map preparation and typesetting of the English and French copy has been with Graphic Services and CFS headquarters for four months. This work will be completed, hopefully, by the end of February. Final photograph selection was made and captions were forwarded to Ottawa for translation and typesetting.

3. "Guidelines for rearing containerized conifer seedlings in the Prairie Provinces" by Carlson was published in the spring of 1979. To date 850 of the 1000 copies made have been distributed. S. Malhotra's technical MS on "Symptomology of SO_2 damage ....." has been delayed due to tardy external reviews and the resignation of the scientific editor. The nineteen color plates have gone to the printer for photograph numbering and color separations.

4. Carrying out essential Information Officer's duties accounts for 10 - 15% of my time. Distribution and maintaining the mailing list place the greatest demands on my time. The revised storage-retrieval system is now in operation.

5. My role in the CFS - CIF Jasper meeting display changed from that of contributor to coordinator. Approximately 1 1/2 months were spent designing, preparing and manning the display. The display was successful in conveying the computer programs being carried by the CFS throughout Canada.

14. Goals for 1980-81:

1. Publish 2 Forestry Reports

   (i) Fire - D. Dubé
   (ii) Silviculture - L. Brace
   (iii) Watersheds - R. Swanson

2. Supervise the paste up of the art boards and printing of the Regina-Winnipeg Ecotour. Ottawa is funding this publication.

3. Complete editing, typesetting, and publishing of S.S. Malhotra's "Symptomology of SO_2 damage ......"

4. Continue responsibility for distribution of NFRC publications, maintenance of the mailing list, responding to requests for information and carrying out necessary correspondence.

5. Develop guidelines and specifications for the production of Forest Management Notes - 2 page brief technical articles and Insect and Disease Survey releases to technical clientele. It is anticipated 10 - 15 Notes will be prepared.

6. Assume duties of the Scientific editor - publisher with respect to printing and introduction of the word processor in manuscript reviews and others as required.

15. Publications:

1979-80

Carlson, L.W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can., Can. For. Serv., North For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-214.

Logan, P.A. and R.M. Waldron (eds) 1979. Northern Forest Research Centre: its first decade. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Rep. 23, 8 p.

Waldron, R.M. and P.A. Logan (eds) 1979. Importance of forestry in Manitoba. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Rep. 22, 8 p.

16. Signatures:

Investigator

Rev Reid
Program Manager

Director

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980 - 81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 26, 1980

1. Project: Technical and scientific information.

2. Title: Scientific information.

3. New: Cont.: X 4. No.: NOR-33-146

5. Study Leader: Vacant

6. Key Words: Journal articles, information reports, editing, publishing, printing.

7. Location of Work: Region wide.

8. Problem:

This is an editing and publishing service designed to assist the scientist in the preparation and printing of publications.

9. Study Objectives:

To assist, principally by providing editorial and publishing services, the research staff and technical writer in the preparation and publication of scientific and technical information through the media of journals, information reports, and other publications.

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: continuing
c. Estimated total Prof. man-years required: Nil
d. Essential new major equipment items for 1980-81 with costs:
   1. continued rental of electronic composer $ 405/month
e. Essential new major equipment items beyond 1979 with costs: Nil
f. 1980-81 man-years

Prof.	-	
Supp.	1.0	(Vacant)
Casual	1.0	(term editor)
Total	2.0	

11. Progress to Date:

A total of 836 scientific and technical publications have been released by the Northern Forest Research Centre since it was established in 1970. Publications include Information Reports, Journal Articles, Forestry Reports, Pest Leaflets and Ecotours.

12. Goals for 1979-80:

1. To assist the research staff, through the provision of editing and publishing services, in the preparation and publication of approximately 20 Information Reports and 20 journal articles.

2. To assist the technical writer, through the provision of editing and publishing services, in the preparation and publication of 2 Pest Leaflets, 1 Forestry Report, and 2 special technical reports. Edit Regina-Winnipeg Ecotour.

3. Oversee all printing and reprinting of locally published scientific and technical information.

4. Continue responsibility for displays in absence of an Information Officer.

5. Introduce computer-assisted revision of manuscripts.

13. Accomplishments in 1979-80:

1. Assisted staff in the publication of 7 Information Reports, and 17 journal articles. A list of 1978-79 publications (total of 26) is appended.

