STUDY STATEMENTS

1979 - 80

NORTHERN FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

MAY 1979

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PROJECT NOR-1

Detection and appraisal of tree pests and vegetative disturbances

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

1979-80 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 1978-79:

    1. A journal paper entitled "Morphology and taxonomy of rust fungi" will be prepared with Dr. N. Hiratsuka.

    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. A. Van Sickle (PFRC) and Dr. J. Powell (NFRC), data from 15 years of plot studies of pine stem rusts will be analyzed and a report will be prepared. This work was started by the late Mr. Joe Baranyay.

    4. A journal paper on the host response of a few exotic hard pines to the infection of *Endocronartium harknessii* will be published.

    5. A significant continued progress will be made to complete the "Check list of Uredinales in Alberta" for an information report.

13. Accomplishments in 1978-79:

    1. The first draft of a journal paper entitled "Morphology of spermogonia and taxonomy of rust fungi" was prepared.

    2. All except two manuscripts were received for the proceedings of an international symposium on rust taxonomy for editing.

    3. No progress has been made to complete data analysis of pine stem rust plots established by the late Mr. Baranyay.

    4. A paper on the host response of *Endocronartium harknessii* was not prepared.

    5. Significant progress has been made to complete the "Check list of Uredinales in Alberta".

Accomplishments not in Goals for 1978-79:

6. In July Dr. A. Tsuneda was awarded NRC Visiting Fellowship to work at NFRC especially on hyperparasites of forest tree rusts and other tree pathogens. Several fungi previously known to occur with western gall rust and other pine stem rusts were found to be active hyperparasites, one of which appear to produce an active antibiotic substance. Their mode of parasitism has been investigated.

7. Following paper was presented at CPS-CSPP Joint Meeting in Winnipeg.

   Hiratsuka, Y. and A. Tsuneda. *Cladosporium gallicola*, an active hyperparasite of western gall rust.

8. Following papers were presented at Alberta Regional Meeting of the Canadian Phytopathological Society, Grande Prairie:

   Hiratsuka, Y. Importance of western gall rust in man-made and man-assisted forests.

   Tsuneda, A. and Y. Hiratsuka. Mycoparasites of western gall rust.

14. <u>Goals for 1979-80</u>:

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.

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 1978-79:

1. A journal paper entitled "Morphology and taxonomy of rust fungi" will be prepared with Dr. N. Hiratsuka.

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. A. Van Sickle (PFRC) and Dr. J. Powell (NFRC), data from 15 years of plot studies of pine stem rusts will be analyzed and a report will be prepared. This work was started by the late Mr. Joe Baranyay.

4. A journal paper on the host response of a few exotic hard pines to the infection of *Endocronartium harknessii* will be published.

5. A significant continued progress will be made to complete the "Check list of Uredinales in Alberta" for an information report.

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1. The first draft of a journal paper entitled "Morphology of spermogonia and taxonomy of rust fungi" was prepared.

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5. Significant progress has been made to complete the "Check list of Uredinales in Alberta".

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6. In July Dr. A. Tsuneda was awarded NRC Visiting Fellowship to work at NFRC especially on hyperparasites of forest tree rusts and other tree pathogens. Several fungi previously known to occur with western gall rust and other pine stem rusts were found to be active hyperparasites, one of which appear to produce an active antibiotic substance. Their mode of parasitism has been investigated.

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   Hiratsuka, Y. and A. Tsuneda. *Cladosporium gallicola*, an active hyperparasite of western gall rust.

8. Following papers were presented at Alberta Regional Meeting of the Canadian Phytopathological Society, Grande Prairie:

   Hiratsuka, Y. Importance of western gall rust in man-made and man-assisted forests.

   Tsuneda, A. and Y. Hiratsuka. Mycoparasites of western gall rust.

14. 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.

15. Publications:

1977-78

Hiratsuka, N. and Y. Hiratsuka. 1977. Morphology of spermogonia and taxonomy of rust fungi (Abstract). Abstracts of the Second International Mycological Congress A-K:288.

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.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

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. Requests for surveys and advisory services in environmental pollution problem areas are being directed with increasing frequency to the Canadian Forestry Service. The Forest Insect and Disease Survey (FIDS) can handle many of these requests.

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

9. Study Objectives:

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

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

10. Resources:

a. Starting date: 1941 at Winnipeg and Indian Head
b. Estimated year of completion: Continuing
c. Estimated total Prof. man-years required:
d. Essential new major equipment items for 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

	Prof.	0.4	(Y. Hiratsuka)
		0.3	(H. Cerezke)
	Supp.	1.0	(J. Petty)
		1.0	(F.J. Emond)
		1.0	(G.N. Still)
		1.0	(R.C. Tidsbury)
		0.2	(H. Gates)
		1.0	(vacant FO-1)
	Casual	-	
	Total	5.9	

11. Progress to Date:

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

12. Goals for 1978-79:

1. In view of requirements for the new National Forestry Statistics program, increased emphasis will be placed on the detection and reporting of pests in three provinces particularly in high-value fibre producing areas. Intensive general pest surveys in high priority management areas in the three provinces will be conducted followed by written report.

2. Provide a diagnostic and pest extension service to client agencies (provincial forest services, forest industries and municipalities) and general public concerning the cause and control of problems of trees and shrubs attributable to insects, diseases and other causes. Positive identification of causes will often be referred to specialists (NOR-1-154, NOR-1-153).

3. Special surveys for particular pests or designated areas will be conducted followed by written reports. Some examples of surveys which probably will be conducted in 1978 are:

    1. *Scleroderris* canker in Jasper.
    2. Jack pine budworm in Saskatchewan and Manitoba.
    3. Spruce budworm.
    4. Tent caterpillar.
    5. Wood borer in fire killed areas in Saskatchewan.
    6. Circular forest disturbance in Hinton area.
    7. Elm bark beetle.
    8. Bark beetle (pine and spruce) in Alberta.
    9. Insects and diseases of young regenerations and plantings.

4. Information collected during the field season will be collated into an information report outlining known pest situations in the region. Also efforts will be made to relate results to volume depletion figures re Goal #8.

5. Make representations and contribute to various advisory committees as required. Few examples anticipated in 1978-79 will be:

   1. Western Committee for Plant Disease Control

   2. Western Forum

   3. DED Advisory Committee - Saskatchewan

   4. DED Action Committee - Alberta

   5. Pest Control Forum

   6. *Scleroderris* Committee

6. Prepare and give lectures and talks on common forest insects and diseases for various audiences as need arises.

7. Prepare articles for an issue of "Forestry Report" on forest insect and diseases in spring 1978.

8. With H. Cerezke (NOR-17-143) an attempt will be made to estimate the amount of damage and volume depletion caused by insects and diseases for 1977. This exercise is to come up with figures for a part of the "National Forestry Statistics" data from the region.

9. Compile available control recommendations for diseases of ornamental and shelterbelt trees for "Guidelines for the control of plant diseases in western Canada".

13. Accomplishments for 1978-79:

1. Aerial and ground surveys of major forest pests (spruce budworm, jack pine budworm and forest tent caterpillar) were conducted in three prairie provinces and major areas of infestation were mapped.

2. Provided pest extension service to various client agencies and the general public concerning the damage caused by insects, diseases and pollutants. About 2500 enquiries and samples were processed in 1978.

3. Following special surveys were conducted in 1978:

   1. Presence of Scleroderris canker in Jasper National Park was re-confirmed but the disease was not found in areas other than the original location near Maligne Lake. (Hiratsuka)

   2. General surveys of insects and diseases in five western national parks (Banff, Jasper, Yoho, Kootenay and Waterton Lakes) were conducted. (Petty and Patterson)

3. Woodborer survey was conducted in Weyaskwin Burn, Saskatchewan. (Cerezke and Gates, reported under NOR-1-143.)

4. Aerial and ground survey was conducted to investigate possible "red belt" damage near Grande Cache, Alberta. Results indicated that the cause was severe hail damage. (Petty and Still)

5. Native elm bark beetle surveys in southern Alberta and southwestern Saskatchewan was conducted with negative results. (Emond and Caltrell)

6. Egg mass surveys of spruce budworm were conducted in Riding Mountain National Park and Duck Mountain Provincial Park, Manitoba. Egg mass surveys of jack pine budworm were conducted in Manigotogan-Caribou Lake area, the Nisbet Provincial Forest and Torch River Provincial Forest, Manitoba. (Still and Campbell)

7. Mountain pine beetle surveys in the Crowsnest Forest, Alberta were conducted in 1978 to find out the situation of the infestations of the insect detected in 1977. More trees showing the red-tops and the insect was found in wider areas. (Petty and Wong)

8. Surveys of insects and diseases of many young regenerations in Saskatchewan and Manitoba were conducted by H. Cerezke and Y. Hiratsuka with assistance from J. Ball, K. Froning and L. Nairn.

4. Draft of a report entitled "Forest Insect and Disease Conditions in Prairie Provinces - 1977" has been prepared.

5. Represented and contributed to various advisory committees (Cerezke's involvements reported in NOR-17-143).

    1. Western Committee for Plant Disease Control - Lethbridge (Hiratsuka)

    2. Western Forum - Lethbridge (Hiratsuka)

    3. DED Advisory Committee - Saskatchewan (Hiratsuka)

    4. DED Action Committee - Alberta (Hiratsuka, Petty and Emond)

    5. Plant Disease Committee - Saskatchewan (Emond and Gardner)

    6. Insect Control Committee - Saskatchewan (Gardner and Emond)

    7. Central International Forest Insect and Disease Work Conference (Hiratsuka and Hildahl)

6. Prepared and gave lectures and talks on forest insects and diseases.

    1. Junior Forest Wardens, Drunheller, High Level (Emond and Caltrell)

    2. Tree Pruning Courses, Brooks, Oliver, Fairview (Emond and Caltrell)

    3. Pine Ridge Tree Nursery (Hiratsuka and Cerezke)

    4. Personnel from Procter & Gamble, St. Regis, North Canadian Forest Products and Alberta Forest Service in Grande Prairie (Cerezke and Hiratsuka)

    5. DED Action Committee - Alberta (Petty, Emond and Hiratsuka)

    6. Alberta Parks and Recreation Association - Red Deer (Emond)

7. Contributed to the publication of an issue of Forestry Report featuring forest insect and disease survey (Editor: Hiratsuka, Contributors: Johnson, Cerezke, Emond, Hildahl, Petty, Still, Waldron, Wong, and Hiratsuka).

8. No request for pest depletion figures from Ottawa.

9. Contributed a chapter (Ornamental and shelterbelt trees) in the "Guidelines for the control of plant diseases in western Canada" (Hiratsuka).

14. Goals for 1979-80:

    1. Detect and report major pests (spruce budworm, jack pine budworm, forest tent caterpillar) in 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 product standard survey instruction manual suitable for the region (FO-1 and Cerezke).

15. Publications:

1977-78

Blauel, R.A. 1977. Survey of a forest community near a cement production industry. File Report.

Blauel, R.A. and D. Hocking. 1977. Forest conditions as benchmarked in the Alberta Oil Sands Area prior to 1976 by Northern Forest Research Centre. File Report.

Campbell, A.E. and V. Hildahl. 1977. Summary of forest insect and disease conditions in Manitoba, 1976. Information Report NOR-X-183. 25 p.

Emond, F.J. and R.M. Caltrell. 1977. Summary of forest insect and disease conditions in Alberta, 1976. Information Report NOR-X-185. 8 p.

Hiratsuka, Y. and H. Cerezke. 1977. Circular forest disturbance in the Edson Forest District. File Report NOR-1-033.

Hiratsuka, Y. and J. Petty. 1977. Forest insect and disease conditions in the Prairie Provinces - 1977. (Interim report submitted for NFFC in Ottawa.)

Patterson, V.B. and R.C. Tidsbury. 1977. Summary of forest insect and disease conditions in Saskatchewan, 1976. Information Report NOR-X-180. 8 p.

Petty, J. 1977. Spruce budworm survey in Alberta. File Report NOR-1-033.

Petty, J., Y. Hiratsuka and W.G.H. Ives. 1977. Forest insects and diseases attacking jack pine in the residual strips and surrounding areas at the Pine Ridge Nursery site. File Report NOR-1-033.

Petty, J. and V.B. Patterson. 1977. Jack pine budworm egg mass survey in Saskatchewan, 1977. File Report NOR-1-033.

Petty, J. 1977. Important forest insects and diseases. Prairie insects and diseases, Prairie Region. *In*: Forest insect and disease survey annual report, 1976. Canadian Forestry Service, Environment Canada (in press).

Petty, J. 1977. Bark beetle surveys, Alberta, 1977. File Report NOR-1-033.

Patterson, V.B. and J. Petty. 1977. Dutch elm disease surveys, Saskatchewan, 1977. File Report NOR-1-033.

Petty, J. 1977. Summary of insects and disease conditions in Kootenay National Park, 1977. File Report NOR-1-033.

Petty, J. 1977. Summary of insect and disease conditions in Waterton Lakes National Park. File Report NOR-1-033.

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 beetle 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.

16. Signatures:

Investigator

Program Manager

Investigator

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

1. Project: Detection and appraisal of tree pests.

2. Title: Sawfly systematics.

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

5. Study Leader: H.R. Wong

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

7. Location of Work: Edmonton, Alberta

8. Problem:

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.

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 1979-80 with costs: Nil.
e. Essential new major equipment items beyong 1980 with costs: Nil.
f. 1979-80 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 1978-79:

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

2. Obtain specimens of *Pristiphora* attacking conifers in Europe and Asia to determine their relationship to the ones in North America.

3. Advise and provide information in those fields of sawfly taxonomy, which I am considered an expert by scientists in North America and Eurasia.

13. Accomplishments in 1978-79:

1. Identified nearly 400 larval and adult sawflies for the Forest Insect and Disease Survey of the Northern Forest Research Centre,

Canadian National Collection, regional clients and in-service personnel.

2. Specimens of *Pristiphora* attacking *Picea* were obtained on loan or as gifts from Japan, Czechoslovakia and Finland this year. A study of the genitalia of these and other European and Asiatic specimens indicate that only three phyletic lines of coniferous feeding *Pristiphora* are present in North America. These are on *Larix* and *Picea*. A relative of the *abietina* group, which is an important economic group in Europe is not present in North America at the present time, but there is a fear that a member of this group like the European spruce sawfly may be accidentally introduced into this country.

3. Visited by Dr. D.R. Smith (Washington) and G. Gibson (Ottawa) to discuss various aspects of sawfly taxonomy, and reviewed papers on this subject for publication in two different scientific journals.

14. 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.

15. Publications:

1977-78

Wong, H.R. 1977. *Fallocampus*: A new sawfly genus for the Nearctic species of *Platycampus* Schiødte (Hymenoptera: Tenthredinidae). Can. Ent. 109:1103-1107.

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

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

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

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

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

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

7. Location of Work: Edmonton and Ottawa

8. Problem:

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

Some of the data on general distribution and abundance and on rates of parasitism were in reports or on raw data sheets, but had not been transferred to forms suitable for computer input. Similarly, the format used by the Meteorological Branch of the Department of Transport for summarizing their weather data was not suitable for some of the 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: 1980
c. Estimated total Prof. man-years required:
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.	0.4	(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.

12. Goals for 1978-79:

1. Complete the plotting of insect population and weather data.

2. Examine the data to determine whether or not any interrelationships can be detected.

3. If the data warrant it, start preparing a manuscript summarizing the results. At the moment, an information report is being contemplated.

13. Accomplishments in 1978-79:

1. Plotting of the insect population and weather data was completed and plates prepared.

2. Examination of the data is currently underway. Population and infestation data were used to sort the weather data into groups. The means for each of these groups were then calculated. Correlations between infestation data and sampling data for the same species of insect were calculated for seven insects. Correlations between each of 21 species were also calculated for the sampling data.

   Examination of the results is currently underway, and although incomplete, it appears that a number of plausible interrelationships may exist.

3. Work on a manuscript has not yet been started, as data analyses are incomplete.

14. Goals for 1979-80:

1. 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".

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 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 extention 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.

12. Goals for 1978-79:

1. Diagnostic and identification service of tree and shrub diseases will be provided.

2. Maintain and upgrade the Mycological Herbarium and the Fungus Culture Collection.

3. A journal paper entitled "A new leaf spot fungus *Marssonina balsamiferae* n. sp. on *Populus balsamiferae* in Manitoba and Ontario" will be published.

4. A journal paper entitled "Morphology and morphogenesis of synnemata of *Ceratocystis ulmi*" will be published with Dr. S. Takai of GLFRC.

5. Cooperate with Dr. Takai (GLFRC) on the study of Dutch elm disease especially in the aspects of scanning electron microscopy. Several journal papers will be prepared jointly with Dr. Takai.

6. Complete first draft of an information publication on diseases of trees and shrubs of the Prairie Provinces.

13. Accomplishments in 1978-79:

1. Diagnostic and identification service of tree and shrub diseases was provided mainly through the pest extention service (NOR-1-033).

2. About 150 new specimens were incorporated into the Mycological Herbarium and a few new cultures were added to the fungus culture collection.

3. The manuscript of a paper entitled "A new leaf spot fungus *Marssonina balsamiferae* n. sp. on *Populus balsamiferae* in Manitoba and Ontario" is completed and ready for internal review.

4. A journal paper "Morphology and morphogenesis of synnemata of *Ceratocystis ulmi*" has been published.

5. Two joint publications with Dr. Takai on DED are in the process of internal review at GLFRC.

6. Little progress has been made to complete a publication on common diseases of trees in the Prairie Provinces.

14. 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.

15. Publications:

1977-78

Hiratsuka, Y. 1977. Annotated checklist of tree and shrub diseases in the Prairie Provinces. Information Report NOR-X-178, 104 p.

Takai, S., W.C. Richards, Y. Hiratsuka, and K.J. Stevenson. Cerato-ulmin, a semipathotoxin of *Ceratocystis ulmi*. Proceedings "Recognition and specificity in plant host-parasite interactions" (in press).

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.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 30, 1979

1. Project: Detection and appraisal of tree pests.

2. Title: Forest Insect Diagnostic and Biosystematic Services

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

5. Study Leader: H.R. Wong

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

7. Location of Work: Edmonton, Alberta

8. Problem:

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

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

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

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

9. Study Objectives:

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

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

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

10. Resources:

a. Starting date: 1976
b. Estimated year of completion: A continuing project. Revised.
c. Estimated total Prof. man-years required. Indefinite
d. Essential new major equipment items for 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

1979-80 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 1977-78:

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. Determine distribution of the mountain pine beetle, *Dendroctonus ponderosae* Hopkins in Alberta.

5. Report on the insects attacking old oak beams at Lower Fort Garry, Manitoba.

6. Determine the parasites of *Archips argyrospilus* complex attacking caragana in Saskatchewan.

13. Accomplishments in 1978-79:

1\. 1. Diagnostic and biosystematic services made several thousand determinations and handled over 1000 inquiries for in-service personnel, clients, outside agencies, scientists and the general public.

   2. Only 25 dead immature insects were examined this year to determine infectious diseases due to the illness of Mr. Melvin.

2\. 1. Amalgamated the insect orders, Hymenopter and Diptera from the old Winnipeg and Calgary collections.

   2. Over 150 insects were added to the reference collection. Most of these were identified by specialists in Ottawa, Ontario.

   3. Over 200 insect samples were reared and 50 overwintered to obtain biological information and specimens for the reference collection.

   4. Over 300 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. J.D. Shorthouse, Laurentian U, Sudbury, Ontario
Dr. J.M. Campbell, C.N.C., Ottawa, Ontario
Dr. A.P. Nimmo, U of A, Edmonton, Alberta
Dr. D.C. Yoshimoto, C.N.C., Ottawa, Ontario

4\. Data published in Bi-Monthly Research Notes 34(b):38, 1978.

5\. Preliminary report sent to H. Van der Putten, Project Manager of Restoration, Lower Fort Garry, Manitoba.

6. The parasites recovered by rearing larvae of *Archips argyrospilus* complex attacking caragana have been identified as *Itoplectus conquisitor* (Say), *Brachymeria ovata* (Say), *Brachymeria fonscolumbei* (Dufour), *Phaeogenes* sp., *Phaeogenes hariolus* (Cresson) and *Nemorilla pyste* (Walker).

7. Updated taxonomic and nomenclatural information in the paper "Common insect and mite galls of the Canadian Prairies" before the second printing (not listed in objectives).

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.

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.

15. Publications:

1977-78

Wong, H.R., J.C.E. Melvin and A.M. Harper. 1977. Common insect and mite galls of the Canadian Prairies. North. For. Res. Cent., Edmonton, Alberta. Information Report NOR-X-146. 81 pp.

1978-79

Wong, H.R. and J. Petty. 1978. The Mountain pine beetle in Alberta. Bi-Monthly Research Notes 34(6):38.

Wong, H.R. 1978. Mountain pine beetle. Forestry Report p. 8. Spring 1978.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-3

Resource opportunities and policy guidelines

NOR-3-123

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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, multiplier, costs, benefits, economic impacts.

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 industry 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 1979-80 with costs: Nil
   e. Essential new major equipment items beyond 1980 with costs: Nil
   f. 1979-80 man-years

Prof.	3.0	(W. Ondro 1.0, Vacant Positions 2.0)
Supp.	1.0	(R.A. Bohning)
Casual	-	
Total	4.0	

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.

12. <u>Goals for 1978-79</u>:

    1. Define and priorize needs and opportunities for new economics research and advisory services program.

    2. Determine the need and feasibility of updating the 1972 statistical descriptions of some major economic impacts of forestry in the three Prairie Provinces.

    3. Provide consultation and advice on economic questions and issues, including DREE agreements, as required.

    4. Provide technical supervision and interpret findings from contract study concerning economic feasibility of using biomass as an alternate source of energy.

    5. Recruit an Economist.

    6. Goal added: Prepare Forestry Report - The economic importance of the forestry sector in Manitoba.

    7. Goal added: Recruit Forest Economics Technician.

    8. Goal added: Prepare a paper on "Socio-economic impact of climate on forestry in Alberta".

13. <u>Accomplishments in 1978-79</u>:

    1. The needs and opportunities for new economic research and advisory services were defined and priorized. See goals 1979-80.

    2. The need and feasibility of updating the 1972 descriptions of major economic impacts of forestry in the three prairie provinces were established. The methodology, sampling design and survey questionnaires were prepared for Alberta study and submitted to Statistics Canada for approval.

    3. Consultation and advice on economic questions and issues were provided as required. Good working relationship was established with DREE Western Region.

    4. No input required as yet to provide technical supervision and interpret findings from contract study on economic feasibility of using biomass as an alternate source of energy.

    5. Forest economist position has been advertised internally and surplus list was examined with no suitable prospects. However, new competition will result in a recruitment of the 2nd economist by June 1979.

    6. Accomplishment added: Forestry Report - Importance of forestry in Manitoba was prepared (in editorial review).

7. Accomplishment added: Forest Economics Technican was recruited (R.A. Bohning).

8. Accomplishment added: Paper on "Socio-economic impact of climate on forestry in Alberta" was prepared. Summary provided for Proceedings of Third Workshop of Alberta Climatological Association, Edmonton, March 3, 1979.

14. Goals for 1979-80:

1. Publish Forestry Report - Importance of forestry in Manitoba.

2. Initiate data collection analysis and complete 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.

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

William J. Ondro
Investigator

G. D. Hart
Program Manager

G.T. Silver
Director G.T. Silver

PROJECT NOR-4

Yields of managed stands

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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: 2.0
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	(I.E. Bella)
Supp.	0.2	(J.P. DeFranceschi)
Casual	0.0	
Total	0.4	

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 17 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., Cayford, J.H., Steneker, G.A., and Wilson, G.M. between 1950 and 1977.

12. Goals for 1978-79:

    1. Prepare a file (establishment) report on the study of the AFS operational mechanical thinning trials (conducted at Edson and Rocky-Clearwater Forests).

    2. Remeasure thinning experimental plots in jack pine due for measurement in 1978:

        - Study 3, Merchantable Selection Thinning, Sandilands — 20 plots

        - Study 4, (a and c), Mechanical Strip Thinning, — 15 + 15 plots

- Study 5, Selection and Strip Thinning,
  Duck Mtns. 5 plots

Total	55 plots

3. Remeasure spacing experiments in jP, rP and wS at Moodie, Manitoba and Riding Mtn. National Park, Manitoba.

4. To provide regional growth information and contribute to testing of the Compatible System of Growth Simulation model as used by the Manitoba Forest Service.

13. <u>Accomplishments in 1978-79</u>:

1. A file report has been written on an operational thinning study of the AFS, titled "Mechanical thinning in lodgepole pine in Alberta in the winter of 1976-77: An establishment report".

2. Two thinning studies in jack pine (Study 3, Merchantable Selection Thinning, 20 plots and Study 4a and 4c, Mechanical Strip Thinning, 15 + 15 plots, all in Sandilands) were remeasured.

   Thinning study (#5) in Duck Mtns., 5 plots, were not remeasured because of access problems, and the relatively low value of the data.

3. Spacing experiments in jP, rP and wS at Moodie, Manitoba, and in Riding Mtn. National Park were remeasured.

4. Established contact with members of the MFS to work out ways of cooperating in testing the Compatible System of Growth Simulation model that is being adapted for Manitoba. Growth data suitable for testing has been tabulated. Further involvement on our side will have to wait for initiative by the MFS.

14. <u>Goals for 1979-80</u>:

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.

15. Publications:

1977-78

Bella, I.E. and J.P. De Franceschi. 1977. Young lodgepole pine responds to strip thinning, but ... Can. For. Serv., Inf. Rep. NOR-X-192. 10 p.

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE,

1978

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
1	Prince Albert, Sask.	Medium to coarse sand, dry to moderately Dry	30	1949	1954 1964	2	1.0	Regular Spacing	Control, no thinning Thinned: Heavy - 7 x 7 ft
			40	1949	1954	2	1.0		Control, no thinning Thinned: Heavy - 7 x 7 ft
			60	1949	1954 1964	2	1.0		Control, no thinning Thinned: Light - 9 x 9 ft
2	Sandi-lands, Man.	Stratified sand and gravel outwash; moist	15	1952	1957 1962 1967 1971 1977	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	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

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE, 1978 (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
4	Sandilands Forest Reserve, Manitoba	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	5	.002 - .007	Mechanical Strip-thinning	Thinned 1-way: 5 plots
		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	5	.002 - .007	Mechanical Strip-thinning	Thinned 1-way: 5 plots
		e. Sandy till, fresh	13	1965	1967 1970 1974 (1979A)	10	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots
		f. Sandy till, fresh	17	1966	1968 1970 1975	10	.002 - .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots
		g. Sand, dry	13	1965	1967 1970 1974 (1979A)	10	.002 .007	Mechanical Strip-thinning	Control: 5 plots Thinned 1-way: 5 plots
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	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

SUMMARY OF ACTIVE THINNING EXPERIMENTS IN PINE, 1978 (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	
8	Edson Forest	Silty till, fresh	20	1977	-	18	3.4-289 m^2	Mechanical strip thinned		-	10 plots
								Selective thinned		Control:	5 plots
										Thinned:	3 plots
	Rocky-Clearwater Forest	Silty till, fresh	9	1977	-	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

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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: 1973 Revised: Most of these studies generally extend over the life of the stand.
c. Estimated total Prof. man-years required: 2.0
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.	0.8	(I.E. Bella)
Supp.	0.8	(J.P. De Franceschi)
Casual	-	
Total	1.6	

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, I.E., Bella and De Franceshi, and Steneker, G.A.

12. Goals for 1978-79:

    1. Remeasure a selective thinning study in aspen at Pelly, Sask., (14 0.2 acre plots in May 1978.

    2. Contribute to the supervision of the aspen biomass contract in cooperation with regional sub-offices, and to the preparation of the appropriate biomass yield tables.

13. Accomplishments in 1978-79:

    1. The selective thinning study in aspen at Pelly was remeasured.

    2. Contributed to the supervision of the aspen biomass contract as scientific authority. In cooperation with the Prince Albert Sub-Office, selected suitable sampling areas and stands for the study. Initiated the analysis of data for the preparation of appropriate biomass yield tables.

14. 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".

15. Publications:

    1977-78

    Nil

    1978-79

    Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

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	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 National Park	Non telluric mesic clay loam till	14	1950	1960 1965 1971 1976	4	0.1	Regular spacing	Control, no thinning - 1 plot Thinned: 8' x 8', 10' x 10', 12' x 12' - 1 plot each
		Telluric mesic silty clay loam till	23	1950	1960 1965 1971 1976	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

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

1. Project: Yields of managed stands.

2. Title: Transformation and movement of applied nitrogen 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.

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 nitrogen. It emphasizes the influence of soil properties on the transformation, movement, immobilization, and distribution of soil nitrogen. It also seeks to evaluate the modifications brought about within the several soil nitrogen fractions as a result of artificially applied nitrogen.

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 nitrogen applications are concerned, suggest that fertilization of these and similar soil would prove profitable. 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 operators (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:

Two phases of this study have been initiated. 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 nitrogen distribution, foliar composition and stand growth - initial (first growing season) and residual (subsequent growing seasons) effects are to be studied.

The laboratory study is not to duplicate field conditions but to investigate the influence of certain environmental factors such as soil moisture and temperature, atmospheric temperature and humidity and soil type on the distribution of nitrogen in the various soil nitrogen fractions, on the uptake of nitrogen and its influence on tissue composition and the relationship between these and seedling growth.

9. Study Objectives:

To determine the influence of soil properties on the transformation, distribution and accumulation of the various soil nitrogen fractions, amonium-nitrogen, nitrate-nitrogen, humin-nitrogen, etc., resulting from soil nitrogen 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 1979-80 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 1980 with costs: Nil

f. 1979-80 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-yrs after fertilization) and these have been kept in cold storage pending study review decisions.

12. Goals for 1978-79:

1. Analysis of samples taken November 1977, N-P-S presently in a frozen state.

2. Report on 5-yr residual effects (Journal).

13. Accomplishments in 1978-79:

Above goals were not met. Procurement of necessary spectrophotometer did not materialize. Time originally designated to this study was transferred to NOR-7-114 and NOR-24-160 as discussed under those reviews.

14. Goals for 1979-80:

Those goals for 1978-79 1) analyses of samples and 2) report results, will be undertaken this year.

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

16. Signatures:

Joseph Baker

Investigator

A. D. Hunt

Program Manager

G.T. Silver

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 1980

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

1. Project: Yields of managed stands.

2. Title: Assessment of regeneration stocking standards in Alberta.

3. New: Cont.: X 4. No.: NOR-4-163

5. Study Leader: I.E. Bella. Cooperators: Alberta Forest Service.

6. Key Words: Minimum stocking and site, post logging treatment, *Pinus contorta* var. *latifolia*, *P. banksiana*, *Picea glauca*, *P. mariana*.

7. Location of Work: Alberta

8. Problem:

As harvesting of the forest resource increases in Alberta, it becomes necessary - particularly after clear-cutting - to make special efforts to ensure the perpetuation of forest tree cover for sustained wood fibre yields and other benefits. The Alberta Forest Service has to ascertain that cut-over areas are adequately restocked by appropriate tree species within a reasonable length of time.

To define "adequate stocking" is not easy, as any relevant information we now have comes from old growth stands that originated after wild fires and usually developed from dense regeneration into dense stands, with high suppression mortality throughout their life. Such stands at harvest on the average, may contain 500 to 1,000 trees per acre. This means that over 95% of the original trees could have succumbed to mortality during the life of the stand.

The second growth stands that follow clear-cutting will develop through a very different route. Initial density of regeneration is generally much lower, mortality is less dramatic during stand development, but final number of trees at harvest (and also yield) may not differ greatly from stands grown in a dense regime. However, below a certain level of stocking, the trees could not fully utilize the site and thus wood fibre yield would decline.

The minimum adequate stocking that would achieve full utilization of the site by trees at a given time would depend on, and vary with, site conditions, species characteristics and also with anticipated use of the tree crop, utilization standards and logging practices. The effects of site and species characteristics are relatively permanent and predictable; whereas factors relating to utilization continually change with time and are less predictable. Therefore in evaluating regeneration success on a parcel of land, the effect of site and the characteristics of the tree species that constitute the stocking should be given prime consideration.

Benefit Expected:

Information on adequate minimum stocking of regeneration is needed by forest managers to evaluate regeneration success and in decisions whether planting and/or other treatment should be applied to restock a given area. Wrong decisions can mean waste of funds, or a substantial reduction of yield at harvest.

Probability of Success:

Probability of success for obtaining useful information is good, even if it has to be based, in part, on a review and synthesis of already published data to provide some quick, practical answers. Subsequent studies may refine these answers.

Probability of Practical Application of Results:

Very good, as the A.F.S. needs and requested this information.

Method Outline:

1. Define the minimum number of trees per unit area that are required for complete occupation of the site half way through the rotation (age 40) for the four study species using information gathered from published and unpublished sources and from field sampling.

2. From the above minimum density at 40 years, derive minimum density at age 10, confirming this with tree growth information from thinning and spacing studies, and data collected from individual trees growing in relatively open stands. Also define possible sources and magnitude of mortality and consider its effect when estimating minimum density at 10 years of age.

3. Conduct a sampling survey to develop relationships between density (in number of trees) and stocking percent for each study species and condition classes so that stocking percent can be tied to stand development (usually expressed in number of trees).

9. Study Objectives:

To provide information needed by forest managers for efficient management of second growth stands, on the minimum level of regeneration stocking required at 10 years after logging in lP, jP, wS and bS stands on different sites so as to ensure complete utilization of the site at least halfway through rotation (i.e., by 40 years) and to ensure a reasonably high merchantable wood production.

10. Resources:

a. Starting date: 1975
b. Estimated year of completion: 1977 Revised: 1980
c. Estimated total Prof. man-years required: 1.6
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:

1. Sampling areas were chosen to study regeneration density and stocking of lP and wS on cutovers approximately 10 years old. A range of site and two main treatment (scarified, unscarified) conditions were sampled.

2. Stem growth and crown width information was collected from lP and wS (total number 75) trees growing under open conditions in a variety of sites, between ages 25 and 50 years. From these data, appropriate growth regressions were developed.

3. Using growth regressions described above (#2) average maximum tree size (dbh and crown width) was estimated for different site classes at age 40 years.

4. From a brief review of literature and observations in the field, factors of mortality and their relative importance, were assessed in relatively open stands up to age 40 years.

5. From average maximum tree size, the number of trees needed at age 40 for complete crown closure were estimated. From this, number of trees per acre and stocking % needed at age 10 were worked out.

6. Quadrat-size and seedling pattern interactions were evaluated from the sample and recommendations were made on suitable quadrat size.

12. Goals for 1978-79:

    1. Complete analysis and prepare for publication an Information Report on the final results of the study on the assessment of stocking standards in Alberta.

    2. Analyze spatial pattern data of young 1P stands from large scale photo plots and initiate publication as warranted by the results.

13. Accomplishments in 1978-79:

    1. Analysis of final results from a study of stocking standards was completed and an Information Report was published.

    2. Work has been started on analyzing spatial pattern of young 1P from large scale photo plots. Plots, quadrats and trees were identified on B & W and on color prints. Rectification of tree coordinates were arranged with Al Aldred, FMI, Ottawa. Other priorities postponed further work on this study.

    3. Accomplishment added: Provided advise and consultation in developing a joint research proposal with the AFS for a major long term study of "Development of managed and natural juvenile stands in Alberta".

14. Goals for 1979-80:

    1. Terminate study.

15. Publications:

1977-78

Bella, I.E. 1976. Assessment of regeneration stocking standards used in Alberta. Can. For. Serv., Inf. Rep. NOR-X-167. 38 p.

1978-79

Bella, I.E. and J.P. De Franceschi. 1978. Assessment of regeneration stocking standards used in Alberta: A follow-up. Can. For. Serv., Inf. Rep. NOR-X-211. 24 p.

16. Signatures:

I. Bella

Investigator

A. D. Kiil

Program Manager

G. T. Silver

Director G.T. Silver

PROJECT NOR-5

Fire management systems and guidelines

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1979

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: 1980
c. Estimated total Prof. man-years required: 3.2
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.	0.5	(R.G. Newstead)
Supp.	1.0	(R.J. Lieskovsky)
Casual	-	
Total	1.5	

11. Progress to Date:

Within the study the use of fire retardants, long-term in particular, has been promoted to regional fire control agencies and, due in part to that liaison development and service activity, fire retardants are now in common use with concomitant improvement in air drop effectiveness.

