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Report of the Eleventh Annual Forest Pest Control Forum
Government Conference Centre
Ottawa, Ontario
November 15-16, 1983

Canadian Forestry Service
Ottawa, Ontario
March, 1984

REPORT OF THE
ELEVENTH ANNUAL FOREST PEST CONTROL FORUM
GOVERNMENT CONFERENCE CENTRE

Ottawa, Ontario

November 15-16, 1983

The Forest Pest Control Forum is held under the aegis of the Canadian Forestry Service to provide the opportunity for representatives of provincial and federal governments and private agencies to review and discuss forest pest control operations in Canada and related research.

Canadian Forestry Service
Ottawa, Ontario
February, 1984

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

LIST OF ATTENDEES

In attendance (full or part time)

United Sates Forest Service

Peter W. Orr, Broomall, PA

David Grimble, Broomall, PA

Maine Forest Service

Ancyl S. Thurston, Augusta

Newfoundland Department of Forest Resource and Lands

N.E. Carter, St. John's

Nova Scotia Department of Lands and Forests

T.D. Smith, Truro

New Brunswick Department of the Environment

Wendy Sexsmith, Fredericton

Quebec Department of Energy and Resources

Louis Dorais, Quebec

Gilles Gaboury, Quebec

Ontario Ministry of Natural Resources

S.A. Nicholson, Maple

Bruce H. McGauley, Maple

Department of Natural Resources Manitoba

Geoff Munro, Winnipeg

Forest Protection Limited

H.J. Irving, Fredericton

Craig Howard, Fredericton

J.D. Irving Limited
Dave Oxley, Saint John

Eastern Spruce Budworm Council
G. Paquet, Quebec

National Research Council
Pat Curry, Ottawa

Agriculture Canada
A.C. Schmidt, Plant Health Division, Ottawa
W. Stewart, Pesticides Division, Ottawa

Fisheries and Oceans Canada
C.S. Rodrigues, Ottawa
P. Ryan, St. John's

Environment Canada

Environmental Protection Service
P.A. Jones, Ottawa

Canadian Wildlife Service
P. Mineau, Ottawa

Canadian Forestry Service
T.E. Sterner, Victoria
B.H. Moody, Edmonton
L.P. Magasi, Fredericton
E.G. Kettela, Fredericton
J. Hudak, St. John's
W.H. Smirnoff, Ste. Foy
D. Lachance, Ste. Foy
G.M. Howse, Sault Ste. Marie
P.D. Kingsbury, Sault Ste. Marie
K.M.S. Sundaram, Sault Ste. Marie

P. de Groot, Sault Ste. Marie
B. Helson, Sault Ste. Marie
J.C. Cunningham, Sault Ste. Marie
J. Turgeon, Sault Ste. Marie
A. Sundaram, Sault Ste. Marie
P. Reynolds, Sault Ste. Marie
J.H. Meating, Sault Ste. Marie
L. Sippell, Sault Ste. Marie
C.R. Sullivan, Sault Ste. Marie
C. Sanders, Sault Ste. Marie
T.J. Ennis, Sault Ste. Marie
E.T. Caldwell, Sault Ste. Marie
R.J. Herring, Ottawa (chairperson)
J.A. Armstrong, Ottawa (chairperson)
C.H. Buckner, Ottawa (chairperson)
E.S. Kondo, Ottawa (chairperson)
A.G. Davidson, Ottawa (retired)
P. Singh, Ottawa
D. Watler, Ottawa
R.G. Taylor, Ottawa (secretary)

NOTICE OF MEETING

The Twelfth Annual Forest Pest Control Forum
will be held in
Sussex Room, 1st Floor
Government Conference Centre
2 Rideau St., Ottawa
November 27, 28, 29, 1984
(8:30 a.m. - 5:00 p.m.)

Eleventh Annual Forest Pest Control Forum

Sussex Room, 1st Floor
Government Conference Centre
2 Rideau Street, Ottawa

November 15-16, 1983
8:30 a.m. - 5:00 p.m.

Tentative Agenda

1. Welcome and Introductory Remarks-Richard Herring

2. Pesticides Review
   - 2.1 Introductory Remarks-J.A. Armstrong
   - 2.2 Royal Commission
   - 2.3 Registration Update-W.D. Stewart
   - 2.4 Review of research underway or planned with reference to the development of more effective or additional materials for controlling pests (including program of Forest Pest Management Institute)
   - 2.5 NRC Publications Report
   - 2.6 Expert Committee on Weeds-D.A. Winston

3. Spruce Budworm
   - 3.1 Introductory Remarks-C.H. Buckner
   - 3.2 Spruce Budworm Dynamics-W.L. Sippell
   - 3.3 Report from Eastern Spruce Budworm Council
   - 3.4 Newfoundland

     Outbreak Status - 1983, Forecast 1984

     Control Program - 1983

       Reports on operations and assessments

       Reports on environmental monitoring

     Prospects and Plans 1984

   - 3.5 Maritime Provinces

     Outbreak Status - 1983, Forecast 1984

     Control Programs - 1983

       Reports on operations and assessments

       Reports on environmental monitoring

     Prospects and Plans 1984

3.6 Quebec
Outbreak Status - 1983, Forecast 1984
Control Programs - 1983

Reports on operations and assessments
Reports on environmental monitoring

Prospect and Plans - 1984

3.7 Ontario
Outbreak Status - 1983, Forecast 1984
Control Programs - 1983

Reports on operations and assessments
Reports on environmental monitoring

Prospects and Plans - 1984

3.8 Other Provinces
Outbreak status - 1983 and Prospects - 1984

3.9 United States
Reports and Comments by representatives of state and federal agencies

4. Other Pest

4.1 Introductory Remarks - E.S. Kondo

4.2 Mountain Pine Beetle
British Columbia
Status and Control 1982, Outlook - 1983

4.3 Gypsy Moth
Ontario
Outbreak Status 1983
Forecast and Plans 1984

Other Provinces and U.S.

4.4 Reports on the Status and Control of Other Pests

British Columbia
Prairie Provinces
Ontario
Quebec
Maritime Provinces
Newfoundland
United States

Informal discussions of topics of interest, working group or committee meetings.

November 17

1) Cone and Seed Insects - Jean Turgeon
2) Vegetation Management Workshop - Phil Reynolds
3) FIDS Heads Meeting

November 14

Committee for the standarization of Survey and Assessment Techniques.

NOVEMBER 15, 8:30 A.M. 1983

11TH ANNUAL FOREST PEST CONTROL FORUM
SUSSEX ROOM 1ST FLOOR
GOVERNMENT CONFERENCE CENTRE, 2 RIDEAU ST.
(OPPOSITE CHATEAU LAURIER)

- IF ENTER FROM RIDEAU ST, ROOM IS DOWN 1ST FLOOR AT BACK
- IF ENTER FROM COLONEL BY DRIVE ENTRANCE ROOM IS TO THE RIGHT

SUGGESTED REMARKS

ON BEHALF OF THE CANADIAN FORESTRY SERVICE I WANT TO WELCOME YOU TO THIS THE 11TH ANNUAL FOREST PEST CONTROL FORUM.

MY NAME IS RICHARD HERRING. I AM ACTING ADM OF THE CFS.

AS MANY OF YOU ARE AWARE LES REED HAS RECENTLY LEFT HIS POSITION AS ADM OF THE CANADIAN FORESTRY SERVICE. I WOULD LIKE TO PAY TRIBUTE TO LES FOR HIS CONTRIBUTIONS TO THE CFS. LES ARRIVED IN AUGUST 1980 WITH THE MISSION TO PROVIDE THE GOVERNMENT WITH A NEW STRATEGY OF INTERVENTIONS IN THE FOREST SECTOR AND TO MAKE THE CANADIAN FORESTRY SERVICE AN INSTRUMENT FOR IMPLEMENTING THESE CHANGES. IN THREE SHORT YEARS LES HAS COLLECTIVELY ACHIEVED AN EXTRAORDINARY SET OF ACCOMPLISHMENTS.

- RENEWED AND STRENGTHENED MANDATE FOR CABINET
- A FEDERAL FOREST STRATEGY
- A RENEWAL POLICY
- A REINFORCED RESEARCH PROGRAM AND THE MEANS TO ENSURE THE VITALITY AND RELEVANCE OF OUR RESEARCH
- SUPPORT FOR FOREST FACULTIES
- RESPONSIBILITY FOR RENEWAL AGREEMENTS WITH THE PROVINCES
- JOB CREATION PROGRAMS
- PROMOTIONS AND ADDITIONS TO THE CFS LEADERSHIP

WE MUST NOW CONTINUE ON THE COURSE THAT HAS BEEN SET. THE SEARCH IS CONTINUING FOR A PERSON WHO WILL CONTINUE THE MOMENTUM, ENSURE THAT THE GAINS ACHIEVED ARE INTEGRATED INTO THE MANAGEMENT OF THE SERVICE AND WHO WILL CONTINUE TO BRING CREDIT TO THE POSITION OF THE HEAD OF THE CANADIAN FORESTRY SERVICE.

I DON'T KNOW HOW LONG THE RECRUITING PROCESS MAY TAKE BUT I PLAN TO EXERCISE THE FULL AUTHORITY OF THE POSITION AND MOVE US FORWARD RATHER THAN FALL INTO A HOLDING PATTERN.

THE YEAR 1983 HAS SEEN SOME OTHER SIGNIFICANT CHANGES FOR ALL OF US. JUST A FEW MONTHS AGO THE HONORABLE CHARLES CACCIA WAS NAMED OUR NEW MINISTER OF THE ENVIRONMENT. YOU ALL RECEIVED, OR SHOULD HAVE, A BRIEF BIOGRAPHICAL SKETCH ON MR. CACCIA. I WILL NOT GO INTO THE DETAILS OF MR. CACCIA'S CAREER. I THINK YOU WOULD RATHER HEAR A FEW WORDS ABOUT MR. CACCIA'S CONCERNS WITH RESPECT TO THE FOREST INDUSTRY IN CANADA. AS YOU ALL KNOW MR. CACCIA IS CONCERNED ABOUT THE FUTUR OF THE FOREST INDUSTRY. HE IS WELL AWARE THAT FOR THE INDUSTRY TO REMAIN COMPETITIVE AND TO CONTINUE TO PROVIDE EMPLOYMENT, IT WILL HAVE TO BECOME MORE EFFICIENT. THIS EFFICIENCY WILL, AS YOU ALL KNOW, DEPEND TO A LARGE DEGREE ON WISE MANAGEMENT OF THE FOREST RESOURCE. IT IS IN THIS AREA THAT THE CANADIAN FORESTRY SERVICE CAN PLAY AN IMPORTANT ROLE, AND IT IS ON OUR, AND YOUR SHOULDERS THAT THE RESPONSIBILITY FOR IDENTIFYING AND IMPLEMENTING NEW PROGRAMS FOR RESEARCH RESTS. WE ARE ALL AWARE THAT THE MANAGEMENT OF THE FOREST RESOURCES WILL

INPUT TO ENCOURAGE THE GROWTH OF NEW TREES AND TO PROTECT THIS VALUABLE INVESTMENT FROM INSECT ATTACK. I NEED NOT REMIND YOU THAT MR. CACCIA IS WELL AWARE OF THE VOCAL PUBLIC'S ATTITUDE ABOUT THE USE OF PESTICIDES. YOU WILL BE INTERESTED TO KNOW THAT IN HIS DESIRE TO KNOW MORE ABOUT FORESTRY AND FOREST PESTICIDE USE PROBLEMS MR. CACCIA ASKED FOR A SEMINAR ON THIS SUBJECT. THIS TOOK PLACE LAST WEEK WITH PRESENTATIONS BY EPS, CFS AND CWS. IN THE ENSUING DISCUSSION MR. CACCIA INDICATED HIS SATISFACTION WITH THE PRESENTATION AND THE KNOWLEDGE HE GAINED. AS YOU CAN IMAGINE IT WAS NOT POSSIBLE TO COVER ALL ASPECTS OF THIS PROBLEM AND WE WILL, IN A FEW WEEKS, BE HAVING ANOTHER SEMINAR SESSION WORK WITH MR. CACCIA.

THE FORUM IS CONVENED BY THE CFS TO PROVIDE THE OPPORTUNITY FOR REPRESENTATIVES OF PROVINCIAL AND FEDERAL GOVERNMENTS AND PRIVATE AGENCIES TO REVIEW AND DISCUSS FOREST PEST CONTROL OPERATIONS AND RELATED RESEARCH. NOT ONLY DOES THE FORUM CONSIDER FOREST PROTECTION, BUT IT IS APPRECIATED THAT CONTROL OPERATIONS CAN EFFECT OTHER SEGMENTS OF THE ENVIRONMENT AND THESE ARE DEALT WITH AS WELL. ALTHOUGH THE FORUM IS CONVENED BY THE CFS, IT HAS BEEN SUCCESSFUL IN ACHIEVING ITS PURPOSE ONLY BECAUSE IT HAS BEEN SUPPORTED BY THE PRINCIPAL FOREST PEST CONTROL AGENCIES IN CANADA AND BY OTHER CONCERNED AGENCIES WHO HAVE PARTICIPATED AND CONTRIBUTED THEIR KNOWLEDGE TO THE DISCUSSIONS. I AM TOLD THAT IN SPITE OF AUSTERITY 64 PERSONS WERE PRESENT FOR ALL OR PART OF

LAST YEAR'S MEETING. THIS TYPE OF RESPONSE CONFIRMS THAT THE FORUM IS A VALUABLE VEHICLE FOR THE TRANSFER OF INFORMATION BY THE FOREST MANAGER AND RESEARCH MANAGER ALIKE. AS MY PREDECESSORS HAVE INFORMED YOU, IT IS OUR INTENTION TO CONTINUE CONVENING THE FORUM AS LONG AS INTEREST AND SUPPORT CONTINUES. WE ARE AGAIN PLEASED THAT THE UNITED STATES COULD BE REPRESENTED AT THE MEETING.

YOU HAVE BEFORE YOU A TENTATIVE AGENDA THAT WE PROPOSE TO FOLLOW, SUBJECT TO ANY CHANGES THAT ARE SUGGESTED AS THE MEETING PROGRESSES. I AM TOLD THAT THE AGENDA THROUGH THE YEARS HAS BEEN FAIRLY STANDARD WITH THE EXCEPTION OF THE ADDITION OF SPECIFIC TOPICS THAT ARE SINGLED OUT FOR SPECIAL ATTENTION. PESTICIDES HAVE BEEN FEATURED AT THIS YEAR'S MEETING AND WE HAVE, THEREFORE INCLUDED "A PESTICIDE REVIEW" AS THE FIRST ITEM ON THE AGENDA. WE HAVE NOT ASSIGNED TIMES TO THE VARIOUS TOPICS BUT HOPE TO FINISH THE FORMAL PART BY TOMORROW AFTERNNON LEAVING THURSDAY FREE FOR INFORMAL DISCUSSIONS.

I REGRET THAT OTHER COMMITMENTS MAKE IT IMPOSSIBLE FOR ME TO SPEND AS MUCH TIME WITH YOU AS I WOULD HAVE LIKED, HOWEVER I WILL STAY AS LONG AS I CAN.

Pesticides Review J. Armstrong

This session of the Pest Control Forum covers the areas of research dedicated to the development of improved forest pest management practices. I think that it is accepted by all that in using the word "improved" we are referring to the development of new products, new formulations and tank mixes of existing products, new or improved spray emission systems and new tactics and techniques to apply the material. Of prime importance in the development work is the need for the new material as tactic to be equally or more efficaceous than existing materials but environmentally acceptable.