2. Participated in the writing, reviewing, editing, layout and publishing of two Forestry Reports. Edited one special technical report (Guidelines for rearing containerized conifer seedlings in the Prairie Provinces by L.W. Carlson). Carried out the initial broad brush editing of S.S. Malhotra's Technical report entitled "Symptomology of SO_2 damage .....".

3. Coordinated, wrote specifications for, and monitored the printing of 7 Information Reports, 2 Forestry Reports and the reprinting of 3 previously published reports. Renewed the standing offer agreement for printing, NFRC publications (Waldron).

4. Erected four displays in the foyer of NFRC: rare bottle collection by H. Gates; wild fire in the forests by D. Dubé; northern relics by S. Zoltan; and wildlife by R. Stevenson.

5. Analyzed the productivity of the typing pool and prepared the specificaitons for ordering a word processor for use in the preparation of manuscripts (Waldron).

14. Goals for 1980-81:

1. To assist the research staff, through the provision of editing and publishing services, in the preparation and publication of approximately 20 Information Reports and 20 journal articles.

2. To assist the technical writer, through the provision of editing and publishing services, in the preparation and publication of 2 Forestry Reports, approximately 10 Forest Management Notes and 2 special technical reports.

3. Oversee all printing and reprinting of locally published scientific and technical information.

4. Continue responsibility for displays in the absence of an Information Officer.

5. Introduce computer-assisted revision of manuscripts.

15. Publications:

1979-80

1. Ball, W.J. and V. Kolabinski. 1979. An aerial reconnaissance of softwood regeneration on mixedwood sites in Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta, Inf. Rep. NOR-X-216.

2. Bella, I.E. and J.P. DeFranceschi. 1980. Biomass productivity of young aspen stands in Western Canada. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-219.

3. Carlson, L.W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-214.

4. Drouin, J.A. and D.S. Kusch. 1979. Chemical control trials of the box elder twig borer in Alberta. Environ. Can., Can. For. Serv., Bi-Mon. Res. Notes 35:23.

5. Drouin, J.A. and D.S. Kusch. 1979. Ornamental and greenhouse insects. In press.

6. Drouin, F. and D. Kusch. 1979. Pesticide field trials on share and shelterbelt trees in Alberta, 1978. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-213.

7. Hiratsuka, Y., A. Tsuneda and Lynn Sigler. 1979. Occurrence of *Scytalidum urediricola* on *Endocronartium Larnessii* in Alberta, Canada. Plant Dis. Report 63:512-513.

8. Klein, J.I. 1979. Height growth of Russian Scots pine plantations in Saskatchewan and Manitoba. Environ. Can., Can. For. Serv., Bi-Mon. Res. Notes 35:14.

9. Kojima, S. and G.J. Krumlik. 1979. Biogeoclimatic classification of forests in Alberta. For. Chron. 55:130-132.

10. Logan, P. and R.M. Waldron (eds). 1979. Northern Forest Research Centre: its first decade. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Rep. 23, 8 p.

11. Malhotra, S.S. and A.A. Khan. 1979. Acid phosphatase activity and air pollutants. In press.

12. Malhotra, S.S. and S.K. Sarker. 1979. Effects of sulphur dioxide on sugar and free amino content of pine seedlings. Physiol. Plant. 47:223-228.

13. Powell, J.M. 1978. Climatic classifications of the Prairie Provinces of Canada. *In* Essays on Meteorology and Climatology, U. of Alberta, Dept. of Geog., Mono. 3. p.211-229.

14. Powell, J.M. (Comp.). 1979. Socioeconomic impacts of climate: Proceedings of the workshop and annual meeting of the Alberta Climatological Association, March, 1979. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-217.

15. Powell, J.M. 1979. Additional notes on the birds of the Kananaskis Forest Experiment Station and surrounding area. Alberta Naturalist 9:94-97.

16. Quintilio, D. 1979. Proceedings of the International fire management workshop. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-215.

17. Sarker, S.K. and S.S. Malhotra. 1979. Effects of SO_2 on organic acid content and malate dehydrogenase activity in jack pine needles. Biochem. Physiol. Ptlanzen 174: 438-445.

18. Takai, S. and Y. Hiratsuka. 1979. Accumulation of the material containing the toxin cerato-ulmin on the hyphal surface of *Ceratocystis ulmi*. Can. J. Bot. In press.