Air drop patterns have been delineated for most airtankers and helitankers in use in the region in aid of improved aerial suppression throughout the region. Portable ground mixing units and retardant mixing systems within aircraft have been developed and are being utilized to good effect by fire control agencies. Work continues in assessing new retardants and mixing systems.

Aerial fire suppression research has evolved into a two-pronged approach within the Northern region. The first involves on-site evaluation of fire retardants and airtanker effectiveness on wildfires. The second is concerned with simulation of this theme, using parameters determined through static testing of tank and gating characteristics and utilization of available retardant delivery and fuel related models.

Airtanker accuracy has been investigated under simulated bombing conditions, however results achieved suggested that economically constrained sampling methods used were inadequate and statistically unreliable. Numerous variables within the experiment could not be accounted for in the analysis of results.

Studies of mixing and storage of long-term fire retardants in Alberta have demonstrated that continuous quality control in the preparation and storage of these commercial products is of utmost importance in maintaining their viability during relatively short and uncertain periods of demand.

Preliminary drafts of specifications for flame-inhibiting and water modifying fire retardants remain subject to continuing revision in order to incorporate user suggestions, up-dated technical information and potential corrosive and environmental damage.

A first generation initial aerial attack computer simulation model has been developed and published.

12. Goals for 1978-79:

1. Continue effort to assess on-site effectiveness of fire retardants through experimental and wildfire evaluation. Cooperation and cost-sharing is assured by the AFS in support of this investigation throughout the province during the initial month of the airtanker contract season. Cooperation of other agencies (e.g., Saskatchewan, and NWT) is anticipated whenever the fire situation arises and access and logistical support are favorable.

2. Provide technical assistance to regional fire control agencies. Specifically:

   a) Respond to a request by the Department of Northern Saskatchewan concerning S-2 Tracker loading problems as affected by pumping facilities and/or delivery system characteristics.

   b) Assist the AFS in monitoring new developments in their air attack program as it may be affected by possible changes in the type(s) of retardant used, retardant mixing equipment and/or airtanker contracts.

   c) Assist the NWL & F Service in a retardant testing program where spoilage problems persist and where new or modified short-term retardant compounds are under consideration.

   d) Additional training and consultation as requested.

3. Conduct air drop tests with new or existing retardant products where such field trials are warranted or requested in support of laboratory investigations. Such tests are anticipated in Alberta in an effort to identify an optimal mixing ratio for a new Chemonics water thickening compound; and to determine the effect of changes in viscosity of gum-thickened Fire-Trol 931 on drop patterns.

4. Upon completion and calibration of a retardant spray apparatus, tests will be initiated to determine the coating and penetration effects of different retardant rheological properties.

5. Complete masters thesis at the University of Alberta.

6. Publish reports in review 1977-78.

7. Goal added: Attend and/or serve on conferences, workshops or annual meetings of benefit to the study program in the areas of fire suppression technology, fire retardants and operations research methods.

8. Goal added: Conduct laboratory tests with several experimental short-term retardant polymers to evaluate their water thickening properties.

9. Goal added: Provide technical assistance where requested to industries and agencies involved in developing new or modified retardant mixing systems, and help resolve retardant mixing and storage problems.

10. Goal added: Prepare viscosity tables for long-term retardant Phos-Chek XB.

11. Goal added: Meet with personnel from various fire control and research agencies in southern California to discuss technological and chemical advances in fire control in that region.

13. Accomplishments in 1978-79:

1. During the initial month of the AFS airtanker contract, sporadic fire occurrence and limited accessibility restricted the assessment of on-site effectiveness of fire retardants to one wildfire. This occurred while on stand-by for one week at the Whitecourt tanker base. Although on-site assessment was curtailed once again, AFS air attack personnel continued to submit completed aerial observation forms. This information has been analyzed and forwarded to the AFS and is being amalgamated with earlier information for further processing.

   Again uncooperative weather conditions prevented completion of the scheduled six experimental black spruce burns designed to determine retardant effectiveness. Only two plots were burned and interim results have been summarized and presented at the annual AFS fire control officers meeting.

2. Provided technical assistance to regional fire control agencies; specifically:

   a) Assisted the Department of Northern Saskatchewan with calibration of retardant meter flow rates at two tanker bases; and conducted static venting and tank capacity measurements on a typical Tracker delivery system.

   b) Held informal preliminary discussions with AFS air attack personnel re: use of short-term retardant with land-based bombers in lower priority regions of Alberta. These discussions also considered the types and versatility of retardant mixing equipment required to incorporate this level of air attack flexibility. Questions concerning tank and gating efficiency of the Super Canso to be added to the fire bombing fleet were also reviewed.

   c) The NWL & F Service rescinded their earlier request for assistance in identifying and correcting retardant spoilage conditions in favor of having this problem considered by DINA Water Pollution Control branch in Yellowknife.

   d) Research technician Lieskovsky presented lectures on retardants, mixing systems and delivery systems at the AFS spring training sessions for bird-dog officers and mixmaster personnel.

3. Conducted drop tests with five short-term retardants including three experimental water thickeners at Hay River, NWT and Slave Lake, Alta. The B-26 tanker was used to permit the assessment of drop pattern responses to high shear drop conditions. Preliminary interpretation of results suggests that recovery and pattern response generally improve with increasing product elasticity, i.e., break-up and evaporation resistance. In addition,

drop tests with gum-thickened Fire-Trol 931 retardant were completed.

4. Some progress towards completion of a retardant spray apparatus has been made despite the effects of alternate project priorities imposed upon the equipment development staff.

5. A first draft copy of the masters thesis is nearing completion. Results of computer model runs are complete and text prepared to date is under review by Advisory Committee.

6. Reports in review in 1978:

   Hodgson, M.J. and R.G. Newstead. 1977b. "Short-term variation of forest fire locations: toward a suppression strategy", The Canadian Geographer.

   This publication was withdrawn from review and has undergone major revision prior to submission for review by an alternate journal as follows:

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

   See publications also.

7. Accomplishment added: Attended and/or served on the following:

   - Fire Retardant Symposium sponsored by Monsanto Canada Ltd., at Harrison Hot Springs, B.C., April 3-7, 1978.

   - Intermountain Fire Research Council Annual Meeting held in Edmonton, Alta., October 30-November 3, 1978.

   - Alberta Forest Service Annual Fire Control Officers Meeting, Kananaskis, Alta., December 11-13, 1978.

   - Western Regional Science Association Annual Conference, San Diego, Calif., February 22-25, 1979.

8. Accomplishment added: Conducted preliminary laboratory tests to screen water thickening properties of three experimental short-term retardant polymers: General Mills XAP-104, Grain Processing Corp'n 35A-100, and Dow Chemicals of Canada Ltd., Gelgard 60.

9. Accomplishment added: Research technician Lieskovsky provided technical assistance to the Alberta Forest Service, Monsanto Canada and Chemonics Industries on retardant or equipment evaluations at Calgary, Pincher Creek and Red Deer air bases.

10. Accomplishment added: Prepared viscosity tables for Monsanto's Phos-Chek XB fire retardant. These tables are based upon a correlation between Brookfield viscometer and Marsh Funnel measurements at room temperature.

11. Accomplishment added: While on work travel in southern California, met with personnel from Monsanto Wildfire Centre, Los Angeles County Fire Department, and San Dimas Equipment Development Centre to review new developments in the durable retardant and fugitive color programs, the use of computer technology in resource inventory and dispatching procedures, and retardant and tanker base standards being considered by the U.S.F.S., respectively.

12. <u>Goals for 1979-80</u>:

    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).

15. Publications:

1977-78

Hodgson, M.J. and R.G. Newstead. 1977a. "Location-allocation models for one-strike initial attack of forest fires by airtankers", Can. J. For. Res. Vol. 8 No. 2. pp. 145-154.

Forestry Report Vol. 5, No. 2 1977 - Water thickening compounds - how effective are they?

1978-79

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

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1979

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: 1973 Revised: 1983
c. Estimated total Prof. man-years required: 8.0
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.	0.9	(Chrosciewicz)
Supp.	1.0	(Gordey)
Casual	-	
Total	1.9	

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 8 of the plots in 1978.

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. <u>Goals for 1978-79</u>:

1. Submission of the following for publication:

    (1) Jack pine regeneration following burning and seeding treatments in central Saskatchewan. Inf. Rep.

    (2) Moisture variations of conifer foliage in central Alberta. Can. J. For. Res.

    (3) Calorific variations of conifer foliage in central Alberta. Can. J. For. Res.

2. Continuation of destructive sampling for preburn fuel-weight assessments on jack pine plots in central Alberta.

3. Experimental burning for fire behavior determinations on jack pine plots in central Alberta.

4. Experimental burning for aerial suppression studies on black spruce plots in central Alberta.

5. Postburn assessments of plant succession and pine regeneration on experimental plots in southeastern Manitoba.

6. Processing field and laboratory data as they become available.

7. Providing on request consultative services and conducting seminars.

8. Goal added: Preparation and publication of a report on the "Silvicultural uses of fire in midwestern Canada".

9. Goal added: Designation of "Fire Hazard Ratings" for (23) forest ecosystems in the Mixedwood Section (B. 18a) of central Saskatchewan.

10. Goal added: Provided the burning is done on jack pine plots in central Alberta as planned, acceleration of obtaining and processing of data on total biomass, weather, fuel moisture, fire behavior, fire effects, and fuel depletion.

13. Accomplishments in 1978-79:

1. Out of the three reports proposed, the first one ("Jack pine regeneration ... etc.") is now completed, and the second one ("Moisture variations ... etc.") is nearing completion; both of them will be submitted for publication before the end of the fiscal year 1978-79. The preparation of the remaining third report ("Calorific variations ... etc.") is postponed until a few additional laboratory tests (freeze-drying of controls) are carried out.

2. All destructive sampling for preburn fuel-weight determinations was completed on pine plots in central Alberta.

3. Experimental burning, fire behavior studies, and detailed post-burn fuel assessments were successfully carried out on half (8) of the available pine plots in central Alberta.

4. Aerial fire suppression was studied (NOR-5-037) on spruce plots (2) in central Alberta, and for this, weather instrumentation and fuel-moisture determinations were provided.

5. Postburn assessments of plant succession and pine regeneration were done on experimental plots in southeastern Manitoba.

6. Field samples and laboratory data were processed as they became available.

7. Consultative services were provided to senior forestry officials from Newfoundland, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia.

8. Accomplishment added: An extra report on the "Silvicultural uses of fire in midwestern Canada" was prepared and published. This was done in response to an internal request.

9. Accomplishment added: In consultation with other fire researchers at the N.F.R.C., "Fire Hazard Ratings" were established for (23) forest ecosystems in the Mixedwood Section (B. 18a) of central Saskatchewan. This was done in response to a request by the Saskatchewan Department of Tourism and Renewable Resources.

10. Accomplishment added: For the pine plots in central Alberta, acquisition and processing of data on total biomass, weather, fuel moisture, fire behavior, fire effects, and fuel depletion were substantially accelerated during the fiscal 1978-79. This was done in response to a request by Dr. M. Potter (Gradient Modelling, Ltd.) who is currently under contract to test the "Rothermel's Fire Spread Model" with the requested data.

14. 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 (8) 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.

15. Publications:

1977-78

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.

1978-79

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.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1978

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: D. Quintilio

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.	0.2	(D. Quintilio)
Supp.	0.5	(M. Maffey)
Casual	-	
Total	0.7	

11. Progress to Date:

An inter-agency study group was formed to develop a simulation model for three initial attack methods, i.e. helicopters, airtankers, 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 1978-79:

   1. Continue serving 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 - Steering Committee

f) Fire Danger Rating Working Group

2. Conduct a joint AFS/CFS fire behavior/retardant evaluation study in Slave Lake Forest in spring of 1978.

3. In cooperation with the AFS, host the annual meeting of the Intermountain Fire Research Council (Montana, Idaho, Utah, Alberta) in Edmonton in the fall of 1978.

4. Goal added: Re-survey mortality and vegetation trends on 1972 aspen burns prior to conducting a repeat burn.

5. Goal added: Supervise contract OSS78-00093 (Timmerlin Ltd.).

6. Goal added: Participate in supervision of contract SS78-00050 (Peterson).

7. Goal added: Attend annual AFS Fire Control Officers meeting.

13. <u>Accomplishments in 1978-79</u>:

1. Continued membership on the following committees:

a) Western Fire Weather Committee
- met locally at AES headquarters in December.

b) Central Fire Weather Committee
- met in Prince Albert, Saskatchewan in December.

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

d) Regional Fire Research Committee
- did not meet.

e) Intermountain Fire Research Council - Steering Committee
- met in Missoula, Montana in February and June.

f) Fire Danger Rating Working Group
- met in Edmonton in November.

2. Completed one aspect of the fire behavior/retardant evaluation study. Water and short-term retardant effectiveness was evaluated relative to full crown fire intensity in the black spruce fuel-complex. Results indicate need for increased use of the short-term retardants.

3. Served as chairman of the Intermountain Fire Research Council meeting co-hosted by AFS and CFS in Edmonton, Oct. 31 - Nov. 3.

Compiled and reviewed papers for proceedings and submitted to NFRC editor.

4. Accomplishment added: Conducted two aspen re-burns, incorporated data with original burn summaries, and submitted report for review.

5. Accomplishment added: Supervised the survey of forest floor fuels in three AFS districts. A three-man contract crew ran 25 miles of line intersect survey and data is currently being analyzed (ENFOR contract).

6. Accomplishment added: Participated in supervision of the survey of forest floor fuels in a variety of aspen stands. Determined specific gravities for 270 wood samples in various stages of decay. Line intersect data is currently being analyzed.

7. Accomplishment added: Attended the AFS Fire Control Officers meeting, Dec. 11-13, and presented a summary of the fire behavior/ retardant evaluation.

14. 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.

15. Publications:

1977-78

Chandler, C. and A.D. Kiil. 1977. Wildfires and tame fires. Fire Journal, Vol. 71 (6).

Kiil, A.D., R.S. Miyagawa and D. Quintilio. 1977. Calibration and performance of the Canadian Fire Weather Index in Alberta. Dep. of Environ., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-173.

Kiil, A.D. 1977. Integrating fire research into forest land management. For. Rep., Vol. 5, No. 2.

Kiil, A.D. 1977. Coping with forest residues. For. Rep., Vol. 5., No. 2.

Kiil, A.D. 1977. Overwinter monitoring the Drought Code is recommended. For. Rep., Vol. 5, No. 2.

Quintilio, D. 1977. Lodgepole pine flammability. For. Rep., Vol. 5, No. 2.

1978-79

Quintilio, D. Fire behavior in natural forest stands. *In*: Dubé, D.E. 1978. Fire ecology in resource management: Workshop Proceedings.

16. Signatures:

D. Quintilio
Investigator

A. D. Kiil
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1978

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 loses 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:
c. Estimated total Prof. man-years required:
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.	1.8	(C. Ogilvie, 0.8; Vacant 1.0)
Casual	-	
Total	1.8	

11. Progress to Date:

Reports on communications and fire detection plans were prepared for the Yukon, Northwest Territories and Wood Buffalo National Park.

A "Barnes Airborne Fire Spotter" was purchased and tested, but because of too many false alarms the unit was found to be too unreliable to be of value.

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 prototype of a device intended to cover a strip of terrain approximately 2 km wide with the AGA 750 was built and tested with promising results.

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

The field work for a detection system evaluation of 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.

The office work related to the Saskatchewan detection system evaluation is partially completed. Including profiling 88 towers, processing and interpreting 66 sets of panoramic photographs and completing 45 seen-area maps.

12. Goals for 1978-79:

1. Complete the seen area mapping for Saskatchewan by profiling the remaining 14 lookouts and:

    a. take sets of panoramic photographs from 34 existing lookouts,

    b. draw seen area field sketches from each site and investigate seen area obstructions or possible alternate sites in the immediate vicinity of each lookout location,

    c. inspect lookout installations for safety and efficiency.

2. Process field information collected as follows:

    a. process, assemble, annotate, orient and interpret panoramic photographs,

    b. construct cross-section profile for each lookout site,

    c. compile seen area maps for each lookout based on panoramic photographs and cross-section profiles,

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

3. Complete seen area mapping for Prince Albert National Park subject to good weather during photography field trips.

4. Goal added: Evaluate as requested 8 idle towers in northern Saskatchewan and 6 towers in Manitoba that are near the Saskatchewan border and interact with adjacent Saskatchewan towers.

13. Accomplishments in 1978-79:

1. Profiled 14 lookout sites in Saskatchewan and:

    a. took 34 sets of panoramic photographs,

    b. drew field sketches from each site and investigated seen area obstructions and possible alternate sites in the immediate vicinity of each lookout location,

    c. inspected lookout installations for safety and efficiency.

2. Processed field information collected as follows:

    a. processed and interpreted 42 sets of panoramic photographs,

    b. there are no cross-section profiles done as yet because it is expedient to wait until all seen area maps are complete,

    c. completed 15 seen area maps.

3. Completed field work for Prince Albert National Park lookouts and have processed 6 sets of photographs and finished the profiles for 6 sites.

4. Accomplishment added: Drew profiles and took panoramic photographs for 14 towers in Manitoba and northern Saskatchewan at request of Saskatchewan fire control people.

14. 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 cooperation with the Alberta Forest Service on 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.

15. Publications:

1977-78

Niederleitner, J. 1977. A look at fire mapping. Forestry Report 1978.

1978-79

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

16. Signatures:

C. J. Ogilvie
Investigator

G. D. Hart
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1979

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. Dube

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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

Prof.	0.8	(D. Dubé)
Supp	1.0	(M.A. Walters)
Casual	-	
Total	1.8	

11. Progress to Date:

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

12. Goals for 1978-79:

1. Prepare as Information Reports:

    1. Early plant succession following fire in the subalpine forest of the Canadian Rockies by D. Dubé.

    2. Proceedings: Fire Ecology in Resource Management - A Workshop. Compiled by D. Dubé.

2. Write an operational fire management plan for Nahanni National Park.

3. Prepare a study proposal and conduct field work to develop an operational fire management plan for Wood Buffalo National Park.

4. Prepare guidelines and operational plan for a prescribed fire in Elk Island National Park.

5. Provide guidelines, advice and consultation for fire management planning in Western and Prairie National Parks.

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

7. Goal added: Present paper at "Fire and Range Management Workshop", Regina, Saskatchewan.

8. Goal added: Present paper at "Intermountain Fire Research Council Meeting", Edmonton, Alberta.

13. Accomplishments in 1978-79:

1. Submitted for review, "Early plant succession following wildfire, Kootenay National Park".

   Published as information report NOR-X-210, "Fire ecology in resource management: workshop proceeedings".

2. Nahanni field work completed. Writing of operational plan to be completed by April 30, 1979.

3. Study proposal for Wood Buffalo National Park and first years field work completed. Data analysis 75% complete.

4. Guidelines and operational plan for Elk Island National Park completed. Burn did not take place due to adverse weather conditions.

5. Attempted prescribed burn in Jasper in spring, 1978. Fall burning cancelled due to adverse weather conditions.

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

   a. Review of Nahanni biophysical program with Forest Management Institute in Ottawa (Feb. 6-10).

   b. Forest Technology School - Hinton (Feb. 15).

   c. North-west Lands and Forest - Ft. Smith (Feb. 20).

   d. Gradient Modeling Workshop (Mar. 20-23).

   e. National Training School - Jasper (April 14).

   f. Fire and Range Management Workshop - Regina (April 6).

   g. Fire Management Workshop - Jamestown, North Dakota (April 24-28).

   h. Intermountain Fire Research Council (Oct. 30 - Nov. 2).

   i. Alberta Forest Service - Fire Control Meeting - Kananaskis (Dec. 11-13).

   j. Environment Council of Alberta (Feb. 16, 1979).

7. Accomplishment added: Prepared and published paper titled "Considerations in the use of prescribed burning", for Fire and Range Management Workshop.

8. Accomplishment added: Prepared and submitted paper titled "Notes on fire management in National Parks" for Intermountain Fire Research Council Proceedings.

14. 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.

15. Publications:

1977-78

Quintilio, D., G.R. Fahnestock, and D.E. Dubé. 1977. Fire behavior in upland jack pine: The Darwin Lake Project. Inf. Rep. NOR-X-174. Northern Forest Research Centre, Edmonton, Alberta.

Stevenson, R.E., R.M. Waldron, P.A. Logan and D. Dubé. 1977. Trees and Forests of Jasper National Park. Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta.

Dubé, D.E. 1977. Prescribed burning in Jasper National Park. Forestry Report: Vol. 5, No. 2. Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta.

Dubé, D.E. 1977. Progress report for Nahanni Fire Management Study. File Report. NFRC, CFS. Edmonton.

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.

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

16. Signatures:

Dennis Dubé
Investigator

G.D. Stuart
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT (PROPOSAL)

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 27, 1978

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. Quintilio, 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 about 2,000 fires burn 1.5 million acres 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. A new thrust in the area of systematized data processing is being proposed here to add a new dimension to the fire program.

9. Study Objectives:

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

   2. To build and test relevant decision-aid models which will improve the rationale of fire control logic during multiple-fire 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 1979-80 with costs: Nil
   e. Essential new major equipment items beyond 1980 with costs: Nil
   f. 1979-80 man-years

Prof.	0.8	(D. Quintilio)
	0.5	(R.G. Newstead)
	0.2	(D. Dubé)
	0.1	(Z. Chrosciewicz)
Supp.	0.5	(M. Maffey)
	0.2	(C. Ogilvie)
Total	2.3	

11. Progress to Date:

   See current accomplishments.

12. Goals for 1978-79:

   1. Conduct a systems appraisal workshop to determine the current state of U.S.F.S. model development.

   2. Collate and classify existing relevant data from regional sources.

   3. Process and store data on magnetic tape in preparation for study use.

   4. Test available spread models against documented AFS fires available from Hinton Forest Technology School.

   5. Goal added: Review and discuss new program direction with regional fire management agencies.

13. Accomplishments in 1978-79:

1. Gradient Modelling Inc. conducted an informative three-day seminar at NFRC which described and summarized fire modelling progress in the U.S.

2. Supervised contract OGR 78-00429 lent to Dr. G.R. Fahnestock to review the current state of fuel inventory and management relevant to NFRC fire program.

3. Merged fuel moisture and Fire Weather Index data from Sask., Man., Alta. and NWT. Ran regression equations and covariance analysis to determine site differences.

   Stored NWT fire report forms from 1969-1974 on magnetic disc and merged with Fire Weather Index data.

   Updated AFS fire summary tape to include all years from 1961 to 1977.

   Identified high resource demand periods in Alberta from 1971 to 1972 tape records.

4. The Whitecourt elipse, Rothermel's equations and Kourtz's algorithm program are on file at NFRC as well as the "Flash Fire" program which utilizes Rothermel's model to develop fire management strategy exercises. Following test runs of all models the Whitecourt elipse, with modification, remains valid for present resolution levels.

5. Goal added: Met with AFS in January and February to discuss new program direction.

   Met with NWLF in November to discuss new program and in cooperation with C. Kirby jointly proposed a remote sensing/fire applications study.

14. 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 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 eliptical fire growth model.

15. Publications:

Nil

16. Signatures:

Investigator	Program Manager
Investigator	Director G.T. Silver
Investigator	
Investigator	

PROJECT NOR-7

Reduction of damage from pollutants
in the atmosphere

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1979

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: J. Baker, 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. Resources:

a. Starting date: 1971
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 1.2
d. Essential new major equipment items for 1979-80 with costs:

Dilutor - $1,000

e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

	Prof.	0.2	(Malhotra)
		0.3	(Addison)
		0.5	(Baker)
		0.2	(Hogan)
		1.2	Total Prof.
	Supp.	0.5	(Shuya)
		0.2	(Ridgway)
		0.4	(Fenn)
		1.1	Total Supp.
	Total	2.5	

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 1978-79:

1. Establish 3 benchmarking and air pollution biomonitoring sites in the Saskatchewan forest area around the Flin Flon smelter operation. (Hogan, Baker)

   a. Conduct heavy metal and total sulphur analyses on selected forest vegetation and soils. (Hogan, Baker)

   b. Establish precipitation traps in study plots and analyze the collected material for pollutant content and distribution. (Hogan, Baker)

   c. Conduct lichen study for air pollution biomonitoring purposes. (Hogan)

d. Investigate metal toxicity symptoms and physiological effects in native vegetation. (Hogan)

e. Conduct biochemical and physiological measurements on selected tree species from the Flin Flon area. (Addison, Malhotra)

2. Study the response of selected lichen species to gaseous and aqueous SO_2 in order to interpret field observations on natural and transplanted lichen communities. (Addison)

3. Establish contacts with appropriate personnel from the Saskatchewan Dept. of Environment, EPS, IWD, FMS and industry regarding our study around Flin Flon. (Hogan, Baker, Malhotra)

4. Because of the trends noted in the field work, continue the study on the effect of aqueous SO_2 on nutrient levels in soils and lodgepole pine. (Baker) (This goal transferred from NOR-7-162.)

5. Goal added: Write up a handbook entitled "Pollution symptoms on boreal forest vegetation. A field guide to assist diagnosis of air pollutant injury". (Malhotra)

13. Accomplishments in 1978-79:

1a. & b. Six new sites (5 along the Hanson Lake Road and 1 at Sandy Bay) in Saskatchewan were established. Sites along the Hanson Lake Road at 2, 8, 16, 20, and 24 km from the Flin Flon smelter were equipped with precipitation collectors above the canopy and stemflow collectors. Two soil pits were dug and sampled and 5 sample trees (jack pine) were sampled at each site.

Soil samples and stemflow analyses have been completed. Foliar and precipitation samples while processed are yet to be analyzed. Preliminary data (file report) has been prepared.

1c. Lichen communities were examined at each site to determine whether or not there had been any impact of industrial emissions on this forest component. The examination revealed that the distribution of lichens was discontinuous. However, this zonation of lichens did not appear to be as a reulst of smelter activities. No obvious lichen degradation that may be indicative of air pollution injury was found. It would appear that the lack of epiphytic lichens may at least be partly due to the differences in local microenvironment.

1d. Investigations into metal toxicity in native vegetation were initiated. These preliminary studies on jack pine and white spruce were performed to study the effects of copper and nickel in nutrient culture on the growth and nutrient composition of both species. Concentrations of 2.5 and 5.0 ppm were shown to bring about considerable reductions in both fresh and dry weight in jack pine roots and shoots. Nickel was clearly less toxic to jack pine bringing about reductions in growth at 10 ppm and mortality at 20 ppm. White spruce was not as responsive to the metals as jack pine and this may be due to the difference in their natural growth rate.

Since these experiments were run under most ideal conditions to cause phytotoxicity, this information may not be directly applicable to the field situation.

1e. Branches of jack pine exposed to air pollutants under field conditions were collected from the "impingement" and "control" areas around Flin Flon and analyzed for their biochemical, physiological and chemical characteristics. Considerable differences in lipid biosynthesis were found between the above areas and there appeared to be a direct relationship between the pollutant content of the tissues and the biochemical response.

2. Lichen material from *Evernia mesomorpha* was exposed to 6 gaseous concentrations of SO_2 under controlled conditions. The results showed that many of the discrepancies in lichen response to gaseous and aqueous SO_2 lie in the rate of gaseous SO_2 uptake. The data are currently being analyzed for publication in a scientific journal.

3. Good relations and cooperative working arrangements have been established with representatives from IWD, EPS, industry and Saskatchewan Dept. of Environment.

4. Effects of aqueous SO_2 on the composition of lodgepole pine seedlings were inconsistent. Soluble constituents in seedling buds, needles, bark and wood showed general trends related to concentration of added aqueous SO_2 - this was not seen in total values. A file report is in preparation.

   Since soils are still supporting seedlings, soil analysis has not yet been undertaken.

5. Accomplishment added: the handbook on air pollution symptomology has been written up and is currently being typed for submission to the NFRC review board.

14. 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)

15. <u>Publications</u>:

1977-78

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 on the forest ecosystem p-714-719. *In*: The Oil Sands of Canada - Venezuela 1977. The Canadian Institute of Mining and Metallurgy pp. 782.

1978-79

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.

16. <u>Signatures</u>:

Joseph Baker
Investigator

Program Manager

Investigator

P.A. Addison
Investigator

G.D. Hogan
Investigator

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1979

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: X Cont.: 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 pollutent 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 15 k 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. <u>Resources:</u>

a. Starting date: 1977
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 0.8
d. Essential new major equipment items for 1978-79 with costs: Nil
e. Essential new major equipment items beyond 1978-79 with costs: Nil
f. 1979-80 man years

Prof.	0.8	(Hogan)
Supp.	0.6	(Fenn)
Total	1.4	

11. <u>Progress to date:</u>

A network of biomonitoring sites has been established in the vicinity of smelters in Thompson and Flin Flon, Manitoba. Studies are being undertaken to determine the effects of smelter effluents on the quality of rainfall, on forest species and on soil processes. The area currently under the influence of metal pollutants is being monitored to determine the present rate of influx of these particulates.

12. <u>Goals for 1978-79:</u>

1. Establish 6 benchmark and air pollution biomonitoring sites in the forest area around the Flin Flon smelter operation (Hogan and Baker).

2. Conduct heavy metal and total sulphur analyses on selected forest vegetation and soils in Flin Flon area (Hogan and Baker).

3. Conduct histological examination of vegetation suspected of pollutant injury from Flin Flon area (Hogan).

4. Establish precipitation traps in study plots in Flin Flon area and analyze the collected material for pollutant content and distribution (Hogan and Baker).

5. Examine existing lichen communities to determine the impact of air pollutants on this component of the forest (Hogan).

6. Transplant healthy lichens into affected and control area to determine the impact of present levels of pollution on lichen communities as indicators (Hogan).

7. Investigate metal toxicity symptoms in native vegetation by studying the physiological effects of metals (Hogan).

8. Determine the impact of air pollutant contaminated soils on seed germination and growth of various species (Hogan).

9. Maintain plots in the Thompson area (Hogan).

10. Write up an information report on the biomonitoring program in the vicinity of Thompson (baseline information) (Hogan).

Added Goals

11. Examine areas east and southeast of Thompson not previously examined for lichen distribution and for total metal burdens in the LFH layer.

12. Examine soils in the heavily contaminated sector (within 5 km) to determine the rate of downward movement of metal particulates. Foliar levels of metals should be examined at each site at the same time.

13. Accomplishments in 1978-79

1. The establishment of eight benchmark and air pollution biomonitoring sites in the Flin Flon forest area was completed. The plots were arranged in two gradients (S & SE) away from the stack. Soil and vegetation (vascular plants and masses) descriptions were carried out at each site.

2. Foliar samples of jackpine, black spruce, alder, and labrador tea were taken at each site. These samples have been prepared and are currently undergoing analysis. Soil horizons are being analysed to aid in soil classification and to provide information about the nutrient status of each site. Soil and litter samples are being analysed to provide information about the acidification of soils and the movement of metals into the mineral horizons.

3. Histological examination of vegetation suspected of pollution could not be attempted because adequate facilities were not available in the field. Field examination of foliar material suspected of SO_2 injury was made in Flin Flon; this work may be carried out in the following year provided adequate arrangements for field "lab." facilities can be made.

4. Precipitation traps developed at NFRC by P. Addison and myself were installed at crown height at all study sites. The bulk precipitation has been analysed but the ions trapped by the resin columns are currently undergoing analysis.

5. Lichen communities were examined at each site to determine whether there had been any impact of industrial emissions on this forest component. This examination revealed that the distribution of lichens was not continuous. However, the zonation of the lichens did not appear to be as a result of the smelting activities. There were no lichen remnants such as those that are found on previously examined polluted sites. It would appear that at least part of the discontinuity in the distribution of these species could be accounted for by differences in local microenvironment. If lichen examinations are to be included in the study in the future it would be profitable to reexamine epiphytic communities while examining ground and rock lichens which have proved to be sensitive in other areas.

6. Lichen transplants were not attempted as it seemed pointless to transplant lichens into what might be an area with a hostile micro environment.

7. Investigations into metal toxicity in native vegetation were initiated. These preliminary studies on jack pine and white spruce were performed to study the effects of copper and nickel in nutrient culture on the growth and nutrient composition of both species. Concentrations of 2.5 and 5.0 ppm were shown to bring about considerable reductions in both fresh and dry weight in jack pine roots and shoots. Nickel was clearly less toxic to jack pine bringing about reductions in growth at 10 ppm and mortality at 20 ppm. White spruce was not as responsive to the metals as jack pine and this was due to the difference in their natural growth rate.

8. Experiments on the effects of air pollutant contaminated soils on seed germination and growth are currently underway and will be completed within the next 2-3 months. Experiments on the effects of metal contaminated solutions in the germination of white spruce and jack pine seeds have been performed. The results of these experiments indicate that in both species, nickel, copper or cadmium applied in concentrations up to 100 ppm do not have an effect on seed germination. This suggests that the seed coat is impermeable to these elements and that the failure of seeds to grow on metal contaminated soils is because of the effect of the metal on root growth not because of its effect on germination. This result was confirmed in our experiments; when seeds germinated the roots failed to elongate in metal contaminated solutions. These experiments are continuing.

9. Sampling activities were carried out in Thompson to maintain our activity at the establishing sites. The newly developed precipitation gauges were installed at each site and collected at the end of the summer. The precipitation has been analysed in part and will be completed within the next month. Examinations were made of the natural epiphytic communities and of

the lichen transplants. The latter were photographed and the photos are being analysed to determine changes in lichen frequency and cover.

10. The information report awaits the completion of all analytical work related to the field activities.

11. Three sites were visited east of Thompson in order to establish a gradient in the easterly direction. These collection points should complete the mapping of pollutant dispersion in the east and south directions. Litter samples were taken at each site and the lichen communities were examined. The distribution of lichens is not greatly affected in this sector and it appears that this zone receives less metal deposition. This would confirm that the southern sector is the most heavily contaminated.

12. Areas closer than 5 km to the stack were examined for the leaching of metal particulates into the soil. LFH samples from these indicate high levels of metal accumulation the movement of these metals into the mineral soil is being monitored. Foliar analysis of jack pines from these sites is also underway.

14. 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. 1. Complete information report on Thompson (Hogan)

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

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

R. Reid

Program Manager

G.S. Silver

Director G.S. Silver

PROJECT NOR-9

Insect and disease management systems

NOR-9-061

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 8, 1979

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 dimidiatus*, parasites, encapsulation, hyperparasites, *Larix*, Boreal Region "B".

7. Location of Work: Throughout Northern Forest Region.

8. Problem:

This study is an attempt to control the larch sawfly by the introduction of exotic biotic natural enemies. Tamarack is the fastest growing conifer in the Boreal forest. If protection from the larch sawfly could be obtained there would undoubtedly be an increased use of tamarack for pulpwood, sawtimber, piling, poles, ties, veneer, etc., and its use in forest plantings would increase. Moreover, with sawfly control, *Larix* spp. would be used more frequently in park, boulevard and home-ground ornamental plantings. The benefits from success would be reduced mortality of tamarack and appreciable increases in the total incremental growth of tamarack and western larch. The increased vigor of tamarack would allow it to better fulfill its role in the ecology of the forest as a pioneer species invading areas not previously occupied by trees.

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

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

9. Study Objectives:

   1. To achieve biological control of the larch sawfly.

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

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

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

10. Resources:

    a. Starting date: 1950
    b. Estimated year of completion: 1975 Revised: 1980
    c. Estimated total Prof. man-years required: 0.3
    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.	0.4	(0.3, J.A. Muldrew, 0.1, W.G.H. Ives)
	Supp.	0.1	(R.M. Smith)
	Casual	-	
	Total	0.5	

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 cooperation with the Entomology Research Institute, Ottawa, revealed that the hyperparasite had a holarctic distribution before *O. benefactor* was released in America.

Maximum detected dispersal from the Pine Falls release point was 1.8 miles in 1967, 8.3 miles in 1968, 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%.

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.

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 1978-79:

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

2. Examine collections of larvae from McMunn and "The Bog", Manitoba. (Muldrew)

3. Obtain larch sawfly egg population estimates (expressed as mean number per branch in the mid crown) for trees in three of the old life-table plots; Rennie, Pine Falls and Seddon's Corner. (Ives)

4. Collect late-instar larch sawfly larvae from these plots and rear until cocoons are formed, the latter to be examined later for parasitism. (Ives)

5. Determine parasitism, of collected cocooned larvae, by *Olesicampe benefactor*, *Bessa harveyi* and *Mesoleius tenthredinis* and the attack rate on *O. benefactor* by *M. dimidiatus*. (Muldrew)

6. Compare the data from (3) and (5) to comparable data from previous life tables to determine if any detectable trends are evident. (Ives and Muldrew)

   Note: Goals 4-6 are contingent upon surplus funds being available in study NOR-9-150 after completion of the necessary field work.