In introducing this session you will note changes. You all know Errol Caldwell as the Agriculture Canada specialist dealing with forestry insecticides. Errol is now program manager at FPMI, replacing me. The FPMI research program also reflects changes. For years this forum has thought of pest management only in terms of insects. Weeds and competing vegetation are also a pest to the forest manager yet there has been relatively little work done in the area of developing herbicides for forestry use. In acknowledgement of the serious problems we are now facing the FPMI has set up a herbicide research and development program to not only investigate new herbicides but also to study improved application techniques and the environmental effect of their use. Although my introductory comments have dwelt on FPMI I am not forgetting the research done by the other establishments. Before turning the meeting over to the first presentation I would like to note the presence of Dr. Grant Davidson here with us today.

Report to 11th Annual Forest Pest Control Forum
November 15-16, 1983

I would like to provide information and an update on the status of submissions for Forest and Woodland products--these were discussed at the CCREM Forest Task Force Meeting in Saskatoon, October 19-20, 1983:

1. Orthene FSC (acephate) #14226

Had temp. reg. for 1983. IBT replacement studies of pivotal multi-generation reproduction studies were submitted in mid-August/83 but review is not complete. Concern re: major metabolite Methamidophos--it is IBT and no replacement studies are available yet.

Further concern from CWS re: higher rates of application of ACP (acephate)--prefer split applications of 275 g/ha to avoid cholinesterase inhibition in birds.

2. Permethrin:

Approved for Commercial Woodland Use: by ground application only in Christmas tree plantations and nurseries; high valued stands used for seed production and other high valued woodland areas that are extensively managed. (Farm woodlots and shelter belts are excluded).

FPMI has environmental studies on parameters of drift in woodlots under way.

Agriculture would be agreeable to registration in nurseries and woodlots with appropriate buffer zones. No data in at present nor is there a submission for registration to cover the above mentioned uses.

Ambush 500EC has a temp registration for ground use at present.

3. Viruses: Two viruses have been reg'd in 1983:

(i) Douglas Fir Tussock Moth-Virtuss (#17786)

(ii) Red headed Pine Sawfly-Lecont virus (#17824)

Both are temporary registrations. Dermal hypersensitivity data must be generated. Protocols are being worked out with H & W.

4. Gypsy Moth Virus--No submissions or inquiries have been received regarding this virus.

Problem recognized by Forestry: In order to collect the virus, would have to rear Gypsy Moth larvae under Quarantine conditions. Potential for introducing the insect into an area where it doesn't occur.

5. Futura--No further review of Biochem submissions is possible at present as company is involved in a major Compliance matter regarding their one registered product Novebac. Nova Scotia and Ontario had major problems with shipments of Novebac from company. Company has been uncooperative in rectifying matter. Pesticides Division has serious concerns regarding Company's quality control and packaging capabilities and integrity.

Furthermore, Futura submission was supported by limited efficacy and stability data. Further data required.

6. Roundup (Glyphosate)--Forest use is pending review of long term studies by Health and Welfare. Also pending submission of some short term studies.

Agriculture Canada would have agreed to Temp. Reg. for 1983 but the company withdrew the submission. Company may reapply when the review is finished.

7. Velpar (Hexazinone)--Health and Welfare wants the reproduction study redone but company hasn't decided whether they will redo it or not. May be possible to have a Temp. Reg. for Woodland use (ground application) for 1984. This is pending submission of some efficacy data.

8. Garlon (Triclopyr)--Two year mouse feeding study is being redone by DOW. Protocol has been submitted and approved. Rat study which was IBT has been validated and is acceptable. Reproduction study available is only 1 generation.

Health and Welfare has agreed to Temp. Reg. for Brush Control; but for Forest Use, Health and Welfare requires reproduction study to be redone and the chronic mouse feeding study must be completed. Health and Welfare would probably approve a Temp. Reg. for Forest use if DOW commits to undertake another reproduction study. We have received a submission from DOW for Forest Use (2 months ago). Have not received any environmental impact review comments yet.

9. 2,4,5-T--DOW has announced withdrawal of their action against EPA and withdrawal from U.S. market. DOW's actions are based on economics (are said to have spent $10 million so far) not safety. Since our registration system is based on safety, merit and value, and since we have no evidence re: a safety factor, there is no justification nor any plans for us to cancel the registration.

IBT Update: Press release of October 14, 1983 provided the latest IBT update. The only forest-use pesticides affected are acephate and glyphosate, and neither of these have changed categories.

Research Permit Memorandum:

The new T-1-216 Memo went out for comment over the last year and comments, etc., have been considered. We anticipate having the Memorandum out before the end of 1983. The new forms and guidelines for Research Permits will be followed for the 1984 season.

Update on PSR:

Registration of technical actives will begin in January 1984 as per Memorandum T-1-241.

New memoranda re: PSR requirements have been released--these replace T-1-223 and T-1-212 as follows:

	Active Ingredient	Formulated Product
T-1-223 (Chemistry)	T-1-238	T-1-240
T-1-212 (Index)	T-1-237	T-1-239

Proposed Amendments to PSR:

PSR was introduced on Sept. 8, 1980 for two reasons:

(i) Industry pressure to move away from generic registration and to recognize data ownership, and

(ii) secondly, presence of microcontaminants in Active Ingredients (AI's), e.g. Dioxin and Nitrosamines (at the time we didn't know the extent of the problem or differences between different sources). The intent of PSR was to provide greater assurances of safety for each registered product, since safety is the cornerstone of our Act.

PSR Definition: For each formulated product we must know the source of the AI, and each AI from each source must have its own supporting data base.

PSR Requirements: Good knowledge of the chemistry of the AI and a good index of the supporting data. Chemistry package must include specs to 0.1% and information on microcontaminant potential.

PSR has been in place for 3 years and as with all systems, some adjustments are necessary in some areas. Last year we decided the only way to put PSR on a SOLID footing was to register all sources of AI's rather than products only (January 1984).

Experience with PSR has shown that it is necessary to use broader strokes in defining significant differences between sources of AI's.

- Present (PSR) policy provides no incentive for existing sources of AI's to improve data.

- Present (PSR) system blocks newcomers and protects existing AI sources no matter how poor the data base is.

We propose to amend PSR: To encourage new data and to encourage new sources.

Proposed Categories:

(a) For a New source of New AI or a re-evaluated AI (post 1980), which require a full data package, there will be a 15 year protection period.

(b) Generic Category: Status occurs after the 15 year period as well as AI's with old data packages. New sources will be required to provide only a minimum of data (Min. Data = chemistry to show equivalency, acute toxicology and a negotiable package of other smaller studies). Generic AI's become priorities for re-evaluation.

(c) There is a potential for a 3rd category--INTERMEDIATE CAT:--AI's with at least some data which meet modern standards. Want to encourage generation of data to fill data gaps. For this we propose providing a protective period (5 or so years).

e.g's DATA:
i) 2 year chronic feeding study
ii) combined oncogenicity/chronic feeding
iii) multigeneration reproduction & teratology (2 species)
iv) negotiable

The basic ideas relating to a modification of PSR have been presented to various industry organization representatives. There will be a draft memorandum going out seeking comment and feedback from industry, and there will be another general meeting with industry sometime in the first half of 1984. This will be similar to the meeting held last February. Notices will be going out well in advance once a date has been established.

W.E. Stewart, Ph.D.
Evaluation Officer
Pesticides Division

November 1983

11th Annual Pest Control Forum
Ottawa, Ontario
15-17 November, 1983

Overview Statement, Forest Pest Management Institute

T.J. Ennis

In my introductory remarks, I will attempt to be quite brief, touching in a very summary manner on some of the highlights, good and bad, of the past year in the areas of pesticides and herbicides. I will then focus more closely on recent developments and changes at the Forest Pest Management Institute which will set the stage for the more specific reviews of programs that Errol Caldwell and I will present shortly.

Having just mentioned Errol's name, it is appropriate to introduce him to this forum as the most recent addition to our staff. Errol has assumed duties as Program Manager, Chemical Control Agents, taking over the position vacated by Jack Armstrong when he moved to CFS Headquarters as Pesticides Advisor. Errol of course is no newcomer to the Forum, but this is his first appearance here as a representative of the FPMI.

Many of the highlights of this year, as well as the follow-up to last year's Forum items, will be covered in the Program Managers' overview statements and in tabled reports, so I will not cover them at this time. There are those areas I would like to touch upon. The first of these is the Nova Scotia Supreme Court Decision on Phenoxy Herbicide Use. Many if not all of you will have seen this report, but in summary, the Honorable Mr. Justice D. Merlin Nunn handed down his decision on September 19, 1983, regarding the trial between Nova Scotia Forest Industries (NSFI) and a group of Nova Scotia landowners who sought a permanent injunction on

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the use of 2,4,D and 2,4,5-T for Forestry use in Nova Scotia. NSFI's need for and interest in the use of these chemicals will be clear to all of us and need not be discussed here. Most of the plaintiff's concerns arose from perceived health risks of the phenoxy herbicides and associated dioxin contaminants, of water contamination, food residues and environmental impact of proposed spraying near their lands.

This trial apparently was the first in which perceived health hazards were addressed, rather than technicalities associated with the approval process. In reaching his decision that "I am satisfied that the overwhelmingly currently accepted view of responsible scientists is that there is little evidence that, for humans either 2,4-D or 2,4,5-T is mutagenic or carcinogenic and that TCDD is not an effective carcinogen, and further, that there are no-effect levels and safe levels for humans and wildlife for each of these substances", Mr. Justic Nunn had some additional and relevant observations. As to the restrictions in several jurisdictions on 2,4,5-T which is a Federally registered product, he states "However, I have no evidence before me indicating that any restriction or prohibition is the result of a scientific enquiry. All seem to be political decisions made for whatever reason". Concerning the fact that the court proceedings were to some extent an appeal of the regulatory decision to continue registration of these compounds, he stated "any such approach through the courts ought to be discouraged in its infancy. Opponents to a particular chemical ought to direct their activities toward the regulatory agencies or indeed, to government itself where broad areas of social policy are involved. It is not for the courts to become a regulatory agency of this type".

Although the debate will no doubt continue over the use of these and other materials in forest renewal, it is hoped that the precedent setting decision in this case will help keep this debate in the scientific arena where they belong, and not in an emotional one.

A second area of major progress in 1983 has been the granting of Registration to the first two insect viruses ever so approved for forestry use in Canada: Lecontvirus, for use against the red-headed pine sawfly; and Virtuss, for use against the Douglas fir tussock moth. Lecontvirus was used operationally this year by OMNR personnel while Virtuss was not for a variety of reasons including rapid insect development. Some additional data requirements have been identified for these viruses, and acquisition of this data is proceeding, either with Institute resources, or in the case of safety related tests such as delayed dermal sensitivity, by contract. Much of the data for the Virtuss registration package was derived from the EPA submission for TM Biocontrol-1, the U.S. product. With registration in the U.S. of Gypchek, the gypsy moth NPV, and NeoCheck-S, the European pine sawfly NPV, much of the data necessary for submission for registration in Canada is now available, easing the burden on us as we move forward on registering these in Canada.

Mention of these viruses brings up a topic that we have addressed in the past with quite limited resources, and one that will become increasingly important as more biological control agents become available. That is the need for a Biological Control Facility which can produce such agents in amounts sufficient for operational use. In the absence of industrial interest at present in the development and production of highly specific pathogens with relatively small potential markets, they are presently being produced by time and labour expensive methods at Research centres such as the Institute. With anticipated increased future requirements for not only pathogens but also parasites and predators, the need for, and operation of a Biological Control Production Facility is an issue that we are actively looking at at the Institute.

An additional area of progress has been the institution by CFS of the Program for Research by Universities in Forestry or PRUF. Using funds allocated to the Institute under this program, we have initiated contracts with several universities to conduct research into the environmental fate of Velpar, Garlon and glyphosate; for evaluation of insecticides used in spruce budworm control on non-target aquatic organisms using a flow-through stream system; and for production and provision of mono-clonal antibodies for use in our B.t. and virus research programs. It is anticipated that the output from these contracts will help accelerate research and development in the areas named above.

One disappointing development in the past year has been the decision by Dow to cease the production of 2,4,5-T. This decision will have significant impact on the potential effectiveness of herbicide usage, as it removes a very effective herbicide from what is already a severely limited selection of materials registered for forestry use.

This then is a brief overview of the past year. One additional item I would like to cover before moving on to our report on the studied carried out is to update the participants in this Forum on the Institute organization, which has been changed in the last year. A copy of this and of our Project Staff Listing is available as a handout. Briefly, we have organized our Projects into two programs, Biorational Control Agents, under my management, and Chemical Control Agents, under Errol's. Within the first, we now have all pathogen projects under Microbial Control, our complementary research projects such as tissue culture, cell biology, immunochemistry and systems analysis under Biological Interactions, and our pheromone, IGR and genetics projects under Physiological and Genetics Mechanisms. Moving to Chemical Control Agents, we have grouped insecticide toxicology, field efficacy, insect biology, high value stand protection and herbicide development and use into the Pesticide Toxicology and Efficacy Program. Application Technology now includes dispersal system, pesticide formulations and spray cloud behavior, while the Environmental Concerns Program encompasses environmental impact and chemical accountability. The Complementary Services project with insect, plant and pathogen production is jointly managed by the Program Managers.

Associated with this reorganization has been some staffing additions and changes. We have recruited a systems analyst, Richard Fleming, as well as a professional in spray cloud behavior, Nicholas Payne. The professional complement in the herbicide project is now complete. In addition to Raj Prasad, we now have Phillip Reynolds as Project Leader responsible for herbicide efficacy and application, and Joe Feng responsible for chemical residue analysis. Peter DeGroot has assumed leadership of the high value stand project. Cecilia Feng is now the residue chemist in the chemical accountability section. Our remaining professional vacancies are in the field side of bacterial pathogens, in immunochemistry and in dispersal systems, and we are actively engaged in identifying candidates for these.

The net result of the reorganization and of staffing is that we feel we are now in an improved position to pursue our research, both in terms of a nearly full professional complement and in the inter-project working relationships that have been established.

FPMI Report on Studies Carried Out by

the Biorational Control Agents Program 1983

T. J. Ennis

As I earlier mentioned, in the reorganization at the Institute the insect pathogen, pheromone, Insect Growth regulator and genetics projects were grouped together under the biorational control agents program. The use of the term biorational should be explained. It is derived from the EPA registration protocols document and is intended to infer to control agents that are either naturally occurring agents or synthesized compounds identical in structure to naturally occurring compounds. Pathogens pose no difficulties in inclusion under this term, but the Insect Growth Regulators and many of the pheromones are synthetic analogues that bear little relationship to naturally occurring compounds. Such compounds have been, and undoubtedly will continue to be, treated as chemicals in the registration process. Nonetheless, we have included them in the Biorational Control Agents Program, partly for administrative reasons and partly because they are functionally related to the other projects in this program.

This brief review will serve to highlight progress made in these projects during 1983 and plans for 1984. Where warranted, more detailed reports have been tabled for some of the projects, specifically Mycology, Protozoology, and Virology.

FP-10 Toxicity and Mode of Action of *B.t.*

Over the past year, work has continued on purification and isolation of the low molecular weight fragment that retains its toxicity.

Some difficulty has been encountered in consistently obtaining a stable preparation of the fractions, but it is anticipated that the recent acquisition of HPLC equipment for this project will permit more rapid progress towards isolation and identification. It is of interest to note that genetic research at other research institutes has resulted in the development of a nearly complete genetic map for the B.t. crystal. Possession of such a map should rapidly increase our knowledge of the mode of action of B.t. and, potentially, means for improving it. As a followup to laboratory work that demonstrated that spruce budworm larval mortality is both dose and time dependant, and is significantly affected by droplet density and concentration on the foliage, a field trial was carried out this summer by Research and Productivity Council, New Brunswick, under the joint sponsorship of MFRC, CFS Headquarters, FPMI, FPL and CANUSA (U.S. East). The objective of the study was to relate foliar deposit of B.t. to field efficacy at a single concentration and application rate by measurements to define deposit on trees selected for efficacy evaluation and by measurements to define deposit on shoots selected for the laboratory bioassay. Results are still being analysed, but preliminary indications are that deposit-mortality relationships identified in laboratory bioassays are being reflected in the field data.