19. Takai, S., W.C. Richards, Y.P. Davies, Y. Hiratsuka and Y. Krywienczyk. 1979. Evidence for the presence of the toxin cerato-ulmin in the synnema head fluid of *Ceratocystis ulmi*. Can. J. Bot. In press.

20. Tsuneda, A. and Y. Hiratsuka. 1979. Mode of parasitism on a mycoparasite, *Gladosporium gallicola,* on western gall rust, *Endocronartium harknessii*. Can. Jour. Plant. Path. 1:31-36.

21. Tsuneda, A., Y. Hiratsuka and P. Maruyama. 1980. Hyper-parasitism of *Scytalidium uredinicola* on western gall rust, *Endocronartium harknessii*. Can. J. Bot. In press.

22. Wong, H.R. 1979. Insect damage to old oak beams at Lower Fort Garry, Manitoba. Quaest. Entomol. 15:335-339.

23. Wong, H.R. 1979. Biological observations on overwintering larvae of the large aspen tortrix in Alberta. Environ. Can., Can. For. Serv. Bi-Mon. Res. Notes 35:21.

24. Waldron, R. and P. Logan (eds) 1979. Importance of forestry in Mantioba. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Rep. 22, 8 p.

25. Walker, N.R. and H.J. Johnson. 1980. Containerized conifer seedling field performance in Alberta and the North-west Territories. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-218.

26. Zoltai, S.C. 1979. Ecological land classification projects in northern Canada and their use in decision making. Proc. 2nd Meeting Can. Comm. Ecol. Land Classif. p. 373-381.

27. Zoltai, S.C. and V. Woo. 1979. Fragile soils of permafrost terrain. In press.

16. Signatures:

Investigator

Rex Reid
Program Manager

G. Stiltner
Director

PROJECT NOR-34

Forest biomass as an energy source

NOR-34-180

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1980-81

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 22, 1980

1. Project: Forest biomass as an energy source.

2. Title: An assessment of the energy potential of forest biomass in the Prairie Provinces and the Northwest Territories.

3. New: Cont.: X 4. No.: NOR-34-180

5. Study Leader: A. D. Kiil

6. Key words: Biomass, energy, fuels, climate, productivity, simulation models, resource data.

7. Location of work: Western and Northern Region.

8. Problem:

Fossil fuels such as crude oil, natural gas, tar sands and coals are relatively abundant in Canada, but nevertheless of finite extent. Because such reserves are dwindling, there has been a fresh look at forest fuels which are theoretically infinite. Forest biomass, the total quantity of organic matter in the forest, is an energy source that is currently untapped and in many cases going to waste.

Current biomass productivity in the forested areas of the Prairie Provinces and the Northwest Territories ranges from less than 1 t/ha/yr in the north to over 3 t/ha/yr in some southern parts of the provinces. The initial estimate of the above-ground tree biomass reserve in Alberta alone is more than 1 billion tons of oven-dry material. Annual biomass production amounts to 25 million oven-dry tons, which in methanol represents twice the annual energy production from oil sands at the Syncrude plant in Fort McMurray.

The Canadian Forestry Service is the lead agency in administering the federal Energy from the Forest (ENFOR) program. The NFRC project is an integral part of the national CFS ENFOR program to assess the potential of biomass as an alternate energy source.

9. Study Objectives:

   1. To develop and test biomass prediction equations for regional tree species and lesser vegetation and demonstrate their integration with resource inventory programs.

2. To investigate the impact of biomass removal on site quality, nutrient status, silvicultural options and long-term site productivity on selected sites in the Prairie Provinces.

3. To determine production and delivery costs of biomass under various operating conditions to provide a basis for evaluating the feasibility of using various forms of biomass for energy production in the boreal forest.

4. To develop and operate a computerized biomass data bank and information retrieval system to provide for more effective technology transfer.