7. Goal added: Collect larch sawfly from the Obed release area, Alberta, and at adjacent locations to estimate percentage parasitism by *O. benefactor* and make a mass collection of sawfly cocoons for shipment to B.C. (Ives)

13. <u>Accomplishments in 1978-79</u>:

1. First draft of this paper completed.

2. A sample of 153 larch sawflies reared from larvae collected at McMunn, Manitoba, showed *O. benefactor* parasitism still at a low level (22%). All the *O. benefactor* larvae were attacked by the hyperparasite *M. dimidiatus*. Encapsulation of *O. benefactor* larvae was 20%. Encapsulation has remained approximately at this level since the high value of 60% was obtained in 1975.

   Dissection of a sample of 45 "small" larch sawfly larvae from "The Bog", Manitoba, revealed the presence of the hyperparasite *M. dimidiatus* in this region for the first time. Its attack rate on *O. benefactor* was 62%. This caused a severe reduction in the numbers of *O. benefactor* recovered from the 10,000 cocoons sent to B.C. and the 4,000 sent to Ontario.

3. Only one egg cluster was found in the Pine Falls plot on 40 branches sampled. The eggs hatched but there was no evidence of larval feeding. At Seddon's Corner no curled shoots were found in the plot. Five colonies of larvae were found within 300 yards at the plot in a one-hour search. At the Rennie plot no evidence of the presence of the larch sawfly was found.

4. Larch sawfly larvae were collected from a number of areas in southeastern Manitoba. Small numbers were preserved in 70% alcohol, but a large collection made near the original Pine Falls release site was reared until the larvae spun cocoons. These will be incubated in early spring, to obtain estimates of parasitism.

5. Whereas in 1977 none of 72 fourth and fifth-instar larch sawfly larvae collected near the Pine Falls release point were parasitized by *O. benefactor*, a small sample of typically small prepupae reared from the 1978 larval collections revealed its presence.

6. The rearing and examination of larch sawflies collected near Pine Falls in 1978 is not yet completed. A file report on egg populations was prepared which shows that *O. benefactor* is still controlling the larch sawfly in southeastern Manitoba.

7. Two collections of larch sawfly cocoons were made near the release site at Obed Lake, Alberta. These cocoons will be incubated. A mass collection of cocoons (still in the moss) was made and shipped to Victoria, for subsequent release in British Columbia.

14. Goals for 1979-80:

1. Final revision and publication of the paper "Dispersal and impact of the introduced larch sawfly parasites, *Oleisicampe 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.

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 8, 1979

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 courterparts 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.

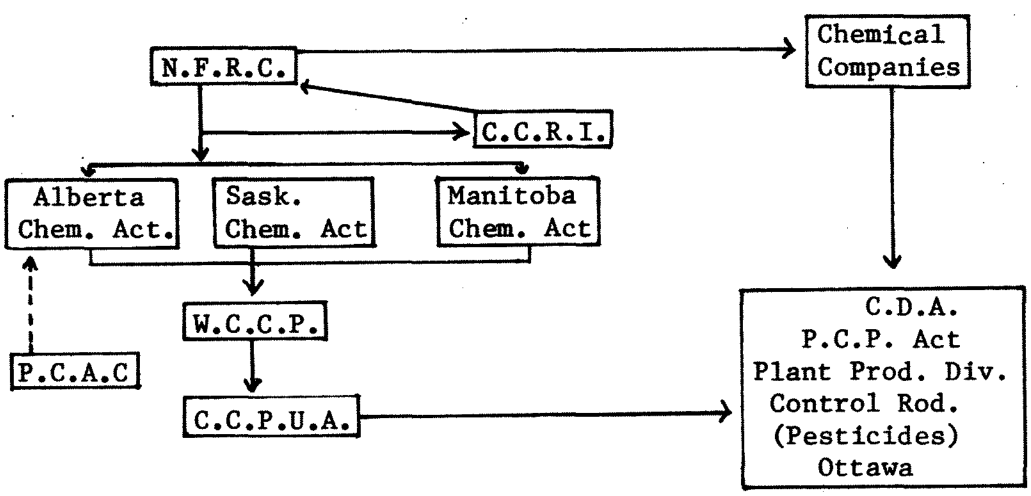
Where controls are not feasible, or economically or biologically justified, such will be reported and included in Canadian Forestry Service control recommendations to the chemical firms.

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: 1979 Revised:
    c. Estimated total Prof. man-years required: 0
    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. -
       Supp. 1.9 (J. Drouin 0.9, D. Kusch 1.0)
       Casual -
       Total 1.9

11. Progress to Date:

Implemented a viable working unit, established contacts at the Federal, Provincial levels, municipal agencies and private industries involved in the use, manufacture and distribution of pesticides and related products. Determined and selected safety clothing, equipment, ground spray instruments, techniques and methods. Established a pest priority list of 13 insect species requiring control recommendations. In 1972, conducted 59 efficacy tests consisting of mist blower, soil drench and bark paint applications. Analyzed the data, summarized the results and submitted performance reports to 9 chemical firms, a report of treatments and conclusions to the Western Committee on Crop Pesticides and prepared a file report NOR-Y-66. In 1973, 25 insecticides were tested on 99 field treatments on 20 insect species using hydraulic mist blower, Ultra low volume, soil drench and bark paint applications. Collaborated with C.C.R.I., C.W.S. and Fisheries Research (Manitoba) on large scale spruce budworm aerial and ground sprays with insecticides and microbials and evaluation of air-emulsion spray adjuvants and song/game birds and small mammals censusing. Analyzed the data, submitted performance reports to 14 chemical firms, report of tests, conclusions and recommendations to W.C.C.P., report on insecticide field development to joint Can. Ent./Alta. Ent. Societies at Banff, input into technical sessions on Biocides for the Alta. Environmental Conservation Board. Prepared Information Report NOR-X-81 and special report to C.C.R.I. on Furadan (Carbofuran) tests for proposed registrations. During 1974, 6 insecticides were being considered for registration as a result of 77 efficacy tests of 26 pesticides.

Analyzed the data and submitted performance reports to 14 chemical firms, submitted a summary of pesticide efficacy tests from 1972-74 (230 treatments) to the Pesticide Research Report (C.C.P.U.A.), a report to the American Phytopathological Society for publication in the Fungicide & Nematocide tests for 1974 and a report of these tests with conclusions and recommendations to the Western Crop Committee on Pesticides. In 1975, completed 2nd year data requirements on 17 insecticides to support their legislation on a result of 95 evaluations with 37 insecticides and 1 fungicide on 14 insect species and 1 fungal species at 12 sites in Alberta.

Commenced trials with foaming and spray adjuvants on deciduous foliage with systemic insecticides. Completed first year treatments and life history studies on the chokecherry midge (request from W.C.C.P.), completed soil drench and foliar spray tests on the yellow-headed spruce sawfly.

Analyzed data and submitted performance reports to 14 chemical firms, summary of 75 evaluations to the Pesticide Research Report (C.C.P.U.A.) Ottawa, prepared Information Report, CC-X-150, submitted manuscript for publication on the poplar borer, presented a seminar on registration at the NFRC, a report on the biology and control of a willow stem sawfly to the Oliver Nursery and control of the pitch nodule maker to a private nursery, reviewed, edited, 6 pest leaflets and gave lectures on chemical control to school, college teachers and students.

During 1976, 28 insecticides, 2 microbials and 3 adjuvants were tested against 10 insect species at 9 sites in Alberta. A total of 66 separate evaluations were made using 5 application methods. Soil drench treatments were continued on the northern pitch twig moth for second year data. Similarly soil drenches were continued at the Oliver Nursery on willow shoot-boring sawfly. Completed second year data on the forest tent caterpillar, chokecherry midge/sawfly, using 33 foliar sprays and 6 ultra low volume applications.

Analyzed data and submitted reports on performance to 14 chemical companies, summary of 66 evaluations to the Pesticide Research Report (CCPUA) Ottawa, prepared information report, CC-X-184, submitted manuscript on shoot-boring sawfly, presented paper on chokecherry midge/sawfly at Alberta Entomological Society, reviewed, edited, illustrated 8 pest leaflets, submitted reports to Oliver, Devon Nurseries, a summary of recommended controls for label expansion/registration to Plant Products, Ottawa and lectures on controls to school/college groups.

In 1977, 26 insecticides, a nucleopolyhedrosis virus and 2 additives were tested against 11 insect species. A total of 71 separate evaluations using six application methods. Thirty-six sprays were applied with a mistblower on birch leaf mining sawflies, insects attacking the fruit of saskatoon and chokecherry. Twenty-four soil drenches were conducted for the birch sawflies, pitch twig moth and a willow shoot boring sawfly.

Analyzed data and submitted performance reports to 13 chemical companies, summary of 71 evaluations to the Pesticide Research Report (CCPUA) Ottawa, prepared Information Report NOR-X-205, submitted manuscript on chemical control of a seed boring sawfly and a midge attacking chokecherry in Alberta, edited proceedings of A.E.S., and presented a paper on the boxelder twig borer to Alta. Ent. Soc., reviewed, edited, illustrated 4 pest leaflets submitted a complete review of new and modified use products summary and recommendations of tests from 1972-77 by NFRC to Plant Products Div. Ottawa for Canadian registrations.

12. Goals for 1978-79:

1. Continue evaluations for pesticides previously tested and showing promise with a view to completing 2-3 year data required for label expansion or registration, Basudin, Baygon, Cygon, Dimecron, Dimilin, Dylox, Malathion, Metasystox-R, NRDC 143, Orthene, Shell W43775, and ULVA...see attached recommendations for chemicals showing promise and requiring more data.

2. Continue nuclear polyhedral virus spray treatments with Ives/Muldrew and an ovicide spray treatment on a 2-acre plot.

3. Complete chemical control studies on a midge and a seed boring sawfly on chokecherry, follow up on phytotoxicity with adjuvants on *Prunus & Amalanchier* spp. and biology and control of a *lepidoptera* sp. feeding on the pulp of fruit.

4. Re-evaluate present insecticidal controls for the birch leaf miner with efficacy tests of foliar sprays, bark paints or soil drench applications.

5. Expand the knowledge, biology and chemical controls of insects attacking Saskatoon fruit and foliage. (Requested by Brooks Hort. Stn. Alta. Agric. and Stoneycroft Wines Calgary.)

6. Complete chemical controls with irrigation assist on the pitch nodule maker in nurseries. Report to be updated and submitted to Tree Planters Notes as "Chemical controls of the pitch nodule maker, *Petrova albicapitana* Busck., in Alberta".

7. Complete chemical control studies on a willow stem sawfly attacking acute/golden willow including phytotoxicity.

8. Complete foliar applications to boxelder twig borer. Update and submit report "Chemical control of the boxelder twig borer, *P. willingana* Kft. in Alberta" to Tree Planters Notes, USDA.

9. Continue efficacy tests on the root collar weevil, *H. warreni* if time permits.

10. Consult with Messrs. Ives and Carlson prior to treatments at 4, 5, 6, and 7 re statistical analysis.

13. Accomplishments in 1978-79:

1. Continued evaluations, submitted updated new and modified uses which was instrumental in obtaining Canadian reigstration for 11 insecticides on 22 hosts aginst 33 insect pests as well as label expansions by chemical firms for 3 products (see attached). Also additional submission now made for completed 2 year data (also attached).

2. NPV sprays applied as planned...see Ives report on NPV trials in Alberta.

3. Completed intensive trial on birch leaf mining sawflies, established timing, phytotoxicity techniques, dosages, and established biology of the species involved and registration was obtained as well as the label expansions by 3 firms inclusive of recommended techniques.

4. Completed biology and chemical controls on chokecherry and saskatoon fruit insects, registrations obtained, published results in Bi-Monthly.

5. Completed evaluation of the northern pitch twig moth, concluded that chemical control alone not practical with available insecticides, cost etc. Results to be published, Tree Planters Notes, USDA.

6. Completed foliar applications on boxelder twig borer, registrations obtained. Report to follow on results in Tree Planters Notes, USDA.

7. Work on root collar weevil not completed due to low priority.

8. Accomplishment added: Reporting, CFS representation, handling of requests, surveys, consultations and information provided to the following:

   a) Western Committee on Crop Pest (ECPUA)

   b) New and Modified Uses, Plant Product Division, Ottawa, CCPUA

   c) Yellow Headed Spruce Sawfly Infestation, Mr. Bossard, Hanna, Alberta

   d) Plant Industry Laboratory, Alta. Agric., chemical firms, clients, general public

   e) Presented paper to Alta. Entomological Soc. on "Chemical controls the the boxelder twig borer in Alberta, 1978". Edited proceedings of the 25th Annual Ent. Soc. of Alberta.

   f) Wrote, reviewed, edited and illustrated front cover art work and wrote controls for 4 pest leaflets, prepared 2...White pine weevil and A willow shoot boring sawfly, the other two are Ticks and Fire Blight.

   g) The mountain pine beetle infestation, southern Alberta, AFS, spray timing controls and survey of Crowsnest area, Kananaskis, Castle River.

h) Forest tent caterpillar infestation in Saskatoon, Sask. aerial sprays, ovicides, etc. for CDA.

i) D. Zukerman, G. Monson, B. Freiz, J. Roger, tree farm, plantation, or nursery operators for surveys, inspection, identification of insect/disease problems.

14. 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 2nd instar, 4th 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.

15. Publications:

1977-78

Drouin, J.A. and D.S. Kusch. 1977. Pesticide field trials on shade and shelterbelt trees in Alberta, 1976. Environ. Canada, Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-184.

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

Drouin, J.A. 1977. Pest leaflet series, Spruce budworm, PL 20-77, Sprayers and spraying, PL 18-77. Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta

Kusch, D.S. 1977. Pest leaflet series, Pine needle scale, PL 16-77, Wasps, PL 19-77, Large aspen tortrix, PL 21-77. Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta.

Drouin, J.A. and A.E. Campbell. 1977. Summary of the spruce and jack pine budworm aerial operations at the Spruce Woods and Belair Provincial Forests in Manitoba, 1977. File Rep. NOR-132.

1978-79

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

16. Signatures:

J.A. Drouin
Investigator

Program Manager

Director G.T. Silver

Table 8. Products registered in 1978 by the Pest Control Products Division for new and modified uses as a result of field tests 1972 to 1978

Marketing Type, Pest	Host	Method
Basudin (diazinon) 50 EC		
Malacosoma disstria	aspen	MB, H
Sawflies (open-feeding)*	spruce, larch, willow, pine,	MB, H
	currant, cotoneaster	SD
Lithocolletis sp.	poplar, aspen	MB
Proteoteras willingana	M. maple	H
Aphids (open-feeding)*	maple, caragana, saskatoon, spruce, pine, aspen	H, MB
Oligonychus ununguis	spruce	MB, H
Contarinia virginianiae	chokecherry	MB
Hoplocampa lacteipennis	chokecherry, saskatoon	MB
Neoborus amoenus Reuter	ash	MB
Lecanium corni Bouché	cherry, hazel, saskatoon	MB
Birch leaf miners*	birch	MB, SD
Baygon (propoxur) 1.5 EC		
Malacosoma disstria	aspen	MB, H
Euura atra Jurine	willows	SD
Birch leaf miners*	birch	MB
Cygon (dimethoate) 4 E		
Malacosoma disstria	aspen	MB, H
Sawflies (open-feeding)*	spruce, larch, willow, cotoneaster, hawthorn	MB, H
Lithocolletis sp.	aspen poplar	MB
Proteoteras willingana	M. maple	MB, H
Aphids (open-feeding)*	M. maple, spruce	MB
Contarinia virginianiae	chokecherry	MB
Hoplocampa lacteipennis	chokecherry	MB
Hoplocampa montanicola Rohwer	saskatoon	MB
Hoplocampa cookei (Clarke)	pincherry	MB
Hoplocampa halcyon (Norton)	saskatoon	MB
Euura atra	willows	SD
Birch leaf miners*	birch	MB, SD
Cythion (malathion) 50 EC		
Malacosoma disstria	aspen	MB
Sawflies (open-feeding)*	spruce, larch	MB, H
Birch leaf miners*	birch	MB
Dutox (metasystox + trichlorfon) 24 EC		
Malacosoma disstria	aspen	MB, H
Aphids (open-feeders)*	M. maple, caragana, saskatoon	MB
Euura atra	willows	SD
Malathion (malathion) (ULV)		
Malacosoma disstria	aspen	ULV
Sawflies (open-feeders)*	spruce, cotoneaster, hawthorn	ULV

Corythuca pallipes Parshley	alder, birch	ULV
Aphids (open-feeding)*	M. maple, caragana, saskatoon, mayday	ULV
Lecanium corni	cherry, hazel	ULV
Orthene (acephate) 75 SP		
Malacosoma disstria	aspen	MB, H
Sawflies (open-feeding)*	spruce, larch, cotoneaster, Mtn. ash	MB
Birch leaf miners*	birch	MB
Resmethrin (resmethrin) (ULV)		
Malacosoma disstria	aspen	ULV
Sawflies (open-feeding)*	spruce, larch	ULV
Sevin (carbaryl) 50 WP		
Malacosoma disstria	aspen	MB, H
Sawflies (open-feeding)*	spruce, larch, pine, cotoneaster	MB
Birch leaf miners*	birch	MB
Systemic (dimethoate-dicofol) ULV		
Caliroa cerasi (Linnaeus)	cotoneaster	ULV
Nearctaphis sensoriata (Gillette & Bragg)	saskatoon	ULV
Aphid spp.	cherry, hawthorn, apple	ULV
Tetrachlorvinphos (ULV)		
Caliroa cerasi	cotoneaster, hawthorn	ULV
Vapona-methoxychlor (dichlorvos-methoxychlor) (ULV)		
Malacosoma disstria	aspen	ULV
Caliroa cerasi	hawthorn, cotoneaster	ULV
Aphids (open-feeders)*	saskatoon, hawthorn, lilac	ULV

*Sawflies (open-feeding)
- *Pikonema alaskensis*
- *Pristiphora erichsonii* (Hartig)
- *Nematus fulvicrus*
- *Neodiprion pratti banksianae* Rohwer
- *Nematus ribesii* (Scopoli)
- *Caliroa cerasi*

*Aphids (open-feeding)
- *Periphyllus negundinis* (Thomas)
- *Acyrthosiphon caraganae* (Cholodk)
- *Nearctaphis sensoriata*
- Aphid spp.

*Birch leaf miners
- *Fenusa pusilla*
- *Heterarthrus nemoratus*
- *Profenusa thomsoni*

TWO YEAR TESTS COMPLETED FOR REGISTRATION DATA
(not on 1978 registration list)

Ambush 50 EC

H. lacteipennis &		
C. virginianiae	chokecherry	(MB)
M. disstria	aspen	(OD)

Baygon 1.8 EC

H. lacteipennis &		
C. virginianiae	chokecherry	(MB)

Belmark (WL 43775) 30 EC

Sawflies (open)	spruce	
	willow	(MB)
M. disstria	aspen	(MB)

Dimecron 94 EC

M. disstria	aspen	(OD)
Birch miners	birch	(MB) (SD) (BP)

Dutox 25 EC

H. lacteipennis &		
C. virginianiae	chokecherry	(MB)
Sawflies (open)	larch	
	willow	(MB)

Dylox 4 E

H. lacteipennis &		
C. virginianiae	chokecherry	(MB)
M. disstria	aspen	(MB)

Nem-A-Tak 25 EC

Birch miners	birch	(SD)

Supracide 40 EC

Birch miners	birch	(MB)
Aphids (open)	maple	
	cargana	(MB)
M. disstria	aspen	(MB)

Vydate L 25

M. disstria	aspen	(MB)

WL 43479 (Shell) 40 EC

M. disstria	aspen	(MB)
P. alaskensis	spruce	(MB)

- 1979 -

ONE MORE TEST REQUIRED FOR REGISTRATION DATA
(mist blower or as indicated)

Ambush 50 EC

M. disstria	aspen
Birch miners	birch
Sawflies (open)	spruce willow etc.
Aphids (open)	cargana maple etc.
L. corni (scale)	small fruit
O. ununguis (mite)	spruce

Basudin 50 EC

Birch miners	birch
N. aemoenus (bug)	ash

Baygon 1.8 EC

Aphids (open)	cargana etc.
L. corni (scale)	small fruit
P. alaskensis (soil drench)	spruce

Belmark 30 EC

Aphids (open)	cargana etc.
Birch miners	birch
O. ununguis (mite)	spruce

Cygon 4 E

C. conflictana	aspen
N. aemoenus (bug)	ash
Lithocolletis sp.	aspen
Altica populi	poplar

Cythion 50 EC

H. lacteipennis	chokecherry

Dacamox 10 G

Birch miners (soil drench)	birch

Dimecron 94 EC

Aphids (open)	cargana etc.
C. conflictana	aspen
H. lacteipennis & C. virginianiae	chokecherry
L. corni (scale)	small fruit

Dutox 25 EC

Birch miners	birch
C. conflictana	aspen
L. corni (scale)	small fruit

M 3726 50 EC

P. alaskensis	spruce

Nem-A-Tak 25 EC

Birch miners	birch
M. disstria	aspen
O. ununguis (mite)	spruce
C. conflictana	aspen

Orthene 75 SP

C. conflictana	aspen

Ripcord 40 EC

M. disstria	aspen
P. alaskensis	spruce

R 28627 25 W

O. ununguis (mite)	spruce

PP 199 25 EC

O. ununguis (mite)	spruce

Sevin 50 WP

C. conflictana	aspen
L. corni (scale)	small fruit
C. pallipes (lacebug)	alder

Supracide 40 EC

Sawflies (open)	willow larch etc.

Temik 10 G

Birch miners (soil drench)	birch

Volaton 10 G

Aphids (soil drench)	elm etc.

Vydate L 25 EC

Sawflies (open)	larch willow etc.
Aphids (open)	cargana etc.

Zolone 35 EC

M. disstria	aspen
O. ununguis (mite)	spruce

Ultra Low Volume

Malathion 1.8%

L. corni (scale)	small fruit

Systemic

Sawflies (open)	spruce willow etc.

Tetrachlorvinphos 2.5%

M. disstria	aspen
Aphids (open)	saskatoon etc.

Vapona-Methoxychlor 6%

Sawflies (open)	spruce willow etc.

WL 43479 40 EC

C. conflictana	

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 8, 1979

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 artificial media. Similarly, it is probable that the virus can eventually be propagated on tissue cultures. This has been done with other viruses, without loss of virulence, but has not yet (as far as we know) been done with the forest tent caterpillar, although tissue cultures of this insect have been established. It therefore seems probable that stock cultures of both the parasites and virus could eventually be maintained for use in applied biological control as needed. Before such a program is initiated, or advocated, it is essential that preliminary studies be undertaken to determine whether or not the required densities of parasites and virus can be produced and manipulated advantageously. For example, it will be necessary to determine the dispersal of released parasites under field conditions.

9. Study Objectives:

To determine whether or not localized incipient outbreaks of forest tent caterpillar can be prevented or their severity minimized by manipulation of natural biotic control factors, particularly nuclear polyhedrosis virus, augmented where necessary by chemical or bacteriological control measures.

10. Resources:

a. Starting date: 1977
b. Estimated year of completion: 1980
c. Estimated total Prof. man-years required: 6.5
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.	0.7	(J.A. Muldrew)
	0.5	(W.G.H. Ives)
Supp.	0.9	(R.M. Smith)
	0.1	(J.A. Drouin)
Total	2.2	

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.

12. Goals for 1978-79:

1. Apply various concentrations of virus as an aerial spray on eggs and early-instar larvae of the forest tent caterpillar, using a helicopter. (Ives)

2. Assess the larval mortality in each of the sprayed plots and unsprayed check areas. (Ives)

3. Obtain colored aerial photographs of plots and surrounding areas after defoliation is complete. (Ives)

4. Establish and maintain fly feeding stations in the Thorsby area, in an attempt to introduce virus into the forest tent caterpillar populations in this area. (Ives)

5. Trap wild flies in the Lake Wabamun area and release near feeding stations near Thorsby. (Ives) (Provided Howard Gates is available.)

6. An attempt to obtain virus-infected material will be made, using refined techniques, so that a stock of virus will be on hand. (Ives and Muldrew)

7. To assess the populations of *M. disstria* in the Joussard area to determine if the carry-over of virus detected in 1977 extends into 1978 and if so, whether additional dispersal can be demonstrated. Because of the appearance of *M. disstria* populations in 1977 between Joussard eastward to the town at Slave Lake, a more extensive set of check plots can be used. (Muldrew)

8. Goal Added: Establish plots for 1979 field trials.

9. Goal added: Provide Sault Ste. Marie with a supply of Bruce spanworm eggs so that a limited supply of NPV for this insect can be produced.

13. <u>Accomplishments in 1978-79</u>

1. Various concentrations of virus were applied by helicopter when the larvae were in the second instar. Foliage was only dime-sized, or in the bursting-bud stage, and the weather was poor - frequent showers and cool.

2. Larval mortality was assessed and a file report summarizing the results was prepared. The virus sprays introduced additional virus-caused mortality into the populations. However, natural virus was also present, so the differences in mortality between the sprayed areas and nearby check areas was not as large as had been hoped for.

3. Aerial photographs were not taken, as defoliation was complete in all areas, mainly because of poor synchronization between larval hatch and foliage flushing, but also due in part to the fact that the area was over-populated. There were so many larvae present that many trees were stripped before the foliage had had a chance to develop fully, and while the larvae were still in the fourth instar. Under the circumstances there seemed to be no point in taking aerial photographs.

4. Fly feeding stations were established and maintained in the Thorsby area. Egg bands were collected near the traps and farther away in the same stand. Results on the prevalence of virus in the two areas have not yet been received from Sault Ste. Marie.

5. Dropped as a goal.

6. Additional virus-infected material was obtained, but not as much as in 1977. However, the total amount of field-collected virus on hand should be sufficient to conduct our 1979 trials, provided it is free from dangerous bacteriological contaminants.

7. Virus infection of forest tent caterpillar in the Joussard area carried over into 1978 in the "Railroad Crossing" plot, causing about 80% mortality. However, additional spreading of the infection could not be demonstrated.

8. Three 20-acre plots were established for 1979 virus trials against the forest tent caterpillar. In addition, a number of trees were selected in the Obed area for possible small-scale tests of NPV against the Bruce spanworm.

9. About 100,000 Bruce spanworm eggs were collected and shipped to Sault Ste. Marie, so that they could propagate the NPV of this insect and provide us with a limited amount for field testing in 1979.

14. 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.

15. Publications:

1977-78

Nil

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. Info. Rep. NOR-X-204.

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

16. Signatures:

Investigator	Program Manager
Investigator	Director G.T. Silver

PROJECT NOR-10

Silvicultural prescriptions

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

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; PAR Industries, Prince Albert, 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 1979. 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

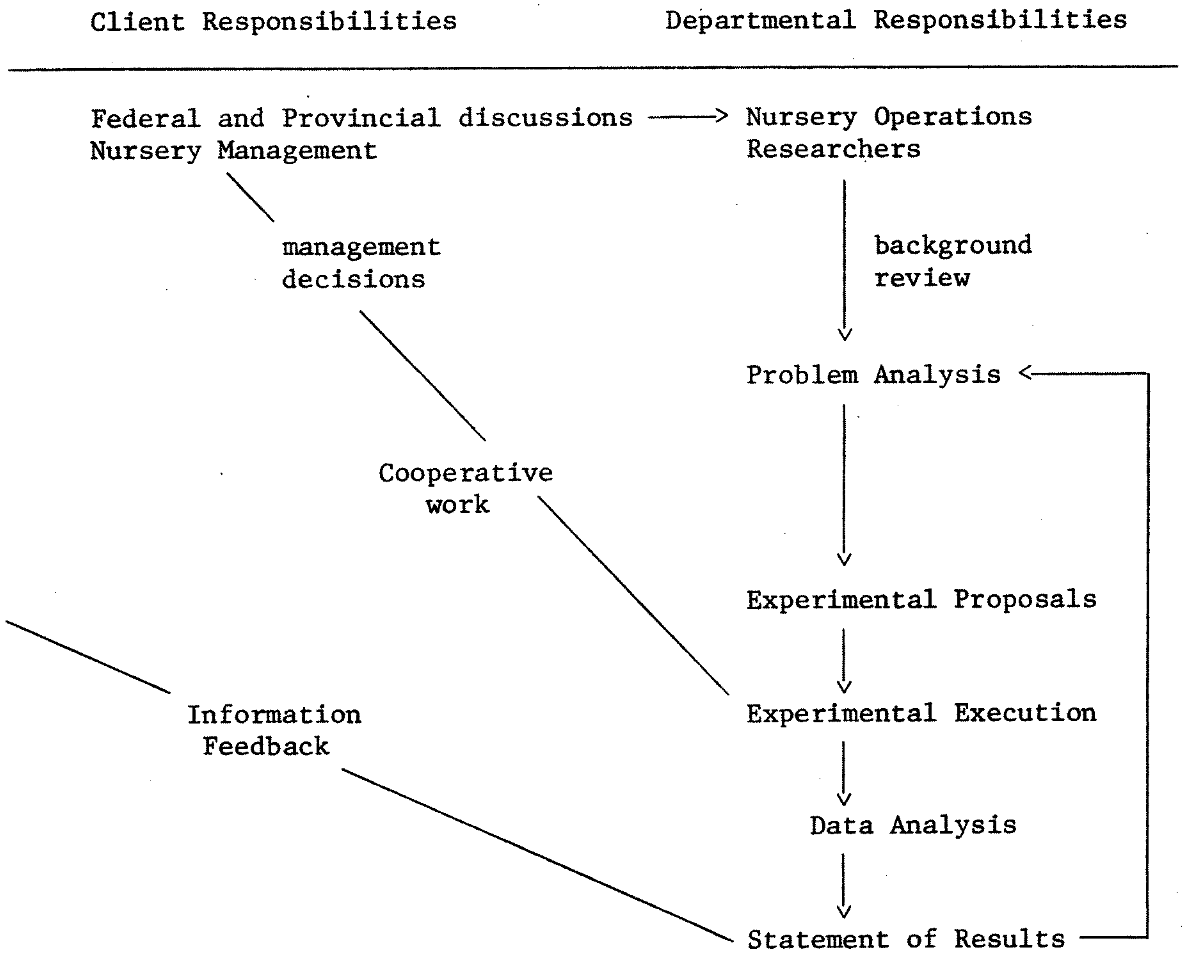
Determine priority of problem--relating to demands for the crop.

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:



9. Study Objectives:

   1. To improve general nursery practices, including seedling handling, disease control, weed control, cultural operations, and inovations for seedbed treatments.

   2. To advise on container production of seedlings.

10. Resources:

   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 1979-80 with costs: Nil
   e. Essential new major equipment items beyond 1980 with costs: Nil
   f. 1979-80 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 southeastern 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.

12. Goals for 1978-79:

1. To survey regional nurseries, to contact regional private nurseries for problem assessment, and to perform related liaison functions.
2. To obtain 6th and 4th year data on spacing trials in poplar cutting beds at Alberta Provincial Tree Nursery and Prince Albert Forest Nursery respectively.
3. To continue the 2nd phase of the study on use of special cropping schedules for increasing the organic matter content of P.A. nursery soils.
4. Continue the study on the control of western gall rust of lodgepole and jack pine at the Pine Ridge Forest Nursery.
5. Publish Information Report, "Guidelines for rearing containerized seedlings".
6. To organize two workshops, in Edmonton and Prince Albert, on basics of fertilization, insect and diseases common to nurseries and greenhouses.
7. Prepare Information Report on "The effect of the initial pH of peat on conifer seedling growth".
8. Prepare File Report on "The effect of the coarse-fine ratio of peat on conifer seedling growth".

9. Organize a meeting of federal and provincial nurserymen within the region to discuss operation problems. Meeting to be held at Prince Albert or Indian Head.

10. Goal added: Parks Canada requested a study on government nurseries willing to cooperate with a native shrub program.

13. Accomplishments in 1978-79:

1. All regional nurseries were visited in 1978. Examples of problems are: (a) fertilizing at Pine Ridge and Prince Albert container facilities, (b) insects at Rocky Mt. House and Oliver, (c) cultural problems at PAR Industries and St. Regis.

2. Yield data from 6th and 4th year cuttings from poplar spacing trials at Provincial Tree Nursery, Oliver and Prince Albert Forest Nursery has not been received. Stools have been cut but whips not made into cuttings.

3. The second phase of the study on use of special cropping schedules continued. Seedlings maintained on a growing regime.

4. The study on the control of western gall rust of pine was continued at Pine Ridge Nursery. Seedbeds sprayed with fungicides and innoculated with spore.

5. Information Report, "Guidelines for rearing containerized seedlings" was reviewed but not published.

6. Two workshops, one in Edmonton and one in Prince Albert, on Basics of Fertilization, Insects and Diseases Common to Nurseries and Greenhouse were organized. They were both well received.

7. & 8. Combined into one report to be published in an upcoming forestry silviculture report

9. A meeting of the federal and provincial nurserymen was organized and held at Prince Albert. Cultural practices and new equipment were discussed. These meetings are held to exchange ideas among the nursery managers.

10. Study on government nurseries willing to cooperate with Parks Canada was carried out and a preliminary report presented to Parks Canada.

14. 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 2nd 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.

15. Publications:

1977-78

Huber, R.F. and L.W. Carlson. 1977. Jack pine storage molds. p. 274. *In*: C.W. Averre (Ed.), Fungicide-Nematicide Tests, Results of 1976. A.P.S. Vol. 32.

L.W. Carlson and L.D. Nairn. 1977. Root deformities in some container grown jack pine in southeastern Manitoba. The For. Chron. Vol. 53, No. 3. June 1977. pp. 147.

1978-79

Nil.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

1. Project: Silvicultural prescriptions.

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-10-050

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 source 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: 8.9
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.	0.1	J. Klein
	Supp.	0.3	A. Nanka
	Total	0.4	

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 (1976).

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.

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, and early results were reported in Bi-Monthly Research Notes in 1971.

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.

12. Goals for 1978-79:

White spruce

Nil for 1978-79. A report on the fall 1976 measurement will be published as soon as possible after 1978-79. There are no firm plans for further remeasurement.

Red pine

Nil for 1978-79. A report has been published on the most recent remeasurement, in spring 1973. The next remeasurement may be in fall 1982.

Scots pine

Publish an article in Bi-Monthly Research Notes entitled "Growth of Russian Scots Pine populations in Saskatchewan and Manitoba 15 years after planting".

Norway spruce

Nil for 1978-79. A report has been published on the most recent remeasurement, in fall 1976. There are no firm plans for further remeasurement. Depending upon priorities in future program development, there may be an opportunity for collection of breeding materials from selected trees growing in the Riding Mountain plantations.

Jack pine

Nil for 1978-79. A report on the fall 1976 measurement (5 years from planting) will be published as soon as possible after 1978-79. The next remeasurement is scheduled for fall 1981

Black spruce

Draft a file report entitled "Establishment of black spruce provenance test plantations in Alberta, Saskatchewan, and Manitoba, 1975".

13. Accomplishments in 1978-79:

Scots pine

Following in-house review, a revised draft of a manuscript entitled "Height growth of Russian Scots pine populations in Saskatchewan and Manitoba 15 years after planting" was submitted to the NFRC editor on November 24, 1978.

Black spruce

A file report entitled "Establishment of black spruce provenance test plantations in Alberta, Saskatchewan, and Manitoba" was not drafted owing to lack of sufficient time.

This study consumed 0.05 professional man-years in 1978.

14. 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. A report has been published on the 1973 measurement. The next remeasurement may be in 1982.

Scots pine

Publish the manuscript now under review, entitled "Height growth of Russian Scots pine populations in Saskatchewan and Manitoba 15 years after planting".

A 20-year measurement would be due in fall 1979, and would be of moderate interest, but does not appear to be practicable.

Norway spruce

Nil for 1979-80. A report has been published on the 1976 measurement. There are no firm plans for further remeasurement. When the next planting site at Chip Lake is ready for use, there would be an opportunity for propagation of genotypes that could be selected in the Riding Mountain plantations.

Jack pine

Nil for 1979-80. A 5-year measurement was made 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, under present circumstances, than a report on the 5-year measurement.

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.

A tabular summary of the six experiments in this study is presented at the end of this statement, in Appendix A.