During 1984, chemical characterization of the toxic moiety will be continued. Plans for further field research into host - B.t. interactions are dependant upon the outcome of this year's trials. It is anticipated that staffing of the vacant entomologist/pathologist position before 1984 will permit increased effort in this area.

FP-11 Mycology. Determination of the conditions necessary for spore formation, sporulation and maturation have continued. Germination and conidial formation can now be obtained for several species, leading to the expectation that the stages necessary for field experimentation will be available on a small scale in vitro production basis. Field study plots have been established in Lake Superior Provincial Park and at Black Sturgeon Lake, where the progress of infection in naturally occurring populations at two different levels is being monitored. It appears that the fungi can overwinter on the tree and initiate mycosis in subsequent years, given favorable environmental conditions. As a follow-up to 1982 experiments, further attempts were made to initiate mycosis by spraying single trees. Infection was successfully obtained.

In 1984, work will continue on developing and improving methods for spore germination and conidial formation for mass production purposes. Study of field populations will also continue, and the information gained will be incorporated into process models of budworm-fungus interaction. Studies on the initiation of fungal mycosis in single tree populations will continue to determine conditions necessary for occurrence, and optimal stage and timing of application.

FP-12 Protozoology. There was significant input by this project into the population studies described under Mycology in terms of diagnosis of levels and intensity of infection in field collected insects over the annual life cycle. Bioassays of *Nosema fumiferana* against the spruce budworm were carried out to determine LD_{50}'s for different larval instars. As well, three microsporidia were bioassayed against the forest tent caterpillar to determine their relative infectivities. Relating mortality figures obtained in laboratory bioassays to the levels and intensities of infection in field populations will provide a better understanding of the influence of low, increasing and high levels of infection on normal development of budworm populations.

In 1984, work will continue on defining the effects of microsporidian infection on spruce budworm populations, as part of an overall effort to better define and therefore understand the naturally occurring disease complex affecting the spruce budworm and its effects on population dynamics.

FP-13 Virology. Spruce budworm NPV was applied aerially against 2nd instar larval populations in Quebec; one early application, and one early and late application. Preliminary analyses indicate early applications were ineffective due primarily to the critical timing of application necessary. Follow-up studies were carried out on several insect population sprayed with virus in 1982. In B.C., it appeared that the Douglas fir tussock moth virus had spread from the treated plots to the buffer zones in 1982 and carryover provided a virus inoculum which had an impact early in the 1983 season. In western spruce budworm populations in B.C. that were treated with NPV and GV in 1982, limited carryover occurred, with some larval mortality being attributable to virus carryover. Carryover was somewhat better in the NPV-treated plot. In Ontario plots of gypsy moth sprayed with Gypchek in 1982, virus was found in both treated and untreated plots. The highest incidence in all plots was recorded at the onset of pupation.

The newly registered Lecontvirus was distributed by FPMI personnel to OMNR staff in 7 districts, and was used to treat 40 plantations with a total of 211 ha.

In addition to these field studies, research continued into the conditions and mechanisms involved in the spread and carryover of virus in natural populations, as did work on the identification and quantitation of viruses present in soil and foliage samples in treated areas. With the return of Dr. B. Arif from Career Development Leave, work is continuing into the biochemical characterization of viruses for registration purposes, as well as developing genetic information necessary to establish the potential of genetic manipulation for improving the efficacy of viruses.

In 1984, follow-up sampling will continue in the areas treated with western spruce budworm, Douglas fir tussock moth and gypsy moth viruses to determine extent of carryover into the second year post application. Studies on the environmental distribution of applied and endemic viruses will be carried out in conjunction with the above and in additional study plots. Biochemical and biophysical characterization studies will also continue. Through contract and in-house research, data requirements identified in the two virus registration packages will be met to the extent possible within resource limitations. Lecontvirus and Virtuss will be made available, as stocks permit, to provincial agencies interested in their use.

FP-20 Insect Pathogens *in vitro*

Effort in this project continued to be directed towards development of insect cell lines susceptible to virus infection. Accompanying this were studies designed to develop an *in vitro* bioassay for the tussock moth viruses, which has proven successful. Three eastern spruce budworm lines have been developed that are susceptible to homologous viruses, and a western spruce budworm cell line is being developed that hopefully will be more susceptible to the *C. fumiferana* virus. In the coming year, this work will continue with the aim of developing in vitro systems for the characterization and eventually the manipulation of viruses.

FP-21 Cell Biology. This project has continued to provide, on a cooperative basis, expertise in the cellular and subcellular effects of applied control agents, both biological and chemical, as well as in the identification of organs and glands involved in the production of sex pheromones and various hormones. The Project Leader is currently on Career Development Leave at the University of Texas, and during 1984, effort will concentrate on completing current cooperative work with the Institute projects.

FP-22 Immunochemistry. Until a new Project Leader is successfully recruited, hopefully by early 1984, this project has been and will continue to provide technical support to cooperating Institute projects.

FP-23 Biological Systems Analysis

A Project Leader, Richard Fleming, was successfully recruited in June, 1983, and has spent the time since identifying areas of Institute program that can best benefit from systems analysis input, as well as providing expert modelling input into development of process models for a variety of biological and physical systems. A project analysis is also being prepared, and upon review and acceptance by management, this project will provide very significant input into Institute's aim of using a systems approach to entomology, pathology, and application technology as they relate to control methods.

FP-30 Pheromones

Much of the FPMI effort in pheromones involves cooperative studies to identify sex pheromones of forest insect pests or to at least provide adequate attractants. Good attractants are available for such insects as *Croesia semipurpurana, Choristoneura occidentalis* and some of the *Orgyia* species complex, but much more work is required to improve the attractants for *Zeiraphera canadensis, Dioryctria reniculloides* and *Orgyia leucostigma*. In addition, for some of these species, trap baits are being optimized to provide the basis for a monitoring system that can be used for detection or monitoring of population trends.

The Project Leader, Gary Grant, was on Career Development Leave during 1983. In 1984, work will continue on improving the attractiveness of known baits, identifying new ones and investigating the potential for mating disruption in populations of selected insect species.

FP-31 Growth Regulators

In the absence of the Project Leader, Arthur Retnakaran, on Career Development Leave during 1983, work in this project has centered primarily in screening of new IGR's such as CGA-112913 (formerly UC-62644), Avermectin and products from Nihon and Cela Merck. Limited single tree trials were carried out against the jack pine budworm using Dimilin, and results were unsatisfactorily at the equivalent of 70 g/ha. Follow-up studies were carried out on the effect of juvenile hormone analogues and IGR's on overwintering survival and fecundity of the white pine weevil. Laboratory studies on the hormonal control of cuticle formation and moulting continued. In 1984, screening and biochemical studies will continue, with specific program to be developed upon the Project Leader's return in January, 1984.

FP-32 Genetic Mechanism

This project is in abeyance and remains unstaffed because of Person Year limitations.

EXPERIMENTAL LABORATORY AND FIELD

STUDIES WITH ENTOMOGENOUS FUNGI

(Study Ref. No. FP-11-2)

Report to the Annual Pest Control Forum,

Ottawa

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Sault Ste. Marie, Ontario

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ANNUAL FOREST PEST CONTROL FORUM - 1983

Experimental Laboratory and Field Studies with Entomogenous Fungi

Introduction

This study has evolved into a multi-faceted approach to the investigation of the epidemiology of fungal pathogens and their interactions between other microbial pathogens and entomogenous parasites. This involves:

- detailed natural history studies on the spruce budworm and its role in the forest as defoliator and host to a large number of parasites and pathogens. Data is used to describe the degree of mortality inflicted on life stages of budworm by each separate cause of death, as well as to define the subtle relationships between the natural enemies, even at sub-lethal levels.
- determination of the influence of abiotic parameters on the development of the parasites and pathogens.
- simulation and process modelling of the above for use in devising strategies for the management of budworm numbers.
- attempting to artificially induce fungal epizootics under field conditions, by first testing different strategies in the laboratory and greenhouse and then at a small-scale in the field.
- screening fungal isolates for their effects on spruce budworm and other forest pests, with the idea of utilizing pathogens which do not naturally occur in large numbers on pest insects but present advantages in terms of mass production, formulation and storage.

In the past it has been felt that although fungi of the Entomophthorales can cause dramatic levels of mortality in spruce budworm and other forest pests, the use of these pathogens would be limited due to climatic constraints, most importantly humidity. This study has been designed to determine the role of fungi in regulating spruce budworm numbers and to assess the potential for the operational use of fungi in forest insect management. Although fungi have been used in agriculture against several pests and great success has been obtained with some, as exemplified by the recent registration of fungal agents as insecticides such as Verticillium lecanii (= Vertalec), and Hirsutella thompsonni (= Mycotal), the integration of fungal pathogens into an effective management program in the forest has yet to be achieved. Research to date has shown that it is probable that there will be factors which may limit the efficiency in which fungi can be used, but this is not different than any other biocide. The extent that fungi can be employed in any long-term management plan will depend on many things, perhaps most importantly a thorough understanding of their epidimiology.

Objectives

To study the interaction of entomophthoraceous fungi with other pathogens and parasites and forest insect pests, to determine and realize the potential for the use of a fungus in forest management. This involves:

- the monitoring of micro- and macroclimatic conditions while determining both quantitatively and qualitatively the role of fungi in the natural enemy complex which causes mortality in spruce budworm.
- controlled climate studies to examine the effects of abiotic conditions on pathogen development.

- studying the processes that lead to infection of the host in order to construct strategies for the use of pathogens in pest management.

The realization of the above objectives is being attempted through field, greenhouse and laboratory studies to provide data for analyses and detailed process modelling of the epidemiology of the host and pathogens. Results are actively being tested in the models and through treatment trials.

Progress

Field Studies-Natural History

In 1982 a collaborative study was initiated with J. Régnière and G.G. Wilson and intensive sequential sampling of spruce budworm was undertaken in Lake Superior Provincial Park. In 1983 the study was expanded to include a comparison with a separate budworm population at Black Sturgeon Lake. This was done in order to investigate mortality in budworm at different stages of their proposed population cycle. This portion of the research pertains to a detailed determination of the role of each causal agent in the death or debilitation of Choristoneura fumiferana. Through the combined effort of the three research scientists samples were taken throughout the life of the host, from both Abies balsamea and Picea glauca. Insects were then reared in the laboratory until they died or became adults. Sub-samples were examined microscopically for the presence and quantity of fungal, protozoan, viral or bacterial diseases. As insects died, individuals were diagnosed and the cause of death determined. Entomogenous parasites were identified to species; with the exception of Tachinid flies, all microbes were identified and in selected individuals spore counts were made. In this way detailed survivorship curves were established for each stage and mortality factor.

Emerged moths were mated and offspring at the egg stage as well as each instar were examined for spore concentration of Nosema fumiferanae, a major protozoan pathogen.

Field Studies-Persistence

Resting spores and conidia of Zoophthora radicans and conidia of Entomophthora egressa were released in controlled areas and their subsequent survival monitored throughout the spring and summer. These experiments will continue all year long until the limits of survival are determined. It is interesting to note that an infective inoculum can survive in the canopy as well as on the soil surface and that resting spore germination may take place under snow cover. These results are being compared with experiments at constant temperatures and humidities in the laboratory.

Field Studies-Treatment Strategies

In conjunction with the above several attempts were made to artificially introduce Zoophthora radicans and Entomophthora egressa into spruce budworm populations under field conditions. In 1981, 1982 and 1983, these fungi were released on small trees (< 2 m) where larvae had been introduced. In 1981 and 1982 collaborative studies were run in parallel in Ontario and Newfoundland (with the cooperation of K.P. Lim). In 1982, through field experiments involving the release of in vivo produced conidia of E. egressa and in vitro produced conidia of Z. radicans it was possible to cause mortality levels higher than 60% in infestations comprised of fourth, fifth and sixth instar individuals. In 1983 several refinements were made. Insects were established on the test trees six weeks prior to treatment with conidia or resting spores, which were applied with a spinning disk nozzle. At the treatment dates larvae were well hidden in the foliage; however it was possible to infect insects with all treatments although no background mycosis was observed.

Greenhouse Experiments

A methodology for bioassay experiments in the greenhouse was developped for use with Entomophthorales fungi. Conidia were collected in solution and applied in known dosages to small balsam fir trees infested with spruce budworm. A microprocessor controlled misting system maintains sufficient humidity (leaf wetness) for infection and disease to occur. The effects of conidial concentration and distribution on different budworm stages are currently under investigation.

Screening of Potential Pathogens

In 1982 a cooperative project with J. Fargues (INRA, France) was begun. Oviphagous isolates of six imperfect fungi were added to the culture collection at FPMI and testing was begun to determine the effect of temperature on germination, growth and persistence as well as a screening of isolates for infectivity against several forest pests, notably _C. fumiferana_ and _Zeiraphera canadensis_. Methodology is being developped for the determination of virulence of each isolate and for each stage of a potential target species.

Laboratory investigations

Throughout the period extending from 1981-1983 a large amount of data was accumulated on the influence of temperature on the development of the two Entomophthorales species under study. Rates of germination, growth and persistence were determined. These results were used to design the above field experiments, through the use of simulation and process models, constructed for this purpose.

Modelling

The following models were adapted or created to aid in the design of experiments and more importantly to be used in the derivation of strategies for the operational use of fungi in forest pest management:

- A process model for temperature dependent development of C. fumiferana;
- A process model of the life cycle of Zoophthora radicans based on developmental rates for each stage at different temperatures;
- A simulation model for the persistence of a fungal inoculum under field conditions.

Other

Resting spore germination studies were continued with Z. radicans and expanded to Erynia crustosa, where germination was obtained and described for the first time. Various insects were tested as in vivo sources of conidia or resting spores and success was obtained with the forest tent caterpillar and the tobacco hornworm. These insects were used to provide experimental material for the manipulation of the fungi in the laboratory, greenhouse and field. The complete bibliographical collection was catalogued and digitized for easy access as was the record for fungal collections that have been processed at FPMI.

A 1983 SURVEY OF TWO UNTREATED PLOTS AND TWO PLOTS SPRAYED IN 1982 WITH GYPCHEK (NUCLEAR POLYHEDROSIS VIRUS) TO CONTROL GYPSY MOTH IN ONTARIO

(Study Ref. Nos. FP-13-3 and FP-13-4)

Report to the Annual Forest Pest Control Forum, Ottawa

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ANNUAL FOREST PEST CONTROL FORUM - 1983

A 1983 survey of two untreated plots and two plots sprayed in 1982 with Gypchek (nuclear polyhedrosis virus) to control gypsy moth in Ontario

Summary

Three samples of gypsy moth larvae were collected from four plots and examined microscopically to determine the incidence of nuclear polyhedrosis virus (NPV). Two of these areas had been sprayed with Gypchek in 1982 and two had no history of virus treatment. Virus was found in larvae from all four locations and the highest incidence in all plots was recorded at the onset of pupation. In one treated plot 76.5% of larvae were found to be infected and in one check 76.8% were infected; disease incidence in the second treated plot and second check plot was much lower.

Introduction

In collaboration with staff of Great Lakes Forest Research Centre (GLFRC) and Ontario Ministry of Natural Resources (OMNR), aerial spray trials were conducted in 1982 near Kaladar, Ontario to determine the efficacy of Sevin-4-Oil®, Bacillus thuringiensis (Dipel 88®) and a nuclear ployhedrosis virus (Gypchek) for the control of gypsy moth. Results of this trial are reported in detail in Canadian Forestry Service Information Report O-X-352. Incidence of virus infection was recorded at weekly intervals following the application of Gypchek on two plots in 1982 and compared to buildup of naturally occurring disease in two check plots. A suprisingly high incidence of naturally occurring NPV was found in one untreated check. Monitoring of these four plots was continued in 1983.