10. Resources:

a. Starting date: 1979
b. Estimated year of completion: 1984
c. Estimated total Prof. man-years required: 7
d. Essential new major equipment items for 1980-81 with costs:
Computer hardware: $35,000 (ENFOR funds)
e. Essential new major equipment items beyond 1981 with costs:
Computer hardware: $50,000
f. 1980-81 man-years Prof. 1.0 (Bella 0.1, Johnstone 0.1, Kirby 0.5, Brace 0.1, Powell 0.1, Ondro 0.1)
Supp. -
Total 1.0

11. Progress to Date:

Two contract studies were completed during the 1978-79 fiscal year:

1. Development of biomass yield tables for young aspen stands in the Prairie Provinces. About 400 variable-size plots, each with 100 trees, were selected and measured. About 25 young aspen trees, covering a size range of 10 to 25 cm dbh, were felled, measured and weighed for weight determinations. Data have been analyzed and the final publication will be available for distribution in early 1980 (Scientific Authority: I. Bella).

2. Evaluation of the line intersect method for biomass inventory. Field work was completed in summer, 1978. Owing to resignation of Scientific Authority in fall, 1979, data analysis and final publication will not be completed until spring, 1980 (Scientific Authority: D. Quintilio).

The 1979-80 biomass program involved the following contract studies:

1. Upper limits of standing crop density and growth rates for woody species in the Prairie Provinces (contract with Western Ecological Services). Field work has been completed. Final report to be published in spring, 1980 (Scientific Authority: L. Brace).

2. Development of biomass prediction equations for six commercial tree species in the Prairie Provinces. Over 400 individual trees have been felled, measured and weighed to date (Scientific Authority: W. Johnstone).

3. Development of a stand growth model for trembling aspen in the Prairie Provinces (Scientific Authority: I. Bella).

12. <u>Goals for 1979-80</u>:

1. Coordinate and supervise work on four ENFOR contracts approved for the Western & Northern Region (refer to NOR-4-075, NOR-29-173, NOR-10-176 and NOR-17-118 re: Scientific Authority).

2. Develop and coordinate the implementation of regional ENFOR program within the framework of national objectives.

3. Initiate work to synthesize all regional biomass data and initiate preparation of manual on guidelines and procedures for setting up and maintaining operational biomass inventory data systems.

13. <u>Accomplishments in 1979-80</u>:

1. Coordinated and supervised work on three ENFOR contracts (itemized in item 11. above).

2. Developed a three-year ENFOR program plan within the NFRC Forest Resources Research Program. Participated as NFRC representative on CFS Production and Main Committees and coordinated integration of NFRC objectives within framework of national program. Attended 1979 Bio-Energy meeting in Ottawa.

3. Dr. Singh initiated work to synthesize all regional biomass data (see NOR-30-183). Biomass data sources have been identified. Four new ENFOR project proposals were prepared and approved by ENFOR Committee for implementation in 1980-81.

14. <u>Goals for 1980-81</u>:

1. Coordinate and supervise the following ENFOR contracts in 1980-81:

Study	Title	Scientific Authority	1980-81 Contract Funds
P-51	Crop Density & Growth Rates	L. Brace	39,800
P-92	Biomass Prediction Equations	W. Johnstone	42,000
P-102	Stand Growth Model for Aspen	I. Bella	53,500
P-148	Demo. of Biomass Inventory System	C. Kirby	85,000
P-149	Climate & Tree Growth	J. Powell	22,000
P-150	Climate Literature Review	J. Powell	24,000
P-163	Harvesting & Chipping Aspen	W. Ondro	48,500

2. Develop and refine three-year ENFOR program plan to reflect regional objectives and priorities for 1981-82, 1982-83 and 1983-84.

3. Coordinate preparation of new proposals for ENFOR funding. Represent the NFRC on ENFOR Production and other committees as required.

4. a) Publish Inf. Report, "Use of the line intersect method for sampling of forest biomass"(D. Quintilio).

   b) Publish Inf. Report, "Upper limits of standing crop density and growth rates for woody species in the Prairie Provinces"(contractor).

   c) Prepare progress reports on P-92, P-102, P-148, P-149, P-150 and P-163 (various contractors).

15. Publications:

Up to 1979-80

Kiil, A. D. 1978. The energy from the forests (ENFOR) program in the Prairie Provinces: An overview (paper presented at the Annual Meeting of the CIF, Manitoba Section, Winnipeg).

1979-80

Bella, I. and J. P. De Franceschi. 1980. Biomass productivity of young aspen stands. Inf. Rpt. NOR-X-219.

16. Signatures:

C. D. Hall
Investigator

C. D. Hall
Program Manager

G. Silver
Director G. T. Silver