15. Publications:

1977-78

Klein, J.I. 1977. Survival and growth of Norway spruce populations in Manitoba 14 years after planting. Environ. Can., Environ. Manage. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-179. 8 pp.

1978-79

Nil

16. Signatures:

J D Klein
Investigator

Program Manager

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	1969	1984
Scots pine, USSR	Carberry, Man.	RB; 11-4-49	May 1960	1965 1969 1974	1969	1984
Scots pine, USSR	Holbein, Sask.	RB; 9+ jack pine-4-100	May 1960	1968 1974 earlier by Sask. DNR	1969 by Teich and Holst	1984
Scots pine, USSR	Indian Head, Sask.	CR; 9-3-50 some rows cut	May 1960	1968 1974 earlier by PFRA Nursery	1969 by Teich and Holst	1984
Norway spruce	Riding Mountain N.P., Man.	RB; 12-8-9	May 1963	1963 1965 1970 1976	1976	none planned
jack pine	Sundown, Man.	LS; 81-5-4	May 1972	1976	none	1981

Species	Location	Design; nos. of populations-replicates-trees per plot	Month and year planted	Years measured	Latest measurement reported	Year of next measurement
black spruce	Mafeking, Man.	LS; 49-4-9	June 1975	1976	none	1979
black spruce	10 km NE of Nipawin PP, Sask.	LS; 49-4-9	June 1975	1976	none	1979
black spruce	Reno, Alta.	RL; 30-3-9	June 1975	1976	none	1979

[1] RB - randomized blocks, CR - completely random, LS - lattice square, RL - rectangular lattice.

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

1. Project: Silvicultural prescriptions.

2. Title: Breeding jack pine for the Northern Region. I. First selection cycle.

3. New: Cont.: X 4. No.: NOR-10-051

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 changes 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: 11.9
d. Essential new major equipment items for 1979-80 with costs:

Brush mower, $1,300

e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

Prof.	0.9	J. Klein
Supp.	0.7	A. Nanka
Casual	1.2	
Total	2.8	

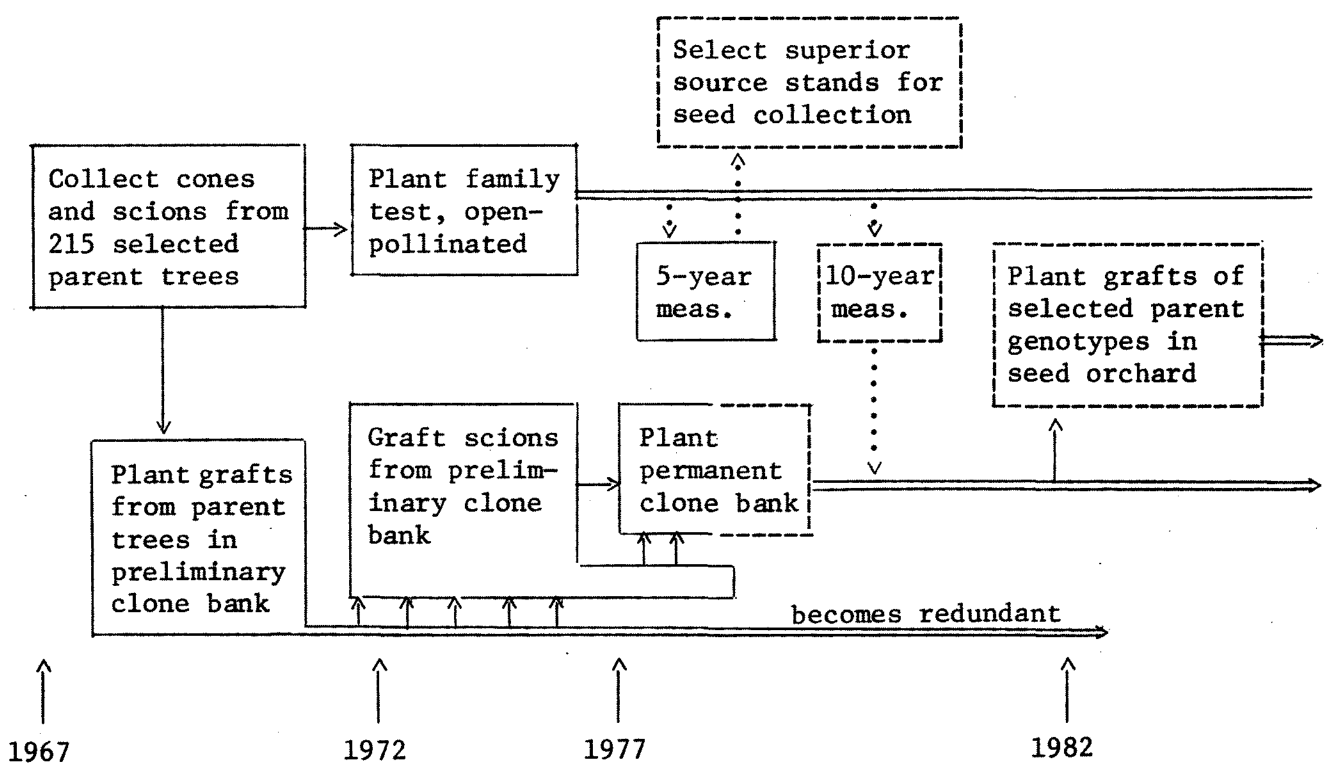
11. Progress to Date:

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 1,700 ramets, grafted from 1974 to 1977, were planted in the clone bank at Chip Lake, of 3,185 required to fill it.

The eastern district family test was measured after the second and fifth growing seasons from planting. Statistical analysis is in progress.

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 1978-79:

1. Complete drafting of a file report entitled "Establishment of jack pine family test plantations in central and western Saskatchewan".

2. Prepare and present an invited major discussion paper on "Selection programs and genetic parameters" at April 1978 workshop on Tree Seed Production and Improvement in Canada.

3. Carry out other work that may be assigned on tree seed production and improvement needs project.

4. Graft 1,500 scions, including 1,000 from selected eastern district progeny trees lacking a parental clone.

5. Rear 1,500 rootstocks for 1979 grafting.

6. Prepare a development plan for the Chip Lake research planting area showing requirements and costs, and begin implementation as resources permit.

7. Tend regional clone bank at Chip Lake area and complete fence erection for it.

8. Plant 1978 grafts in regional clone bank.

9. Maintain family test plantations as required.

10. Measure the western breeding district family test following the fifth growing season from planting.

11. Prepare and present a paper on five-year results of the eastern breeding district family test at meeting of I.U.F.R.O. working party on progeny testing, Vancouver, B.C., August 1978.

13. Accomplishments in 1978-79:

1. A file report entitled "Establishment of jack pine family test plantations in central and western Saskatchewan, 1974" was completed, and distributed to selected cooperators and colleagues.

2. An invited major discussion paper entitled "Selection programs and genetic parameters" was read at the April 1978 Workshop on Tree Seed Production and Improvement in Canada. The manuscript was submitted for the Proceedings of the Workshop in May 1978.

3. Approval was secured for publication of four background statements in the Proceedings of the Workshop, with revisions in some instances.

4. There were 1,347 grafts made in 1978, including 1,090 from selected eastern district progeny trees lacking a parental clone. The success rate was 59% (800 grafts).

5. About 500 rootstocks are on hand from 1978, along with 1,000 recently potted seedlings being reared to rootstock size.

6. A development plan for the Chip Lake Research Planting Area was prepared and submitted. Development work on the area absorbed a major part of this study's field work resources in 1978.

7. Grafts planted in the clone bank at Chip Lake were pruned, staked, and inventoried. Cutting of aspen and other hardwood sprouts has been done for about 80% of the clone bank. The clone bank fence was completed.

8. There were 615 grafts planted in the clone bank in 1978, all but a few made in 1978. In October 1978, 2,102 of the 3,185 planting positions were stocked, and 519 of 637 tested families were represented in the clone bank.

9. Cutting of sprouts and pulling of volunteers were carried out as required in the four plantations of the western breeding district family test. Time and funds were not sufficient to allow plantation maintenance for the central breeding district plantations.

10. The western breeding district family test was measured following the fifth growing season from planting.

11. A paper entitled "Preliminary report on height growth in a jack pine family test five years after planting" was read at the meeting of the I.U.F.R.O. working party on progeny testing, Vancouver, August 1978. Copies were later mailed to all persons on the working party's mailing list.

This study consumed 0.95 professional man-years in 1978.

14. 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.

15. <u>Publications</u>

1977-78

Klein, J.I. 1978. Jack pine breeding and provenance experiments with conifer species in the Prairie Provinces. Proc. 16th Meet. Can. Tree Improv. Assn. Pt. 1:167-170.

1978-79

Klein, J.I. 1978. Selection programs and genetic parameters. Proc. Workshop on Tree Seed Production and Improvement in Canada; R & D Needs, 1977-87. In press.

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.

16. Signatures:

J I Klein
Investigator

Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

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: 1980
c. Estimated total Prof. man-years required: 9.7
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.	1.0	(I.K. Edwards)
Supp.	1.0	(J.J. Van Dyk)
Casual	-	
Total	2.0	

11. Progress to Date:

Various experiments in the greenhouse and in nurseries have been conducted to determine the effect of fertilization (amount, nitrogen source, form, timing) on growth and drought tolerance of seedlings. Also in nurseries, nutrient loss through leaching, amelioration of solonetzic soil, and the effect of sulphur and peat amendments have been studied.

On the basis of the results, fertilizer recommendations for container-grown and bare-root seedlings have been made to industry and government agencies and these recommendations have resulted in improved stock quality. There have been 5 reports.

Operational and growth problems have been investigated whenever they occur and their solution has enabled producers to refine their seedling production systems. There have been 10 reports.

In the forest and in amenity plantings, various tree growth problems directly related to soil, water, and environmental factors have been investigated and recommendations for their alleviation have been made. There have been 6 reports.

12. Goals for 1978-79:

    1. To publish the report, "The 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 publish the Information Report, "The effect of peat and sulphur on growth of conifers at the Prince Albert Forest Nursery".

    3. To publish the Information Report, "The effect of amount and timing of fertilization on seedling growth".

    4. To publish the Information Report, "The effect of fertilization on seedling growth at the Provincial Tree Nursery, Oliver, Alberta".

    5. To complete the File Report, "Effect of nutrient regime on drought tolerance in lodgepole pine and white spruce".

    6. To initiate a soil fertility assessment of the Big River Forest Nursery, Saskatchewan.

    7. To prepare and present lectures on Basics of Soils and Fertilizers in a Short Course for Nursery Personnel to be held at Edmonton and Prince Albert.

13. Accomplishments in 1978-79:

    1. The report is at the second stage of local review but is being held for photographic work.

    2. The report was completed for the Forestry Report.

    3. The report was completed for the Forestry Report. The title is, "Effect of nutrient source and timing of application on seedling growth at Prince Albert, Saskatchewan".

    4. The report was completed for the Forestry Report. The title is, "Effect of fertilization on seedling growth at two prairie nurseries".

    5. The report was completed and is on file.

6. The assessment was initiated. Over 300 soil samples were collected at Big River Forest Nursery and 90% of the analyses have been completed.

7. The lectures were prepared and presented to nursery personnel at Prince Albert and Edmonton. A copy is on file.

14. 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 an Information 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.

15. Publications:

1977-78

Edwards, I.K. 1977. Chemical amelioration of solonetzic soils at the Provincial Tree Nursery, Oliver, Alberta. Inf. Rep. NOR-X-187.

Edwards, I.K. 1977. Fertility of transplant fields at the Prince Albert Forest Nursery. Inf. Rep. NOR-X-189.

Edwards, I.K. 1977. Nutrient movement in a sandy loam forest nursery soil at Prince Albert, Saskatchewan. Inf. Rep. NOR-X-195.

Edwards, I.K. 1977. Soil management program for Pine Ridge Forest Nursery. File Report NOR-135.

Edwards, I.K. 1977. Chlorosis in Colorado spruce at Lakeland College, Vermilion, Alberta. File Report NOR-135.

Edwards, I.K. 1977. Pine chlorosis and maple scorch at the Japanese Gardens, Lethbridge, Alberta. File Report NOR-135.

Edwards, I.K. 1977. Salt damage in roadside-planted spruce in the City of Edmonton. File Report NOR-135.

Edwards, I.K. 1977. Shelterbelt chlorosis and dieback at the Provincial Tree Nursery, Oliver, Alberta. File Report NOR-135.

Edwards, I.K. 1977. Canadian Forestry Service report to the Environmental Subcommittee of the Alberta Horticultural Advisory Committee. File Report NOR-135.

1978-79

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.

16. Signatures:

I.K. Edwards
Investigator

C. D. Hut
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

1. Project: Silvicultural prescriptions.

2. Title: Storage of winter reared containerized conifer seedlings.

3. New: Cont.: X 4. No.: NOR-10-155

5. Study Leader: H. Zalasky

6. Key Words: Winter storage, winter rearing *Pinus* sp., *Picea* sp., container seedlings, dormancy.

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

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 late summer or through the winter months 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, therefore an economically and efficient outdoor method is required.

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. The problem faced with late summer and winter reared material is that natural protection of snow is not readily available, nor are the seedlings in the proper physiological state to enter a winter storage period. 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. Development of methods for winter storage of containerized seedlings:

   1. Use of cold storage facilities (i.e. root cellars).

   2. Use of artificial covers to protect seedlings

      - polystyrene
      - artificial snow
      - plastics
      - straw, etc.

   3. Develop special storage methods to save space.

2. Determine the length of time for initiation to complete dormancy.

3. Manipulate the container system to bring about dormancy.

   1. Regulate photo period.

   2. Regulate greenhouse climatic conditions to approximate onset of fall and winter.

   3. Possible use of physical and chemical stimuli to bring on dormancy (i.e. increased in IAA conc.).

9. Study Objectives:

   1. To develop a method for winter storage of containerized conifer seedlings.

   2. To develop a method to bring about dormancy in winter grown 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.	0.5	
Supp.	0.3	(F. Dendwick)
Casual	-	
Total	0.8	

11. Progress to Date:

Winter storage (1976-77) of containerized pine and spruce seedlings were replicated for five storage periods and three cover treatments. Temperature and wind recorders were installed to provide information on heat lost and heat gained in each cover treatment and the cumulative amount and loss of snow cover. With the aid of a scanning electron microscope 23 wk-old pine was found to be dormant while spruce was not.

In 1977-78 plyofilm and styrofoam storage houses were built to serve as primary barriers to sharp temperature changes and fiberglass and perlite covers on seedlings served as secondary barriers. Temperature and wind recorders provided cryobiological data. Preconditioning treatments showed that pine and spruce seedlings developing earlier in the year under increasing light regime produced full terminal buds 18 weeks after the seed germinated. Seedlings grown later under decreasing light regime were weaker, with pine but not spruce reaching the full terminal bud stage. Spruce required 2 additional weeks to mature the buds. Condition and phenology of overwintered seedlings were described and photographed to serve as a guideline for nursery management.

Growth of 1977-78 pine and spruce germinants chilled at 1.5^{o}C 6 to 48 hrs was affected in all time treatments during the first week in the greenhouse. Subsequent development and growth of hypocotyls was best in the 24 hr treatment. Pine, however, produced 3-needle short shoots. A few runts or stunted seedlings occurred in both pine and spruce.

Seedlings reared at 15^{o}C and 15 hr photoperiod for 10 wks during bud development stored better outside from September to November than the 20^{o}C reared seedlings. Damage by frost caused 25 to 35% root and shoot tip dieback and mortality and delayed flushing by several weeks in 20^{o}C reared seedlings. The 20^{o}C treated seedlings were characterized with mycorhiza and 15^{o}C treated seedlings were without mycorhiza. Temperature, therefore, appears to be more critical than photoperiod in epicotyl and root conditioning for winter storage of seedlings and for spring and fall outplanting.

Septoria canker and leaf spot manuscript (NOR-8-044) was accepted for publication.

12. Goals for 1978-79:

1. To find a cheaper, efficient and reusable secondary barrier to temperature changes inside the storage houses.

2. To determine if 2 to 3 wk old seedlings in the cotyledon stage and with or without terminal needle buds can be overwintered successfully. The 2-wk-old seedlings have the advantage of a faster turn-over in yield, lower overhead cost and less power for heat and light required than by 20-wk-old seedlings.

3. To minimize risk of frost damage during handling of seedlings from growth environment to outside storage under severe winter temperatures.

4. To characterize the phenology and condition of the seedlings before and after overwintering in storage houses.

5. To publish a note in Bi-Mon. Res. Notes on morphogenetic variation of frost damaged seedlings.

6. To prepare a manuscript on frost damaged seedlings for an information report.

13. <u>Accomplishments in 1978-79</u>:

1. Present experimental storage has two different chambers and an outside shaded double wall structure both of which enclose four air layers. These air layers seem to have good control of diurnal ground air temperature for storage of two-age groups of seedlings.

2. With 10 wks of preconditioning 3-wk-old pine and spruce seedlings survived $-10^{\circ}C$ temperatures in equivalent proportions to those of 20-wk-old seedlings.

3. Risk of damage to seedlings was minimized during transport by providing insulation and by moving them between 10 a.m. and 2 p.m. when day temperatures are warmest.

4. Records of phenology and condition of seedlings in 1978-79 have been completed and summarized.

5. Published.

6. Format of present manuscript serves as a guideline for field technician and a portion of it is in manuscript form under review for publication.

14. <u>Goals for 1979-80</u>:

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".

15. Publications:

1977-78

Zalasky, H. 1977. Bibliography of frost damage in tree nurseries. Fisheries and Environment Canada. Forest Service. Information Report NOR-X-190.

Zalasky, H. 1978. Stem and leaf spot infections caused by *Septoria musiva* and *S. populicola* on poplar seedlings. Phytoprotection 59, 43-50.

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, 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).

16. Signatures:

Harry Zalasky
Investigator

A. D. Kiil
Program Manager

G.T. Silver
Director G.T. Silver

NOR-10-156

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

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 Northern Forest Research Centre, Winnipeg

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 artifically. 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. Study Objectives:

To determine what types of preplanting conditioning have significant effects on conifer seedlings field performance.

10. Resources:

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 beyong 1980 with costs: Nil.
f. 1979-80 man-years

Prof.	0.5	
Supp.	0.7	(F. Dendwick)
Casual	-	
Total	1.2	

11. Progress to Date:

A site was selected and two plots were staked out 56 km south of Grande Prairie on Proctor and Gamble lease. Two clear-cuts were selected: one contained clay loam soil with impeded drainage and was partially enclosed with stands on three sides, and one contained a well drained clay soil and was exposed to the elements. Precipitation and temperature recorders were installed on both plots for micro-climatic study because of differences in the direction of the wind, precipitation and temperature.

Three different sources, age and condition of containerized pine and spruce seedlings were outplanted in 1976 on a trial basis to obtain initial field performance data, to assess what kind of seedlings should be produced at NFRC and the design of a controlled rearing-field performance experiment in 1977 that would test the effect of specific rearing practices on seedling performance. The main preconditioning treatments were temperature and photoperiod.

Two short technical notes, one on TOK herbicide effects on development of wood in conifers and one on the variability of fascicles, phenology and phyllotaxy in frost damaged pine, have been published.

Frost damaged 1976 seedlings developed multinodal single or forked leaders with variable development and maturity. To overcome this 1977 18-wk-old seedlings were produced with a full epicotyl and terminal bud 5 wks earlier than in 1976 seedlings. Even so, growth and development of the epicotyls was three times as long as it takes the vegetative bud of pine and spruce trees to produce a new vegetative shoot.

Seedlings with a full terminal bud suitable for May-June and August-September planting performed better during early and late frost than those without a terminal bud. Seedlings with partially developed epicotyls were susceptible to frost and stunting effects except when planted shortly after the last June frost for continuous

4 to 5 wks growth in warm weather. These seedlings would be restricted to a single planting date or 2 wks for a number of sites distributed from a southern to a northern latitude.

A randomized split plot design was used for 1977 field experiments. The 1977 seedlings were characterized before and after outplanting.

12. <u>Goals for 1978-79</u>:

1. To precondition 10-wk-old containerized seedlings in the growth chamber for 10 wks at specific photo period and temperature to enhance full or partial bud development.

2. To develop seedlings to full hypocotyl stage with terminal needle buds for spring planting and assess performance after planting out.

3. To update records and tabulation for first, second and third season of growth and performance in the field.

4. To incorporate information on effects of frost on pine and spruce seedlings with NOR-10-155 manuscript for information report.

5. To prepare manuscript on effects of TOK-E-25 for information report.

13. <u>Accomplishments in 1978-79</u>:

1. The temperature in growth chamber was adjusted to $15^{o}C$ continuous and to $15^{o}C$ day and $10^{o}C$ night. The photoperiod was adjusted to 15 hr day. Reduced thermoperiod and photoperiod relevant to 1977 influenced bud development and hardiness in 18-wk-old pine and spruce.

2. Seedlings were started in late season and tested in the greenhouse rather than the nursery because of excess water in the soil. The seedlings preconditioned at $10^{o}C$ flushed their buds earlier and more uniformly than those reared at $15^{o}C$ with 15 hr photoperiod. This suggests that $10^{o}C$ seedlings flush better and are more suited for spring planting; $15^{o}C$ seedlings are better for fall planting because they are more dormant.

3. Most of the tabulation has been accomplished except for preparation of computer sheets. A few months time was lost during change-over of technicians.

4. Information on the effect of frost on outplanted pine and spruce seedlings was incorporated with NOR-10-155 for guideline information and for a Bi-Mon. Res. Note manuscript.

5. Manuscript on effects of TOK-E-25 (herbicide) was prepared.

14. Goals for 1979-80:

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 coniferous 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.

15. Publications:

1977-78

Zalasky, H. 1977. Anatomical modifications in xylem of lodgepole pine induced by TOK-E-25 (nitrofen). Bi-Mon. Res. Notes 34(5), (27-28).

Zalasky, H. 1977. Alpine fir dieback in the Obed Hills. File Report.

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. Preplanting conditioning and overwintering in nurseries. Forestry Report (in press).

Zalasky, H. 1979. Tracheids of boreal and treeline tamarack (*Larix laricina*). Bi-Mon. Res. Notes (in press).

16. <u>Signatures</u>:

Harry Zalasky
Investigator

G. D. Hiratsuka
Program Manager

Director G.T. Silver

NOR-10-176

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 31, 1979

1. Project: Silvicultural Prescriptions

2. Title: Development of Silvicultural Prescriptions and Management Tools for Forest Resource Planners.

3. New: X   4. No: NOR-10-176

5. Study Leader: L. G. Brace

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 35 percent shortfall in reforestation of the annual cutover, using existing management practices.

The Canadian Forestry Service suggests that much of the information needed to up-grade 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 co-ordinate 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 adqpt 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 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.	2.0	(Brace, Ball)
	Supp.	2.0	(Walker, Wambold)
	casual	-	
	Total	4.0	

11. Progress to Date: N/A

12. Goals for 1978-79: N/A

13. Accomplishments for 1978-79: N/A

14. 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 management options program.

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:

   a) Alberta Technical Committee on Forestry

   b) Task Force for Kananaskis Country

6. Publish silviculture issue of Forestry Report.

(Ball)

1. Complete work carried over from Prince Albert Sub-office

   a) NSR Study Report (Information Report)

   b) Finn Plow Trial Establishment Report (File Report)

2. 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.

3. Initiate similar action in Alberta and Manitoba and combine with data from (2) above for use in preparing a region-wide report on survival and initial growth of major species. Recommend additional data requirements, if any.

4. 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).

5. Co-ordinate initial phases of field performance trials for lodgepole pine and white spruce in Alberta, sponsored by the Alberta Technical Committee on Forestry.

15. Publications:

Up to 1978-79

Nil

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-13

Maintenance and improvement
of water yield and quality

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

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, N. Stevens

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 sub-basin. 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 regime 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: .7 per year
d. Essential new major equipment items for 1978-79 with costs: Nil
e. Essential new major equipment items beyond 1979 with costs: Nil
f. 1979-80 man years

Prof.	0.7	(Swanson 0.6, Stevens 0.1
Support	1.0	(Fisera 1.0;)
Casual	-	
	1.7	

g. Special treatment costs: Twin Subbasin $200,000.00

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. Some data collection, originally a part of various research projects but extended beyond the completion of such projects, has been discontinued due to non-interest in the data.

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. Slash was left in place to allow evaluation of the cut alone without the subsequent soil disturbance of slash disposal and scarification.

   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 2500 1-tree height diameter openings are scheduled to be clear felled by the end of 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. Evaluation is to continue through 1985.

Deer 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 1978-79

1. Continue evaluation of Streeter Basin treatment (Golding).

2. Continue evaluation of Marmot-Cabin commercial harvest under appropriate studies (Swanson).

3. Finish clearing Marmot-Twin research harvest (Swanson).

4. Publish Forestry Report. Results from Marmot, Streeter and Hinton experiments (Swanson with section contributions).

5. Prepare and table final report on National Basin Program Basin Standards at ACH-June in Regina (Swanson).

6. Continue as alternate for Director General on ACH Executive (Swanson).

7. Bring segments of this and other NFRC studies dealing with modeling individual hydrological cycle elements into one systems modeling study (Stevens, Swanson).

   (1) Conduct literature review for background material.

   (2) Assemble operating simulation packages for Leaf and Brink Land Use Simulation and Dickinson Marmot Model.

(3) Write study proposal statement for review in 1978 with planned initiation in 1979.

Added Goals 1978-79:

(4) Determine the extent of forest cover within the Oldman River basin to serve as an indication of the potential for watershed management within this basin. The information would also be suitable for future modelling work in the basin.

(5) Assist the Alberta Forest Service in adopting hydrologic modelling as a management tool.

8. Prepare presentation on effects of forestry practices in Alberta's East Slopes on water yield and regime for Environment Council of Alberta hearings in Lethbridge, Coleman and Edmonton. (Swanson)

9. Prepare program plan and critical path evaluation for completion of Marmot and all other N.F.R.C. Forest Hydrology Research by 1983-84 (Swanson)

13. Accomplishments 1978-79:

1. Some snow course and soil moisture data taken but not analysed due to resignation of Golding.

2. Streamflow, climatic data, etc. continued in 1978.

3. Contracts for all remaining Twin Creek clearing has been let. Treatment was 1/3 complete as of November 1978.

4. Publication deferred to 1979.

5. National Basin standards prepared and tabled as scheduled.

6. Attended ACH annual meeting near Regina as scheduled. Failed to receive notice of executive committee meeting in December 1978, therefore did not attend.

7. 1. An informal literature search was done to determine how existing models might fulfill our needs. Several of the existing models were investigated further to determine their capabilities. The results of which are reported under accomplishment 2.

   2. The models with which simulations were done are as follows:

WATBAL. (Leaf C.F. and G.E. Brink 1973 Hydrologic simulation model of Colorado subalpine forest. Rocky Mt. For. & Ron. Expt. Sta., Res. Pap. RM-107). It was found that insufficient flexibility existed within this model to adopt it to Alberta conditions. Several assumptions were made within the program to allow the Colorado environment to be better simulated; it is felt that these assumptions hampered the model's capability to simulate streamflow in Alberta.

SNOWMELT. (Soloman R.M., Ffolliott P.F., Baker M.B. Jr., and Thompson J.R. 1976. Computer simulation of snowmelt. Rocky Mtn. For. & Ron. Expt. Sta., Res. Pap. RM-174). This smowmelt model is a modified version of the snowmelt model used by Leaf and Brink. It was designed to simulate the intermittent snowpack found in Arizona. The model had improved logic in some sections but results were not much better than those found with the original model. In particular, problems were encountered with the thermal diffusion subroutine.

MARMOT MODEL. (Dickinson, W.T. 1973. Theoretical mathematical models for streamflow from a forested mountain watershed. Report to the Northern Forest Res. Centre.) This model which simulates snowmelt, evapotranspiration and streamflow differs substantially in structure from the models discussed above. It relies on a series of parameters, which in general lack any physical significance, to modify the input to arrive at the desired output. This model uses a computer optimization technique to obtain the parameter values. This type of model is excellent for simulating streamflow given the historical record but it lacks the capability to predict streamflow accurately when modifications to the forest cover have occurred and historical streamflow records are not present.

PROSPER. (Goldstein R.A., Mankin J.B. and Luxmoore R.J. 1974. Documentation of PROSPER. A model of atmosphere-soil-plant water flow. EDFB-IBP 73-9, Oak Ridge Nat. Lab., Oak Ridge Tenn.) The model is essentially on evapotranspiration model. In order to more fully simulate the hydrologic cycle here it must be coupled with a snowmelt model. The model requires more input data than a lot of methods for estimating evapotranspiration but it is also capable of simulating more than just water loss by ET. Soil moisture levels in different soil layers, leaf water potential and flow between the soil layers are also simulated. With some slight modifications, it has been found that PROSPER is capable of simulating ET on watersheds in Alberta quite well.

Since the existing snowmelt models that were tested did not perform well, I developed one myself. It is based largely on the work done by Eric Anderson. As well two or three of the functions used by Leaf and Brink have been incorporated into the model. The model simulates snowmelt and the energy balance on a 12-hour basis. Results with it have been very encouraging. By combining this snowmelt model with PROSPER it is possible to simulate generated runoff which can be equated with runoff on an annual basis.

3. The study proposal statement has been prepared.

4. A computerized map of the Oldman River basin was made and its information has been used in the preliminary selection of the pilot project area.

5. The Alberta Forest Service is very interested in using computer modelling techniques to assist them in evaluating the effects of forest harvesting and other land disturbances on water yield. I have explained the logic of the models that I am currently working with to them. Together we are gathering information to do some simulations on Tri-Creek watershed. If these are successful they will probably use the model for other simulations in the coming year.

   (Further progress on this modeling study will be carried under NOR-13-177 which is entirely devoted to the modeling effort.)

Added Accomplishments 1978-79

8. Prepared paper entitled "Water management aspects at forestry operations in Alberta. Presented at ECA hearings 13, 14 & 17 March, 1978 (Swanson)

9. Prepared program plan and critical path evaluation as requested (Swanson).

14. Goals for 1978-80

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.

15. Publications 1977-1979

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.

1978-79

Swanson, R.H. 1978. Increasing water supply through watershed management. Can. Water Resources Jour. 3(1): 85-93.

16. Signatures:

Robert H. Swanson
Investigator

Neil Stevens

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

1. Project: Maintenance and improvement of water yield and quality

2. Title: Potential energy available for snow evaporation in winter along the east slopes of the Rocky Mountains in Alberta.

3. New: Cont.: X 4. No.: NOR-13-082

5. Study Leader: D.L. Golding

6. Key Words: Chinook winds, snow accumulation, climate, foehn, meteorology

7. Location of Work: Alberta East Slopes

8. Problem:

Watershed management to increase water supply or change the timing of its delivery is principally snowpack management in areas such as Alberta. Some increase in streamflow can be directly attributable to reduced transpiration and interception following vegetation removal, but total removal often results in high flood peaks, in most cases an undesirable alteration of streamflow regime. Properly executed timber removal on snow-covered watersheds has the potential of increasing streamflow and delaying water delivery at the same time. Both of these are generally desirable features.

The east slopes of Alberta's Rocky Mountains produce 90% or more of the streamflow in the Saskatchewan River System, at least 60% of which originates as snow. Snowpack management is an important part of land management for water values. In some years much of the snowpack in particular areas is evaporated by chinook activity. However, we do not know to what elevation chinooks are important in removing snowpack, or the probability of recurrence from year to year.

The climatic maps of Longley (1969) give some indication of where chinooks are an important climatic factor, but this is based only on the criterion of air temperatures being above 40°F. It is very likely that dry winds at temperatures below 32°F have considerable influence on snow removal as well.

To effectively manage forests for water values we must know where and under what circumstances the major precipitation parameter, snow, is a manageable resource. This will allow concentration on those areas where the results of snowpack management for accumulation and melt rates will have a high probability of producing the desired changes in streamflow.

The probability is not very high of completely achieving Objective 2, although the probability is high of achieving a degree of success sufficient to satisfy the need for delineating areas where snowpack-management potential is high. To obtain data to construct isolines of evaporative potential by 10% intervals of probability of recurrence will require a much more intensive meteorological network than is likely in the next few years. Remote sensing information from ERTS will, it is hoped, provide much of the information that would be otherwise available only through an intensive meteorological network.

The results of this study will be pertinent to any forest-management prescription for water values. The probability is extremely high of the results of the study being put into practice. However, it will not be until forest-management schemes to regulate streamflow are put into practice.

A transect will be established from the lower foothills to 8,000-9,000 feet elevation to measure temperature, relative humidity, and evaporation. These data, along with data from existing meteorological stations will be used to determine the relation of chinook intensity, or evaporative potential, with elevation.

Remote sensing imagery in three spectral bands, 0.5-0.6 μ (blue-green), 0.6-0.7 μ (red), and 0.8-1.1 μ (near infrared), will be obtained from ERTS for a test area that includes Banff and KFES. This imagery will be obtained for the satellite passes during February and March, and will be used in conjunction with high-altitude aerial photography and ground photography to delineate areas of heavy snowpack ablation caused by chinooks. If the test of the satellite imagery proves its usefulness, the coverage obtained will be expanded.

9. Study Objectives:

   1. To determine the amount of snowpack ablation during chinooks at selected points along the east slopes of the Alberta Rocky Mountains.

   2. To construct isolines of evaporative potential by intervals of probability of recurrence each winter.

10. Resources:

   a. Starting date: 1969
   b. Estimated year of completion: 1980
   c. Estimated total Prof. man-years required: 0.5

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.	0.0	
Supp.	0.0	
Casual	0.0	
Total	0.0	Study terminated

11. Progress to Date:

Tests were carried out to evaluate the use in this study of the Ogopogo evaporimeter and snow lysimeters. The former were of little use at sub-zero °F but could be used during chinooks to obtain a measure of evaporation. The latter could be used under ideal conditions to measure evaporation from snowpacks, but are impractical during general winter conditions.

Aerial reconnaissance of the east slopes was carried out to ascertain patterns of snow disappearance. Satellite imagery was studied to determine if present resolution and quality is sufficient for this study. Pre-ERTS imagery was not of high enough quality for the needs of the study. However, quality of ERTS imagery is much higher than that from previous satellites.

Compilation was made of location, elevation, and instrumentation of meteorological stations in Alberta. So few stations exist above 4,000 feet elevation that no attempt could be made to delineate areas of different evaporative potential at present.

The use of satellite imagery to determine effect of chinooks on snow accumulation has been reported (Golding 1973).

Three observational transects were located, in the Bow River Valley, Red Deer River Valley, and along the Forestry Trunk Road, on which 19 meteorological sites were designated. These were instrumented by R & D contract in the fall of 1974 and were serviced under the same contract January-March 1975. The transects were serviced under another R & D contract for the period January-March 1976. Both years' data were analyzed and a file report prepared. A Study Progress Report was prepared in 1976-77.

12. Goals for 1978-79:

1. Publish in J. Applied Meteorology "Calculated snowpack evaporation during chinooks along the East Slopes of the Rocky Mountains in Alberta".

2. Wind in openings at James River will be measured to determine for what size opening over-canopy wind changes from laminar to turbulent data to obtain estimates of snowpack evaporation during chinooks by opening size (Swanson and Golding).

3. Snowpack evaporation will be calculated for chinook periods at Marmot Creek in 1975 and 1976 (Golding).

13. Accomplishments 1978-79:

1. Journal article published as planned.

2. Wind not measured due to lack of instrumentation and technical support staff.

3. Done. Report furnished by Golding prior to his resignation in August 1978.

14. Goals for 1979-80:

1. Terminate project. (Transfer wind in openings goal to NOR-13-103.)

15. Publications:

1977-79

Golding, D.L. 1977. Snowpack evaporation during chinooks along the East Slopes of the Rocky Mountains. Proc. Second Conf. on Hydrometeorology, Oct. 25-27, 1977, Toronto. Amer. Met. Soc. pp. 251-254.

Godling, D.L. 1978. Calculated snowpack evaporation during chinooks along the eastern slopes of the Rocky Mountains in Alberta. J. Appl. Meteor. 17:1647-1651.

16. Signatures:

R. H. Swanson for D.L. Golding
Investigator

Reid
Program Manager

GTSilver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

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: 1968
b. Estimated year of completion: 1972 Revised: 1981
c. Estimated total Prof. man-years required: 2.7
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.	1.0	(Hillman)
Supp.	0.5	(Robson)
Casual	-	
Total	1.5	

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 (1978) 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.