Survey of Incidence of NPV

Three collections of larvae were made from the four plots and kept frozen until examined. On May 17, larvae were just hatching and were found localised on egg masses. Larvae were mainly in the fourth instar on May 30 and on June 13th were in the fifth and sixth instars. Larvae from the first collection were too small to dissect so they were smeared, stained with buffalo black and examined for the presence of polyhedral inclusion bodies. Larvae from the two later collections were dissected and squash preparations of gut and fat body tissue examined under phase contrast optics. Dead larvae, included in the third collection, were smeared and examined under phase contrast without staining the preparations.

Results

The results are shown in Table 1 along with the results of the last collection made in 1982. The low levels of virus infection detected in the first sample were most likely the result of hatching larvae ingesting, on eclosion, polyhedral inclusion bodies contaminating the chorion of the egg and dense mat of hair on the egg mass. This virus, which persisted from the previous year, probably provides the primary inoculum for the initial development of a disease epizootic.

The highest incidence of virus was found in the third sample. Virus-killed larvae were also present at that time and it was difficult to collect an unbiased sample for microscopic examination when larvae are found mainly on the branches and trunks of the trees and no standard sample unit was used. Only live larvae were collected in the 1982 survey and this year an attempt was made to obtain a random sample of both living and dead. The figures obtained just prior to pupation in 1983 paralleled those obtained in 1982. In the treated plots, in infestation 1, 48.1% of larvae were infected with NPV in 1982 and 76.5% in 1983 and in infestation 3, 21.3% in 1982 and 23.2%

in 1983. In the untreated plots, a naturally occurring NPV epizootic caused infection in 41.2% of larvae in 1982 and 76.8% in 1983 in infestation 1. In the second untreated plot at Pitts Ferry, located east of Kingston and some distance from the Kaladar outbreak, NPV accounted for infection in 19.8% of larvae in 1982 and 16.8% in 1983.

Conclusions and Recommendations

It is evident that naturally occurring NPV is prevalent in gypsy moth populations in Ontario, making it difficult to distinguish between the effect of virus infection due to an application of Gypchek and that due to naturally occurring NPV.

Application of NPV in 1982 resulted in advancing the timing of the epizootic in infestations 2 and 3 compared to the naturally occurring epizootics which occurred in untreated infestation 1 and the Pitts Ferry check. The progress of epizootics in both the treated and untreated areas was similar in 1983, and it was not until late in larval development that a high percentage of larvae were found to be infected with NPV. This is to be expected as the mechanism of epizootic initiation, probably by contaminated egg masses, was the same in both treated and untreated plots. It is advantageous to spray virus even when natural virus epizootics are anticipated as spraying will kill larvae earlier in their development and reduce defoliation.

It was thought that the high incidence of NPV recorded in infestation 2 (treated) and infestation 1 (check) in 1982 would have suppressed these populations, but this was not the case and a very heavy population was again present in infestation 1 in 1983. Surviving adults and egg masses were observed in 1983 and it is presumed that this outbreak will continue in 1984. It is therefore concluded that even with high levels of a naturally occurring NPV, gypsy moth outbreaks do not rapidly collapse.

Gypchek is manufactured by the USDA Forest Service and is presently not commercially available. Because of gypsy moth quarantine regulations, there are no plans to produce this virus at FPMI. If, however, a commercial product does become available, further testing in Canada is recommended. With the localised nature of gypsy moth infestations in Ontario, use of a biorational control agent, such as NPV, is an attractive alternative to conventional chemical pesticides.

Plans for 1984

One sample, taken late in insect development, will be collected from the same two treated and two untreated plots in 1984 and the incidences of larvae infected with NPV.

Table 1. Incidence of NPV infection in four populations of gypsy moth (two sprayed with Gypchek in 1982 and two untreated) in eastern Ontario in 1982 and 1983.

	Percent NPV and number of larvae examined (within parentheses)			
	Date examined			
Plot	6 July 82	17 May 83	30 May 83	13 June 83
<u>Treated in 1982</u>				
Infestation 2	48.1 (187)	3.8 (210)	18.0 (200)	76.5 (264)
Infestation 3	21.3 (164)	2.4 (210)	2.0 (200)	23.2 (216)
<u>Untreated</u>				
Infestation 1	41.2 (182)	0 (203)	5.0 (200)	76.8 (297)
Pitts Ferry	19.8 (182)	1.8 (217)	1.0 (200)	16.8 (209)

A 1983 SURVEY OF PLOTS SPRAYED IN 1982 WITH GRANULOSIS VIRUS AND NUCLEAR POLYHEDROSIS VIRUS TO CONTROL WESTERN SPRUCE BUDWORM

(Study Ref. Nos. FP-13-3, FP-13-4 and PC-08-289)

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A 1983 survey of plots sprayed in 1982 with granulosis virus and nuclear polyhedrosis virus to control western spruce budworm

Summary

In 1983, two samples of western spruce budworm larvae were taken from a plot sprayed with granulosis virus (GV) in 1982, a plot sprayed with nuclear polyhedrosis virus (NPV) in 1982 and three untreated check plots. The first sample was taken after budflush (June 9-14) and the second sample at the onset of pupation (July 5-10). Population counts were taken from 46 cm branch tips and the population reduction during this period, attributed to virus carry-over, was 14.7% in the GV-treated plot and 33.7% in the NPV-treated plot. In addition to the population studies, two samples of larvae were collected (June 10-14 and June 21-23) and reared individually on artificial diet until death or adult emergence. Successful adult emergence ranged from 42.4 to 49.6% in samples from the two virus-treated plots and from 60.5% to 73.4% in the untreated checks. Dead larvae were examined microscopically for the presence of viruses and other pathogens.

Introduction

In 1982, a spray application was conducted near Ashcroft, B.C., to test NPV and GV as population regulating agents for western spruce budworm. Full details of the application and assessment in 1982 are given in a 1982 Forest Pest Control Forum Report. Briefly, 9 kg of lyophilized NPV-infected spruce budworm larvae were applied to one 172 ha plot and 9 kg of lyophilized, GV-infected spruce budworm larvae were applied to a second 172 ha plot when larvae were in the fourth instar. The dosage of NPV was 5.4×10^{11} polyhedral inclusion bodies (PIB)/ha and the dosage of GV was 1.7×10^{14} capsules

(CAP) /ha. Population reduction due to the GV treatment was calculated to be 34.6% (Abbott's formula) and due to the NPV treatment was 51.8%. Percent successful adult emergence was 52.7% from samples of larvae from untreated check plots reared individually in the laboratory; from samples from the NPV-treated plot, this figure ranged from 6.1 to 12.7% and from samples from the GV-treated plot ranged from 11.8 to 23.8%.

It was considered that successful introductions of both viruses had been made and that the NPV treatment had a greater initial impact than the GV treatment. When these viruses are applied at budflush, there is insufficient time for secondary infection to occur and only larvae which ingest a lethal dose of the actual spray deposit die. It was hoped that dead larvae, remaining over winter on the foliage, would release sufficient virus into the environment to initiate a virus epizootic in 1983. Surveys were conducted in 1983 to determine the impact of virus carried over from one season to the next and the results of these surveys are reported here.

Assessment in 1983

The same assessment procedures were used in 1983 as in 1982. Three lines, with 15 Douglas-fir trees per line, were sampled between June 9 and June 14 on the NPV- and GV-treated plots and again between July 5 and July 10; three check plots with two lines of 15 Douglas-fir trees per line were sampled on the same dates. Two 46 cm branch tips were taken from each sample tree on the first sampling date and four on the second. Population reduction attributed to virus carry-over was calculated from the mean number of larvae/46 cm branch tip in the plots compared to the mean number of larvae/46 cm branch tip in the checks.

In addition to the population studies, two samples of larvae were collected from trees adjoining the trees used for the population counts. These samples were collected on June 10 and 14 and June 21 to 23. Larvae were reared individually on artificial diet until death or adult emergence. Parasite emergence was recorded; dead larvae were smeared, stained and examined microscopically under oil immersion to detect the presence of NPV, GV and other pathogens.

As in 1982, it was not possible to make meaningful defoliation estimates because of pockets of high populations of Douglas-fir tussock moth throughout the area.

Results

Results of the population studies are shown in Table 1. Population reduction attributed to virus carry-over in the GV-treated plot was 14.7% and in the NPV-treated plot was 33.7%.

Results from the samples of larvae reared individually in the laboratory are given in Table 2. Successful adult emergence was 46.0 and 46.4% in the two samples from the NPV-treated plot, 49.6 and 42.4% from the GV-treated plot and was notably higher in the two samples from the check plots at 60.5 and 73.4%.

GV was recorded in the NPV-treated plots as well as NPV; NPV was found in the GV-treated plots as well as GV; and both NPV and GV were detected in the check plots. Incidence of NPV in the NPV-treated plot was 28.4% of larvae in the first sample and 20.5% in the second sample; incidence of GV in the GV-treated plot was 6.7% of larvae in the first sample and 15.2% in the second sample. Incidence of parasitism in both treated plots and the checks ranged from 2.5 to 13.3%.

Conclusions and Recommendations

Naturally occurring NPV and GV have been detected in populations of both eastern and western spruce budworm, but never at levels high enough to exert a population regulating effect. Laboratory tests have shown that both viruses are considerably more pathogenic to the western than to the eastern species. Following application of NPV on western spruce budworm in 1978, virus carry-over was detected in 1979 and 1980, with populations in the treated plots declining as compared to checks in 1979, but increasing dramatically in 1980. The potential of GV as a biocontrol agent for western spruce budworm was tested for the first time last year.

When spruce budworm viruses are applied at budflush, there are only 2 to 4 weeks between the application date and pupation and there is no time for secondary infection to occur by release of virus inoculum from cadavers on to the foliage. It was hoped that sufficient virus would be present in the environment in 1983 to initiate virus epizootics when early instars of spruce budworm were present which, in turn, would regulate the population on reaching the later instars. Both NPV and GV did have an impact in the year following the year of application, but the effects were much less pronounced in 1983 than in 1982. The NPV had a greater impact than the GV in 1982 with 51.8% population reduction due to treatment compared to 34.6%. In 1983, the situation was similar with 33.7% population reduction attributed to NPV carry-over compared to 14.7% GV carry-over. NPV is a faster acting virus than GV, taking about 14 to 20 days to kill larvae under field conditions compared to 20 to 30 days for GV. Based on results from both 1982 and 1983, NPV appears to be the better candidate as a biocontrol agent for western spruce budworm. However, neither virus gave an acceptable level of spruce budworm population regulation either in the year of application or in the following year.

When results from larvae reared singly in the laboratory in 1982 are compared to those obtained in 1983, several interesting trends can be observed. The impact of both NPV and GV, although quite evident in 1983 was much less than in 1982. Percent successful adult emergence in the two treated plots ranged from 6.1 to 23.8% in 1982 compared to 42.4 to 49.6% in 1983. Percentages of virus-killed larvae were much lower in 1983 than in 1982. Levels of parasitism remained about the same in both 1982 and 1983.

The impact of virus carry-over in 1983 was generally considered to be disappointing. As naturally occurring virus epizootics have never been recorded in spruce budworm, no conclusions can be drawn as to why the introduction of either NPV or GV in 1982 did not initiate an epizootic in 1983. Western spruce budworm population densities were considered to be medium to low in both 1982 and 1983 and epizootics of any disease organism are much more likely to occur at very high population densities. Spruce budworm larvae at lower population densities do not come into contact with each other, as one larva usually occupies one bud. At high population densities, all new foliage is consumed and there is much more contact between larvae when back-feeding on old foliage occurs. This prompts one to consider retesting NPV on western spruce budworm when this insect is present at much higher population densities.

Plans for 1984

To resample the NPV-and GV-treated plots and three check areas to determine the incidence of virus infection in the western spruce budworm population in the second year following the year of virus application.

Table 1: Population studies in 1983 on plots sprayed with NPV and GV in 1982 to control western spruce budworm and on untreated check plots near Ashcroft, B.C.

Plot	June 9-14 Mean no. of larvae/46 cm branch tip	July 5-10 Mean no. of larvae/46 cm branch tip	Percent population reduction attributed to virus carry-over*
GV	8.0	4.6	14.7
Checks	12.9	8.7	
NPV	9.4	4.2	33.7
Checks	12.9	8.7	

*Calculated by Abbott's formula

Table 2: Samples of western spruce budworm larvae, colledted in 1983, from plots treated with NPV and GV in 1982 and untreated checks near Ashcroft, B.C., and reared individually on artificial diet in the laboratory. Dead larvae were smeared, stained and examined for pathogens.

Plot	Date sampled	Total number of insects reared	Percent dead containing NPV	Percent dead containing GV	Percent parasitized	Percent dead from unknown causes	Percent successful adult emergence
NPV	14 June	148	28.4	1.4	10.1	14.8	46.0
	23 June	151	20.5	2.7	13.3	18.5	46.4
GV	10 June	135	9.6	6.7	11.9	22.2	49.6
	22 June	198	5.6	15.2	6.1	32.3	42.4
Checks	10 June	296	9.1	2.0	10.1	19.3	60.5
	21 June	158	6.3	0.0	2.5	17.7	73.4

A 1983 SURVEY OF UNTREATED AREAS AND PLOTS

SPRAYED IN 1982 WITH VIRTUSS (NUCLEAR POLYHEDROSIS VIRUS)

TO CONTROL DOUGLAS-FIR TUSSOCK MOTH IN B.C.

(Study Ref. Nos. PC-08-289 and FP-13-3)

Report to the Annual Forest Pest Control Forum, Ottawa

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ANNUAL FOREST PEST CONTROL FORUM - 1983

A 1983 survey of untreated areas and plots sprayed in 1982 with Virtuss (nuclear polyhedrosis virus) to control Douglas-fir tussock moth in B.C.

Summary

Four 10 ha blocks sprayed with Virtuss in 1982, 5 buffer zones adjoining or between these plots and four untreated check plots were sampled twice in 1983 to determine the population density of Douglas-fir tussock moth larvae and the incidence of nuclear polyhedrosis virus (NPV). In the first sample, collected between June 8 and June 24, Douglas-fir tussock moth populations were very low both in the sprayed plots and buffer zones and the incidence of larvae infected with NPV ranged from 7.3 to 43.5% in these areas. Populations in the check plots were high and the incidence of NPV low. In the second sample, collected between July 14 and July 28, populations in the treated plots and buffer zones were even lower and the incidence of larvae infected with NPV has increased, ranging from 39.2 to 80.8%. Populations in three of the four check plots had virtually collapsed and high levels of NPV infection were observed in these plots ranging from 74.4 to 81.7%.

It is concluded that virus had spread from the treated plots to the buffer zones in 1982 reducing the population and introducing virus inoculum which had an impact early in the 1983 season. A naturally occurring virus epizootic decimated populations in 3 of the 4 check plots later in the 1983 season.

Western spruce budworm was also present in all the areas surveyed and population densities of this species were also recorded.

Introduction

Four 10 ha plots near Veasy Lake, Kamloops District, B.C. were aerially sprayed with Virtuss in 1982 and full details of the application and assessment are given in a 1982 Forest Pest Control Forum Report. A dosage of 2.5×10^{11} PIB/ha was applied in an emulsifiable oil formulation on one plot and the same dosage in molasses formulation on a second plot. The remaining two plots were sprayed with dosages of 8.3×10^{10} and 1.6×10^{10} PIB/ha respectively in the oil formulation. Population reduction due to treatment (Abbott's formula) ranged from 90.1 to 93.1% in the three plots treated with higher dosages and 59.6% in the plot treated with the lowest dosage.

Four untreated check plots were sampled in order to calculate the population reduction and incidence of virus infection was also monitored in larvae from both treated and check plots. At 5-6 weeks post-spray, 84.5 to 100% of larvae in the treated plots were infected compared to 1.4 to 11.0% in the check plots.

Population densities of Douglas-fir tussock moth and western spruce budworm were recorded in 1983 on the 4 treated and 4 check plots and the incidence of NPV infection in Douglas-fir tussock moth larvae determined microscopically. Areas adjacent to the treated plots and between them were also monitored to determine if virus had spread from the treated plots.

On June 3, 1983, Virtuss was granted temporary registration status under the Pest Control Products Act (Canada). However, due to a variety of circumstances, no Virtuss was sprayed in 1983.

Assessment in 1983

The four treated plots numbered 2, 3, 4 and 5 in 1982, were located in a straight line with buffer zones between them. Samples were taken at 25 m intervals diagonally across these plots. For population counts a pair of 46 cm branch tips were taken from one tree at each sample point. Douglas-fir tussock moth larvae were counted and kept for microscopic diagnosis and, when numbers were low, they were supplemented by beating larvae from neighboring trees. As fairly high populations of western spruce budworm were encountered in the area, counts of this species were also recorded. The same studies were undertaken in the check plots which were numbered 1, 6, 7 and 8 in 1982.

Plot 2 received the lowest dosage in 1982, Plot 3 the middle and plots 4 and 5 the highest dosage. The area adjoining plot 2 was designated buffer zone A, the area between plots 2 and 3 was designated B etc., and the last buffer zone adjoining plot 5 was designated E. Samples were taken straight across these buffer zones at 25m intervals and the same parameters measured as in the treated and check plots.

Two samples were taken, the first between June 8 and June 24 when larvae were in the third and fourth instars and the second between July 14 and July 28 when larvae were in the fifth and sixth instars.

Results

Results from the first sample are shown in Table 1. There was little difference in Douglas-fir tussock moth population density between the buffer zones and plots sprayed in 1982 with the mean number of larvae/46 cm branch tip ranging from 0.23 to 0.89. In the check plots, populations ranged from 3.07 to 33.67 larvae/46 cm branch tip. Western spruce budworm populations were generally higher in the treated plots and buffer zones (1.5 to 33.9 larvae/46 cm branch tip) compared to the check plots (0.96 to 9.04 larvae/46 cm branch tip). In this sample, the incidence of NPV in Douglas-fir tussock moth larvae was similar in the treated plots and buffer zones. The incidence of NPV was considerably lower in the check plots ranging from 1.9 to 7.9% of larvae infected.

Results from the second sample are shown in Table 2. Populations of Douglas-fir tussock moth were lower than in the first sample and reached levels at which this species was virtually absent. Counts of larvae/46 cm branch tip ranged from 0 to 0.21. Incidence of NPV in the few remaining larvae increased over the first sample and ranged from 39.2 to 80.8%. Western spruce budworm populations also declined and ranged from 0.47 to 4.93 larvae/46 cm branch tip. In the check plots, the situation changed dramatically between the first and second sample with number of larvae/46 cm branch tip ranging between 0.18 and 3.89. High levels of NPV infection (74.4 to 81.7% of larvae) were recorded in three of these check plots and 33.0% was recorded in the fourth. Western spruce budworm populations in these check plots also declined and ranged from 0.06 to 3.75 larvae/46 cm branch tip.

Conclusions and Recommendations

A high degree of species specificity is considered as an asset when viruses are used as biocontrol agents, but it can have limitations too. The treatment with Virtuss to control Douglas-fir tussock moth had absolutely no effect on western spruce budworm. The infestation of budworm is endangering the recovery of trees which had been severely defoliated by Douglas-fir tussock moth, but which are still alive.

The spread of Douglas-fir tussock moth NPV from treated to untreated areas has not been unequivocally demonstrated. However, results from this survey add weight to the hypothesis that it does spread. In the first sample, incidence of virus infection in the buffer zones was considerably higher than in the check plots. This leads one to conclude that spread of NPV occurred in 1982, reducing the population in these buffer zones and introducing virus inoculum which, in turn, had an impact on the insect population early in the 1983 season.

If NPV does spread from treated to untreated areas in the year of application, then it could be introduced into large areas by aerially spraying widely spaced swaths which give only partial coverage. Both Virtuss and the USDA product, TM BioControl-1 (registered by EPA in 1976), are in limited supply and expensive, with material alone for a treatment costing about $50/ha. Virus introductions, as opposed to blanket spraying, would greatly reduce the cost of material and would also save substantially on the cost of aircraft time for the application.

Naturally occurring NPV epizootics usually terminate Douglas-fir tussock moth outbreaks, but not before heavy tree mortality occurs. In 1982, levels of naturally occurring virus were 1.4, 11.0, 4.4, and 4.9% of larvae respectively in check plots 1, 6, 7 and 8. In 1983, a virus epizootic decimated the populations in check plots 6, 7 and 8. In plot 1, only 33.0% of larvae were infected with NPV at the time of the second sample and a population of 3.89 larvae/46cm branch tip remained. This raises an interesting question - what incidence of virus infection at the end of one season is required to reduce the Douglas-fir tussock moth population below the economic threshold the following year?

Plans for 1984

1. To apply Virtuss for operational control of Douglas-fir tussock moth in B.C. in collaboration with B.C. Ministry of Forests provided that suitable areas can be located.

2. To aerially spray an area with Virtuss using widely spaced swaths, giving only partial spray coverage, to determine if the virus spreads in the year of application and gives an acceptable level of population reduction.

3. To conduct tests requested by Agriculture Canada officials in order to obtain full registration status for Virtuss.

Table 1: Survey in 1983 taken between June 8 and June 24 on plots treated with Virtuss in 1982, areas adjoining and between these plots and untreated check plots near Veasy Lake, Kamloops District, B.C.

Plot no.	Plot status	No. of sample points	Mean no. of DFTM[1] larvae/46 cm branch tip	Mean no. of WSB[2] larvae/46 cm branch tip	No. of DFTM larvae examined microscopically	% DFTM larvae infected with NPV
A	Buffer zone	14	0.82	2.46	126	29.4
2	Treated 1982	19	0.89	2.87	388	30.9
B	Buffer zone	18	0.33	1.50	239	43.5
3	Treated 1982	21	0.23	5.52	142	40.8
C	Buffer zone	13	0.80	10.26	180	24.4
4	Treated 1982	20	0.45	36.35	97	35.1
D	Buffer zone	23	0.60	4.84	385	7.3
5	Treated 1982	21	0.40	6.88	63	19.0
E	Buffer zone	14	0.25	1.89	36	8.3
1	Check	14	33.67	2.57	252	3.6
6	Check	14	10.93	0.96	539	4.1
7	Check	14	21.21	0.92	259	1.9
8	Check	14	3.07	9.04	454	7.9

1 DFTM = Douglas-fir tussock moth

2 WSB = Western spruce budworm

Table 2: Survey in 1983 taken between July 14 and July 28 on plots treated with Virtuss in 1982, areas adjoining and between these plots and untreated check plots located near Veasy Lake, Kamloops District, B.C.

Plot no.	Plot status	No. of Sample points	Mean no. of DFTM larvae/46 cm branch tip	Mean no. of WSB larvae/46 cm branch tip	No. of DFTM larvae examined microscopically	% DFTM larvae infected with NPV
A	Buffer zone	14	0.21	0.82	48	75.0
2	Treated 1982	19	0.16	2.55	51	39.2
B	Buffer zone	18	0.06	0.47	14	64.3
3	Treated 1982	21	0.07	3.74	12	58.3
C	Buffer zone	13	0.15	4.65	34	79.4
4	Treated 1982	20	0.08	4.93	26	80.8
D	Buffer zone	23	0.02	2.74	15	71.4
5	Treated 1982	21	0.05	2.86	23	43.8
E	Buffer zone	14	0.00	0.96	7	57.1
1	Check	14	3.89	0.11	518	33.0
6	Check	14	0.43	0.61	224	81.7
7	Check	14	0.68	0.06	164	74.4
8	Check	14	0.18	3.75	38	76.3

OPERATIONAL APPLICATION OF LECONTVIRUS BY ONTARIO MINISTRY OF NATURAL RESOURCES STAFF TO CONTROL REDHEADED PINE SAWFLY

(Study Ref. Nos. FP-53 and FP-40-2)

Report to the Annual Forest Pest Control Forum, Ottawa

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November, 1983

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ANNUAL FOREST PEST CONTROL FORUM - 1983

Operational application of Lecontvirus by Ontario Ministry of Natural Resources staff to control redheaded pine sawfly

Summary

Lecontvirus (nuclear polyhedrosis virus of redheaded pine sawfly) was distributed by FPMI personnel to Ontario Ministry of Natural Resources (OMNR) staff in 7 districts. They treated 40 plantations with a total area of 211 ha.

Introduction

Following submission of a registration petition in March, 1981, a Temporary Registration was granted in June, 1983 by Agriculture Canada for Lecontvirus. This product is produced and formulated at the Forest Pest Management Institute. The label is restricted and it can only be applied by, or under the supervision of, federal and provincial government officials.

As in 1982, lyophilized, virus-infected larvae ground to a fine powder were suspended in an emulsifiable oil (Dipel 88® blank carrier vehicle) for distribution to clients. For ground spraying, the directions were to add 10 mL of this concentrate containing 5×10^9 polyhedral inclusion bodies (PIB) to 20 L of water and apply to 1 ha if larvae were in the first and second instars. Double the dosage was to be applied in the same volume if larvae were in the third and fourth instars.

OMNR Spray Applications

OMNR staff in 7 districts kindly supplied information on their spray operations which is summarized in Table 1. Either mistblowers or hand-held pressure sprayers were used to apply the virus. Rows of trees, alternate rows of trees, individual trees or individual colonies were sprayed. Application volumes ranged from 1 to 62 L/ha and dosages of virus ranged from 2.5×10^8 to 1.55×10^{10} PIB/ha. The recommended application volume of 20 L/ha is for mistblowing every third or fourth row of trees. When other techniques are used, such as spraying individual colonies with a hand-held pressure sprayer, this figure is no longer relevant. Generally, applicators were entirely satisfied with the results and only one treatment was reported as unsuccessful. A total of 40 plantations were treated in Ontario and 211 ha sprayed. Many of the districts reported that areas treated in previous years with the virus did not require retreatment.

Use of Lecontvirus in Ontario

A summary of the number of plantations and areas treated each year in Ontario with Lecontvirus is given in Table 2. Between 1976 and 1980, FPMI staff conducted aerial spray trials and between 1980 and 1983, OMNR personnel applied this virus from the ground. During that 8 year period, a total of 262 plantations have been treated with a combined areas of 2,039 ha. Since OMNR staff initiated their operations, there has been a steady decline in the number of plantations treated annually.

European pine sawfly, *Neodiprion sertifer*, was an important pest of Christmas tree plantations in the 1950s and 1960s, but widespread

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application of nuclear polyhedrosis virus plus parasite releases have reduced its abundance to the point at which it can be considered an insignificant pest. It is hoped that, with continued virus treatments, redheaded pine sawfly will be reduced to the status of a very minor pest in Ontario.

Conclusions and Recommendations

Staff in most OMNR Districts in which redheaded pine sawfly is a problem are now familiar with the use of virus as a biocontrol agent and prefer it to chemical insecticides. Each year, we stress the importance of early detection and early application of virus. At the current recommended dosages, it is virtually useless to treat larvae after they are all in the fourth instar or larger than the fourth instar. When large larvae are found, either a chemical pesticide should be applied or treatment with the virus should be postponed until the following year when that plantation can be closely monitored and first and second instar larvae sprayed.

Plans for 1984

1. FPMI staff, in consultation with reviewing agencies, will attempt to perform the necessary safety tests to get the Temporary Registration for Lecontvirus changed to the status of Full Registration. A contract is being arranged to conduct a delayed hypersensitivity test which has been requested.
2. Lecontvirus will be available for use by OMNR officials who have problems with redheaded pine sawfly in their districts.
3. There is sufficient Lecontvirus, produced in 1981, at FPMI to treat about 2,000 ha. However, serious consideration should be given to

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producing more material. Lecontvirus is obtained by spraying a heavily infested plantation with a high dosage of virus when larvae reach the fourth instar. Diseased colonies are harvested, frozen and processed. Assistance from OMNR staff in locating a suitable plantation for virus propagation would be appreciated.

Table 1. Summary of operational applications of NPV for control of redheaded pine sawfly in Ontario in 1983

OMNR District	No. of plantations treated	Total area of plantations (ha)	Actual area treated (ha)	Application equipment used	Method of application	Range of application rates (ℓ/ha)	Range of dosages (PIB/ha)
Algonquin Park	1	6	6	Mistblower	Individual trees	25	$5x10^9$
Bancroft	16	100	100	Mistblower	Individual trees	3.4-14.8	$3.3x10^9$- $1.12x10^{10}$
Bracebridge	11	42	28	Mistblower Handsprayer	Individual colonies; row spraying	1-50	$2.5x10^8$- $1.25x10^{10}$
Carlton Place	1	1	1	Handsprayer	Individual colonies	62	$1.55x10^{10}$
Parry Sound	4	50	7	Mistblower	Individual colonies & trees; row spraying	12.5-40	$3.1x10^9$- $1x10^{10}$
North Bay	5	65	55	Handsprayer	Alternate rows & individual trees	1.8-32	$1.6x10^9$- $1.3x10^{10}$
Tweed	2	18	14	Mist Blower Handsprayer	Individual trees	20	$8.3x10^9$ $8.7x10^9$

Table 2. Spray operations conducted with Lecontvirus over the last 8 years in Ontario.

Year	Area (ha)	No. of plantations treated from the air	No. of plantations treated from the ground
1976	43	3	-
1977	52	3	-
1978	26	2	-
1979	34	4	-
1980	540	8	88
1981	759	-	65
1982	374	-	49
1983	211	-	40

THE IDENTITY OF A NUCLEAR POLYHEDROSIS VIRUS OF DOUGLAS-FIR TUSSOCK MOTH PROPAGATED IN ITS HOMOLOGOUS HOST AND IN WHITE-MARKED TUSSOCK MOTH

(Study Ref. No. FP-13-2)

Report to the Annual Forest Pest Control Forum, Ottawa

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ANNUAL FOREST PEST CONTROL FORUM - 1983

The identity of a nuclear polyhedrosis virus of Douglas-fir tussock moth propagated in its homologous host and in white-marked tussock moth

Introduction

Baculoviruses (nuclear polyhedrosis and granulosis viruses), in general, are highly specific and represent a potentially viable alternative to chemicals in the control of forest and agricultural pests. Four nuclear polyhedrosis viruses (NPVs) have been registered by the EPA in the United States as biological pest control agents. Outbreaks of Douglas-fir tussock moth usually collapse from naturally occurring NPV epizootics, but not before severe damage and tree mortality occurs. Early application of NPV hastens collapse of the infestation and prevents tree mortality. Two NPVs have been isolated from Douglas-fir tussock moth, *Orgyia pseudotsugata*, a singly enveloped type, OpSNPV, and a multicapsid type, Op MNPV. The multicapsid type was registered by the EPA in 1976 and the product was named TM BioControl-1. OpMNPV has been propagated in white-marked tussock moth, *O. leucostigma*, larvae at FPMI. Our product, which we named Virtuss, received a temporary registration under the Pest Control Products Act (Canada) in June, 1983. Due to a variety of circumstances, it was not applied operationally this year. Further safety testing of Virtuss has been requested by Canadian regulatory authorities and a demand was made to produce unequivocal proof that the virus in the Canadian product is identical to the virus in TM BioControl-1. Restriction endonuclease digestions of viral DNA have been used to confirm the identity of these products.