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.

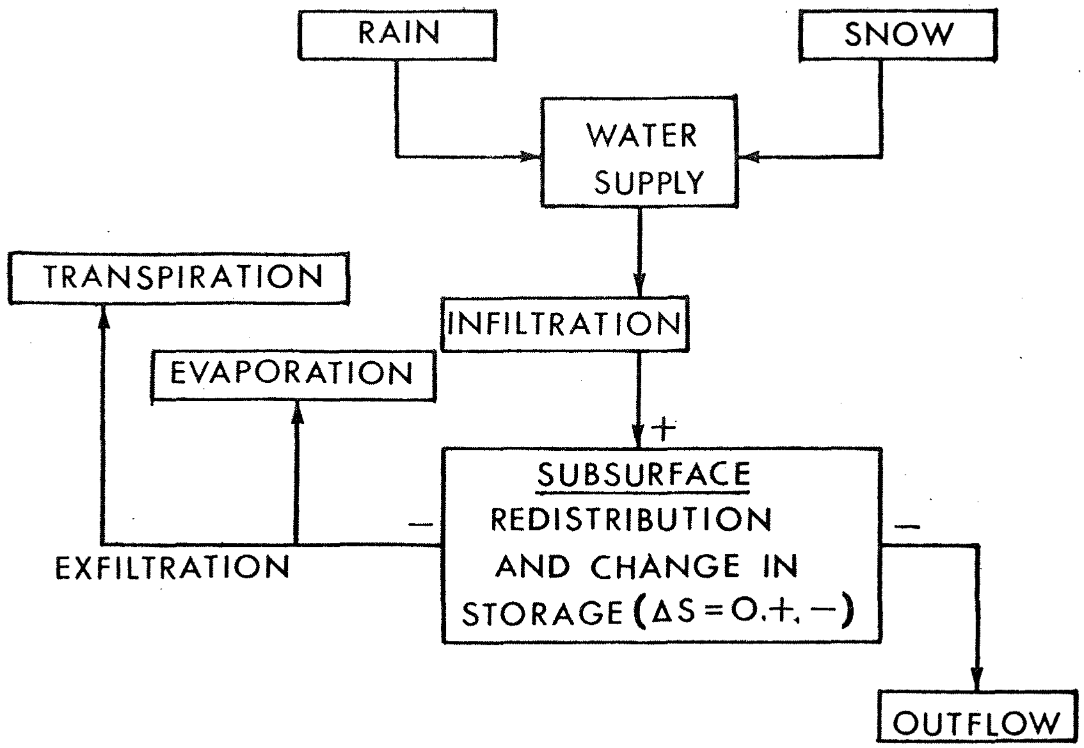


Figure 1. Conceptual hydrologic model

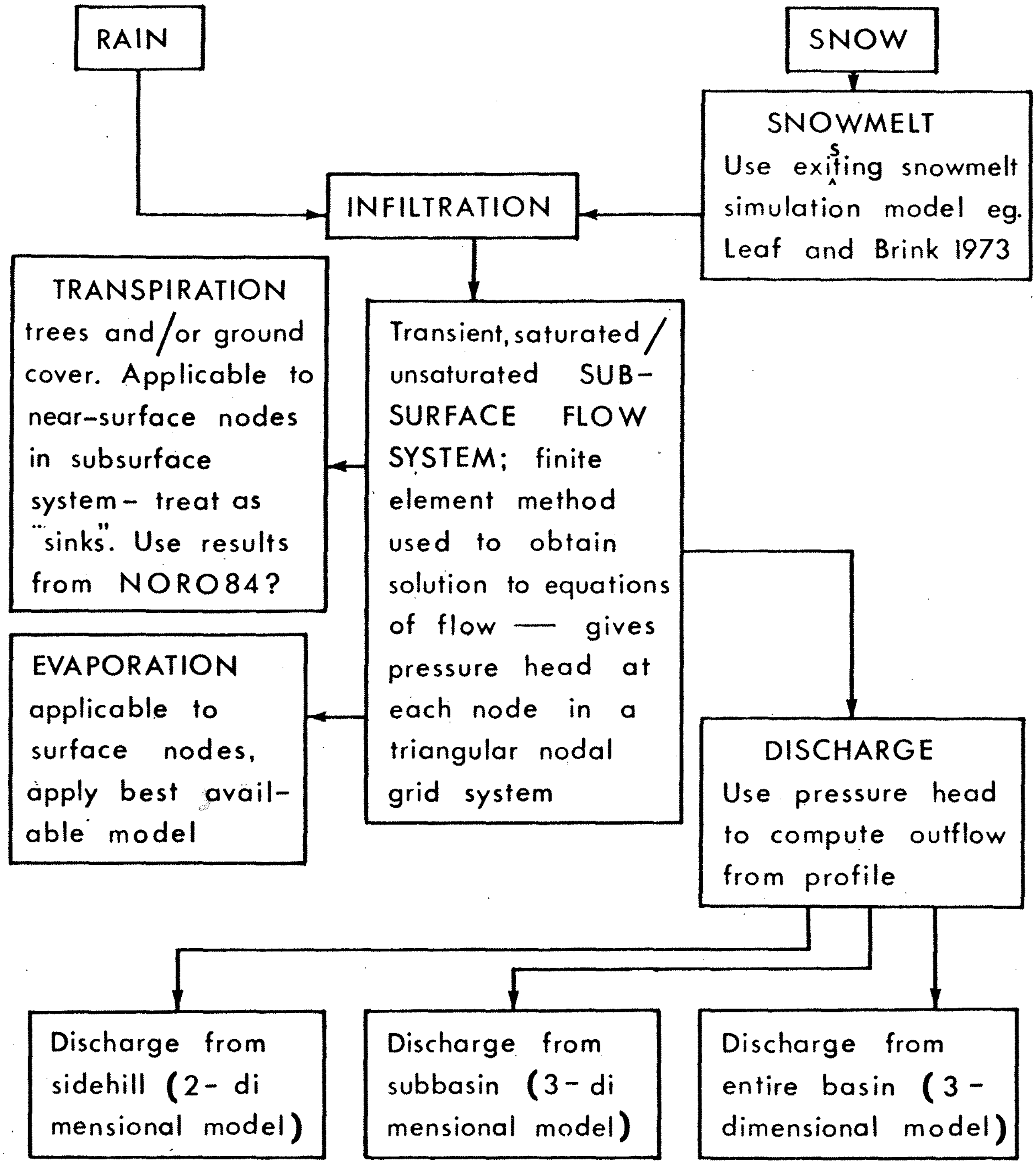


Figure 2. Conceptual hydrologic model applied to vegetated basin.

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.

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.

Most of the information contained in this section has been incorporated into Study Progress Report -13-083, dated January 1978.

12. Goals for 1978-79:

1. Develop the approximating functions for the finite element method applicable to a two-dimensional simulation of the subsurface flow system, using a triangular finite element mesh.

2. Write a computer program to run the model; then test the model using hypothetical data to assess its convergence and stability characteristics, and determine computer storage requirements.

3. Prepare geologic (profile) maps of Marmot Creek sub-basins and use them, together with soils and vegetation data and a suitable finite element mesh, as a basis for the first Marmot simulation model.

4. Run the Marmot simulation model and check results against actual field data.

5. Begin writing Ph.D. dissertation to be submitted to the University of Alberta. The topic will be the development and application of the subsurface flow model.

6. Monitor soil moisture content during snowmelt.

7. Monitor groundwater levels during snowmelt.

8. Install snow-pillow on Cabin Creek sub-basin.

9. Install additional groundwater table wells and/or piezometer nests on Marmot Creek Basin.

10. Process and interpret seismic data obtained on Marmot Basin during 1973.

13. <u>Accomplishments for 1978-79</u>:

1. Approximating functions for the finite element method were obtained by following the development outlined below:

The basis for the subsurface model, taking into account the assumptions listed on page 7, 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.

Since a two-dimensional, linear triangular finite element mesh is to be used, the basis functions for such elements are:

$$\phi_i = a_i + b_i x + c_i z \qquad (2)$$

where a_i, b_i, and c_i are constants identified with the ith basis function. These basis functions are used to approximate the pressure head (h):

$$h \sim \hat{h} = \sum_{j=1}^{N} P_j(t)\phi_j(x,z) \qquad (3)$$

where

N number of nodes
ϕ_j 1 at the jth node, and zero at all other nodes.

This expression, together with application of Galerkin's method and Green's theorem produces the result:

$$\int_A P \left(Kxx(F,h)\frac{\partial\phi_j}{\partial x}\frac{\partial\phi_i}{\partial x} + Kzz(F,h)\frac{\partial\phi_j}{\partial z}\frac{\partial\phi_i}{\partial z} \right) dA \; +$$

$$\int_A \frac{dP}{dt}\, C(F,h)\phi_j\phi_i dA = \int_\Gamma q_n\phi_i \; ds \qquad (4)$$

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 (4) is the final working equation and represents a set of simultaneous equations which can be expressed in matrix form as:

$$[A]\{P\} + [B]\{\frac{dP}{dt}\} = \{F\} \qquad (5)$$

The surface integral $\int_\Gamma q_n\phi_i ds$ (or $\{F\}$) is a flux term, defined only at flux boundaries and designated sink nodes. It is zero at all other nodes. This term is significant because it represents external influences on the subsurface flow system. Thus if afforestation is to be simulated, sinks are added (i.e. the surface integrals are assigned certain negative values) at selected nodes. Comparisons are made of flow patterns and outflow from the seepage face, with and without the additional sinks, to determine the hydrological effects of this practice (afforestation).

Similarly, if the effects of logging are to be simulated, sinks, representing removal of water by trees, are deleted (i.e. surface integrals = 0) and comparisons made as before.

The required solution, pressure head at each node, is obtained by solving the set of equations (5) to determine the unknown constants $\{P\}$. Because of the constraints imposed by equation (3), these coefficients must equal the pressure heads. Once the pressure head field has been obtained, outflow from the seepage face can be determined. Figure 3 is an attempt to illustrate the correspondence between the mathematical terms and the physical situation.

Transient problem: $\left[A\right]\left\{P\right\} + \left[B\right]\left\{\frac{dP}{dt}\right\} = \left\{F\right\}$

Steady state problem: $\left[A\right]\left\{P\right\} = \left\{F\right\}$

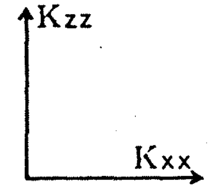
Elements of $\left[A\right]\left[B\right]$ and $\left\{F\right\}$ are:

$$a_{i,j} = \int_A \left(Kxx(F,h)\ \frac{\partial \phi_j}{\partial x}\frac{\partial \phi_i}{\partial x} + Kzz(F,h)\ \frac{\partial \phi_j}{\partial z}\frac{\partial \phi_i}{\partial z} \right) dA$$

$$b_{i,j} = \int_A C\, \phi_j\, \phi_i\, dA$$

$$f_i = \int_\Gamma q_n \phi_i\, ds$$

$$h \sim \hat{h} = \sum_{j=1}^{N} P_j(t)\, \phi_j\,(x,z)$$



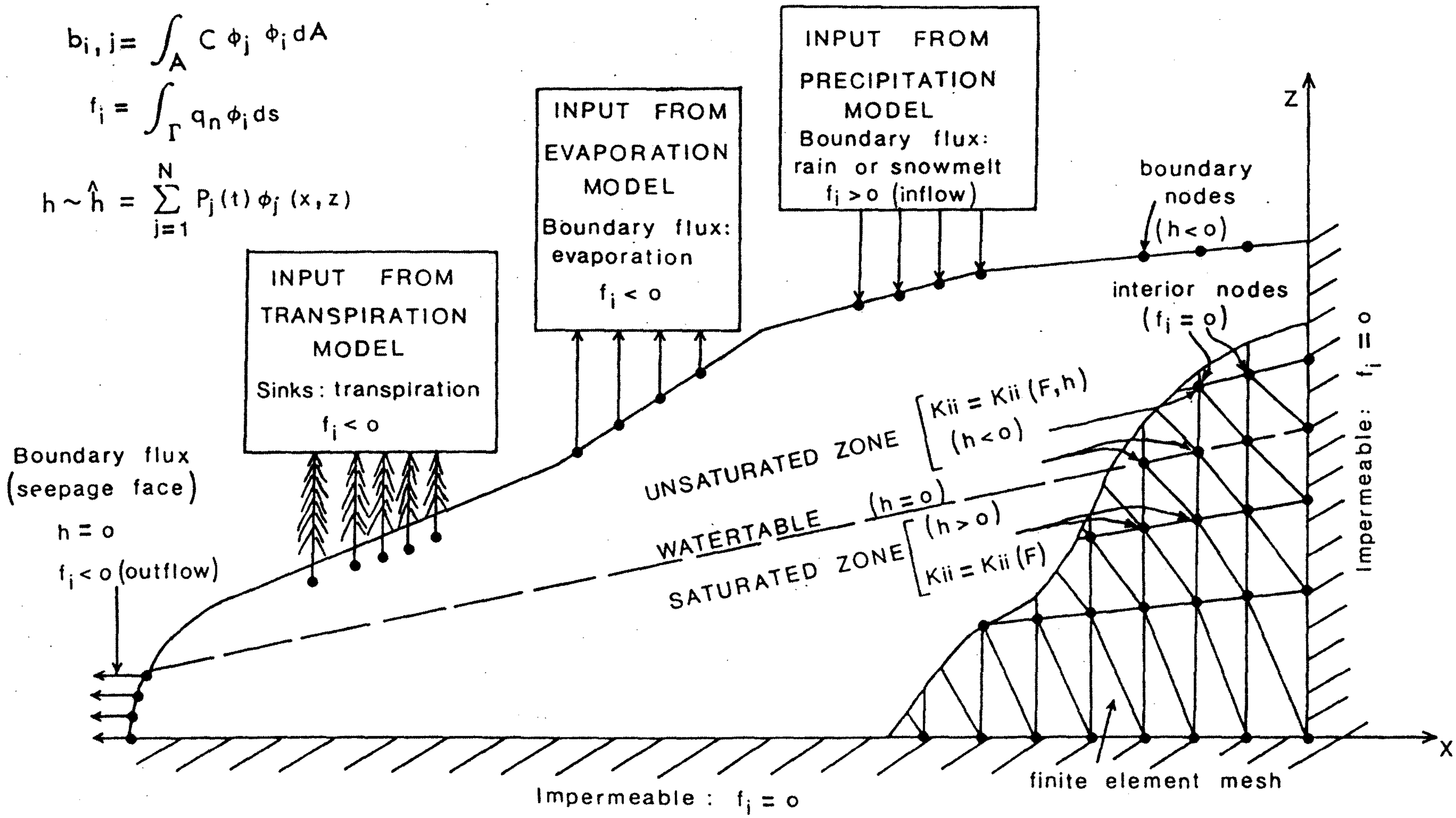


Figure 3. Application of mathematical terms to physical system (watershed profile).

2. A computer program entitled SUBFEM (subsurface finite element model) has been developed. It incorporates most of the features required to run the subsurface flow model. Development progressed through the following steps:

    1. mathematical formulation of the finite element mesh,
    2. incorporation of steady state, saturated flow equations,
    3. addition of equation solver,
    4. modification to include unsaturated as well as saturated flow,
    5. simulation of seepage face.

    Steps 3) and 4) were accomplished using pre-existing subroutines. A "canned" program (LEQT1P) was used to solve the system of equations described under accomplishment 1). This speeded up program development considerably. However, this subroutine will be dropped and SUBFEM made completely self-contained when the program is restructured as described under goal 1), 1979-80.

    Since the hydraulic conductivity-water content relationship, $K(\theta)$, and the hydraulic conductivity-pressure head relationship, $K(h)$ are difficult to measure, it was considered advantageous to use Marshall's pore-interaction model. A program for this model written by Green and Corey (1971) has been adapted for use in SUBFEM.

    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.

    As the program for the model developed, trial runs were made using hypothetical data. It soon became evident that program modifications would be necessary if computing costs are to be curtailed when large systems are simulated.

3. Some planimetric geology maps were prepared, but manpower required to draft vertical sections was not available.

4. The simulation model is not complete so it was not possible to check model results against field data.

5. An introductory chapter was completed. It outlined the need for this study, and reviewed development of the subsurface flow equations and some methods for obtaining their solutions.

6. Soil moisture content was monitored periodically between May 9 and June 27, 1978.

7. Groundwater levels were monitored throughout the year by means of water level recorders.

8. The snow-pillow was installed and operational by the end of September 1978.

9. No additional instrumentation installed. Funds not available.

10. Not done. Main effort during the year directed to completing goals 1 and 2.

14. Goals for 1979-80:

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.

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.

15. Publications:

Up to 1978-79

Nil

1978-79

Nil

16. Signatures:

C. R. Hillman
Investigator

Reid
Program Manager

G. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

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 pluse velocity) have been developed by the author.

Area is being estimated from increment borings, directly from heat pulse velocity values, and non-destructively by the gamma attenuation technique. This involves passing a beam of monoenergetic gamma ratiation of known intensity through a tree stem, and recording its attenuating characteristics of wood and water and tree thickness at the point of measurement. The assumption that all components of the system are constant with the exception of water, permits a direct measure of water content, and a calculation of its areal extent.

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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

Prof.	0.3	(Swanson)
Supp.	0.5	(Campbell)
Casual	0.3	
Total	1.1	

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 sawood 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 would 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. <u>Goals for 1978-79</u>:

1. Publish Information Report based on N.Z. transfer of work data and early HPV work entitled "A preliminary model for estimating transpiration from heat pulse velocities".

2. Prepare and run computer programs for finite difference solutions to heat pulse velocity measurements in real sensing situations (i.e. with wound and finite-sized sensors). Test results on existing data and in growth chamber experiments at University of Alberta (Botany Department as part of Ph.D. thesis work).

3. Publish Journal article on use of heat pulse techniques in estimating transpiration from mountain beech. (In conjunction with U. Benecke, Christchurch, N.Z.).

4. Continue digitize Heat Pulse Velocity instrument development.

13. Accomplishments 1978-79:

1. Report written but publication was delayed pending completion of goal 2 and publication of the results of these numerical simulations.

2. Several computer programs were prepared with varying degrees of realism near the sensors. A satisfactory set of simulations was completed in the fall. These simulations correct all past HPV data-Transpiration estimates to within 5%. A publication is in process.

3. Report written but publication deferred pending completion of goal 2 above.

4. Deferred due to resignation of Instrumentation technician.

14. 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.

15. Publications:

1977-79

Nil

16. Signatures:

Robert H. Swanson
Investigator

R. Reid
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

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, N. Stevens

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 discontinuity 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.

The probability of success in determining empirically the effect of forest opening size on snow accumulation and melt rates is very high. The probability of success is somewhat lower for objectives 2 and 3 (i.e., the theoretical process description of snow accumulation and ablation in forest openings). The first objective (i.e., development of a physically based conceptual model of the system) is even less likely of success, because it incorporates the difficulties of all other objectives. However, even here the probability must be considered as moderately high of developing the desired model within acceptable limits of precision.

The results of this study will provide the foundation on which any forest cover manipulation for water values will be based. The application of these results depends, as do many land use applications, on when the pressures for improving land use and environment become great enough.

The method to be used is as follows: A homogeneous stand of lodgepole pine has been chosen near Sundre, Alberta, where topography is extremely flat and there is reasonably uniform fetch for 4-6 miles in all directions. Ten replicates of 9 opening sizes, 1/4, 1/2, 3/4, 1, 2, 3, 4, 5, 6 tree heights in diameter, plus control will be randomly located 10 chains apart along 10 lines also 10 chains apart.

Snow accumulation and melt will be measured throughout winter and spring. This will provide, empirically, cutting guidelines for snow management and input to the next step in the study. Instrumentation will be installed to measure the radiation regime, wind structure, temperature and humidity in the openings. From this will be derived the theoretical process description of snow accumulation and ablation.

A physically-based hydrologic model will be constructed to predict the effect of timber harvesting of the experimental watersheds on snowpack and the resultant outflow hydrographs.

9. Study Objectives:

To determine the influence of small forest openings on snow accumulation amounts, melt rates and snow melt runoff patterns 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 1978-79 with costs: Nil
e. Essential new major equipment items beyond 1979 with costs: Nil
f. 1979-80 man-years

Prof.	Stevens 0.1	Swanson 0.1
Supp.	Campbell 0.5	
Casual	0.3	
Total	1.0	

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.

One 100-ft and three 30-ft towers were installed in a 3H opening and instrumented with wind direction and intensity sensors and data obtained since 1975. Wind data during snowstorms were obtained from these towers in 1976-77.

Energy budget determinations were made for short-term periods during summer months.

Study Progress Report was prepared in 1976-77.

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.

12. Goals for 1978-79

1. Continue collection and abstraction of data on temperature, humidity, precipitation, and wind run at 4 sites at James River (Golding).

2. Publish "Snow accumulation and melt in small forest openings in Alberta" in Can. J. Forest Research. This satisfies the quantitative part of study objectives 1 and 2.

3. Measure for the second year snow accumulation and melt in the 14-1H openings at James River. Results of the main study (reported on in 2 above) indicated that 1H openings combined high accumulation with low melt rate. This goal is to determine if a group of 1H openings in close proximity to one another (i.e. 66 ft between centers) will accumulate as much snow with as low a melt rate as did the more widely-spaced 1H openings of the main study.

4. A treatment was applied at Streeter basin in 1976 based on the results of the quantitative part of the James River study. A second measurement of snow accumulation in the openings at Streeter will be done (1) to determine the effect of the treatment and (2) to test the results of the James study.

5. Continue measurement and analysis of snow accumulation on the grid network at Marmot Creek. This will be used as input data to the snow accumulation and melt subroutine of the hydrologic model.

13. Accomplishments 1978-79

1. Data has been taken but abstracting work has fallen behind due to lack of technical help.

2. Article published as planned. Acceptance letter of file with editor, however, article is in press as of the date of this review.

3. Measurements taken but data not worked up prior to Golding's resignation.

4. Measurements taken but data not worked up prior to Golding's resignation.

5. Measurements taken but data not worked up prior to Golding's resignation.

14. 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.

15. Publications:

1977-1979:

Golding, D.L. 1977. Watershed treatment to alter snow accumulation and melt rates. Proc. AWRP Symp. Environment Canada, Northern Forest Research Centre, Edmonton. Inf. Rep. NOR-X-176. pp. 237-255.

Golding, D.L. 1977. Climate data and their use by Hydrology Section. In: Powell, J.M. (editor) Applications of Climatology: Proc. Workshop and Annual Meet. Alberta Climatological Comm. Environment Canada, Northern Forest Research Centre, Edmonton. Inf. Rep. NOR-X-193. pp. 108-112.

Golding, D.L. and R.H. Swanson. (In press, 1979) Snow accumulation and melt in small forest openings. Can. J. For. Res.

16. Signatures:

Robert H. Swanson
Investigator
Neil Stevens

Ron Reid
Program Manager

Director

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

1. Project: Maintenance and improvement of water yield and quality.

2. Title: Infiltration and erosion as influenced by land use.

3. New: Cont.: X 4. No.: NOR-13-141

5. Study Leader: T. Singh

6. Key Words: Pulpwood harvesting operations, oil and gas exploration, logging, improved management guidelines, watershed management.

7. Location of Work: Western Alberta

8. Problem:

   1. Project proposed by: Canadian Forestry Service and the Research Coordinating Committee, Alberta Watershed Research Program.

      The hydrologic effects of large-scale clearcuts on infiltration and erosion remain relatively undetermined on most Alberta forest lands. To provide improved management guidelines it is imperative that the inherent vulnerability of forest areas be assessed properly for overland flow and consequent erosion.

      Infiltration, as an important integrator of many soil properties, can be measured directly and objectively. If other site influences could be superimposed on infiltration characteristics, a methodology could be developed for assessing the potential erosion hazards of different forest lands for pre-planning purposes.

   2. Nature of the study: The proposed methodology will provide an onsite evaluation of the infiltration and erosion potentials of forest areas in their natural condition and assist in predicting the hazards involved when such areas are to be subjected to various land use disturbances.

3. Benefits from the solution: The assessment of the work area in terms of its inherent vulnerability to surface runoff and erosion will make the manager aware of the critical sites that should receive his special attention. By providing necessary information as to how some areas are rated more hazardous than others, the manager can be assisted in looking for similar causes elsewhere and take appropriate precautions accordingly.

4. Probability of success: The chances of successful development of the methodology are good. Consequently, it would be possible to identify areas which are inherently more vulnerable to overland flow and erosion than others.

5. Method to be used: The method to be used is based on a consideration of the essential processes involved in erosion on forest lands. Of these, infiltration is the key hydrologic process--it determines the disposition of water at the land surface. Soil porosity and depth to the least permeable horizon determine primarily the soil storage space available for the infiltrating water. When this storage is exhausted and the water is received at a rate greater than that at which the soil is being drained from the least permeable horizon, the excess water becomes available for overland flow. This overland flow, combined with the concentrated subsurface flow in places, determines primarily the rate at which erosion could occur on the sloping watersheds. The steepness of slope, and distance to a buffer strip where the water may infiltrate at a greater rate, are the other important considerations influencing erosion hazards.

   The methodology is thus based on the use of the infiltration rated areas as indicators of potential overland flow. If the measured infiltration capacities show considerable excess over the amount of water likely to be received in long-duration rainstorms, there is no possibility of the overland flow occurring in such areas. An indication of high infiltration potential is therefore indicative of the sites that are likely to be the least erosive and vice versa. A ranking is thus possible for the different areas to be rated for their vulnerability to erosion on the basis of their infiltration potentials.

   Previous work done in Streeter Basin has shown that it is easier to measure infiltration capacities directly than to estimate these from the many vegetative and edaphic factors influencing them. This work also suggested that forest vegetation stratifications can provide a convenient basis for indicating the inherent infiltration potentials of forest lands. Stratifications based on vegetation classification would therefore by used to provide general estimates of the infiltration capacities of the area to be subjected to a particular land use. However, as the forest lands are not uniformly vegetated there would be local areas with different runoff potentials as compared to the conditions represented by the overall vegetation. Vegetation stratifications therefore need to be supplemented with other site considerations in which slope characteristics would be particularly influential. Stratifications based on surficial materials would be used within an overall vegetation cover type in addition to topographic considerations. In view of the management oriented nature of the study these stratifications would be kept as simple as possible.

Experimental areas selected in each stratification would be used to determine the steady infiltration rates by double-ring infiltrometers. The information thus collected would provide a logical basis for ranking the stratifications for their vulnerability to overland flow and erosion according to the infiltration potentials. This would be supplemented with all other related information available in soil maps, topographic (contour) maps, bed-rock and surficial geology maps, and rainfall characteristics maps. All pertinent information would be put in an information report to explain the importance and relevance of each factor to the inherent erosion potential of the study area. The field observations, and the collected information mentioned above, would be used for providing management guidelines for safeguarding against the erosion hazards inherent in a given land use. The data will also find use in evaluating the constants on infiltration models (Philip, Singh, Holtan).

Although the above-mentioned approach would fulfill the objectives of the study on undisturbed forest lands, a different approach needs to be undertaken on the already cut areas. This phase of the study would require the use of a rainfall simulator to obtain actual measurements of overland flow and erosion in disturbed sites. The Rocky Mountain infiltrometer would be used for this purpose and would provide a comparative test on the severity of impact attributable to each land use practice at a given site. The compaction or exposure of the soil surface consequent to land use can thus be assessed directly in terms of the overland flow and sediment produced on such sites. The rainfall simulator will also serve as a test of the methodology developed from the double-ring infiltrometer approach.

9. Study Objectives:

1. To develop and test methodology for on-site evaluation and assessment of infiltration and overland flow potentials of forest lands and to relate these assessments to soil erosion hazards inherent in pulpwood harvesting operations, oil and gas exploration, and related land use disturbances.

2. To provide management guidelines based on such assessments for pre-planning purposes.

10. Resources:

a. Starting date: 1973
b. Estimated year of completion: 1977 Revised: 1979
c. Estimated total man-years required: 2.4
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	0.0	
Total	0.0	Study terminated

11. Progress to Date:

All the necessary field data other than aspen already collected and statistically analyzed. The draft for the publication of an information report on lodgepole pine forests has been completed. Preliminary paper on spruce-fir forests has been prepared. All sites for infiltration runs to be made in the aspen forest were selected and located in the field.

12. Goals for 1978-79:

(Scientist on assignment to FAO, Iran. Will not return prior to 1978-79 field season.)

1. Publish information report on lodgepole pine infiltration.

13. Accomplishments 1978-79:

1. None. Scientist still on assignment to FAO, Iran. Publication deferred pending his return. Study terminated except for this publication.

14. Goals for 1979-80:

1. None. Study terminated.

15. Publications:

1977-79

Nil

16. Signatures:

R.H. Swanson for T. Singh
Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 7, 1979

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: N. Stevens
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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man years:

Prof.	0.8	(Stevens)
Supp.:	0.5	(Robson)
Casual	0.3	
Total	1.6	

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 success 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. Since snowmelt is not simulated by PROSPER and problems were encountered with the snowmelt models tried, I developed one. Simulations with it have been good and it appears as though it will be flexible enough to be applied in different regions.

By combining PROSPER and my 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. Goals for 1979-80:

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 my 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. Signatures:

Neil Stevens
Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-14

Impact of clearcutting on forest environment

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1979

1. Project: Impact of clearcutting on forest environment

2. Title: The climate of clearcut forested areas.

3. New: Cont.: X

4. No.: NOR-14-138

5. Study Leader: J.M. Powell

6. Key Words: Forest climatology, macroclimatology, mesoclimatology, microclimatology, clearcut size, mobile and airborne sensing, SA1, SA2, M4, B19a, B19c.

7. Location of Work: North Western Pulp and Power Ltd. lease area at Hinton, Alberta and Edmonton Laboratory. Data will be obtained from the Prince George, B.C. area on a cooperative basis with Climatology Section, CLI, Victoria, B.C.

8. Problem:

A literature review indicated that there is a paucity of data relating to climatic environmental changes brought about by large-scale logging operations. Background information of the interrelationships of macro-, meso- and microclimate in clearcut areas is required for other forestry studies. Information on the effects of different types and sizes of cutting patterns is particularly lacking. What changes in the various climatic parameters important for forest regrowth can be expected following the removal of the tree cover, and how far does the ameliorating influence of the stand border extend? Can any adverse changes be physically adjusted by modifying cutting patterns to improve the ground-level factors?

A detailed analysis of the problem can be found in the study statement for the year 1974-75.

9. Study Objectives:

   1. To determine the effect of clearcutting of different sizes on the various climatic parameters.

   2. To identify the zones of stand border influence for each climatic parameter and to relate this to size and orientation of cut.

3. To assess the use of fixed ground based climatic stations, with ground level mobile sensors and airborne sensors, for obtaining climatic data for forestry purposes.

10. Resources:

a. Starting date: 1971
b. Estimated year of completion: 1978 Revised: 1978
c. Estimated total Prof. man-years required: 1.8
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: Nil

11. Progress to Date:

Initial field work for the mesoclimatic aspects were begun in June 1971 when up to 21 stations were operated at 53 locations on 5 cutting compartments. Sixteen to 20 stations were run throughout the winter of 1971-72 and detailed measurements of snow were taken. In 1972 58 locations were sampled, including 22 on a continuous basis from May to early October, but only one station was operated through the winter. In 1973, 47 weekly and two monthly climate stations were run from mid-April or early May to early October. In 1974 stations were run at 50 locations, in 1975 at 48 locations, in 1976 at 41 locations, but in 1977 only at 18 stations (all associated with completing field work for NOR-139). All regular or satellite stations were equipped for measuring temperature, humidity and precipitation each year. Base stations and some other stations also have equipment for measuring wind, radiation, soil temperature (some soil moisture) and some evaporation (one or two years only). In 1972 soil moisture neutron probes were installed and maintained for a few months at 27 stations, and gravimetric soil moisture sampling was obtained at 15 stations as a check against the neutron probe readings. In addition to the standard climatological stations additional precipitation only stations were run from 1972 to 1976 to increase the precipitation network density to provide better precipitation information for this and the hydrology studies especially NOR 121. Tabulations have been completed each year for all the precipitation recording stations and for stations in and adjacent to the study area operated by other agencies for the years 1972 to 1976 inclusive. The total area network represents summer precipitation totals obtained from almost 150 locations each year. Snow survey measurements have been taken each spring at 10-20 locations from 1972 to 1976. Much of this precipitation data was summarized for the report "Hydrometeorology of the Hinton-Edson area 1972-75", which included a general section on the climate of the area. A report was also published on the "Precipitation Climatology of the Eastern Slopes". Descriptions have been completed for all climate stations giving location information, including elevation, slope, aspect, cut block no., year cut, any post-harvesting treatment, vegetation cover, degree of harvesting residue and other features. Also descriptions have been completed for all the micro-climate soil temperatures sites. Photographs are on file for many of the mesoclimate stations.

In 1972 six areas, two strip cuts, two block cuts and two large irregular cuts were selected for microclimatic studies, with 6 to 16 stations per cut. In 1973 soil temperature measurements were made at approximately weekly intervals from mid-May to late September on four of the networks installed in 1972. In 1973 transects of soil temperature profiles (24 to 26 stations) were established on two additional areas in association with NOR-14-139. Transects of Gen atmometers and rain gauges were also established on these two areas, along with continuous recording soil and air temperature probes. In 1974 two further microclimate networks were established in connection with NOR-14-139 with similar instrumentation to the two networks established in 1973. Measurements were continued through 1976 on four of the networks established in 1972 and on a further network established in 1975. In 1977 measurements were only taken on the remaining two networks (established in 1974) in association with NOR-14-139.

All 1971-76 meso- and microclimate temperature data has been extracted and key punched and all 1977 temperature data has been extracted ready for key punching. All 1971-77 precipitation data has been extracted, tabulated and summarized. All 1971-77 radiation data has been extracted and all except 1977 data has been put on punch cards. Humidity data was extracted and key punched for selected stations and years, including ten extracted for 1977. Wind direction data has been extracted and key punched for about half the stations for the period 1971-76. Weekly soil temperature and maximum and minimum temperature has been extracted up to 1976 and put on cards up to 1975.

Soil temperature profile data has been extracted and key punched for the period 1971-77 and the supplementary air and soil temperature probe systems data has been extracted up to mid-1977 and put on cards up to 1976.

Daily and monthly summaries in metric units have been prepared for the mesoclimate temperature data for the years 1971, 1973-76. The radiation data has also been summarized for the years 1972-76, and the supplementary air and soil temperature probe data for 1976. Preliminary analysis was undertaken for the paired station data for some of the years.

In 1971 and 1972 a dozen mobile temperature traverses, most at dawn were run through and between four of the study compartments. Thermal infrared line scan images were taken in August and October 1971 along two transects in the McLeod Working Circle to develop a computer technique to present some of the thermal imagery. Information on three pairs of stations set up in the Prince George area on a cooperative basis by the B.C. Resource Analysis Branch, Ministry of the Environment was received for 1972 to 1976 for comparison purposes with similar station pairs in the Hinton area.

Further more detailed summaries on the above progress up to the spring of 1975 along with location maps can be found in the Study Progress Report, and the master summary charts available on file. Prior to the year 1977-78 some 10 reports or papers had been published on different aspects of the climate of clearcut forested areas.

Progress on the former study NOR-2-115 transferred to this study in January 1977 can be obtained from pages 46-48 of "Study Statement 1977-78" and is not repeated here. Prior to the year 1977-78 some 14 reports or papers had been published on different aspects of the climate classification for the forested areas of the Prairie Provinces. Reporting to complete this study is nearly complete with two reports "in press" and a final report in preparation.

12. Goals for 1978-79:

1. The extraction and key punching of the data collected between 1971 and 1977 will be completed.

2. An information report will be prepared to compare the summer climate regime in a forest and in the open for stations in the Hinton and Prince George areas.

3. A report will be prepared to identify the zones of stand border influence for each of the climatic parameters measured.

4. The mesoclimatic station data will be analyzed and summarized to provide monthly and seasonal values for all temperature and radiation stations and for selected humidity stations. Initial analysis will also be undertaken for the stations measuring wind and soil temperature and some further analysis may be undertaken on the precipitation data. Emphasis will be given to completing those stations associated with NOR-139 first.

5. Other reporting goals for the Hinton study will depend on the results of the trip to Toronto to consult with D.C. MacIver (see 13.4).

6. Complete and publish the information report "Maps of selected climatic parameters for the Prairie Provinces, May-September, 1961-1970".