Materials

A standard sample of OpMNPV was supplied by Dr. M.E. Martignoni, USDA Forest Service, Corvallis, Oregon. This sample, labelled 75-L-04, was used to infect several thousand white-marked tussock moth larvae then this first passage material was used to produce more virus by a second passage in white-marked tussock moth larvae. Material from the second passage (Virtuss) is available for operational control of Douglas-fir tussock moth in British Columbia. A sample of TM Bio-Control-1, the product registered in the USA for Douglas-fir tussock moth control, was also supplied by Dr. M.E. Martignoni. TM BioControl-1 is a preparation of lyophilized, finely ground Douglas-fir tussock moth larvae infected with OpMNPV and Virtuss is a similar preparation of white-marked tussock moth larvae infected with OpMNPV. These preparations contain 95-97% milled insect parts and 3 to 5% polyhedral inclusion bodies.

Basically, the comparison reported here is between OpMNPV produced in its homologous host in the USA and the same virus propagated in white-marked tussock moth in Canada.

Experimental Procedures and Results

Polyhedral inclusion bodies from a sample of TM BioControl-1, and from first and second passages of OpMNPV (75-L-04) propagated in white-marked tussock moth larvae, were purified and their genomic deoxyribonucleic acid (DNA) isolated according to published procedures. The principle behind verifying the identity of these three virus samples is to digest their DNAs with restriction endonuclease enzymes followed by electrophoretic analysis on agarose gels. Restriction endonuclease enzymes produce a definite number of fragments and can be used to "finger print" any particular DNA. If the DNA samples from these three virus samples give similar banding patterns on agarose gels, then one must conclude that the three viruses are one and the same.

The DNA samples were digested with two restriction endonucleases, HindIII and BamHI, at 37° for 2 hr. The reaction was stopped and the DNAs were analysed on 0.7% agarose gels. The bands were stained with ethidium bromide and visualized with a long wavelength UV source. The gel was photographed with a Polaroid MP4 camera (Figure 1). Lane 1 is marker DNA; lanes 2,3 and 4 are TM BioControl-1, first passage of 75-L-04 in white-marked tussock moth larvae and second passage in white-marked tussock moth larvae (the final product, Virtuss). Lanes 5, 6 and 7 contain the same materials digested with BamHI. It can be seen from lanes 2, 3 and 4 that HindIII enzyme produced the identical number of bands from each DNA. Also, BamHI produced an identical banding pattern from the same DNA samples in lanes 5, 6 and 7, but, of course, different from HindIII. These results were confirmed when the molecular weight of each band was measured. Table 1 shows the molecular size of each band and the sum total of the molecular sizes is in the order of 135 kilobase pairs.

Conclusion

These data prove that the virus in the American product, TM BioControl-1, is identical to the virus in the Canadian product, Virtuss.

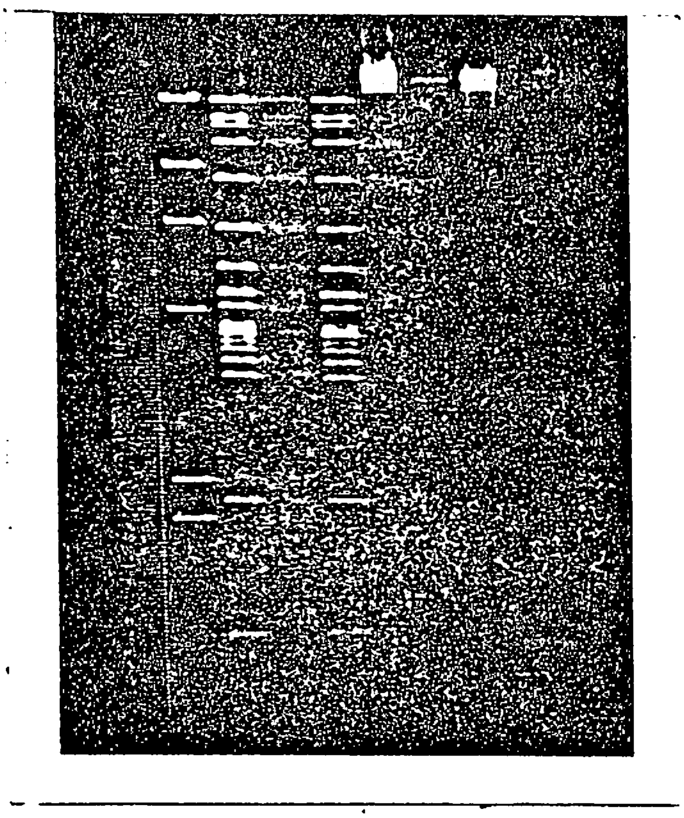

Fig. 1

Table 1

Size of Hind III fragments of OpMNPV DNA

Fragment	kb*	
A	23.0	
B	17.6	
C	16.1	
D	13.2	
E	9.2	
F	6.6	
G	5.3	
H,I	4.6	doublet
J	4.5	
K	4.0	
L,M	3.9	doublet
N	3.8	
O	3.5	
P	3.4	
Q	3.3	
R	2.2	
S	1.5	
T	1.2	
	135.4	

* kb: kilobase pairs

EXPERIMENTAL STUDIES WITH MICROSPORIDIA

(Study Ref. No. FP-12)

Report to the Annual Forest Pest Control Forum,

Ottawa

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ANNUAL PEST CONTROL FORUM - 1983

Experimental Studies with Microsporidia

Summary

A bioassay test using *Nosema fumiferanae* against the spruce budworm was completed. Significant mortality (83%) of larvae occurred after ingestion of 5×10^6 spores, with 5×10^7 spores resulting in 100% mortality. The LD_{50} value for 4 instar larvae was 2.81×10^6 spores/larva with 95% lower and upper fiducial limits of 2.57×10^6 and 3.01×10^6 spores/larva. The mean number of days to 50% larval mortality was about 17 days.

The pathogenicity of three microsporidia, *Nosema disstriae*, *Pleistophora schubergi* and *Vairimorpha necatrix* to larvae of the forest tent caterpillar were investigated. Third and fifth instar larvae were highly susceptible to infection by all three microsporidia. The relative susceptibility of the forest tent to the three microsporidia is indicated by the number of spores needed to kill 50% of the insects when inoculated as fifth instar, these were 2.0×10^3 - *V. necatrix*, 3.4×10^4 *P. schubergi* and 2.5×10^5 - *N. disstriae*.

Analysis of field data for 1982-83 population dynamics of the spruce budworm is just beginning. However levels of microsporidia at the Gargantua plot in 1982 was about 63% and for 1983 56%. In order to have two contrasting populations of spruce budworm, samples in 1983 were also taken from Black Sturgeon Lake (area of increasing density). The levels of microsporidia (*Nosema fumiferanae*) in this area was about 23%.

FPMI Report on Studies Carried Out by the Chemical Control Agents Program 1983

E.T.N. Caldwell

As indicated to you earlier, the Use Strategies and Environmental Concerns Program was reorganized and renamed in 1983 to the Chemical Control Agents Program. It should be emphasized first of all that research in this program is not restricted to chemical control agents alone. There is considerable interplay with the Biorational Control Agents Program in terms of establishing overall FPMI/CFS goals.

In contrast to previous years, 1983 was remarkably quiet for our scientific staff. They were allowed the luxury of concentrating on honest basic research instead of last minute ad hoc emergency research as was unfortunately the case in 1982, especially as a result of the Action Plan arising from the New Brunswick Spitzer Report fiasco.

I will be presenting a brief overview of each individual project in the Chemical Control Agents Program. However more detailed reports are available and will be tabled for inclusion in the Forum report. Any of you wishing to discuss project results further can do so by talking to FPMI scientists later today.

FP-50 - <u>Insecticide Toxicology</u>

The Insecticide toxicology project is involved in tests to determine baseline toxicity of several new active ingredients and also formulations such as Sumithion flowable, Zectran, Bolstar, Larvin and Decis among others to Spruce budworm and also the Spruce budmoth, *Zeiraphera canadensis*. The project is also involved in an interdisciplinary study, coordinated by Peter de Groot, designed to determine using bioassay and various sampling techniques, the potential drift of Ambush 500 EC in plantations when applied using mistblower and other equipment. These studies will continue in 1984. Indications to date would support the implementation of a 100 m buffer zone from bodies of water, for this product when applied using mistblowers.

FP-51 - Insecticide Field Efficacy

The Insecticides Field Efficacy team has been working in close cooperation with the Ontario Ministry of Natural Resources at Thessalon, Ontario to determine and compare spray characteristics of various micronair and boom and nozzle spray systems as a basis upon which to build aerial application strategies for forest insect and vegetation management. This project has also been involved in determining the aerial characteristics of the new Sumithion flowable formulation and also a cooperative project with Viral Applications to test the efficacy of spruce budworm NPV. The Sumithion flowable has been recently withdrawn by Sumitomo, however, this project will hopefully be involved in field trials next year to assess new insecticide formulations containing Zectran.

FP-52 - Insect Ecology and Biology

Insect Ecology and Biology research efforts focussed exclusively on the biology and life cycle of the spruce budmoth, a serious defoliator of white spruce stands in New Brunswick. 1983 results have confirmed that the behaviour of this insect create severe problems in considering efficacious control measures. Larvae appear to be exposed for only a very short period of time before crawling to the bud cap where they become protected from insecticide applications. Another season of data gathering should complete biological observations on this species and the project will then turn its attention to problems affecting cone and seed production. A cone and seed production workshop under the direction of J. Turgeon will take place on Thursday for those of you who are interested.

FP-53 - <u>High Valued Stand Protection</u>

This Project under the direction of Peter de Groot was also devoted to the *Zeiraphera* problem in New Brunswick. Preliminary efficacy trials carried out in 1983 confirmed the difficulty in controlling this insect. Of all the materials tested only permethrin showed any promise in the field. This research will continue in 1984 in order to investigate, using ground equipment only, other possible candidates to control this troublesome insect. It is anticipated that once these candidates are determined, hopefully in 1984, that MFRC will test aerial application methods and fine tune *Zeiraphera* control strategies. In 1985 this project will, similar to Jean Turgeon's project, become heavily involved in cone and seed insect problems.

FP-54 - <u>Herbicides Development and Use</u>

This project under the direction of Phil Reynolds was established to address probably the most serious problem facing forestry today - the lack of suitable herbicides for forest renewal. Dr. Reynolds has spent considerable time this summer and fall discussing with forest managers at regional levels, the specific vegetation problems that need to be addressed by the Institute. A detailed problem analysis will form the basis of the Institute's goals and this should be available before the end of the year. For those who are interested, there will be a separate workshop on Herbicide

Use and Development on Thursday chaired by Dr. Reynolds.

The Herbicide toxicology study team has been involved in greenhouse and field trials to test potential of several herbicides such as Velpar, Garlon, Roundup, Herbec and Spike 80, for forest use. In addition, the Herbicides Residue study team has been developing an analytical capability to determine the chemical accountability of these products. Three contracts have been awarded to Forest Universities to aid in determining the analytical methodology and environmental fate of glyphosate, velpar and garlon.

FP-60 - Dispersal Systems

The Dispersal Systems project is still not staffed and is therefore under abeyance.

FP-61 - Pesticide Formulations

This project, under the leadership of Alam Sundaram, has concentrated on the development of suitable emulsifiers and solvents for tank mixing with fenitrothion and aminocarb formulations and was instrumental in developing new formulations in response to the NB Action Plan. Several additional Action Plan formulations are currently under investigation and this will hopefully fulfill our committment to this project. Formulation characteristics for the Sumithion flowable and Zectran formulations have been investigated, spray mimics have been developed for several cooperative field projects including the permethrin drift study, and several studies have been initiated to determine spray droplet characteristics using a variety of techniques. Additives are being sought that might prove more useful in extending the residual effectiveness of certain B.t. formulations, and a cooperative study was performed with the Canadian Wildlife Service to determine effects of fenitrothion exposure on cholinesterase levels in

Zebra finch.

FP-62 - Spray Cloud Behaviour

This project is under the direction of Nicholas Payne and has recently been involved in a cooperative study in New Brunswick designed to gain some preliminary comparative drift and deposit data based on boom and nozzle and the new TVB (Through Valve Boom) aerial application systems. Dr. Payne is now in the process of formulating a project proposal for his team and is expected to be involved in several drift trials and new equipment testing in 1984.

FP-70 - Environmental Impact

The Environmental Impact project has concentrated on the generation of baseline biological data from the Icewater Creek experimental area north of Sault Ste. Marie. In addition this project has been involved in the cooperative project investigating drift potential of permethrin and has also carried out studies on the effects of timber stand alterations on songbird behaviour.

FP-71 - Chemical Accountability

The Chemical Accountability project has been involved in the permethrin drift trials, investigated storage stability and suspendability of Matacil 180 F, participated in the CWS Zebra finch study, determined analytical chemistry for a number of insecticides and completed a study initiated last year and presented to the forum on the persistence of fenitrothion in forestry substrates. Somu Sundaram will present a brief summary of his follow-up studies with fenitrothion.

Laboratory Evaluation of the Toxicity of Insecticides Against Forest Insect Pests in 1983

(Study Ref. FP-50)

Report to the Annual Pest Control Forum

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The objectives of the program in 1983 were:

- To assess the potential of several insecticides and formulations for the control of spruce budworm, including a new Zectran® DB formulation, Sumithion® 20 Flowable, Larvin®, new dimethoate formulations, AC 268, 962, formulations of AC 217, 300, UC 72987, U 56295, MV 770, Sevin® FR and Decis®.

- To compare the toxicity of different pyrethroid formulations in oil and water to spruce budworm larvae.

- To determine if the species of foliage treated affects toxicity to spruce budworm larvae.

- To test the suitability of an insecticide screening technique to determine relative toxicities using mountain ash sawfly.

- To determine the relative toxicity of forestry insecticides to selected wild bee pollinators in comparison with honeybees (Joint Project with FP-70).

- To determine the toxicity of selected insecticides to *Zeiraphera canadensis* larvae [separate report] (Joint Project with FP-52 and FP-53).

- To develop suitable bioassay techniques with mosquito larvae to assess the biological significance of permethrin drift [separate report] (Joint Project with FP-23, 53, 61, 62, 70 and 71).

Insecticides and formulations tested against spruce budworm larvae were evaluated by as many as 3 methods, contact toxicity, toxicity on treated foliage and residual toxicity. To determine contact toxicity and toxicity on treated foliage, a selected concentration of the insecticide was sprayed at 6 standard dosages over a 10 fold range on fully exposed, laboratory reared fifth instar larvae or European larch foliage respectively in a Potter's tower. Untreated fifth instar larvae were then placed on the treated larch foliage in the latter method. Mortality was assessed at 24, 48 and 72 hr. or longer after treatment and LD 50 and LD 95 values determined by probit analysis. Residual toxicity was determined by spraying potted, 45-60 cm tall, balsam fir and white spruce trees with a selected concentration at a standard dosage of 11.2 ℓ/ha. Untreated field collected and laboratory-reared larvae were then exposed separately to clipped foliage from the trees shortly after treatment and again at 1, 3, 5 and 10 days in most cases after the trees had been exposed to natural weathering conditions. Mortality was recorded 24, 48 and 72 hr. or longer after each exposure.

The broad dosage range technique tested with mountain ash sawfly was similar to the contact toxicity method described above except that 5 dosages over a 100 fold range were tested by using 2 concentrations differing by an order of magnitude at different application rates over a 10 fold range.

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The toxicity of technical fenitrothion in acetone to field collected bees belonging to the Family Andrenidae and to queen's and workers of *Bombus terricola*, a bumble bee species, was determined by topical application of 2 μℓ of different concentrations to each CO_2 anaesthetized bee with a microapplicator and determining mortality at periodic intervals up to 72 hr or longer after treatment. Honey bee workers collected from hives established locally were treated in similar fashion. Aminocarb was also tested against andrenid and honey bees.

Results

Results of the 1983 toxicity tests are summarized in Tables 1, 2, and 3. The insecticides tested are listed in Table 4.

The toxicity of Sumithion Flowable on treated larch foliage was higher than its contact toxicity to spruce budworm larvae. It was comparable to other fenitrothion formulations on treated foliage. In 1983 the residual toxicity of this flowable formulation was slightly better than the other aqueous and oil-based formulations tested. Its toxicity appeared to be similar to laboratory 5th instar, 6th instar and field collected 6th instar larvae. In preliminary contact toxicity tests at different temperatures (10° and 25°C), mortality rate but no toxicity appeared to be temperature-dependent.

The contact toxicity of Zectran DB, an oil-based formulation of mexacarbate was similar to Zectran FS15, technical Zectran and MATACIL oil based formulations. Its toxicity appeared to be similar to laboratory 5th instar, 6th instar and field collected 6th instar larvae. The residual toxicity of Zectran DB in 1983 was slightly better than MATACIL 180 F.

The contact toxicity of Larvin (thiodicarb) to spruce budworm larvae was intermediate to MATACIL 180F and Sumithion Flowable while its toxicity on treated foliage was comparable to MATACIL. Its residual toxicity was excellent. This carbamate shows considerable promise for spruce budworm control.

The contact toxicity of a new dimethoate aqueous formulation from Cheminova was comparable to Cygon 4E in H_2O. However, the toxicity of both was poor and much lower than oil-based mixes of the same formulations.

The toxicity of Sevin FR on treated foliage appeared to be ca 4 x better than its contact toxicity.

The results to date with the carbamate U 56295 indicate that it warrants further investigation for spruce budworm control.

The carbamate, UC 72987 on treated foliage was very toxic to spruce budworm larvae in agreement with previous contact toxicity tests.

Decis, (deltamethrin) is a highly residual pyrethroid at a very low dosage. The residual toxicity of an oil solution appeared to be better than an aqueous emulsion, at least on balsam fir.

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Two formulations of the amidinohydrazone, AC 217-300 on treated foliage were comparable in toxicity to standard insecticides. The residual toxicity of a Flowable formulation apparently was much better than an EC formulation. However, the actual dosages of active ingredient deposited with each formulation must be checked.

A WP formulation of AC 268-962, a new insecticide related to a naturally occurring substance in a marine annelid exhibited little contact toxicity to spruce budworm larvae but was toxic on treated foliage. Mortality occurred gradually indicating that this material acts primarily by ingestion. Its residual toxicity appeared to be moderate in one abbreviated test.

Aqueous-based, EC formulations of permethrin and fenvalerate were less toxic than comparable oil-based formulations tested previously. However, an aqueous mix of the cypermethrin formulation tested was comparable in toxicity to previous oil mixes.

The toxicity of an oil based formulation of technical fenitrothion to spruce budworm larvae was similar on treated, balsam fir and white spruce foliage. Its toxicity was slightly higher on treated larch.

A broad dosage range, insecticide screening technique tested with mountain ash sawfly larvae proved successful. Approximate relative toxicities were: deltamethrin ≥ cypermethrin > diazinon ≥ permethrin > malathion > dimethoate > acephate > methoxychlor in 1 test with each against 4th instars. Dosages giving high mortality ranged from 0.01 $\mu g/cm^2$ or less for the most toxic insecticides to 0.4 $\mu g/cm^2$ for the least toxic. Carbaryl (Sevin 80S) also was very toxic giving 100% mortality at 0.036 $\mu g/cm^2$, the lowest dosage tested. Chlorpyrifos also exhibited good toxicity against 5th instar larvae.

Aminocarb was more toxic to both andrenid and honey bees than fenitrothion but the difference in toxicity was greater with the former (2-3x) than the latter bees (1.1 - 1.4 x). The susceptibility of the different bees to fenitrothion based on µg AI/bee varied by as much as 32 fold with andrenid bees the most and *B. terricola* queens the least susceptible. However, based on µg AI/g body weight susceptibility varied much less (8 fold). *B. terricola* queens were still the least susceptible but honeybees were now the most susceptible. Andrenid bees were more susceptible to aminocarb than honeybees based on µg AI/bee, but little difference existed based on µg AI/g.

Plans for 1984

Continue investigations with new insecticides or formulations for forest insect control, particularly, Zectran, Larvin, U 56295, AC 217-300, AC 268-962 and an antifeedant Margosine - 0.

Continue studies on the differences in toxicity of oil based and aqueous based formulations of pyrethroids and other insecticides.

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Continue studies on the effects of the type of foliage treated on the toxicity of insecticides to spruce budworm.

Continue and expand studies on the relative toxicity of current and potential forestry insecticides to wild bees, honey bees and other beneficial insects.

TABLE 1

The Contact Toxicity of Insecticides to Spruce Budworm in 1983

Insect	Instar	Insecticide/Formulation	% Conc.	# Tests	LD 50	LD 95
					at 72 hrs. μg AI/cm^2	
Spruce Budworm	V	Bolstar + H_2O	0.5	3	.266	.575
Spruce Budworm	V	Cygon 4E + AR-60	0.5	3	.382	.856
Spruce Budworm	V	Cygon 4E + H_2O	5.0	1	3.340	12.10
Spruce Budworm	V	Cypermethrin EC + H_2O	.008	3	.004	.013
Spruce Budworm	V	Dimethoate + AR-60	1.0	3	.357	1.227
Spruce Budworm	V	Dimethoate + H_2O	1.0	3	3.010	9.287
Spruce Budworm	V	Fenitrothion Flowable + H_2O	.7	3	.283	.862
Spruce Budworm	V	Fenitrothion Technical + Cyclosol + ID 585	.2	3	.113	.173
Spruce Budworm	V	Fenvalerate EC + H_2O	.04	3	.030	.152
Spruce Budworm	V	Larvin 500 + H_2O	.5	3	.134	.458
Spruce Budworm	V	Matacil 180 F + Triton X-114 + H_2O	.1	1	.055	.128
Spruce Budworm	V	Matacil Technical + Mix #1	.08	3	.041	.099
Spruce Budworm	V	Permethrin EC + H_2O	.03	3	.023	.078
Spruce Budworm	V	Permethrin Technical + ID 585	.03	3	.008	.023
Spruce Budworm	V	Sevin Fr + Pa3 + H_2O	1.6	1	1.440	5.402
Spruce Budworm	V	Zectran DB + ID 585	.1	3	.027	.098
Spruce Budworm	V	Zectran FS + Mix #1	.1	3	.025	.062
Spruce Budworm	V	Zectran Technical	.1	3	.027	.076

TABLE 2

The Toxicity of Insecticides to Spruce Budworm Larvae on Treated Larch Foliage in 1983

Insect	Instar	Insecticide/Formulation	% Conc.	# Tests	LD 50	LD 95
					at 72 hrs. µg AI/cm²	
Spruce Budworm	V	Fenitrothion Flowable + H_2O	.2	3	.073	.187
Spruce Budworm	V	Fenitrothion Technical + Triton X-114 + H_2O	.2	3	.113	.237
Spruce Budworm	V	Fenitrothion Technical + Cyclosol	.2	3	.070	.185
		+ ID 585 Technical *(Bf)	.2	3	.097	.280
		+ ID 585 Technical *(Ws)	.2	2	.101	.253
Spruce Budworm	V	Larvin 500 + H_2O	.1	2	.028	.125
Spruce Budworm	V	Matacil 180 F + Triton X-114 + H_2O	.1	3	.036	.090
Spruce Budworm	V	Matacil Technical + Mix #1	.1	3	.021	.066
Spruce Budworm	V	MV 770 - 4E + Dowar 7:3	.4	2	.090	.284
Spruce Budworm	V	U 56295 Technical + Mix #1	.25	3	.033	.481
Spruce Budworm	V	UC 72987 Technical + Mix #1	.05	3	.012	.057
Spruce Budworm	V	Sevin FR + H_2O	1.6	1	.339	1.279
				AT 7 DAYS		
Spruce Budworm	V	AC 268,962 + H_2O	0.5	2	.106	.463
Spruce Budworm	V	AC 217-300 + Dowar 7:3	0.5	1	.048	.104
Spruce Budworm	V	AC 217-300 Flowable + H_2O	0.5	1	.056	.169

*(Bf) - Balsam fir
*(Ws) - White spruce

Table [illegible]. Residual Toxicity of Insecticides on Balsam Fir and White Spruce to Spruce Budworm Larvae under Natural Weathering Conditions in 1983

Insecticide/Formulation	Dosage	Host	% Corrected Mortality after 72 hr. exposure to treated foliage DAYS POST				
			0	1	3	5	10
Decis® EC, ID 585	11.2	Bf	97	100	99	83	26
		Ws	55	94	59	36	7
Decis® EC, H_2O	11.2	Bf	95	97	54	32	0
		Ws	100	99	52	30	9
Sumithion Flowable, H_2O	336	Bf	99	89	35	13	5
		Ws	84	64	23	5	6
Sumithion Technical, ID 585, Cyclosol	336	Bf	100	68	28	16	10
		Ws	95	20	0	0	3
Sumithion Technical, Triton X-114, H_2O	336	Bf	97	64	13	0	2
		Ws	97	29	0	0	0
Larvin, H_2O	224	Bf	98	100	97	95	99
		Ws	95	90	94	95	94
Matacil 180 F, ID 585	112	Bf	99	72	62	39	42
		Ws	100	79	26	0	5
U 56295, H_2O	336	Bf	100	80	72	87	58
		Ws	92	45	62	46	42
Zectran DB, ID 585	112	Bf	100	78	80	51	50
		Ws	100	91	40	0	26

Insecticide/Formulation	Dosage	Host	% Corr. Mort. after 10 days exposure to treated foliage				
			0	1	3	5	10
AC 217-300 EC, H_2O	560	Bf	99	58	0	13	
		Ws	93	21	4	19	
AC 217-300 Flowable, H_2O	560	Bf	99	92	80	97	
		Ws	79	66	68	64	
AC 268-962, H_2O	336	Bf	89	67	35		
		Ws	73	50	22		

TABLE 4

INSECTICIDES TESTED IN 1983

Compound	Formulation	Type	Source
Acephate	75% soluble powder	Organophosphate	Chevron
AC 268-962	50% WP	(new)	Cyanamid
AC 217-300	17.2% EC	Amidinohydrazone	Cyanamid
AC 217-300	21% flowable	Amidinohydrazone	Cyanamid
AC 217-300	98.6% technical	Amidinohydrazone	Cyanamid
Bolstar	64% EC	Organophosphate	Mobay
Cygon 4E	48% EC	Organophosphate	Cyanamid
Cypermethrin	250 g/ℓ EC	Pyrethroid	Chipman
Decis	2.5% EC	Pyrethroid	Hoechst
Diazinon	50 EC	Organophosphate	Ciba Geigy
Dimethoate	600 g/ℓ premix	Organophosphate	Cheminova
Dursban	48%	Organophosphate	Dow Chemical
Dylox 4.2	41.9% EC	Organophosphate	Mobay
Fenvalerate	30% EC	Pyrethroid	Shell
Guthion	2S-24%	Organophosphate	Mobay
Larvin 500	44%	Carbamate	Union Carbide
Malathion	500 g/ℓ	Organophosphate	Chipman
Matacil 180F	18% flowable	Carbamate	Mobay
Matacil	98% technical	Carbamate	Mobay
Methoxychlor	240 g/ℓ EC	Chlorinated Hydrocarbon	Chipman
MV770 - 4E		Organophosphate	Stauffer
Permethrin	500 g/ℓ EC	Pyrethroid	Chipman
Permethrin	93.1% technical	Pyrethroid	Chipman
Sevin FR	47.9% FR	Carbamate	Union Carbide
Sevin 80s	80% wettable powder	Carbamate	Union Carbide
Sumithion	21.6 flowable	Organophosphate	Sumitomo
Sumithion	99.8% technical	Organophosphate	Sumitomo
U 56295	44% flowable	Carbamate	Upjohn
U 56295	99% technical	Carbamate	Upjohn
UC 72987	90.5% technical	Carbamate	Union Carbide
Zectran DB	21.7% by wt.	Carbamate	Union Carbide
Zectran FS15	15% by wt.	Carbamate	Union Carbide
Zectran	92% technical	Carbamate	Union Carbide

EXPERIMENTAL AERIAL SPRAY TRIALS WITH NUCLEAR POLYHEDROSIS VIRUS FOR THE REGULATION OF SPRUCE BUDWORM IN QUEBEC

(Study Ref. Nos. FP-51, FP-13-3 and FP-13-4)

Report to the Annual Forest Pest Control Forum, Ottawa

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Experimental aerial spray trials with nuclear polyhedrosis virus for the regulation of spruce budworm in Quebec

Summary

Two 20 ha plots, near St. Eugene, Quebec, were aerially sprayed with nuclear polyhedrosis virus (NPV) to control spruce budworm, *Choristoneura fumiferana* (Clem.), on balsam fir, *Abies balsamea* (L.) Mill., trees. The virus was applied in an emulsifiable oil formulation (25% Dipel 88® blank carrier vehicle and 75% water) emitted at a volume of 4.5 L/ha. One plot was treated with a dosage of 1.15×10^{12} polyhedral inclusion bodies (PIB/ha) as second instar larvae were emerging from their hibernacula. The second plot received two applications, the first, with a dosage of 3.44×10^{12} PIB/ha, when second instar larvae were emerging from hibernacula and the second, with a dosage of 2.30×10^{12} PIB/ha, at budflush when larvae were at the peak of the third instar.

The impact of the treatments was assessed by weekly counts of the spruce budworm population density on the two treated plots and one check plot until the onset of pupation. All the larvae collected from the second plot and check plot were smeared on microscope slides for subsequent diagnosis to determine the incidence of NPV infection. Additional collections of larvae were made from both treated plots and the check plot and examined microscopically as wet mounts for the presence of NPV and other pathogens. Defoliation estimates were made on the

two treated plots and check plot in the fall. A preliminary analysis of the results indicates that neither treatment effectively regulated spruce budworm populations.

Introduction

Spruce budworm NPV has been extensively field tested since 1971 with over 50 plots, totalling about 2100 ha, treated. This virus has also been tested on western spruce budworm in B.C. and 5 plots totalling 152 ha treated between 1976 and 1982. Such parameters as dosage, emitted volume, timing of application, tank mix and application equipment have been studied. Results have varied considerably and have never been considered outstanding.

Naturally occurring virus epizootics have never been reported in spruce budworm populations. When NPV is applied at budflush, there is only a 2 to 4 week period before the onset of pupation. As NPV takes about 14 to 20 days to kill its host under field conditions, there is little or no time for secondary infection to occur and only larvae which ingest a lethal quantity of the actual spray deposit will die. Following application of NPV one year, carry-over of virus to the following year has been observed in some plots, but never causing dramatic population reductions.

There are some obvious attractions to applying NPV on second instar larvae as they emerge from their hibernacula. The LD_{50} for the second instar is 25 PIB and for the fourth instar is 462 PIB (Bird, unpublished); there is also ample time for a virus epizootic to develop following application on second instar larvae. From a logistical standpoint, timing can be very critical and access to the forest can be difficult due to the melting snow and muddy roads in late April. If the weather stays warm and the number of degree days necessary to break diapause is reached, second instar larvae have been observed to emerge over a period of a few days, but if fluctuations between warm and cool weather occur, emergence in a given area can take place over a prolonged period. To date, three attempts have been made to apply NPV on second instar larvae with only one considered successful, following correct timing of the application.

The trials in 1983 were planned with two objectives in view. Firstly, to attempt to repeat the results of the one relatively successful application on second instar larvae using pure NPV; in the previous trial the NPV used contained traces of cytoplasmic polyhedrosis virus (CPV). The second objective was to initiate and maintain an NPV epizootic in the spruce budworm population, so that detailed epidemiological studies could be conducted. With this in view, it was decided to apply two heavy dosages of NPV, the first when larvae were emerging from their hibernacula and the second at budflush.

In previous years, viruses have been applied at an emitted volume of 9.4 L/ha. As Micronair® AU-3000 rotary atomizers were fitted on the aircraft used to apply the virus, it was decided to reduce the volume to 4.5 L/ha, as the optimal atomization is not obtained with this equipment using higher volumes.