7. Provide advice on climate input for the Biogeoclimatic ecosystem classification (NOR-27-169) as required.

8. Prepare a paper on "Climatic networks for forestry purposes" to be given at the Annual Meeting of the Alberta Climatological Association in April. Compile the proceedings of the meeting for publication.

13. Accomplishments for 1978-79:

1. The extraction of the data collected between 1971 and 1977 were completed including wind speed and direction. Missing temperature data was interpolated for the years 1971 to 1977 as part of the quality control procedure, and the quality of most of the thermograph data were checked against thermometer recordings prior to any necessary adjustments being made. Very little key

punching of the extracted data was completed during the year as no personnel were available, or when available priority was given for NOR 139 or other NFRC studies.

2. A start was made to summarize the data from the paired stations at Hinton, but further work towards the goal was dropped when the study had to be curtailed in mid-year and also no support personnel were available. Summaries of the Prince George area data was made available by Resource Analysis Branch, B.C. Ministry of Environment.

3. This goal was eliminated with the curtailment of NOR-14 and lack of support staff and key punching.

4. The available temperature and radiation data were analyzed and summarized to provide monthly and seasonal values for all stations employed in the study between 1971 and 1976. 1977 data still awaits further key punching before being summarized. Some adjustments of the summaries will be made when the interpolated data is key punched and other quality control proceedures are included in the computer analysis. Emphasis has been given throughout to stations associated with NOR-139.

5. Consultations were had in late May with D.C. MacIver in Toronto but no further goals were estblished as the study was already being curtailed at that time.

6. The report "Maps of selected climatic parameters for the Prairie Provinces, May-September, 1961-1970" was published.

7. Advice on climate input for the Biogeoclimatic ecosystem classification (NOR-27-169) has been provided on a number of occasions. Maps were provided to the Alberta Forest Service who are now preparing estimated climatic parameters for use in the study. The climate classification data has also been utilized by the AFS to amalgamate some zones and the resulting zonation is being used as a planting hazard and seed collecting guide.

8. A paper on "Climatic networks for forestry purposes" was presented at the Workshop of the Alberta Climatological Association. This was subsequently published in the Proceedings of the "Climate Network" Workshop and Annual Meeting. I also chaired the meeting, presented three other reports and compiled the proceedings for publication.

14. <u>Goals for 1979-80</u>:

1. Nil. Any further reporting on this study will be accomplished under NOR-31-179, Climatic Studies Program. Study terminated.

15. Publications:

1977-78

Powell, J.M. 1977. Climatic classifications of the Prairie Provinces. (Abs.). Atmosphere Vol. 15. 11th Annual Congress Issue 1977. Abstracts p. 27.

Powell, J.M. and D.C. MacIver. 1977. A summer climate classification for the forested area of the Prairie Provinces using factor analysis. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton. Inf. Rep. NOR-X-177. 51 pp.

Powell, J.M. 1977. Precipitation climatology of the Eastern Slopes area of Alberta. Pages 187-204 in R.H. Swanson and P.A. Logan (compilers). Alberta Watershed Research Program Symposium Proceedings, 1977. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-176. 342 pp.

1978-79

Hillman, G.R., J.M. Powell, and R.L. Rothwell. 1978. Hydrometeorology of the Hinton-Edson area, Alberta, 1972-75. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-202. 171 pp.

Powell, J.M. and D.C. MacIver. 1978. Maps of selected climatic parameters for the Prairie Provinces, May to September, 1961-1970. Fish. & Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-206. 31 pp.

Powell, J.M. 1978. Climatic classifications of the Prairie Provinces of Canada. Pages 211-229 in Hage, K.D. and E.R. Reinelt (Eds.). Essays on Meteorology and Climatology: in honour of Richmond W. Longley. Univ. Alberta, Dept. Geography, Geog. Studies Monograph 3. 427 pp.

Powell, J.M. 1978. Climatic networks for forestry purposes. Pages 20-32 in Powell, J.M. (Compiler). Climatic networks: Proceedings of the workshop and annual meeting of the Alberta Climatological Association, April 1978. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-209. 101 pp.

16. Signatures:

J.M. Powell
Investigator

R. Reid
Program Manager

G.T. Silver
Director G.T. Silver

PROJECT NOR-17

Forestry services in forest management

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 1, 1979

1. Project: Liaison and technical advisory services in forest management.

2. Title: Technical and advisory services re insect pests and diseases

3. New: Cont.: 4. No.: NOR-17-068

5. Study Leader: V. Hildahl

6. Key Words: Tree biology, entomology, pathology, detection, insects, diseases, appraisals, protection, pesticides, chemical control, spraying, demonstrations, Dutch elm disease.

7. Location of Work: Manitoba

8. Problem:

Provincial, municipal and industrial resource managers are responsible for forest, park and amenity tree programs in Manitoba. Therefore, they must derive maximum benefits from results of research pertaining to tree protection, maintenance and establishment. Research managers also need feedback on the requirements and views of the user agencies in order to initiate research and demonstrations aimed at resolving problems associated with effective and intensive forest management.

9. Study Objectives:

   1. To provide technical advice and guidance to resource managers of the province in developing and implementing forest protection programs aimed at keeping tree losses due to insect and disease outbreaks within acceptable limits.

   2. To provide a technical advisory service to provincial and municipal government agencies and the general public with regard to appropriate detection, diagnostic and control procedures for Dutch elm disease in the Manitoba region.

10. Resources:

a. Starting date: 1966
b. Estimated year of completion:
c. Estimated Prof. man-years required: N/A
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.	-
	Supp.	-
	Casual	-
	Total	0.0

11. Progress to Date:

Since 1966, when the study was initiated, liaison has been developed and maintained with authorities of government and industry associated with forest utilization, reforestation and amenity programs in the Region, and a technical advisory service has been established to provide expert advice on insect pest and disease problems. To date, the study has been highlighted by: 1) interpreting and disseminating (in the form of brochures, special reports and personal contacts) results of scientific research that have practical application in dealing with resource management problems; 2) evaluating current insect and disease outbreaks with respect to impact on forest stands, and on park, shelterbelt and amenity plantings; 3) developing, demonstrating and evaluating ground and aerial techniques and procedures for applying chemical insecticides used in suppressing outbreaks of the jack pine budworm, spruce budworm, forest tent caterpillar, cankerworms, and poplar bud-gall mite; 4) developing 10-year jack pine mistletoe eradication programs in the Belair Provincial Forest and western district of Manitoba, based on market demands for jack pine; and 5) directing provincial and municipal sponsored Dutch elm disease detection (including the use of infrared aerial photography for early recognition of diseased trees) and control programs in Manitoba.

12. Goals for 1978-79:

1. Continue liaison with resource managers throughout the province, and provide technical advisory services, especially with regard to insect and disease problems in forest, urban and rural environments. Close contact will be maintained with the Forest Insect and Disease Survey and their facilities utilized in achieving this goal.

2. Continue cooperative programs with provincial and municipal agencies regarding Dutch elm disease detection and diagnosis, and provide technical advisory services in relation to sanitation practices and control procedures.

3. Complete publication "Control of poplar bud-gall mite with insecticides". (This publication to be prepared jointly with R.F. DeBoo, Chemical Control Research Institute.)

4. Complete preparation of information report on results of the operational spray programs (1974-76) against the spruce budworm outbreak in the Spruce Woods Provincial Forest and Park in Manitoba.

5. Publish paper entitled "Dutch elm disease in Manitoba 1975-1977" in Plant Disease Reporter.

13. Accomplishments in 1978-79:

1. Contacts and liaison with resource managers were maintained and technical advisory services (including lectures and seminars) were provided, especially on current insect and disease problems in forest, urban and rural environments. Regular contact was also maintained with Forest Insect and Disease Survey personnel of the Northern Forest Research Centre in achieving this goal.

   In addition to these services, public information was provided in the form of media releases and interviews.

2. Cooperative programs with regard to Dutch elm disease detection and diagnosis were continued. This involved the direction and supervision of 18 summer student employees provided by the Manitoba government and the City of Winnipeg. Technical advisory services in relation to sanitation practices and control procedures were also provided as required.

3. Publication "Control of Poplar Bud-Gall Mite with Insecticides" is incomplete. A summary in the form of a file report will be prepared before March 31, 1979.

4. Information report on results of operational spray programs 1974-76 against the spruce budworm in the Spruce Woods Provincial Forest and Park in Manitoba is incomplete.

5. Paper entitled "Dutch Elm Disease in Manitoba 1975-78" will be prepared for publication before March 31, 1979. This will cover past CFS involvement.

6. Accomplishment added: One publication "Dutch Elm Disease Continues to Spread in Manitoba".

14. Goals for 1979-80:

1. Study terminated.

15. Publications:

1977-78

Hildahl, V. 1977. Forest tent caterpillar. Environ. Can., North. For. Res. Cent., Pest Leaflet NFRC PL 17-77.

Hildahl, V. 1977. Recognition and control of Dutch elm disease in the Prairie Provinces. The Blue Jay 35(2):7 p.

Hildahl, V. 1977. Dutch elm disease in Manitoba, distribution and symptomatology. *In* Proceedings of the 1977 Shelterbelt Committee meeting. Manitoba Dept. Mines and Resources, Winnipeg, Manitoba. 47-48.

1978-79

Hildahl, V. 1978. Dutch elm disease continues to spread in Manitoba. *In* Forestry Report, Northern Forest Research Centre, Edmonton, Alberta.

16. Signatures:

W. Johnson for V. Hildahl

Investigator

W. Johnson

Program Manager

G.T. Silver

Director G.T. Silver

NOR-17-071

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 1, 1979

1. Project: Liaison and technical advisory services in forest management.

2. Title: Liaison and technical advisory services - Winnipeg Sub-office.

3. New: Cont.: 4. No.: NOR-17-071

5. Study Leaders: K. Froning and L.D. Nairn

6. Key Words: Public relations, silviculture, trials, demonstrations, spruce, pine, poplar management.

7. Location of Work: Manitoba

8. Problem:

Forest resource managers in Manitoba have been required over the years to manage their forests more intensively. The manager must remain aware therefore of research findings which are relevant for meeting his management objectives. In many instances existing knowledge can be applied but in other cases new investigations are required to solve current problems. A line of communication between CFS research staff and the resource managers is essential for an exchange of information, discussion and examination of problems. The execution and maintenance of various trials and demonstrations requiring less than 0.2 professional man-years are also included in this study.

9. Study Objectives:

   1. To establish a working rapport with administrative, operational and research personnel in the renewable resource field in order that resource managers can obtain the benefit of research on the one hand and on the other that research personnel may conduct studies of value to the resource managers.

   2. To provide a technical advisory service to resource managers and the general public.

3. To conduct and maintain various demonstrations and field trials.

4. To survey or appraise forest operations or problems in order to suggest means of improving techniques and methods and also as a means of determining research needs.

10. Resources:

a. Starting date: 1966
b. Estimated year of completion:
c. Estimated total man-years required: N/A
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.
Supp.
Casual
total

11. Progress to Date:

Liaison was maintained with provincial and industrial resource managers. Knowledge was gained on a broad spectrum of forest management problems and assistance was provided in finding solutions to technical problems through technology transfer. Advisory services have made resource managers and the general public aware of research findings relevant to their problems. Demonstrations, studies and appraisals have been conducted to meet the request of resource managers in the field.

12. Goals for 1978-79:

1. To provide technical advisory services in forest management to provincial and industrial forest managers and the general public.

2. To conduct and maintain various silvicultural demonstrations and field trials.

    1. To maintain the value of the aspen management demonstration area.

    2. To reappraise Prairie forest plantations surveyed as one-, three-, and five-year-old plantations in 1971, to provide base data for computer modelling of managed stands.

    3. In cooperation with provincial forest service, plan and initiate a program of intensive management of a red pine seed production area for the maximum production of seed.

3. To publish information report on logging damage in stands with spruce understory.

4. To prepare an information report on 10-year performance of 61 provenances of ponderosa pine in Drumheller, Alberta.

5. Goal added: To prepare a file report on Forestry in Germany.

13. Accomplishments in 1978-79:

1. Technical advisory services in forest management were provided to provincial and industrial forest managers and the general public. This was achieved primarily through participation in and organization of technical formal and informal meetings, through personal contacts, by telephone or mail.

2. A limited silvicultural trial and demonstration program was conducted because of retirement of M. Pratt (EG-ESS 7) and subsequent loss of that position.

    1. As a direct consequence of the above, no work was done on the aspen management and demonstration area.

    2. Prairie forest plantations were resurveyed in Manitoba, Saskatchewan and Alberta. Results in areas other than southeastern Manitoba were disappointing in that survival and stock performance in frequently heavy competition were unsatisfactory. Two articles, dealing with the results of that survey have been prepared for the silvicultural issue of the next 1979 Forestry Report.

    3. Work on the red pine seed production areas had been progressing through soils analysis and individual tree selection to tree tagging. However, additional work was not carried out because of sub-office closure. All current information and plans will be turned over to the Province for their use or rejection.

3. The information report on logging damage in stands with spruce understory has not been completed but is under intense preparation and expected ready for reviews by April 1, 1979.

4. The information report on ponderosa pine performance in Drumheller has received only little attention and is incomplete.

5. Accomplishment added: The file report "Forestry in Germany-Tour Notes", was completed and received limited distribution.

14. Goals for 1979-80:

With the closure of the Winnipeg Sub-Office, this study will be closed. Some incomplete goals such as the publication of the information report on logging damage and ponderosa pine provenances will be transferred to study NOR-17-118.

15. Publications:

1977-78

Schultz, N.B. and K. Froning. 1977. Establishment of jack pine following seeding on barrel scarified sites. File Report NOR-17-071.

Nairn, L.D. and K. Froning. 1977. Grasshopper damage to pine container seedlings in southeastern Manitoba. Information Report NOR-X-191.

Schultz, N.B. and K. Froning. 1978. Container planting trials 1972-74 in Manitoba. File Report NOR-17-071.

1978-79

Pratt, M. 1978. Silvicultural operations in the Riding Mountain Forest Research Area from 1961 to 1969. File Report NOR-17-071.

Froning, K. 1978. Forestry in Germany-Tour Notes. File Report NOR-17-071.

16. Signatures:

N.J. Johnson for K. Froning

Investigator

Program Manager

Investigator

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 1, 1979

1. Project: Forestry services in forest management.

2. Title: Forestry services in Saskatchewan.

3. New: Cont.: X 4. No.: NOR-17-113

5. Study Leader: J. Ball, A. Gardner.

6. Key Words: Contact, dissemination, research, lectures, public relations, trials, demonstrations, shade tree maintenance.

7. Location of Work: Saskatchewan.

8. Problem:

The primary role of the Prince Albert Sub-office is to establish and maintain strong lines of communication with various forest management agencies to ensure that the results of departmental research are known and utilized, keeping well informed on forest management problems in the province and to acquaint the regional director and program managers with forest management problems in Saskatchewan by advising on opportunities and priorities for research. It is necessary to maintain close contact with other federal departments, universities, technical schools and the general public to promote CFS activities in the province. The execution and maintenance of various trials and demonstrations are also included in this study.

9. Study Objectives:

   1. To provide advisory services in silviculture, fire management, nursery management and tree pest extension services to federal, provincial industrial forestry agencies and the public.

   2. To provide general liaison between provincial forestry agencies and staff members of Northern Forest Research Centre.

   3. To conduct and maintain various demonstrations and field trials.

10. Resources:

a. Starting date: 1970
b. Estimated year of completion: Terminated
c. Estimated total Prof. man-years required: Nil
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	Ball	0.0	Gardner	0.0
Supp.	0.0	Kolabinski	0.0	Bohning	0.0
Casual	0.0	Mazurak	0.0		
Total	0.0				

11. Progress to Date:

Advisory and extension services in areas such as silviculture, tree pest, and nursery management have been provided to federal, provincial, and municipal governments and the general public. Liaison between provincial and private forestry agencies and Canadian Forestry Service has developed and as a result several studies were undertaken to improve the level of forest management in Saskatchewan. Examples include a current study to determine the magnitude of poor softwood stocking on highly capable sites and a study of aspen harvesting investigating damage to existing spruce understories of various densities and heights. Several silvicultural demonstrations such as the interprovincial forest fertilization trials, triploid and hybrid aspen trials, reforestation - site preparation demonstrations (and their post planting maintenance) are included in this study.

12. Goals for 1978-79:

1. To provide continuous advisory and consultative services in forest management to provincial and industrial forest managers and general public.

2. To provide advisory and consultative services to federal, provincial, and municipal park personnel in shade tree maintenance in response to requests.

3. To provide general liaison between provincial agencies and staff members of the Northern Forest Research Centre.

4. To obtain forest resource data from provincial and industrial agencies for new core forestry program.

5. To continue the Finn plough study by:

   (a) Rearing stock.
   (b) Planting 1978 spring replicates (from overwintered stock).
   (c) Ploughing approximately 8 acres.
   (d) Measuring 1977 plantings.
   (e) Miscellaneous, maintenance (pin seedlings, plot layout, etc.).

6. To conduct and maintain various silvicultural demonstration and field trials.

   (a) To remeasure seeded Finn Plough furrows at Hudson Bay and Chitek Lake.

   (b) To obtain fifth year remeasurements for third consecutive year on bare-root and container seedlings at Candle Lake and publish results in an Information Report.

   (c) To maintain and remeasure triploid aspen plantations at Candle Lake and Hudson Bay.

   (d) An evaluation of the herbicide Round Up as a release treatment for white spruce plantations.

7. To prepare a file report on an exotic plantation of Norway Spruce and Scots Pine at Candle Lake.

13. Accomplishments in 1978-79:

1. Advisory and consultative services in silviculture were provided to provincial and industrial foresters.

2. Advisory and consultative services on shade tree maintenance were provided to individuals from various agencies.

3. Several meetings were arranged with provincial and industrial forest managers for visiting Canadian Forestry Service staff. Arrangements for personnel (from NFRC, DTRR and U of S) for staying at Candle Lake were made through the Prince Albert Office.

4. Goal was not accomplished. Wayne Johnstone looked after this.

5. The Finn Plough work (originally a proposed study, "Rehabilitation of non-productive high quality sites in eastern Saskatchewan) was continued as an added goal in this study with the cooperation of Simpson Timber and the Saskatchewan Department of Tourism and Renewable Resources.

   (a) White spruce seedlings in containers from 2.4 to 45 in^3 and bare-root stock were planted on a well drained site at Rice River in the spring and in the fall.

   (b) Survival, height and microsite data were taken on the 1977-78 spring and fall replications at Bertwell.

   (Stock is available for final planting this spring at Rice River.)

6. Various silvicultural demonstrations and field trials were conducted.

   (a) Seeded Finn Plough furrows at Hudson Bay were measured after five years at Greenbush and after three years at Leoville. An article has been prepared for the Forestry Report.

(b) Final remeasurements for the third consecutive year on bare-root and container seedlings at Candle Lake were taken and a report is being prepared. Another report on wind damage and root deformation on pine is in preparation.

(c) Triploid aspen plantations at Hudson Bay and Candle Lake were maintained and remeasured; a file report is being prepared.

(d) The herbicide Round Up was evaluated and a report has been prepared.

7. A file report on an exotic plantation of Norway Spruce and Scots Pine at Candle Lake is currently under preparation.

14. Goals for 1979-80:

Project NOR-17-113 has been terminated.

15. Publications:

1977-78

Gardner, A.C. 1977. The C & H scarifier - tree planter. File Report NOR-17-113.

Gardner, A.C. 1977. An evaluation of the Bräcke Cultivator. File Report NOR-17-113.

1978-79

Ball, W.J. and V.S. Kolabinski. 1978. Seedling performance and site treatment on moist mixedwood sites in Saskatchewan. File Report NOR-17-113.

Ball, W.J. 1978. Monitoring regenerated areas from the air. File Report NOR-17-113.

Bohning, R.A. 1978. Results of a 1975 preliminary field trial using Krenite and Velpar herbicides. File Report NOR-17-113.

Bohning, R.A. 1978. Peat/duff mixture has beneficial effect on white spruce container seedling root growth. File Report NOR-17-113.

Bohning, R.A. 1978. A comparison of two types of planting dibbles on different soil densities as they affect seedling survival and growth. File Report NOR-17-113.

Bohning, R.A. 1978. Core dibble reduces impact of soil compaction on seedling growth. File Report NOR-17-113.

Kolabinski, V.S. 1978. The seedbed can make a difference. File Report NOR-17-113.

Gardner, A.C. 1978. A field trial of a glyphosate herbicide - Round Up. File Report NOR-17-113.

Gardner, A.C. 1978. Plantation release with herbicides. Sub. to Forestry Report on Silviculture.

Gardner, A.C. 1978. Advances in mechanical reforestation. Sub. to Forestry Report on Silviculture.

Walker, N.R. and W.J. Ball. 1979. Increasing shoot/root ratio improves first year seedling performance. Sub. to Forestry Report on Silviculture.

16. Signatures:

W.J. Ball
Investigator

Program Manager

A.C. Gardner
Investigator

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979-80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 1, 1979

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: Nil.
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.	2.0	(H.J. Johnson)
	Supp.	3.0	(Gorman 1.0, Rentz 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 (Soos, Johnson).

2. Establishment and maintenance of interprovincial forest fertilizer trials in Slave Lake Forest (3 installations) (Soos, Johnson).

3. Coordination and preparation of a literature review and interpretation of the effects of large-scale clearcutting in Alberta (Johnson *et al.*).

4. Evaluation of reforestation practices in Alberta, Saskatchewan and Manitoba. Two information reports prepared (Froning, Johnson, Appraisal Crew).

5. Coordination, preparation and presentation of technical lectures, workshops and seminars on forestry subjects - national parks, provincial parks, technical schools, and University of Alberta (Stevenson).

6. Silvicultural advisory services in Alberta and the Territories (Johnson).

7. Assistance to several projects in collection of special survey data, compilation and preliminary analyses (Appraisal Crew).

8. Prepared a report on regeneration following strip-cutting in Alberta.

12. Goals for 1978-79:

1. Appraisal crew assignments were made as follows:

April-May

4 man-months (Quintilio) - Slave Lake
2 man-months (Ives) - Slave Lake

June-July

1.5 man-months (Klein) - Chip Lake
1.0 man-months (Klein) - Fencing Chip Lake

August

1.0 man-months (Klein) - Chip Lake

September

1.0 man-months (Froning) - Alberta
1.0 man-months (Bella) - Manitoba

Winter

2.0 man-months (Klein) - Intermittent
Fire, Genetics, National Statistics, Mensuration, etc.

2. Prepare an Information Report on "Monitoring of Spencer-Lemaire container seedlings".

3. Prepare a final report on 5-year performance results of BC/CFS and ARC sausage container trials in Alberta and the Territories.

13. Accomplishments in 1978-79:

1. Appraisal crew assignments accomplished:

		Man Months
a.	Biomass study of forest fuels - jack pine. Pre-burning data. Fire data collection and compilation. (Chrosciewicz)	12
b.	Jack pine progeny test. Removal and relocation of fencing. Planting and sucker removal. (Klein)	7
c.	The effect of clear-cutting on microclimate compilation. (Powell)	5.5
d.	Field checks - large scale photography Whitecourt. (Kirby)	2
e.	Various spacing trials. Biomass (aspen suckers). (Bella)	2
f.	Special collection tent caterpillar Slave Lake. (Ives)	1

g. Inspection of plantations. Reforestation evaluation. (Froning) 2

h. Miscellaneous Plot location book, bibliography, mailing list, trailer moving, NFRC inventory. 3

2. Published Information Report NOR-X-207 - Walker, N.R. 1979. "Field performance of coniferous Spencer-Lemaire container seedlings in west central Alberta".

3. A draft report has been completed on the 5-year performance of BC/CFS styroplugs and ARC sausage container seedlings. An information report will be published by March 31, 1979.

14. 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 performance.

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.

15. Publications:

1977-78

Johnson, H.J. and J.R. Gorman. 1977. Effect of strip width on the regeneration of white spruce in the Mixedwood Forest Section of Alberta. Information Report NOR-X-88.

1978-79

Walker, N.R. 1979. Field performance of coniferous Spencer-Lemaire container seedlings in west-central Alberta. Information Report NOR-X-207.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 -80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 1, 1979

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, such as 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.

A prime function of this study 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 1979-80 with costs:
e. Essential new major equipment items beyond 1980 with costs:
f. 1979-80 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 and extension services and seminar-workshops were provided to various clients and agencies on insect problems of forest and shade trees. Special surveys involving field data collection and reporting were made on woodborers, jack-pine budworm, spruce budworm, seed and cone insects, insect and disease problems of young regeneration and on root-collar weevils. Aerial surveys were carried out on spruce budworm and dwarf mistletoe in northeastern Alberta. Contributions were made toward 1978 "Forestry Report".

12. Goals for 1978-79:

1. Complete the preparation of an information report on spruce budworm species with particular emphasis on Alberta-N.W.T. region, summarizing cumulated information on history of outbreaks, damage impact, budworm life history, and seasonal development.

2. Complete first draft of "Common insects of trees and shrubs of the Prairies".

3. Provide CFS representation on various regional and provincial shelterbelt, pest control, and regulatory committees including the following:

   a. Western Committee on Crop Pests

   b. Alberta Pest Control Advisory Committee

   c. Saskatchewan Advisory Council on Insect Control

   d. Shelterbelt Committee on Western Canadian Society for Horticulture

   e. Contact officer for federal Pest Control Products Act, Trade Memorandum 104

   f. D.F.E. Regional Biocide Committee

4. Provide information and consulting services to other scientists and to various clients in response to their requests on insect identifications, abundance, hazard, damage impact, and control.

   a. Complete report on jack pine budworm assessment for Saskatchewan Forestry Branch.

   b. Initiate exploratory studies with Dr. Y. Hiratsuka and in consultation with provincial forestry personnel, establishment of guidelines, locations, methodology, etc. for locating sampling plots in regeneration to monitor losses due to insect, diseases and other organisms.

   c. Undertake, with assistance of FIDS, aerial mapping and defoliation assessment of spruce budworm infestation in the region (see also NOR-1-033).

5. Provide input into National Forestry Statistics on insect losses as necessary (see also NOR-1-033).

13. Accomplishments in 1978-79:

1. No information report prepared but similar information on spruce budworm in western and northern region summarized for feature article in Forestry Report; "Spruce budworm - how important is it here in the west?"

2. A few color plates prepared, additional photographs and literature citations assembled but no written contributions made due to other commitments.

3. CFS representation was provided on the following committees:

   a. Western Committee on Crop Pests and Western Forum - served as chairman of sub-committee for revising and reporting on shelterbelt, ornamental tree and shrub insects.

   b. Alberta Pest Control Advisory Committee - reported on insect and disease conditions for 1978.

   c. Saskatchewan Advisory Council on Insect Control - compiled information for presentation at meeting.

   d. Shelterbelt Committee of Western Canadian Society for Horticulture: Presented report on "Shelterbelt Protection" at meeting (summary printed in 1978 Proceedings of Shelterbelt Committee).

   e. Contact officer for federal Pest Control Products Act, Trade Memorandum 104 - little involvement in 1978; received literature to up-date information.

   f. D.F.E. Regional Biocide Committee - disbanded in 1978; no involvement.

4. Information and consultory services were provided as follows:

   a. A report summarizing the jack-pine budworm situation in the Nisbet Provincial Forest of Saskatchewan was completed and copies sent to provincial forestry personnel. The report provides a review of literature and past outbreaks, and provides an analysis of the current outbreak pattern and its likely consequences.

   b. Reported under NOR-1-033
   (Survey conducted in Manitoba and Saskatchewan)

   c. Reported under NOR-1-033
   (Athabasca Forest surveyed and mapped for spruce budworm outbreak; an additional aerial survey of northeastern

Alberta carried out to map dwarf mistletoe infections. Map and report completed.)

d. Additional studies were undertaken in Nisbet Provincial Forest to evaluate the current jack-pine budworm infestation on tree growth. Sampling was done at seven locations, trees were cut, discs collected from stems and measurements were made of radial increment profiles throughout the stem. Results have been graphically summarized. Other data were collected to document the defoliation effects. The data demonstrate growth changes in relation to years of defoliation.

e. Branch units of two sizes were collected from jack-pine study plots (Nisbet Prov. Forest) to compare and evaluate the present larval sampling (jack-pine budworm) method used for surveys, and to compare with FIDS data. Data were highly variable and no clear relationships were found between larval numbers and buds. Further work is necessary on both egg and larval sampling methods.

f. Two surveys of woodborers were completed in the Weyakwin and Nipiwin areas of Saskatchewan. The first, conducted in May, 1978, assessed *Monochamus* populations and development in log decks in the "Weyakwin Burn", while the second study in August, 1978 rated fire-scorched white spruce trees for degree of burn, woodborers present and crown color change. Reports of both studies were submitted to Superintendent of Forest Management, Dept. of Northern Saskatchewan.

g. Assessed white spruce cones in Lac La Biche Forest for seed and cone insect damage; seed loss due to insects was 31% and 42% in two collection areas respectively. Three main insect species were responsible. A system was partially developed to aid in assessing seed losses due to insect damage.

h. Obtained identifications on two potential greenhouse-nursery insect pests, causing losses to Lpp and Sw seedlings. Both were previously unreported.

i. Collections of pine foliage were made with AFS personnel west of Rocky Mt. House to examine for causes of apparent yellowing and premature needle fall of the recent years needle compliment. An aphid species may be responsible.

j. Examined Lpp regeneration plots (I. Bella) near Edson, mechanically thinned 1976-77, for incidence of insect, diseases and other damaging agents. Data not summarized yet.

5. No request received in 1978 for data on National Forest Statistics of insect losses.

6. Accomplishment added: Committee representation and meetings.

   (a) Prepared a report with I. Edwards for presentation at Environmental Sub-Committee meeting November 24, 1978 of Alberta Horticultural Advisory Committee:

   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.

   (b) Represented CFS at Alberta Hort. Adv. Committee meeting December 5, 1978.

   (c) Attended annual Entomological Society of Alberta meeting.

   (d) Attended and prepared submissions for Annual Pest Control Forum meeting, Ottawa, and attended *Bacillus thuringiensis* seminar (Ottawa, November 28-30, 1978).

   (e) Served as member of Steering Committee to review Plant Protection Act proposed for Alberta (January 19, 1979).

7. Accomplishment added: Seminar - workshops - p-r extension.

   (a) Presented workshop on insect pests of greenhouse and nursery to staff at Smoky Lake Nursery.

   (b) Presented workshop on forest insect pests to staff of Proctor and Gamble, AFS, and other industry representatives at Grande Prairie.

   (c) Presented two lectures at Olds College for Pesticide Applicators course.

   (d) Participated at meeting in Winnipeg to review Manitoba's insect- and disease-related problems and gave presentation on "The budworms and survey and control advances" to representatives of forestry, agriculture, provincial parks, national parks and City of Winnipeg.

   (e) Provided interviews to Prince Albert newspaper, radio station and local t.v. for information on forest tent caterpillar, jack pine budworm and other pests of shade and shelterbelt trees.

8. Accomplishment added: Provided a variety of other consultory and editorial services.

   (a) Information was provided to CAN/USA Committee for this region.

   (b) Several scientific papers and technical reports reviewed from this laboratory and one major one from PFRC (over 400 pp.) on

Cone and Seed Insects of North American Conifers, sponsored by North American Forestry Commission.

(c) Information provided to Riding Mt. National Park officials on spruce budworm management.

(d) Information provided to Manitoba Parks personnel on jack-pine budworm sampling and control.

(e) Inquiries handled on woodborers in Alberta, root-collar weevil in Ontario.

(f) Provided slide material on seed and cone insects to PFRC, and other photo material to GLFRC, Cornell University and for Alberta school material.

(g) Information provided to Plant Quarantine Divison on European weevil pests of seedlings.

(h) Information provided on current shade tree and shelterbelt concerns for Great Plains Annual meeting, Lincoln, Nebraska.

(i) Other miscellaneous consultations reported under NOR-033.

9. Accomplishment added: Contributions to spring 1978, NFRC Forestry Report.

(a) Spruce budworm - how important is it here in the west?

(b) Jack pine budworm.

(c) Birch leaf-mining sawflies.

14. Goals for 1978-80:

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.

15. Publications:

1977-78

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.

1978-79

Cerezke, H.F. 1978. Jack pine budworm, (*Choristoneura pinus pinus* Free.) in the Nisbet Provincial Forest of Saskatchewan: an analysis 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.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-20

Public awareness program

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 16, 1979

1. Project: Public Awareness Program

2. Title: Working plan, Kananaskis Forest Experiment Station

3. New: Cont.: X 4. No.: NOR-20-043

5. Study Leader: L.G. Brace

6. Key Words: Management, development, subalpine, SA_1, public awareness, land use

7. Location of Work: Kananaskis

8. Problem:

The Kananaskis Research Forest has in the past been exclusively managed to serve forest research needs. The development included the construction of essential roads, stand improvements by thinning and the gathering of inventory information for research and operational purposes.

A management plan was initiated in 1967. The major objective of that plan was the diversification of age classes in the classical forest management concept. Shortly after beginning to implement the plan, it became necessary to abandon it. In view of changing demands by research personnel and public land managers and users, cutting patterns and cut block sizes were altered from the rigid strip system originally planned and more flexible planning and management procedures were adopted.

Continuing study and revision will ensure that the management of the Kananaskis Research Forest will remain flexible.

A demonstration of integrated land use could be one valuable current use of property. If demonstrations are developed and carried out with some input from provincial agencies, they promise to be highly successful. Results may be taken by the Province and applied under similar conditions throughout the area of the East Slopes. National Parks managers and planners have expressed interest in demonstrations of integrated land use, and there is a good possibility that in the near future demonstations provided under a management plan may be useful to parks managers. Initial steps will involve re-examination of management philosophy and priorities and rezoning of the Research Forest. Once these decisions have been made, detailed planning for each of these zones can proceed.

9. Study Objectives:

   1. To maintain and improve the Research Forest to serve research needs and forest management demonstrations in the context of integrated land use.

   2. To accommodate and facilitate a public awareness program which will capitalize on the location, natural features, facilities and research and demonstration information at the Station, in order to promote public understanding of forest land and resources and management alternatives (NOR-149).

10. Resources:

   a. Starting date: 1937
   b. Estimated year of completion: 1979
   c. Estimated total Prof. man-years required:
   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.	-
Supp.	-
Casual	-
Total	-

11. Progress to Date:

Following establishment of the station, research and forest management activities were conducted on various parts of the forest resulting in changes in composition and structure of some of the original stands. These operations affected about 1,000 acres with the largest portion in the categories of empirical thinning and selection cutting. There was no extensive clearcutting except for 100 acres of over-mature spruce-fir which were cut in a saw-log operation during 1951-53. These operations produced a considerable variety of products including fuel-wood, saw-timber, poles, piling, pulpwood, mine timbers, fence rails, posts, Christmass trees, and landing-strip markers. A limited road system was developed to service the operation.

In 1936 a grid system of 836 sample plots was established on the Research Forest to provide growth and inventory information. These plots were remeasured in 1946 and again in 1961.

In 1966 the terms of reference for the operational organization of the Kananaskis Research Forest were set out in Internal Report A-4; 18 miles of primary road system were surveyed with transit and mapped to provide horizontal control for aerial photo mapping and for operational ground mapping; the location of compartment boundaries was completed on the ground with the cutting of 80 chains of line to a 6-foot width.

In 1967 the management plan for the Kananaskis Research Forest was set out in Internal Report A-10. All strips designated for cutting in the first 10 years under the management plan were located and marked on the ground (1200 acres), and logging operations commenced in 1968. The engagement of small operators resulted in undercutting and need for clean-up work.

Acceleration of the logging program combined with greatly improved logging standards was achieved in 1970. Along with intensified logging, a regeneration program was launched which is considered successful in reforesting all cutovers immediately. Scarification and hand planting of container grown "plug" seedlings were the primary techniques used. Some 40 000 seedlings were planted on different sites and a provenance trial with over 2000 seedlings of Scots pine and Norway spruce from 22 Scandinavian sources was established on a 5-acre cut block.

No new research or demonstration inititive was undertaken in 1974. All facility development for the Public Awareness Program was completed and the 1975 opening occurred on schedule. This program has run successfully for three seasons--1975, 1976, and 1977, under contract. During the period 1974 to 1977 inclusive the Station has been operated on a "caretaker" basis with essential work for fire protection, access control, building maintenance, service maintenance (sewer and water) and cleanup of blowdown in the forest, the primary activities other than support for the Public Awareness Program. During 1977-78 the entire operation of the Station was budgeted in support of the Public Awareness Program.

12. Goals for 1978-79:

1. Continue operation and maintenance of the Station on a regular basis. Specific items for the coming season include:

   1. Install 3 highway "Station Signs" - four concrete piles
      - extend steel legs on 2 signs

   2. Study, and if possible, divert water flow to water gathering system from spring to west of existing spring.

   3. Complete fencing on north boundary fence.

   4. Complete blow-down clean up (6 extra students plus Ray).

   5. Install 2 public control gates along highway
      - move 1 gate to new location
      - install 2 permanent road closing fences (posts & wire).

   6. Redo exterior finish on two log houses at old H.Q. (surface is prepared).

2. Continue to provide service to the Public Awareness Program in terms of grounds maintenance, equipment use, board and dormitory services and contact with users to arrange visits as required.

3. Continue to explore possibilities for logging the mature and overmature lodgepole pine stands on the Station. Any logging would be in consultation with the Province as regards appropriate layout and suitability with respect to park status of adjacent lands as "Kananaskis Backcountry".

13. Accomplishments 1978-79:

All goals but the fourth were accomplished.

14. Goals for 1979-80:

Terminate study. Negotiations are underway via offices in EMS to transfer station to the province of Alberta by April 1979.

15. Publications:

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-21

Public information

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 20, 1979

1. Project: Public information

2. Title: Public Information

3. New: Cont.: X   4. No.: NOR-21-147

5. Study Leader: Vacant

6. Key Words: News releases, radio, television, displays, lectures and publication distribution

7. Location of Work: Region wide

8. Problem:

The general public and special interest groups (i.e. Fish and Game Association, Boy Scouts, Naturalists, etc.) are not fully or correctly informed about the forest, forestry, land management, related resource and amenity uses nor the Research and Development program of the Northern Forest Research Centre. There is some urgency in keeping the public better informed, particularly in those areas of open conflict such as (1) the allocation of forest land for consumptive and non-consumptive uses and (2) the effects of current forest management practices and forest products manufacturing on environmental quality. In addition the R & D programs of the CFS and in particular of the NFRC have yielded information of interest or use by the general public such as (1) the control of tree and shrub pests, (2) techniques for preserving fence posts and (3) ecological interpretations of forest landscapes. It is essential that this type of information be readily available to the general public.

9. Study Objectives:

To initiate, develop and implement an information program designed to inform the public about CFS research and development programs, about forestry and forests as they relate to the economics and social well-being of Canadians and to encourage the application of R & D findings by the public sector.

10. Resources:

a. Starting date: 1974
b. Estimated year of completion: continuing
c. Estimated total Prof. man-years required: 0
d. Essential new major equipment items for 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1979-80 with costs: Nil
f. 1979-80 man-years Prof. 0.0
Supp. 1.0 Vacant
Total 1.0

11. Progress to Date:

With the assistance of the Public Relations Advisor (EMS), the public information media program for 1978 was designed and approved by the Director. With the exception of items cancelled because of weather or other unforseen circumstances the proposed program will be completed by March 31, 1979. A tentative program for 1979-80 was submitted by CFS management to the Public Relations Advisor (EMS) in December 1978. An improved distribution and storage system will permit the incumbent to spend more time fulfilling the more personal public information programs.

12. Goals for 1978-79:

1. Provide newspapers, radio and T.V. outlets with 6-10 feature stories.

2. Provide to newspaper materials for production of a weekly pest column.

3. Continue organizing internal research seminars, guided public tours, speaking, and lectures to schools and clubs.

4. Upgrade displays and expand as necessary and opportunity permits.

5. Continue management of EMS publications distribution centre of NFRC.

6. Provide regional officer with the photo material suitable for a travelling display.

7. Continue operating an EMS Distribution Centre from the NFRC.

8. Continue maintaining maling lists.

9. Continue producing in-house Monthly Highlites.

10. Establish a mailing list for CWS and IWD.

11. Research on a pilot (slide) library and retrieval system.

12. Continue liaison with West Advertising (contractor).

13. Continue with in-house seminars.

14. Continue lectures and film showings.

15. Prepare for an NFRC "Open House"--fall 1978.

13. Accomplishments in 1978-79:

1. Feature articles were prepared and distributed to the news media. Most items appeared in rural newspapers as it appears difficult to obtain copy in the major dailies. Subjects covered included:

   Prescribed burning in National Parks--D. Dubé
   Land classification in National Parks--W. Holland
   Retardants--D. Quintilio

2. The weekly pest column was held in abeyance in order to permit reemphasis as related to the use of chemicals, relative importance of pests and the timing of the information release. It is proposed that individual items be prepared and released as appropriate during 1979.

3. Internal research seminars, guided tours, public speaking to interested organizations, and lectures to schools were low keyed after the Information Officer became ill in early August. In the early part of 1978 eleven building tours (300 people) were conducted and one career day lecture given to a city high school.

4. A cooperative display was prepared for Forestry Week with the Alberta Forest Service and Canadian Institute of Forestry and shown at Southgate and Meadowlark Shoping Centres in the early spring. An Ottawa-produced display was erected for the International Soils Conference held at the University of Alberta in September. An EMS display relating to National Parks was developed by Inland Waters, Canadian Wildlife Service and Canadian Forestry Service. Goldwin McEwan and Pat Logan contributed to the production and showing of the display in Banff at the annual meeting of the National and Provincial Parks Association in early October.

5. Demand for Canadian Forestry Service scientific and technical publications remained heavy. Requests for public information fluctuated considerably and most were of a general nature. No Inland Waters or Canadian Wildlife Service publication of a scientific or technical nature are stocked. Demand for the Who's Who series remains brisk. Clarification of the EMS distribution policy regarding IWD and CWS publication is required.

6. Attempts at collecting photographic material which illustrates the R & D program of NFRC was cut short when the Information Officer became ill.

7. See item 5 above.

8. The NFRC mailing list was totally revamped with a decrease in addresses from 2500 to 1500. A new distribution policy was developed by R.M. Waldron which emphasizes regional forestry clientele and libraries. Storage and the publication retrieval systems were upgraded.

9. Except for the months of August and September the Monthly Highlights were prepared throughout the year. Beginning in November, R.M. Waldron assumed responsibility for this duty.

10. No action taken.

11. No action taken.

12. Liaison with West Advertising was maintained at a low level. Currently this agency is not under contract with the CFS (See item 2 re weekly pest column).

13. No in-house seminars were organized by the Information Officer. Two were arranged for by R.M. Waldron and details may be found in Study Statement NOR-33-145.

14. No film showings were given in 1978. The career days lecture is outlined in item 3 above.

15. The open house planned for the fall of 1978 was held in abeyance.

14. Goals for 1979-80:

1. Install new display units in the foyer of NFRC and arrange for program coverage on a two month basis. Develop a simple display for use in shopping centres, libraries, etc. and coordinate and contribute to the production of displays for seminars, conferences etc. as required (P. Logan).

2. Provide the EMS Public Information Advisor with suitable forestry topics for release in newspapers, radio and TV outlets (Program Managers).

3. Continue supervision of the EMS publications distribution centre at NFRC, maintain mailing list, retrieval system and storage facilities (R.M. Waldron).

4. Continue the production of the in-house Monthly Highlights (R.M. Waldron).

5. Hold in abeyance the following items until an Information Officer is appointed:

   (i) Guided tours, speaking engagements, lectures and career days, film showings, etc.

   (ii) In-house seminars.

   (iii) An audio-visual covering the research program of the Northern Forest Research Centre.

   (iv) Input into feature stories, news releases, and other media related subjects.

15. Publications:

1978-79

Nil

16. Signatures:

Investigator	Program Manager
	Director G.T. Silver

PROJECT NOR-22

Remote sensing application

NOR-22-142

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: March 1, 1979

1. Project: Remote Sensing Application

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 1979/80 with costs:
e. Essential new major equipment items beyond 1979 with costs:
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.

2. Aerial photography has been obtained for research workers in EMS for assessment of: timber volumes, forest regeneration, SO_2 damage to vegetation, oil spill damage, insect and disease damage to forests.

3. Small experimental forest inventories were completed at cost or contracts supervised for: Ochise, Stony and Sunchild Indian Reserves, Birch Creek (NWT), Cameron Hills (NWT) and Wilson Creek Watershed (Manitoba).

4. Test sites in the boreal and subalpine forest regions have been established.

5. Large and small-scale photo sampling techniques for estimating timber volumes and forest regeneration have been developed.

6. Landsat optical and computer interpretation techniques have been developed for subalpine and boreal forest regions.

7. 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 forest region. Applications of the highly efficient forest inventory design have been completed by Simpson Timber Co. and are being planned for the N.W.T.

8. Appropriate scale, film and filter for aerial photography, and a sampling design have been defined for forest regeneration surveys.

9. Forest site index and tree volume equations have been developed.

10. Computer mapping techniques have been tested and applied.

11. Large-scale aerial photography on approximately 300 line miles in the Hudson Bay Region of Saskatchewan was obtained and partial analysis of aerial photography was completed at NFRC.

12. An annual program of aerial photography for the past six years monitoring the Peace Athabasca delta and assessment of habitat types has been provided to Parks Canada and the CWS.

13. 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 one week training session in remote sensing.

14. 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.

15. 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.

12. Goals for 1978-79

1. To test and evaluate the Honeywell Radar Altimeter and Vinten Camera System.

2. To test and evaluate the use of a 6 m boom and two Vinten cameras to obtain large-scale aerial photography free of tip and tilt errors.

3. In cooperation with PFRC and the Yukon Forest Service demonstrate NFRC's large-scale photo sampling system.

4. To cooperate with CCRS in organizing a 3-day workshop on "Multistage Forest Inventory," to be held in Edmonton, November, 1978.

5. To cooperate with FMI in establishing a large-scale photo sampling system for the Province of Alberta.

6. To serve as a member of: the Canada Centre for Remote Sensing, Canadian Advisory Committee on Remote Sensing for Forestry, Wildlife and Wildlands and of the Alberta Task Force on Remote Sensing.

7. To continue as chairman of the Canadian Institute of Forestry working group for remote sensing. Liaison with SAF working groups will be established to determine what type of program they would like to have at the next annual meeting.

8. Explore the feasibility of multistage--inventory techniques for estimation of biomass in the boreal region.

9. Obtain aerial photography for

   1. Estimation of insect and disease damage.

   2. Estimation of regeneration.

   3. Estimation of habitat types for Wildlife Parks Canada (CWS).

10. To present a paper on "Sampling of Forest Regeneration using Large-scale Aerial Photography", at the Canadian Remote Sensing Symposium to be held in Victoria, B.C. August, 1979.

13. <u>Accomplishments in 1978-79:</u>

1. Evaluation of the Honeywell radar altimeter was completed and an information report is under review.

2. A prototype of a 6 m boom was assembled. Department of Transport approval to fly the boom cannot be obtained without considerable expense, probably $10,000 or more. Project shelved until outside financial support gained.

3. Two test strips of large-scale aerial photography in the Yukon were obtained. Mr. D. Morgan is presently comparing results from the FMI and NFRC systems.

4. A three day workshop sponsored by N.F.R.C., Alberta Remote Sensing Centre, Alberta Energy and Natural Resources and the Canada Centre for Remote Sensing is now planned and approximately 100 delegates are expected to attend the meeting set for September 26, 27 and 28, 1979 in the Chateau Lacombe in Edmonton.

5. Comparison of some results from the N.F.R.C. and FMI large-scale photo sampling systems are being made by the Alberta Forest Service and the Yukon Forest Service.

6. A meeting of the Canadian Advisory Committee on Remote Sensing for Forestry, Wildlife and Wildlands was attended in Victoria where a review of regional activities and priorities was initiated. Lectures to the Alberta Remote Sensing Training Session were given.

7. As chairman of the Canadian Institute of Forestry working group for remote sensing, liaison with the SAF working group has been established. An invitation to present a paper at an international gathering of Remote Sensing and Forest Inventory experts at the University of Idaho on September 10 to 14, 1979 was accepted. A report to the SAF/CIF meeting in St. Louis was forwarded to Dr. R. Heller.

8. A paper on the estimation of logging residues was prepared and presented at the Intermountain Fire Research Council Workshop. This report along with the previously published report "A basis for Multistage Forest Inventory in the Boreal Forest Region is sufficient for estimating biomass measures on large-scale aerial photographs. Additional testing under the ENFOR program is planned.

9. Large-scale aerial photographs of forest regeneration and habitat types were obtained on the St. Regis (Hinton) limits. A contract to obtain aerial photography in the Peace Athabasca delta for monitoring and assessment of muskrat habitat was supervised for Parks Canada and the CWS.

10. A paper on "Sampling of Forest Regeneration using Large-scale Aerial Photography" at the Canadian Remote Sensing Symposium held in Victoria, B.C. in 1979 was presented.

14. 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 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.

15. Publications:

Up to 1978.

Van Eck, P.I. and Bihuniak, P. 1977. A two-camera intervalometer with sampling options. Photogrammetric Engineering and 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.

1978-79

Kirby, C.L. and R.J. Hall. 1978. The estimation of logging residues using large-scale aerial photographs and line-intersect sampling. In press of proceedings of the Intermountain Fire Research Council Workshop. Edmonton, October 31-November 2, 1978.

Kirby, C.L. and R.J. Hall. 1978. Description and accuracy evaluation of the Honeywell radar altimeter (submitted for review as an information report).

Kirby, C.L. 1978. A camera and interpretation system for assessment of forest regeneration. (Submitted for review as an information report).

16. Signatures:

C L Kirby
Investigator

Ben Reid
Program Manager

Gistilue
Director

PROJECT NOR-23

Land and vegetation resource inventory
of Banff and Jasper National Parks

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1979

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.

Further, the knowledge gained will permit consultation and the possibility of critical review of resource management recommendations, either with individual Parks personnel or through the establishment of a liaison committee. It also permits participation in seminars with Parks personnel and students.

The approach to this inventory uses the Guidelines for Biophysical Land Classification (Lacate, 1969). It will, however, include interpretative guides, and methodology similar to that developed for Waterton Lakes National Park (Holland and Coen, 1973) but adapted to the biophysical guidelines. The scale to be used is assumed to be to the 1:50 000 National Topographic Series for base maps. These can readily be reproduced by a 2 colour offset printing.

Experience since 1970 indicates that a number of the Parks problems appear to be one of a lack of knowledge on how to manage specific areas of land. Research projects could be initiated, using the inventory data for guidance, to determine how such areas can best be managed. Such research may be concurrent with the survey or post-survey. Preparation of a field guide to solve problems in applied management is suggested.

An assessment of land use problems encountered in Banff and Jasper National Parks could do much to improve the data collected by the inventory and the subsequent resource interpretations. Especially pertinent is the experience of field personnel from Banff and Jasper.

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 1979-80 with costs: Nil
e. Essential new major equipment beyond 1980 with costs: Nil
f. 1979-80 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 Soil Research Institute

Prof.	7.0	G.M. Coen, R.E. Wells, B.D. Walker, W.S. Taylor, Peter Achuff, J. Cuddeford, Goldwyn McEwen, Janet Marsh
Supp.	1.0	U. of A. Soil Lab.
Casual	.6	2 Summer students

11. Progress to Date:

Summary of field work progress since 1974:

VEGETATION AND SOIL SAMPLING

	Banff	Jasper
No. of vegetation plots	2077	1090
No. of vegetation types	90	90
Bryophytes and lichens collected	≃9000	≃6500
Vascular plants collected	≃5000	≃5500
Soil observation points (daily & notebook)	2534	2503
Soil laboratory samples	687	505
In situ soil tests	1446	1060
Notebook records	682	1419
CanSIS soil description sheets:		
Daily forms	1829	1059
Semi-detail	1	18
Detailed (sampling sites)	117	68
Approximate total area	2565	4200
Approximate area completed:		
Square miles	2565	3270
% of total	100	78

The project is on schedule except for a backlog of identifications of vascular plants and soil analyses.

Interim reports have been submitted annually.

12. Goals for 1978-79:

1. Completion of Progress Report No. 4 for Banff.

2. Completion of Progress Report No. 3 for Jasper.

3. Continuation of soil and vegetation inventory in the Cascade valley area, the upper Red Deer and upper Clearwater valleys in Banff. This 1978 summer field work completes the field work in Banff (approximately 800 square miles), except for some correlation work.

4. Continuation of soil and vegetation inventory in Jasper; namely the Rocky River valley and upper Brazeau.

5. Publication of NOR-X-160, Lake Louise report.

6. Continued cooperation with the SRI development of the CanSIS data bank.

7. Continuation of committee meetings, seminars, workshops, assistance with site specific problems as requested by National Parks, or others.

8. *Continuation of phytosociological investigation of Banff and Jasper.

9. *Continuation of floristic investigations of Banff and Jasper.

10. Supervision of contract with Dr. D. Vitt for identification and report on approximately 1500 bryophytes and lichens collected in Banff and Jasper.

11. To develop a method of obtaining better integration of the wildlife resource component with the soil and vegetation component.

12. *To develop a method of computer-plotting plant species distributions or ranges on a small scale map, with the help of SRI in Ottawa.

13. *To further develop vegetation classification programs to facilitate comparison of plot data from many plots, with help of SRI and CFS (Bill Chow).

14. *To complete thesis entitled "Forest Site Relationships in Wapiti Map Area, Alberta" and submit manuscript(s) for publication.

15. To develop a methodology of computerization of field data in the field.

* I.G.W. Corns

13. Accomplishments in 1978-79:

1. 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. G.M. Coen, W.D. Holland, Eds. North. For. Res. Cent. Edmonton. 112 pp. plus 5 appendices.

2. 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. G.M. Coen, W.D. Holland, Eds. North. For. Res. Cent. Edmonton. 112 pp. plus 5 appendices.

3. Approximately 800 square miles inventoried in the Cascade, upper Red Deer, and upper Clearwater valleys in Banff. This completes the field work in Banff, except for some correlation and sampling work.

4. Approximately 780 square miles inventoried in the Rocky River valley and upper Brazeau, Jasper.

5. Walker, B.D., S. Kojima, W.D. Holland, and G.M. Coen. 1978. Land classification of the Lake Louise study area, Banff National Park. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Inf. Rep. NOR-X-160. 121 pp. plus map.

   Published in 500 copies; will soon be out of print; Lake Louise area development public hearings scheduled for March 5, 6, 7, 1979 in Edmonton.

6. Cooperation continued with J. Dumanski, Land Resource Research Institute (formerly Soil Research Institute, S.R.I.) Ottawa. A local data processing and analysis system was developed in 1978-79; see Appendix A.

7. Liaison activities as follows:

   1. Warden's workshop, Banff, May 1978.
   2. Warden's workshop, Jasper, October 1978.
   3. Final report workshop, Banff and Calgary, Dec.-Jan.
   4. Pilot project CanSIS, Jan. 1979, Calgary.
   5. Advice to Parks Canada re: Marmot ski basin, Mt. Edith Cavell road redevelopment, twinning of Trans-Canada highway, interpretive service queries, youth hostel relocation, Pocahontas warden station relocation, picnic site expansion at Johnson Lake.
   6. Advice to graduate students conducting thesis research in Jasper and Banff.
   7. Assistance to the International Soil Science Congress tours through Banff and Jasper.

*8. General phytosociological investigation of Banff-Jasper National Parks was extended into the upper Red Deer, Clearwater, and Cascade River valleys of eastern Banff and into the east boundary area of Jasper from Roche Miette to Brazeau east of Maligne and Brazeau

Lakes. Four new vegetation types were added to the integrated Jasper-Banff vegetation descriptions, bringing the total to 90 for both Parks.

*9. General floristic investigation was continued in the above field survey areas. Approximately 140 new species, the majority of which are lichens and mosses, were added to the previous collections for Banff and Jasper. Range extensions of several species were noted. Checklists of vascular and non-vascular plants are being updated.

10. Identification has been received from Dr. Dale Vitt, U. of A. Botany Dept. of approximately 3000 bryophyte specimens collected in Banff and Jasper in 1978. (All vascular and non-vascular plant collections are destined for the N.F.R.C. herbarium and the Banff and Jasper herbariums).

11. Better integration of the wildlife resource component, largely through the efforts of Geoff Holroyd, C.W.S. wildlife biologist, Banff, and partly through contacts with wildlife biologists like Larry Beeman, Tennessee Valley Authority, and Richard M. Kerr, Bureau of Land Management, met last January at the Workshop on Integrated Inventories of Renewable Natural Resources, Tucson, Arizona. While Parks Canada is much happier with the wildlife data integration, there is still considerable work to be developed in this area. Also see final report format, Appendix B.

12.* We do not yet have the capability of computer-plotting plant species distributions or ranges on a small scale map. This work is now being done by N.F.R.C. rather than by L.R.R.I. in Ottawa; see section 6 above and Appendix A.

13.* One vegetation classification program is functional, with work planned on others; see appendix A. Most of the vegetation data has now been edited using N.F.R.C. and University of Alberta facilities.

14.* Completion of Ph.D. thesis entitled "Tree growth prediction and plant community distribution in relation to environmental factors in lodgepole pine, white spruce, black spruce, and aspen forests of western Alberta foothills." Manuscripts for publication are currently in preparation.

15. No feasible method was found for computerization of field data in the field.

* I.G.W. Corns

14. 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

15. <u>Publications</u>:

Since 1977

a) Published reports

Holland, W.D. 1977. Biophysical land classification of Banff and Jasper National Parks. In: Proceedings of the First Meeting National Committee on Biophysical classification, Petawawa Experimental Station 25-29 May, 1976. John Thie (Chairman) Lands Directorate, Ottawa.

b) Unpublished reports

Banff biophysical inventory Progress Reports 1 to 4, 1975 to 1978. File Rep. NOR 148.

Jasper biophysical inventory Progress Reports 1 to 3, 1976 to 1978. File Rep. NOR 148.

Environmental impact study of Fiddle River area, Jasper National Park. File Rep. NOR 148, 1977.

1978-79

a) Published reports

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. Inf. Rep. NOR-X-160.

Holland, W.D. and P.J. Rennie. 1978. Forest land classification in Canada and current projects at the Northern Forest Research Centre. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton.

b) Unpublished reports

Twardy, A.G. and I.G.W. Corns. 1979. Soil survey of the Wapiti map area, Alberta. Alberta Institute of Pedology Report No. 39. In press.

16. Signatures:

W.D. Holland
Investigator

R. Reid
Program Manager

Ian G.W. Corns
Investigator

G.T. Silver
Director G.T. Silver

Northern Forest Research Centre
24 January 1979
I. Corns

Appendix A

CFS Computer Files

Data

1975-77 Veg. plot (≈2300) data (B & J) key punched and edited with exceptions of approx. 1/4 of '76 data and 1/2 of 77 data.

Programs

1. Veg. edit program functional
2. One veg. classification program functional (Ceska-Roemer), with others to follow, (i.e. cluster analysis and ordination).
3. Soil edit program to be ready January 31.
4. Soil sort program to be ready January 31.
5. Other programs to be developed:
    1. Soil-veg. files interface (to retrieve site data from soil file).
    2. Plot locations put on small scale map.
    3. Conversion of UTM coordinates to latitude-longitude for use on herbarium labels.

Within next month:

Key punch 1977 Soil Dailies; manual and computer edit of 75, 76, 77.

Duplicates of all programs and edited data files to CanSIS when they are ready.

CanSIS Computer Files

1975 & 76 B & J Daily (Soils) raw, unedited, key punched	unedited copies on tape sent to CFS
1975 (B & J)/76 (J) Veg. plots raw, unedited, key punched	

Detailed Soil Forms

*1. Field 1974 (38B); 1975 (8B, 9J); 1976 (7B, 36J)

*2. Analytical 1974 (38B); 1975 (8B)

*Within next month:

Send to Ottawa raw sheets.

1. Field 1977 (26B, 9J); 1978 (73B, 18J)

2. Analytical 1975 (9J); 1976 (7B, 36J); 1977 (26B, 9J)

Cartographic File

Lake Louise Sheet 7-1; pilot project test forwarded by Parks Canada January 17, 1979.

1. What tapes have we here?

   1975 & 76 B & J unedited, key-punched Dailies

   1975 to 77 incl. (veg. plot data)

2. What form?

   Soils--unedited

   Veg.--All 75 edited; 76 3/4 edited; 77 1/2 edited

3. What CanSIS has?

   1. Unusable veg. data (unedited 75-76 data)

   2. 1975-1976 B & J Dailes (unedited)

   3. Detailed soil forms: (see 1 & 2 under CanSIS).

4. What is going to CanSIS?

   Copies of all tapes when ready.

Wildlife computer input by Geoff Holroyd, Canadian Wildlife Service, Banff.

Appendix B

ECOLOGICAL RESOURCES

OF

BANFF NATIONAL PARK, CANADA

Vol. 1: Introduction and Summary

Vol. 2: Soils and Vegetation Detail

Vol. 3: Wildlife Resource

Vol. 4: Field Guides

ECOLOGICAL RESOURCES

OF

BANFF NATIONAL PARK, CANADA

Vol. 1: Introduction and Summary
(includes maps)

ECOLOGICAL RESOURCES OF BANFF NATIONAL PARK, CANADA

Vol. 1: Introduction and Summary

Preface:

Part 1. General Description of Area:
1. Location and extent:
2. Park development:
   - History
   - Development
   - Present cultural features
   - Land use patterns
3. Physiography and topography:
4. Geology:
   - Structure
   - Landforms
5. Drainage:
6. Climate:
7. Vegetation:
8. Soil formation:
9. Wildlife:
10. Ecological concepts:--the basis for mapping.

Part 2. Methodology:
1. Operational methodology for mapping
2. Landform, soil, and vegetation classification
3. Wildlife study methods
4. Evolution of ecological (biophysical) methodology
5. Analytical methodology:
   - Field
   - Chemical and physical soil analyses
   - Vegetation data processing
   - Wildlife data processing
6. CanSIS--data bank:
   - Data forms
   - Uses and limitations

Part 3. Extended Legend:
1. Map legend for Banff:
2. Summary of land systems and map unit descriptions e.g. Baker Creek--BK
   - Physiographic setting
   - Landform and parent materials
   - Environment:
     - Dominant soils
     - Representative vegetation types
     - Wildlife

BK1--) main characteristics;
BK2--) brief pedon description;
BK4--) brief vegetation type description;
BK5--) wildlife use--species
intensity of use

Part 4. Interpretative Classification

Background--how land characteristics relate to land qualities for specified Park land uses.

Definitions--land use capability
land use suitabilities
land use limitations:-
degree and nature of limitations
kinds of limitations
- soil
- vegetation
- wildlife

degree of limitations:
- none to slight
- moderate
- severe
- very severe
- unsuitable

Sources of Interpretative Information
1) Field measurements
2) Research measurements
3) Indirect measurements
4) User experience

Principles of Interpretative Classifications

Assumptions and Problems in Interpretative Classifications

Formats of Interpretative Classification
- Assessment guides; eg. Waterton report
- Tabular formats
- Indexes
- Suitability map format
- Computer printouts

Process of Making Interpretations:

Application of Interpretations

Techniques of Resource Management

Part 5. Conclusions:

Ecological processes

Observational results

Quantitative results

Land Management Principles

Part 6. Maps

ECOLOGICAL RESOURCES

OF

BANFF NATIONAL PARK, CANADA

Vol. 2: Soils and Vegetation Detail

ECOLOGICAL RESOURCES OF BANFF NATIONAL PARK, CANADA

Vol. 2: Soil and Vegetation Detail

Preface:

Part 1: Detailed Map Unit Descriptions:

- Central concept
- Associated map units
- Competing map units and differentiae
- Detailed map unit descriptions include:
  - pedon description
  - tabular soil data where applicable
  - representative vegetation types
  - vegetation plot data
  - vegetation stand tables
  - referenced CanSIS data

Part 2: Appendixed vegetation type data

ECOLOGICAL RESOURCES

OF

BANFF NATIONAL PARK, CANADA

Vol. 3: Wildlife Resource

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ECOLOGICAL RESOURCES OF BANFF NATIONAL PARK, CANADA

Vol. 4: Field Guides

(e.g. Oregon examples)

PROJECT NOR-24

AOSERP: Effects of SO_2 on vegetation

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1979

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: 0.7
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	(Malhotra)	
	0.2	(Addison)	
	0.4	Total NFRC	
	+0.3	(Khan, AOSERP term)	
	0.7		
Supp.	0.1	(Ridgway)	
	0.1	Total NFRC	
	+1.0	(Hurdle, AOSERP term)	
	1.1		
Total	1.8		

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 (presently SO_2). 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.

12. Goals for 1978-79:

1. The following study will be conducted to determine the physical mechanism of plant tolerance to SO_2 under controlled conditions: (Addison, Malhotra, AOSERP-term)

    a. Impact of SO_2 on stomatal opening as related to pollutant uptake.

    b. Rate of total sulphur uptake as related to visual and physiological injury to vegetation.

    c. Using above information, examine the relationship between plant tolerance, SO_2 uptake and physical characteristics of leaves. This information will be beneficial in screening candidate revegetation species for SO_2 tolerance.

2. Continue studies to verify the existing ambient air quality standards and to establish threshold level of air pollutant injury to vegetation from the Oil Sands area.

13. Accomplishments in 1978-79:

1. The development of experimental facilities has been partially completed and the response of the equipment to experimental conditions has been measured. The stomatal resistance study is currently underway and is expected to be completed within the next 3 months.

2. 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 indicated a distinct separation between conifer and broad-leaf species as well as some differences among species in each group. In order of physiological tolerance, the species studied are willow, paper birch, trembling aspen, green alder, labrador tea, jack pine, white spruce, and black spruce.

14. 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)

15. Publications:

1977-78

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.

1978-79

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.

16. Signatures:

Investigator

Program Manager

Investigator

Director G.T. Silver

NOR-24-159

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1979

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: 0.8
    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.	0.5	(Malhotra)
	0.5	Total NFRC
	+0.3	(Khan, AOSERP term)
	0.8	Total Prof.
Supp.	0.5	(Shuya)
	0.5	(Grandmaison, AOSERP term)
	1.0	Total Supp.
Total	1.8	

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 have also been conducted with air pollution mixtures (SO_2 + heavy metals - as is the case under field conditions) to compare their biochemical effects with those produced by individual pollutants. In jack pine, the effects of mixtures on certain biochemical functions were additive while they were antagonistic on others. So far none of the combinations was shown to be synergistic. NO_2 has been added to the list of pollutants and the study is continuing to determine the impact of various mixtures on jack pine as well as some other predominant forest species.

12. Goals for 1978-79:

The following studies will be carried out to confirm the existing ambient air quality standards or help establish new standards in the light of experiments with native plant species:

1. Characterize peroxidase from various forest species and develop peroxidase assay as a measure of plant sensitivity to air pollutants. (Malhotra, Khan)

2. Initiate a study on the impact of air pollution mixtures (SO_2 and heavy metals etc.) on various biochemical processes. (Malhotra, Khan)

3. Write up and report the previous work. The possible titles are: (a) A gas chromatographic method for amino acid analysis, (b) Effects of SO_2 and other air pollutants on acid phosphatase activity in pine seedlings. These papers will be published in scientific journals. (Malhotra, Khan)

4. Depending upon the availability of time, study the effect of SO_2 on enzymes involved in energy metabolism. A substantial amount of time will be required to develop techniques before testing for SO_2. (Malhotra, Khan)

5. Goal added: Study physiological and biochemical responses of jack pine exposed to air pollutant under field conditions (Ft. McMurray).

13. Accomplishments in 1978-79:

1. Peroxidase assay was developed for the detection of air pollution injury to vegetation (jack pine, alder and birch) prior to and after the appearance of visual symptoms of SO_2 toxicity. The increase in peroxidase activity after SO_2 fumigation was directly

related to the amount of sulphur uptake by the plants. In an SO_2 free atmosphere, the fumigated plants were able to partially recover by reducing their enzyme activity. It appears that if the plants are exposed to SO_2 over extended periods of time, the change in enzyme activity would be more or less permanent.

Heavy metals such as vanadium, cadmium, arsenic and copper also stimulated the enzyme activity. Nickel and zinc, however, did not have any appreciable effect. Since peroxidase appears to be a good indicator of total air pollution, the enzyme assay coupled with foliar analyses of sulphur and heavy metal(s) would provide an excellent diagnostic tool to monitor air pollution injury to sensitive forest species.

2. Experiments were designed and conducted with air pollution mixtures (SO_2 and heavy metals) to determine if the pollutants in various combinations (as is the case under field conditions) produce effects that are different from those produced by single pollutants. In jack pine, the effects of mixtures on certain biochemical functions were additive while they were antagonistic on others. So far, none of the conbinations was shown to be synergistic. NO_2 has been added to the list of pollutants and the study will be continued to determine the impact of various mixtures on jack pine as well as some other predominant forest species.

3. Reports

   (a) The manuscript entitled "Gas-liquid chromatographic separation of common amino acids in pine needle extracts" has been accepted for publication in "Journal of Chromatography".

   (b) The manuscript entitled "Effects of sulphur dioxide and other air pollutants on acid phosphatase activity in pine seedlings" has been written up, reviewed by the NFRC review board and submitted to the international journal "Planta" for publication.

4. Ribulose 1, 5-diphosphate carboxylase and glycollate oxidase are extremely important enzymes involved in energy metabolsim. Carboxylase is responsible for photosynthetic CO_2 fixation while glycollate oxidase is required for photorespiration. In jack pine, SO_2 ($SO_3^=$ species, not $SO_4^=$) was shown to cause a dramatic reduction in the activities of both enzymes prior to visual symptom development. These observations strongly support our earlier work on the mechanism of SO_2 phytotoxicity. It is suggested that SO_2 phytotoxicity may be at least partially due to the inhibitory effect on photosynthetic enzyme, ribulose di-phosphate carboxylase and photorespiratory enzyme, glycollate oxidase.

5. Accomplishment added: Branches of jack pine exposed to air pollutants under field conditions (Ft. McMurray) were collected from the "impingement" and "control" areas and analyzed for several biochemical and physiological responses. No appreciable differences were found in these responses between the sites around Ft. McMurray. However,

in other areas where vegetation has been subjected to air pollutants for a much longer period of time (Flin Flon) a sensitive biochemical function namely lipid biosynthesis was affected and there appeared to be direct relationship between the pollutant content of the tissues and this biochemical response.

14. 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)

15. Publications:

1977-78

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.

1978-79

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. *In*: The Oil Sands of Canada-Venezuela 1977. p. 714-719. The Canadian Institute of Mining and Metallurgy. 782 pp.

Sarkar, S.K. and S.S. Malhotra. 1979. Gas-liquid chromatographic separation of common amino acids in pine needle extracts. J. Chromatography. In press.

Malhotra, S.S. and A.A. Khan. 1979. Effects of sulphur dioxide and other air pollutants on acid phosphatase activity, in pine seedlings. Submitted to Planta for publication.

Malhotra, S.S. 1979. Interim Report of symptomology and threshold levels of air pollutant injury to vegetation, 1975 to 1978. *In*: Alberta Oil Sands Environmental Research Program Land Systems Report, L.S.3.1, Edmonton, Alberta. 34 pp.

16. Signatures:

S Malhotra
Investigator
A.A. Khan

Rew Reid
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 6, 1979

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: 0.9
   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.	0.5	(Addison)
		0.1	(Malhotra)
		0.6	Total NFRC
		+0.4	(Khan, AOSERP term)
		1.0	
	Supp.	0.7	(Ridgway)
		0.7	
		+0.5	(Grandmaison, AOSERP term)
		2.2	
	Total	2.4	

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 cryptogram 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. Precipitation was collected at eight sites in the vicinity of GCOS and gaseous SO_2 content at these sites was estimated with sulphation plate. Soils both under a canopy and in the open were sampled in detail and analyzed at two sites.

12. Goals for 1978-79:

1. Examine and assess the influence of air pollution characteristic of oil sands operations on forest soils and vegetation impingement area by utilizing various chemical and biomonitoring techniques developed in the last two years.

   a. Chemical analyses of selected plant species (6) for Al, Ca, Fe, K, Mg, P, and S. (Addison)

   b. Plant community description including stand age and density. (Addison)

   c. Soil description, classification and chemical analysis. (Baker, Addison)

   d. Lichen community description, transplant studies and physiological responses on samples collected from the field. (Addison)

   e. Precipitation collection and analysis and sulphation plate installation, collection and analysis. (Addison, Baker)

f. Biochemical and physiological measurements on tree species collected in this area. (Malhotra, Addison, AOSERP term)

2a. Reexamine the lichen community and physiological transplants at the 5 gradient sites established in 1977. (Addison)

b. Determine pollutant levels at gradient sites (1977) through precipitation collection and sulphation plate analysis. (Addison, Baker)

3. In cooperation with AES in Downsview, collect and analyze lichens from 20 locations in the Athabasca river valley and on the east bank to complete pollutant depositional mapping study. (Addison)

4. Write an information report on the status of the benchmark sites in the oil sands area. (Addison)

5. Goal added: Develop a technique for total digestion of soils to permit quantification of total elemental content in soils from the biomonitoring plots.

6. Goal added: Write an information report on soil effects of air pollutants in the vicinity of GCOS. (Baker)

13. Accomplishments in 1978-79:

1a., b., c. A site was established about 2 km southeast of the GCOS pollution source and the influence of pollutants was assessed. No measurable damage to the vascular plant community was observed using community analysis, plant and soil pollutant content, species list and visual and photographic examination of forest crown. Soil samples from open spaces and from under a jack pine canopy and jack pine foliage from 2 gradient sites were analyzed for 8 elements. Results were compiled and written up as an information report. (Addison, Baker)

1d. Lichens were examined both at the gradient sites and at 5 biomonitoring plots in the vicinity of GCOS. Transplanted lichen plots demonstrated that lichens could detect pollutant impingement through community, chemical and physiological responses. (Addison)

1e. Precipitation collectors and sulphation plates were installed at eight sites in the vicinity of oil sands pollution sources in order to measure deposition of pollutants at biomonitoring sites. Precipitation samples were currently being analyzed and will be completed within the next month. Sulphation plates were replaced monthly and showed not only a distinct gradient in SO_2 concentration in the air in the vicinity of GCOS but also significant effects of different canopies on pollutant concentrations within sites. (Addison)

1f. Pine foliage was collected at the new site (see accomplishment 1a., b., c.) within the impingement zone and at a control area.

No differences in any biochemical or physiological response could be detected between the two sites.

2a. The lichen transplants established in 1977 were reexamined at the 5 gradient sites. Community analysis of these transplants showed a distinct gradient in lichen damage that was related to pollutant distribution as measured by sulphation plates. K^+ efflux from the physiological transplants also followed pollutant concentration in the air. (Addison)

b. The eight sites that were monitored for pollutant deposition using precipitation collectors and sulphation plates included 4 of the gradient sites that were established in 1977 (see accomplishment 1e.).

3. Lichen material of two structurally different species were collected from 25 new sites in the Athabasca River valley and on the east side of the river. Samples have been analyzed for sulphur, potassium and thallus condition at NFRC and are presently in Toronto for neutron activation analysis of heavy metals. (Addison)

4. A report entitled "Baseline conditions of jack pine biomonitoring plots in the Athabasca Oil Sands area" by P.A. Addison has been completed and is currently under internal review at NFRC.

5. Accomplishment added: Soil samples collected in 1976 and 1977 at all biomonitoring sites in the Athabasca Oil Sands area were digested using a technique that was modified for the soils found in the Oil Sands area. Samples were analyzed for sulphur, potassium, iron, aluminum, calcium, magnesium and phosphorus. (Addison)

6. Accomplishment added: A report entitled "Soil and foliar compositions as influenced by cover and distance from a pollutant source" by J. Baker has been completed and is currently under NFRC review.

14. <u>Goals for 1979-80</u>:

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".

15. Publications:

1977-78

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 Albrta. File Report NOR-24-160.

1978-79

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. 1978. Interim report of ecological benchmarking and biomonitoring for detection of airborne pollutant effects on vegetation and soils, 1975 to 1978. *In*: Alberta Oil Sands Environmental Research Program Land Systems report - L.S.3.4. Edmonton, Alberta. 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.

16. Signatures:

P.A. Addison
Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-27

Biogeoclimatic ecosystem classification
of the Province of Alberta

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 8, 1979

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.

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 bases, to meet this demand. The project aims to provide ecological zonation of the province in terms of biogeoclimatic zone and ecosystem classification of the forested zones in terms of plant association. It was understood that the study would follow basically the concept and approach of biogeoclimatology 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.

For 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 1979-80 with cost: Nil
e. Estimated new major equipment beyond 1980 with cost: Nil

f. 1979-80 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 1.0 3 summer students

Total 5.0

11. Progress to Date:

Two of the four sections the province is divided into have been completed, i.e. the NW and NE sections. The two remaining sections to be completed are the SW and SE sections. A preliminary classification of the forests of northwestern Alberta was prepared and presented in the form of a progress report.

Provisional biogeoclimatic zones of Alberta have been proposed and outlined on a base map.

12. Goals for 1978-79:

1. To continue field investigations. The major effort will be concentrated in the northeastern section of the province, comprising Athabasca, Lac La Biche, and Slave Lake Forest Districts. The majority of the area would represent the boreal white and black spruce biogeoclimatic zone, with the small exception of the summit of Swan Hills, which may belong to the subalpine Engelmann spruce-subalpine fir zone.

2. To establish sample plots representing different forest ecosystems of the study area mentioned above.

3. To obtain preliminary classification of the area investigated after determination of plant specimens and analyses of soil samples.

4. To complete a progress report for the fiscal year.

13. Accomplishments in 1978-79:

1. Field investigation of northeastern Alberta was completed. The investigation covered Lac La Biche, Fort McMurray, Slave Lake regions and part of the Whitecourt Forests.

2. Number of plots established (Appendix 1) 101
Number of plant specimens collected
Vascular plants approx. 150
Bryophytes and lichens approx. 2000

Total number of trees measured	2619
average number of trees per plot	26
Total number of tree core samples obtained	1048
average tree core samples per plot	10
Number of soil samples collected	446
Number of water samples collected	20
Total mileage driven for reconnaissance and plot setting	approx. 13500

3. Nine forest types were provisionally recognized in the area investigated. All these types belong to the Boreal White and Black Spruce zone.

4. A preliminary progress report for the 1978-79 fiscal year was submitted to the Chairman of the Alberta Forest Development Research Trust Fund along with a renewal application for the 1979-80 fiscal year.

Additional accomplishments:

1. A preliminary classification of the sample sites in NW Alberta (established during the 1977 field season) was compiled. Environmental parameters, soil data and plant species characteristics of individual forest types were compiled. Management practices were outlined for each forest type, i.e. type of logging, site treatment after logging, type of regeneration, and tree species selection to be used for regeneration. Limitations to timber production were outlined. This information was submitted in the form of a detailed progress report for the 1977-78 fiscal year to the Chairman of the Alberta Forest Development Research Trust Fund.

2. Soil samples from 1978 field season were analyzed. N, P, %C, pH and texture were done by Norwest Soil Research Ltd. CEC and exchangeable cations (Ca, Mg, K, Na) were done at the Northern Forest Research Centre.

3. Rock samples from soil parent material are being identified by Alberta Research Council.

4. All vascular plant, bryophyte and lichen specimens from the 1978 field season and bryophytes and lichens from the 1977 field season were identified.

5. Climatograms depicting the most important climatic features of selected sites representing various biogeoclimatic zones were prepared.

6. Soil data from the 1977 field season, tree mensuration data from the 1977 and 1978 field seasons, and deck of plant species were delivered to D.D. Munro and Associates Ltd. in Vancouver to be keypunched, stored on computer magnetic tape and used in computer analyses and synthesis of project data.

The following data are in preparation to be mailed in the near future: soil data from the 1978 field season, deck of environmental relevés from 1977 and 1978, and deck of vegetation relevés from both 1977 and 1978 field seasons.

14. 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 the climate, physiography, geology, and soils of the province and to continue the literature review as it relates to the goals of biogeoclimatic classification.

15. Publications:

Up to 1978-79

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.

1978-79

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.

16. Signatures:

G. Krumlik
Investigator

Rex Reid
Program Manager

J.D. Johnson
Investigator

G.T. Silver
Director G.T. Silver

PROJECT NOR-28

Environmental impact assessments

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 26, 1979

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 diameter pipelines to deliver natural gas resources to southern markets have been proposed. The impact of the proposed development on the terrestrial environment is evaluated by the proponents and by governmental agencies. During the assessment process the expertise of CFS is requested. This may take the form of membership in the 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 existing or new mines, roads, 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 impact of proposed developments.

3. To record the total effort of NFRC to specific environmetal 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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 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 Dalta 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.

12. Goals for 1978-79:

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 1978-79:

1. As member of the Regional Transportation Committee, contributed to the environmental impact assessment of the Liard Highway, and the twinning of the Trans Canada Highway in Banff National Park.

2. As member of an advisory group, participated in the development and supervision of a large contract to evaluate the post-construction impacts by linear facilities on northern ecosystems, commissioned by EPS to Beak Consultants Ltd.

14. 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.

15. Publications:

Up to 1978-79

Nil

1978-79

Nil

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: January 26, 1979

1. Project: Environmental Impact Assessments

2. Title: Environmental Assessment--Dempster Highway

3. New: Cont.: X

4. No.: NOR-28-172

5. Study Leader: S.C. Zoltai

6. Key Words: Arctic, land use, permafrost, pipeline, thermal erosion.

7. Location of Work: Dempster Highway, N.W.T.

8. Problem:

Explorations for hydrocarbon resources identified commercially exploitable natural gas occurrences in the Mackenzie Delta and adjoining Beaufort Sea areas. Original plans were that these gas resources would be added to the gas pipeline carrying Alaskan gas from the Prudhoe Bay area. With the abandonment of the Mackenzie Valley route and the development of the Alaska Highway route, the Delta gas will likely be developed at a somewhat later date and transported to markets by a pipeline along the Dempster Highway. This route would follow the now abandoned prime route of Canadian Arctic Gas Pipeline from the Delta to near Arctic Red River, and a lateral route from here to Fort McPherson. Impact studies were made for this section of the possible route, but not for the portion from Fort McPherson southward.

The Dempster Highway route crosses some of the most sensitive terrain in the Arctic and Subarctic regions of Canada. The combination of high ice content of soils, slope patterns, and silt-rich soil materials represent a potentially dangerous situation. Serious degradation can be expected following the destruction or disturbance of the living vegetation of the insulating organic mat. Such conditions are known to exist in the Ogilvie Mountains and north to the Mackenzie Delta. In the areas south of the Ogilive Mountains the active layer is thick and surface disturbances of the vegetation are not likely to affect the icy permafrost, except in areas of deep excavation.

Studies in the past (Mackenzie Valley pipeline proposals) provided us with an ability to predict the consequences of disturbances. The ice content of the soil, soil texture and stoniness, slopes, etc. give an indication of the expected magnitude of terrain degradation after the disturbances. We are, however, lacking the knowledge of the rate at which such disturbed, subsided, or eroded surfaces become stabilized and revegetated. There are numerous examples of impressive terrain damage during the first few years of the disturbance, but later inspections of the same areas reveal a remarkably rapid stabilization of the terrain and the establishment of desirable plants.

It is anticipated that a proposal for pipeline construction will include methods of minimizing or mitigating terrain and vegetation disturbances. Past experience along the Dempster and Mackenzie Highways and with the Mackenzie Valley pipeline proposals indicate that such measures are often not effective because they are not flexible enough to adopt to local conditions of soil and vegetation. This results in overdesigning or, more frequently, underdesigning. In the former case unnecessary restrictions are prescribed, such as scheduling work according to freeze up, or snow conditions, enforcing certain slope gradients on the right-of-ways, etc. Underdesigning results in ineffectual disturbance prevention measures, manifested in thermal subsidence, erosion, lack of revegetation, etc.

A terrain sensitivity rating of the route would identify areas which could be the subject of degradation. Such areas could be avoided, or special precautions would be taken when crossing them. A knowledge of the rate of natural rehabilitation of disturbed areas of various sensitivity would give a strong indication of acceptable levels of disturbance that will cause only minor or short-term degradation. When keyed to terrain-vegetation types, this knowledge would allow more flexibility in the planning and execution of pipeline construction activities and ensure successful rehabilitation of disturbed areas.

9. Study Objectives:

1. To determine the relationships between terrain, vegetation, and permafrost, developing a terrain sensitivity classification along the proposed pipeline route and establishing the rate of natural rehabilitation of the terrain following disturbances.

2. To cooperate with CFS staff from the Pacific Region in identifying and mapping the forest and other vegetation types along the proposed route, determining the presence of rate or unique vegetation communities, and considering vegetation-related problems associated with pipeline construction and operation.

3. To provide expertise in the development of environmental criteria for the design and rehabilitation of pipeline right-of-ways and ancillary structures.

10. Resources:

a. Starting date: 1978
b. Estimated year of completion: 1980
c. Estimated Prof. man-years required: 1.5
d. Essential major equipment items for 1979-80 with costs: Nil
e. Essential major equipment items beyond 1980 with costs: Nil
f. 1979-80 man years

Prof.	0.5
Supp.	1.0
Casual	0.0
Total	1.5

11. Progress to Date:

Proposal was submitted through EMS for approval of special funding. The funding, however, did not materialize for this or any other project related to the Dempster Highway. No work was carried out due to lack of funding.

12. Goals for 1978-79: (Dependent on special funding)

1. Conduct field work along the northern section of the Dempster Highway, investigating natural rehabilitation rates of disturbed areas and determining the terrain sensitivity of adjoining undisturbed areas.

2. Cooperate with CFS Pacific Region in vegetation mapping of the N.W.T. section of the route.

13. Accomplishments for 1978-79:

None of the above goals was attained due to lack of funding.

Participated in a cooperative study with CWS to assess a 50 000 km^2 area in the Horton-Anderson basins for potential national park reserve. This study was financed by Parks Canada.

14. 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.

15. Publications:

Up to 1978-79

Nil

1978-79

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. Apl. Res. 10:581-594.

Zoltai, S.C. 1978. A portable sampler for perennially frozen stonefree 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.

16. Signatures:

S. C. Zoltai

Investigator

Ron Reid

Program Manager

G.T. Silver

Director G.T. Silver

PROJECT NOR-29

Forest resource data

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

1. Project: Forest resource data.

2. Title: The effect of spacing on the growth of lodgepole pine.

3. New: Cont.: X 4. No.: NOR-29-008

5. Study Leader: W.D. Johnstone

6. Key Words: *Pinus contorta*, thinning, stand development, stand density, B.19c.

7. Location of Work: Hinton, Tee-Pee Pole Creek and McKay, Alberta.

8. Problem:

Although growing space has a pronounced effect on the development of individual trees and forest stands, little is known in Alberta concerning the effect of spacing on native spruce and pine. 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 following wildfire by pre-commercial thinning. In order to determine the optimum thinning regime, a study was established in 1954 in a pure stand of 22-year-old lodgepole pine trees. The following treatments were carried out in each of three blocks:

1. Single thinning to 5' x 5' espacement.

2. Single thinning to 6' x 6' espacement.

3. Single thinning to 8' x 8' espacement.

4. Multiple thinning - initially to 6' x 6' then after 50 years reduced by 40% basal area. (This treatment was subsequently dropped from the experiment.)

5. Multiple thinning - initially to 6' x 6' then every 14 years reduced by 30% basal area.

6. Control, untreated.

In addition an unreplicated 12' x 12' treatment was included. All trees were measured in each treatment plot in 1954 and remeasured in 1960 and 1969. The next thinning is due in 1984.

In order to determine the influence of spacing on the growth of very young trees the study was expanded in 1963. Spruce and pine 3-0 stock were planted on five sites at five spacings varying from 200 to 3,200 trees per acre. In 1963 and 1964 the same espacements were established on three sites in dense 5-year-old pine regeneration on the Gregg burn. In 1966 and 1967 identical treatments were applied in a 25-year-old pine stand in the Tee-Pee Pole Creek area of western Alberta. In 1969 the planted parts of the study were abandoned because the very poor survival invalidated spacing comparisons.

9. Study Objectives:

1. To determine how spacing affects diameter, height and volume growth, tree form and wood quality.

2. To determine at what age and density spacing becomes effective in controlling growth.

3. To determine at what age and density trees are able to fully occupy the site.

4. To determine the release potential after various periods or degrees of suppression.

5. To determine the effect of single thinnings of varying intensity on the development of dense young lodgepole pine stands, and to indicate the limitations of a single thinning as opposed to multiple thinning regimes.

10. Resources:

a. Starting date: 1954
b. Estimated year of completion: 1985 (Spacing trials may be maintained longer.)
c. Estimated total Prof. man-years required: N/A
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	(W.D. Johnstone)
Supp.	0.0	(S. Lux)
Casual	0.0	
Total	0.0	

11. Progress to Date:

McKay Thinning Trial:

1954 - treatments introduced, all trees tagged and measured.
1960 - remeasurement of sample trees.

1969 - trees remeasured, treatment 5 rethinned and stem analysis samples collected.
1970 - 1954, 1960 and 1969 data compiled and analyzed. Stem analysis samples measured on Addo-X.

Gregg Burn (Hinton) Espacement Trial:

1963 - 3-0 spruce and pine planted at 5 spacing on 5 sites.
1963 & 1964 - 5 espacements established in 5-year-old pine on 3 sites.
1966 - initial measurements.
1968 - survival measurement in planted trials. Mapping espacement trials.
1969 - planted trials abandoned due to poor survival.
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.

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 1978-79:

1. Complete analysis and prepare report on Gregg Burn trial.

2. Complete analysis and prepare report on Tee-Pee Pole Creek trial.

13. Accomplishments in 1978-79:

1. Analysis of data from Gregg Burn trial not completed.

2. Analysis of data from Tee-Pee Pole Creek trial not completed.

   In both of these trials a much more comprehensive analysis than originally anticipated is warranted and this analysis will be carried out as time permits.

3. Study terminated. To be administered in future under NOR-29-009.

14. Goals for 1979-80:

None. Study terminated.

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

W.D. Johnstone

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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.

7. Location of Work: Foothills section of Alberta.

8. Problem:

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.

9. Study Objectives:

   1. To construct a variable-density yield table.

10. Resources:

   a. Starting date: 1951
   b. Estimated year of completion: Orig. - Cont. Revised: I-1972, II-1973, III-1984
   c. Estimated total Prof. man-years required: 1.7
   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.	0.3	(W.D. Johnstone)
Supp.	0.2	(S. Lux)
Casual	0.0	
Total	0.5	

11. Progress to Date:

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.

12. Goals for 1978-79:

Nil

13. Accomplishments in 1978-79:

1. Study NOR-29-008 (The effect of spacing on the growth of lodgepole pine) incorporated into NOR-29-009.

14. 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.

(Permanent sample plot remeasurement, yield study, due in 1984.)

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

W.D. Johnstone
Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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: 1.5
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	(Johnstone)
Supp.	0.3	(Lux)
Casual	-	
Total	0.5	

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 height-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.

12. Goals for 1978-79:

    1. Complete analysis of greenhouse data and report results if appropriate.

13. Accomplishments in 1978-79:

    1. Analysis of greenhouse data completed but results considered inappropriate for reporting.

    2. Accomplishment added: New trial in greenhouse initiated using different nutrient levels and types of containers than previous trial. Greenhouse phase of trial completed and seedling measurement now underway.

14. Goals for 1979-80:

    1. Complete seedling measurement and initiate analysis of data. (Field plots to be measured in 1981.)

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

W.D. Johnstone
Investigator

A. D. Hunt
Program Manager

G.T. Silver
Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

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. FMI, FFRI, 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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man-years

Prof.	1.5	(W.D. Johnstone 0.5, R.E. Stevenson 1.0)
Supp.	1.5	(S.J. Lux 0.5, G.R. Stevenson 1.0)
Casual	-	
Total	3.0	

11. Progress to Date:

Lines of communication have been established with FMI and the provincial forest services within the region regarding the national forest statistics program. To date the national program has:

1. Prepared a report entitled "Canada's Forest Inventory - 1976" by M.G. Bowen, based upon the results of the 1977 survey. (The report is currently in press.)

2. Completed a pilot study in the province of Saskatchewan using a computer-based information retrieval system to summarize that province's forest inventory.

12. Goals for 1978-79:

1. To monitor and assess the National Forestry Statistics Program during 1978-79.

2. To identify and define regional forest research and management data requirements in cooperation with the regional sub-offices.

3. To complete problem analysis, and formulate standards and procedures for the collection of forest operational statistics to satisfy regional and national requirements.

4. To analyze and publish biomass data collected from *Populus* stands in Alberta (former Alta./Terr. Project A-287).

5. To supervise, coordinate, and analyze and publish results from inventory contract related to regional forest biomass program.

13. Accomplishments in 1978-79:

1. The development and progress of the National Program was assessed periodically during 1978-79 by:

(a) Reviewing the program during 2 meetings of the Statistics Technical Committee and participating in the STC's F.I.D.S. and Growth sub-committees.

(b) Reviewing several reports, including "Canada's Forest Inventory - 1976", arising from the program.

2. Regional forest research and management data requirements have yet to be clearly identified and defined. This problem has been complicated by the demise of the regional sub-offices.

3. Until the intent and objectives of the regional Core Forestry Program have been more clearly defined standards and procedures for data collection cannot be formulated. Preliminary discussions have been held with the Province of Manitoba to incorporate their data in the national computer-based data retrieval system. This data has already been obtained for Saskatchewan as part of the pilot study.

4. Biomass data from *Populus* stands in Alberta has been analyzed and report is in preparation.

5. Although proposals for the biomass inventory contract were received and reviewed, this contract was aborted because delays by DSS jeopardized the successful completion of the contract.

14. 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".

15. Publications:

1977-78

Nil

1978-79

Nil

16. Signatures:

W.D. Johnstone
Investigator

G.D. Hurt
Program Manager

G.T. Silver
Director G.T. Silver

PROJECT NOR-30

Forest resource management alternatives

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

1. Project: Forest resource management alternatives.

2. Title: Development and application of simulation models as decision-aids in forest resource management.

3. New: Cont.: X 4. No.: NOR-30-175

5. Study Leader: A.D. Kiil

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 advise 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 1979-80 with costs:

Mini-computer accessories: $30,000

e. Essential new major equipment items beyond 1980 with costs:

Computer accessories: $25,000

f. 1979-80 man-years

Prof.	2.0	(Vacant)
Supp.	-	
Casual	-	
Total	2.0	

11. Progress to Date:

NFRC computer requirements have been analyzed in cooperation with EMS Computer Services Directorate in Ottawa. Decision has been made to purchase a PDP 11/60 mini-computer to satisfy our computing requirements over the next 3-5 year period. A 3-yr Core Forestry Research

Program Plan is being implemented with initial emphasis on acquisition of new skills, installation of computer facilities, and evaluation and testing of resource management models.

A series of meetings have been held to clarify program objectives and strategy to staff and to initiate further definition of data management systems requirements. Interviews have been held to hire a Forestry Systems Analyst and it is expected that the position will be filled by early spring, 1979.

12. Goals for 1978-79:

    1. Hire a Forestry Systems Analyst.

    2. Establish a program development group of Project Leaders to identify, synthesize and integrate information from all projects to provide approach and methodology for providing resource management prescriptions and alternatives.

    3. Complete a problem analysis to identify specific work areas and methodology for developing and using available simulation models and data systems as decision-aids in resource management.

13. Accomplishments in 1978-79:

    1. The position is vacant as of March 1, 1979. Interviews were held in mid-January and an offer has been made to the top-ranked candidate.

    2. Several meetings were held with Project and Study Leaders to finalize a 3-yr Program Plan for the Core Forestry Program. Project Leaders in particular made substantial contributions to the identification and definition of goals and objectives. The CPM/PERT approach was used to facilitate program development and integration.

    3. In the absence of a Study Leader, this goal was not fully completed. A number of operational data management systems (Stats. Canada, City of Edmonton, IWD, EMR, CFS National Statistics Pilot Study, Etc.) were visited and assessed in terms of their relevance to NFRC program needs. Several simulation models were identified for further evaluation and testing.

14. 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.

15. Publications:

Up to 1978-79

Nil

1978-79

Nil

16. Signatures:

G. D. Hunt

Investigator

G. D. Hunt

Program Manager

G. T. Silver

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 28, 1979

1. Project: Forest resource management alternatives.

2. Title: An assessment of the energy potential of forest biomass in the Prairie Provinces and the Northwest Territories.

3. New: X Cont.: 4. No.: NOR-30-180

5. Study Leader: A.D. Kiil

6. Key Words: Biomass, energy, management alternatives, productivity.

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. Since fossil fuels will inevitably be exhausted questions arise about other energy sources. A number of issues and controlling factors are central to future energy developments. Energy consumption can be expected to increase for some time. Historically, about 50 years have been needed for the energy economy to shift substantially to a new fuel. Per capita energy consumption can be expected to increase substantially. Environmental considerations including carbon dioxide and suspended particulates, may limit the use of a particular fuel.

Recent approximations of the potential contribution of forest biomass to Canada's energy requirements suggest that a total of 110×10^6 ODt are available for energy conversion annually. As much as 8% of Canada's total primary energy production could be satisfied with biomass by 1985. This will require the conversion of virtually all mill wastes and logging residues. Projections beyond the year 2000 suggest that a substantially greater proportion of the country's energy requirements could be met by forest biomass.

The Canadian Forestry Service is the lead agency in administering the federal Energy from the Forest (ENFOR) program, with funding provided by the Dept. of Energy, Mines and Resources. The purpose of the ENFOR program is to provide, through Research, Development and Demonstration, the technological basis for achieving program goals. This study will provide the coordination and mechanism for implementing an ENFOR program to develop the knowledge and systems to enable achievement of regional and national forestry objectives.

9. Study Objectives:

   1. Develop and test biomass inventory and growth methods and techniques to facilitate the establishment of operational biomass inventories.

   2. 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.

   3. Investigate the impact of biomass removal on site quality, nutrient status, silvicultural options and long-term site productivity on selected sites in Prairie Provinces.

   4. Develop and operate a computerized biomass data bank and information retrieval system to provide for more effective technology transfer.

10. Resources:

   a. Starting date: 1978
   b. Estimated year of completion: 1984
   c. Estimated total Prof. man-years required: 10
   d. Essential new major equipment items for 1979-80 with costs:

      1 computer terminal $3,000

   e. Essential new major equipment items beyond 1980 with costs: Nil
   f. 1979-80 man-years Prof. (Man-year allocations for ENFOR
      Supp. are shown under separate Study
      Casual Statements.)
      Total

11. Progress to Date:

This is a new study. However, the NFRC participated in the 1978-79 ENFOR program by supervising the work on two contract studies totalling $88,000. The terms of these two contracts have been fulfilled. Work is underway inhouse to synthesize findings into Information Reports by late summer, 1979.

The NFRC is represented on the Production and Main ENFOR Committees.

12. Goals for 1979-80:

   1. Coordinate and supervise work on four ENFOR contracts approved for the W & N 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.

15. Publications:

Up to 1978-79

Nil

1978-79

Kiil, A.D. 1978. The Energy from the Forests (ENFOR) Program in the Prairie Provinces: An overview (paper presented at Annual Meeting of CIF, Manitoba Section, Winnipeg).

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-31

Climatic Studies

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 21, 1979

1. Project: Climatic Studies

2. Title: Impact of Climatic Variation on Boreal Forest Biomass Production

3. New: X Cont.: 4. 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, palaeo botany, 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 climatic 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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 person-years: Prof. 1.0 (Powell)
Supp. 1.0
Total 2.0

11. Progress to Date:

Nil

12. Goals for 1978-79:

Nil

13. Accomplishments for 1978-79:

Some initial contacts have been made, and a start has been made to gather relevant literature material.

14. 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, paleo botanical, 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. Provide advice on climate input for the Biogeoclimatic ecosystem classification (NOR-27-169) as required, and possibly seeks 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.

15. Publications:

Up to 1978-79

Nil

1978-79

Nil

16. Signatures:

John M. Powell
Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-32

Long range transport of air pollutants

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: March 21, 1979

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: Vacant

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 the 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: 5.0
d. Essential new major equipment items for 1979-80 with costs:
   Nil in 1979/80.
e. Essential new major equipment items beyond 1980 with costs:
   Not available.
f. 1979-80 man-years Prof. 1.0

11. Progress to Date:

None - new study.

12. Goals for 1978-79:

None - new study.

13. Accomplishments in 1978-79:

None - new study.

14. Goals for 1979-80:

To be determined, but will relate to airborne pollutants arising from smelters in Manitoba and Saskatchewan.

15: Publications:

None.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

PROJECT NOR-33

Technical and scientific information

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 20, 1979

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 conclusion 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 1979-80 with costs: Nil
e. Essential new major equipment items beyond 1980 with costs: Nil
f. 1979-80 man years

Prof.	1.0 (R. Waldron)
Supp.	-
Casual	-
Total	1.0

11. Progress to Date:

Eight technical publications and eight 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 1978-79:

1. Publish 4 Forestry Reports
   (i) Hydrology--R. Swanson (Jan. 1978)
   (ii) Insects & Disease Survey--Y. Hiratsuka (April 1978)
   (iii) NFRC program--Program Managers, R. Waldron (July 1978)
   (iv) Silviculture--to be assigned (Oct. 1978)

2. Continue write up, prepare maps and arrange for art work and photographs, Regina-Winnipeg Ecotour.

3. Assist in the preparation and publishing of a technical report entitled "Symptomology of SO_2 damage" by S. Malhotra.

4. Continue the preparation of articles for release in the Pest Leaflet series. Planned for 1978-79 are:
   (i) Ticks--R. Stevenson
   (ii) Fire blight--P. Maruyama
   (iii) Silverleaf--Y. Hiratsuka
   (iv) Rusty tussock moth--R. Caltrell
   (v) White pine weevil--J. Drouin
   (vi) Willow shoot borer--J. Drouin

5. Publish "Watershed management guidelines" by R. Rothwell.

6. Assist in the review and preparation of "Insects of the Prairies" by H. Cerezke.

Goals added

7. Develop a publication distribution policy and supervise its implementation.

8. Effective October 1, 1978, assume Information Officer's duties relating to requests for information, seminars, correspondence and supervision of the distribution clerk.

9. Develop a storage-retrieval system for publications that will ensure efficient and effective service to NFRC clientele.

13. Accomplishments in 1978-79:

1. (i) The hydrology Forestry Report was withdrawn.
   (ii) A twelve page, 4 colour Forestry Report was prepared on the Insect and Disease Survey which highlighted the Survey and a number of major insect and disease pests.
   (iii) NFRC program Forestry Report held in abeyance pending finalization of the Core Forestry Program.
   (iv) Silviculture Forestry Report--currently in preparation. L. Brace coordinator.
   (v) Added Forest Economics of Manitoba--in preparation. W. Ondro coordinator.

2. Regina-Winnipeg Ecotour slated for publication in 1980-81. Text was finalized and sent to Ottawa for headquarters review and translation; art work including panorama completed; dummy layout prepared; a number of photographs obtained from outside sources for inclusion in the Ecotour.

3. Provided technical advice regarding the reproduction of the over 300 color photographs which will appear in the technical report "Symptomology of SO_2 damage". As yet the draft copy has not been submitted for technical review or editing.

4. Four Pest Leaflets were prepared and printed in 1978-79. They are Ticks, Fire Blight, White Pine Weevil and Willow Shoot Borer. Rusty Tussock Moth was dropped when the proposed author resigned. Silverleaf is currently in draft stage.

5. "Watershed management guidelines: by R. Rothwell was published and distributed.

6. As yet the publication on "Insects of the Prairies: by H. Cerezke has not reached the draft stage.

Goals added

7. A publication distribution policy was developed and its implementation achieved. Currently 119 libraries and senior forestry personnel in our region receive copies of all our publications

automatically. In addition there are 565 individuals on our regional mailing list and 592 individuals in the remaining parts of Canada, the U.S.A. and around the world.

8. Since October 1, 1978, I have been supervising the distribution clerk and assuming full responsibility for publication and information requests.

   Two seminars were arranged:

   Zoltai--Natural resources of the Anderson-Horton Rivers area.

   Gimbarzevsky--"Integrated approach to surveys of renewable resources" Jan. 19, 1979

   Considerable time was spent shipping and receiving portions of the CFS display at the World Soils Conference held in Edmonton.

9. A retrieval-storage system is presently being devised which will ensure the orderly filling of publication requests--both Forestry and Wildlife. A large storage room has been made available for bulk storage. In the meantime the method of handling daily requests is being "tidied up".

14. 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 Prairie 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.

15. Publications:

1978-79

Rothwell, R.L. 1978. Watershed management guidelines for logging and road construction in Alberta. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-208.

Hiratsuka, Y. 1978. Forest Insect and Disease Survey. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Rep. Spring 1978 issue.

Drouin, J.A. 1978. White pine weevil. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Pest Leafl. PL25-78.

Drouin, J.A. 1978 A willow shoot-boring sawfly. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Pest Leafl. PL24-78.

Maruyama, P.J. 1978. Fire blight. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Pest Leafl. PL23-78.

Stevenson, R.E., P.R. Wilkinson, and F.M.M. White. 1978. Ticks. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Pest Leafl. PL22-78.

16. Signatures:

Investigator

Program Manager

Director G.T. Silver

CANADIAN FORESTRY SERVICE

STUDY STATEMENT

1979 - 80

Responsibility Centre: NORTHERN FOREST RESEARCH CENTRE

Date: February 20, 1979

1. Project: Technical and scientific information

2. Titles: Scientific information

3. New: Cont.: X   4. No.: NOR-33-146

5. Study Leader: P. Logan

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 1979-80 with costs:
        1. Continued rental of electronic composer $ 350/month
        2. Display hardware $ 3,000
        3. Word processor with video display $15,000
    e. Essential new major equipment items beyond 1979 with costs: Nil
    f. 1979-80 man-years

Prof.	-
Supp.	1.0
Casual	-
Total	1.0

11. Progress to Date:

Thirteen information reports and 27 journal articles, and 11 other publications were published or in press up to February 20, 1970.

12. Goals for 1978-79:

1. To assist the research staff, through the provision of editing and publishing services, in the preparation and publication of approximately 25 information reports and 35 journal articles.

2. To assist the technical writer, through the provision of editing and publishing services, in the preparation and publication of approximately 5 pest leaflets and 3-5 technical publications, including Forestry Reports. Edit the Regina-Winnipeg Ecotour.

3. Oversee all printing and reprinting of locally published scientific and technical information.

4. Upgrade printing standards and aesthetic quality of locally published scientific and technial information within the constraints of the budget allocated.

5. Introduce computer-assisted revision of manuscripts by means of a computer terminal or typewriter with unlimited memory.

Goals added

6. Assume responsibility for displays.

7. Edit 7 final reports on Arctic Islands Pipeline Program for EMS.

13. Accomplishments in 1978-79:

1. Assisted staff in the publication of 13 Information Reports and 27 journal articles. A list of 1977-78 publications (total of 51) is appended.

2. Participated on Pest Leaflet Review Committee; reviewed, edited, and published 4 pest leaflets. Edited the revised text of Regina-Winnipeg Ecotour. Edited one Forestry Report. Edited one special technical report (Watershed management guidelines, by Rothwell).

3. Coordinated, wrote specifications for, and monitored the printing of 13 Information Reports and 4 pest leaflets and the reprinting of 4 Information Reports and 12 pest leaflets.

4. Retained electronic composer for typesetting publications.

   Introduced coated stock for better reproduction on and more professional appearance of Information Report covers.

   Set up standing offer agreement for the printing of 1979-80 Information Reports and Forestry Reports.

   Attended 5-day workshop on "Management of Publications Programs" at Capilano College, North Vancouver.

5. Inspected AES Plus Word Processor with video display and recommended it for purchase.

6. Coordinated and set up NFRC soils display at National Park Conference in Banff.

   Organized two general-interest displays in NFRC lobby. Ordered exposystem display hardware for permanent displays in NFRC lobby.

7. Completed editing 7 Arctic Islands Pipeline Program reports to meet EMS printing deadlines.

14. <u>Goals for 1979-80</u>:

    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.

15. <u>Publications</u>:

    1978-79

Waldron, R. and P. Logan (eds.). 1978. Forest Insect and Disease Survey. For. Rep. (Spring).

16. Signatures:

P.A. Logan
Investigator

Reid
Program Manager

G.T. Silver
Director G.T. Silver

INFORMATION REPORTS

Bella, I.E. and J.P. De Franceschi. 1978. Assessment of regeneration stocking standards used in Alberta: A follow-up. Inf. Rep. NOR-X-211. (Environ. Can.)

Chrosciewicz, Z. 1978. Large-scale operational burns for slash disposal and conifer reproduction in central Saskatchewan. Inf. Rep. NOR-X-201.

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