Study Area

The research was conducted near St. Eugene, in the Gaspè region of Quebec. The area was natural forest consisting mainly of balsam fir *Abies balsamea* (L.) Mill., white spruce *Picea glauca* (Moench)

Voss and hardwood species. Two 20 ha (1.0 x 0.2 km) plots were selected for treatments. Three lines transected each plot and 15 balsam trees, 8-12 m tall, were selected along each line to assess the budworm populations. Clearings were made around each sample tree and a sample unit[1] placed in each clearing to assess the spray deposit.

An untreated area of approximately 20 ha was selected as an untreated check plot. Forty-five balsam fir were randomly chosent throughout this area as sample trees.

Spray Application

To prepare the tank mix, finely ground, lyophilized, NPV-infected spruce budworm larval powder was suspended in an emulsifiable oil (Dipel 88® blank carrier vehicle). For plot 1, 1 kg of material was used; for the first and second applications on plot 2, 3 kg and 2 kg were used respectively. To prepare the tank mix, 1 part of the oil was mixed with 3 parts of water. Erico acid red at a concentration of 0.1% (w/v) was added to monitor the deposit on Kromekote® cards. The dosage applied on plot 1 was calculated to be 1.15×10^{12} PIB/ha and the two applications on plot 2, 3.44×10^{12} and 2.30×10^{12} PIB/ha respectively.

The sprays were applied using a Cessna 188 Ag-truck® fitted with four Micronair® AU-3000 rotary atomizers calibrated to deliver 4.5 L/ha. The aircraft few at 160 km/h approximately 10m above the tree tops. All treatments were applied in the evening under stable weather conditions (Table 1). Both plots were sprayed for the first time on May 14 when larvae were emerging from hibernacula. Weather was generally cool during the week before application and during the week after, and budworm larvae

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[1]A.P. Randall - Can. For. Serv. Bimonthly Res. Notes V36(5): 23 (1980).

were found in low numbers wandering on the foliage. There was no massive emergence of larvae over a short period of time. Plot 2 received a second application on June 9 when balsam fir buds had flushed and budworm larvae were 94% in the third instar and 5% in the fourth.

Sampling

Assessing second instar budworm populations by manually counting larvae on branches is a tedious task which often results in underestimates. During this study, for the first and second samples when early instars were most prevalent, two 90-cm branches were taken from the midcrown of each sample tree and placed in emergence boxes[1]. On the last three samples dates, two 45-cm branches/tree were taken and threshed using beating drums[2].

All larvae from plot 2 and the check area were smeared on microscope slides and stained for subsequent examination. In addition to this assessment, a further 15 trees per plot were sampled weekly and wet mounts of gut and fat tissue examined microscopically using phase contrast optics to determine the incidence of NPV and other pathogens. A defoliation survey was made on the sample trees in the treated plots and check plot in October.

[1] A.P. Randall - Can. For. Serv. Res. Notes 2(2): 9-12 (1982).
[2] R. Martineau & P. Benoit - Phytoprotection 54(1): 23-32 (1973).

Results and Conclusions

No definitive results from this study are available at the time of this writing. However, preliminary results of the population studies indicate that neither trial was effective in controlling spruce budworm populations (Table 1). These results were substantiated by microscopic examination of wet mounts of samples of larvae. The incidence of infection with viruses, microsporidia and parasites is given in Table 2. The highest level of NPV infection recorded in the plot receiving the single application was 3.8% of the larvae and in the plot receiving the double application was 8.4%. Examination of stained preparations of all larvae collected for population studies has not been completed.

Application of any pesticide applied primarily to affect early instar budworm must be accurately timed if it is to be effective. With viruses, this timing is most critical because the insect is accessible for only a short period prior to mining and the virus tends to be quickly inactivated. It thus appears that early application of NPV should be considered as a viable strategy only after achieving a better understanding of how weather influences, emergence and dispersal of second instar larvae.

The double application with high dosages of NPV also appeared to fail to control the budworm population. In essence this was a single application since the first spray - the early one - could not be considered a viable strategy. The second application had very little impact, due to sub-optimal spray deposits. Indications are that the droplets might be generally <100 μm in diameter and, while these might be optimally sized for chemical insecticides, the evidence emerging from

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this study is that these small droplets might not contain sufficient PIBs to be effective against spruce budworms.

Table 1. Application of NPV and spruce budworm population data (St. Eugene, Quebec 1983)

Plot	APPLICATION					DEPOSIT[1]	BUDWORM LARVAE (Sampling Dates)				
	Date (1983)	Temp. (°C)	% R.H.	Windspeed ($\bar{X}$-km/h)	Dosage (PIBx10^{12} ha)	Drops/cm^2	(13/5)*	(4/6)*	(11/6)†	(16/6)†	(30/6)†
1	1st 14/5	13	77	2	1.15	28	110	93	34	27	11
2	1st 14/5	16	67	5	3.44	13	100	112	32	13	14
	2nd 9/6	12	68	1.5	2.30	5					
Check			N/A			N/A	93	104	29	19	16

[1]Recorded on Kromekote Cards at ground level.

*Per 90 cm branch; †Per 45 cm branch and not weighted accordingly.

At the time of this writing, detailed analyses of spray deposit, budworm population and host tree defoliation have not been completed - thus THESE DATA ARE PRELIMINARY.

Table 2. Microscopic examination (wet mounts) of insects collected from two NPV-treated plots and one check plot (St. Eugene, Quebec 1983)

Plot	Date sampled	No. of insects examined	Percent infected with NPV	Percent infected with CPV	Percent infected with microsporidia	Percent parasitized
1	30/5	178	0.6	0	6.7	0
	6/6	208	1.9	0	12.5	0
	13/6	178	1.1	0	62.9	0
	20/6	182	3.8	1.6	54.4	24.7
	27/6	201	1.5	3.0	59.2	8.5
2	30/5	162	1.2	0	6.2	0
	6/6	210	2.9	0	6.2	0
	13/6	202	4.5	0.5	60.0	0
	20/6	190	5.8	0	56.8	8.9
	27/6	202	8.4	0	51.0	9.9
Check	6/6	201	0	0	20.9	0
	20/6	188	0	0	58.0	16.5
	27/6	172	0	3.5	59.9	10.5

Laboratory Tests and Field Tests with Insecticides for Control of Spruce Budmoth *Zeiraphera canadensis*

Study Ref. No. FP-50 and FP-53

Report to the Annual Forest Pest Control Forum

by

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INTRODUCTION

An insect control strategy for Spruce Budworm (*Zeiraphera* spp.) is needed. This report presents an outline of the lab and field research conducted in 1983 to evaluate potential insecticides for spruce budmoth control and presents the preliminary plans for work to be undertaken in 1984.

Laboratory Studies

This study was done in close cooperation with Jean Turgeon, FP-52.

In 1982, initial contact toxicity tests with fenitrothion and aminocarb were performed against 2nd-4th instar *Z. canadensis* larvae. However, since newly hatched larvae may be the only exposed stage to non-systemic insecticides, studies were initiated in January, 1983 to develop suitable techniques for determining the toxicity of insecticides to first instar larvae. Aqueous mixes of three insecticides, permethrin (Ambush 500 EC), fenitrothion (Technical + Triton X-114) and aminocarb (Matacil 180F + Triton X-114), were tested by two methods; direct contact with larvae and exposure of larvae to treated white spruce buds. By direct contact, permethrin was more toxic than fenitrothion (72 hr LD_{50} - 0.008 μg/cm^2 (1 test) vs. 0.08 μg/cm^2 (2 tests combined) respectively). With aminocarb, the concentration used in 1 direct contact test was too low to provide a suitable dosage-response line for analyses. In the tests exposing larvae to treated buds, little mortality was obtained with these insecticides at the dosages used.

In June, 1983 *Zeiraphera canadensis* eggs were received from New Brunswick to continue toxicity tests against newly hatched, first instar larvae. These larvae were again exposed to treated foliage but the above technique was modified to provide a potentially longer exposure time before the larvae entered buds. Ca 5-cm lengths of white spruce shoots with 2-3 swelling buds were sprayed in a Potter's tower. Larvae were then placed on the end of the shoot-distal to the buds and allowed to move freely over the shoot in search of buds. Three such tests were performed with each of permethrin and fenitrothion and 2 with aminocarb.

The order of toxicity was permethrin (72 hr LD_{50} - 0.01 μg/cm^2) > fenitrothion (0.044 μg/cm^2) $\geq$ aminocarb (0.052 μg/cm^2). The 72 hr - LD_{95} values followed the same order. Both acephate and dimethoate were also tested once by this method. Their toxicity appeared to be considerably lower than the above insecticides but control mortality was too high for a quantitative assessement of their toxicity.

In order to select additional candidate insecticides for *Zeiraphera* control, twelve insecticides were tested as foliar applications on flared buds of white spruce using 3rd and 4th instar *Zeiraphera canadensis* larvae which were sent from New Brunswick in June, 1983. The criteria for selecting the insecticide included current forestry registration or high toxicity to lepidopterous larvae generally. Since only 1 test with each insecticide could be performed and since dosage requirements were not known for most a broad, ca 100 fold dosage range was used in an attempt to obtain approximate toxicities for each which then could be roughly compared. This approach proved successful and approximate relative toxicities were; deltamethrin $\geq$ cypermethrin $\geq$ permethrin > mexacarbate >> azinphosmethrin $\geq$ fenitrothion $\geq$ aminocarb $\geq$ acephate $\geq$ methomyl > trichlorfon > dimethoate >> carbaryl > methoxychlor. High mortality was obtained at dosages of 0.05 μg/cm^2 or less with the more toxic insecticides while no mortality occurred with methoxychlor at 9.3 μg/cm^2. Aqueous mixes were used for all insecticides except mexacarbate. These results are very preliminary and require confirmation.

FIELD TRIALS

Based on the very preliminary data obtained from the laboratory toxicological studies, it was decided to field evaluate three chemical insecticides.

Furthermore a decisive factor in determining which insecticides to test was how quickly we could obtain an effective pesticide for operational use. Therefore, it was decided to test those insecticides which currently are registered for Forestry and Agricultural use, and show some promise in the lab for reducing larval populations of spruce budmoth.

The three insecticides tested were Fenitrothion, Acephate and Permethrin. Single and double applications were evaluated at the following dosage equivalents: Fenitrothion single 280 g AI/ha, double 210 g AI/ha; Acephate single 1.12 kg AI/ha, double 0.56 kg AI/ha; and Permethrin single 70 g AI/ha and double 35 g AI/ha. Since dose/response data were incomplete, field evaluations were made at high dosages.

The field bioassay was conducted by applying the pesticide spray to individual white spruce trees using a modified ULV (Flak®) sprayer. Fifteen trees were used for each treatment for a total of 90 trees. Fifteen trees were selected as untreated controls.

Population levels (expressed as number per branch, number per shoot and number per bud) were monitored before application and 3 and 10 days post-spray.

Effectiveness of treatment was also evaluated on the basis of shoot protection. Spray coverage and droplet size were assessed by analyzing deposits on Kromekote cards and glass slides placed in both the horizontal and vertical positions. Deposit analysis on white spruce foliage was also undertaken in the single application Fenitrothion treatment. Analysis of the results is incomplete at this time, however preliminary analyses of the results indicates that only Permethrin had a noticeable effect on reducing larval populations of *Zeiraphera*.

<u>Work Plans for 1984</u>

a) Laboratory Studies

1. Toxicity tests with 4-6 selected insecticides using first instar larvae on treated foliage. Insecticides: permethrin, azinphosmethyl, mexacarbate, thiodicarb, aminocarb (oil solution) and acephate.

2. Residual toxicity tests in greenhouse with 2-3 insecticides selected from results in (1) with first instar larvae.
3. Toxicity tests with possible ovicides including dormant oil, methomyl, chlorpyrifos and 1 or 2 others using exposed eggs. If any show promise, additional tests using eggs *in situ* on white spruce branches.
4. Tests with systemic insecticides for *Z. canadensis* control on potted, small white spruce trees. Insecticides: dimethoate, oxydemeton-methyl, acephate and others possibly.
5. Relative toxicity tests will be initiated on new insecticides as they become available.

b) Field Studies

1. Single tree or small plot studies will be continued. Candidate insecticides will be selected on the basis of the laboratory screening tests.
2. Timing of applications is extremely critical. Exposure of the first instar from time of eclosion to bud penetration is approximately 15 minutes. The remainder of the larval period is spent in the bud/expanding shoot protected by the bud cap or webbed foliage. Pre-emergence applications may be tested for some insecticides.

Summary of Field Efficacy Research

During 1983

Study Ref. FP-51

Report to the 11th Annual Forest Pest Control Forum

Ottawa, Ontario

by

B.L. Cadogan, B.F. Zylstra, C. Nystrom,
L.B. Pollock and P. Ebling

Forest Pest Management Institute
Canadian Forestry Service
Environment Canada
Sault Ste. Marie, Ontario

November 1983

Summary of Field Efficacy Research FP-51

Erratum - Study 1 has been reported separately (Experimental Aerial Spray Trials with Nuclear Polyhedrosis Virus for the Regulation of Spruce Budworm in Quebec; Cadogan *et al*), thus pages 1-4 should be removed in this report. Studies 2 and 3 then become studies 1 and 2 respectively.

Study 1

Summary of Experimental Aerial Applications of NPV to Control Spruce Budworm in Quebec

A Joint Cooperative Program

by

B.L. Cadogan et. al. (FP-51)

W.J. Kaupp and J.C. Cunningham (FP-13)

(Report to the 11th Annual Pest Control Forum)

A study comprising two trials was conducted to further examine the potential of aerial applications of NPV as a strategy to control spruce budworm *Choristoneura fumiferana* (Clem.) In the first trial a single application of virus was aimed primarily at emerging second instar (L_2) budworm larvae while the second trial investigated the effects of a double application with high dosages.

Study Area

The research was conducted near St. Eugene, in the Gaspè region of Quebec. The area was natural forests consisting mainly of balsam fir *Abies balsamea* (L.) Mill., white spruce *Picea glauca* (Moench) Voss and hardwood species. Two 20 ha (1.0 x 0.2 km) blocks were selected for treatments. Three lines transected each block and 15 balsam trees 8-12 m tall were selected along each line to assess the budworm populations.

An untreated area of approximately 20 ha was selected as an untreated check block. Forty-five balsam fir were randomly chosen throughout this area as sample trees.

Spray Application

The virus formulations were prepared by W.J. Kaupp and J.C. Cunningham[1] This virus-oil formulation was then added to water to form a 25% formulation: 75% water (v/v) tank mix. This was dyed with 0.1% v/v Erio acid dye to monitor the spray deposit. The sprays were applied using a Cessna 188 Ag-truck® fitted with four Micronair® AU-3000 rotary atomizers. The aircraft flew at 160 km/h approximately 10 m above the tree tops. All the treatments were applied in the evening under stable weather conditions (Table 1). The first spray was timed to coincide with the first L_2 emergences and the second was applied when the budcaps were completely shed and the budworm larvae were 94% L_3 and 5% L_4.

Sampling

Assessing L_2 budworm by manually counting them on branches is a tedious task which often underestimates the population. During this study, for the first and second samplings when early instars were most prevalent, two 90-cm branches were taken from the midcrown of each sample tree and placed in emergence boxes[2]. On the last three sample dates two 45-cm branches/tree were taken and threshed using beating drums[3]. Clearings were made around each sample tree and a sample unit[4] placed in each clearing to assess the spray deposit.

DISCUSSIONS

No definitive results from this study are available at the time of this writing. However, preliminary results indicate that neither trial was effective in controlling spruce budworm populations (Table 1). Application of any pesticide applied primarily to affect early instar

[1]See Report to the 11th Annual Pest Control Forum by FP-13
[2]A.P. Randall - Can. For. Serv. Res. Notes 2(2): 9-12 (1982).
[3]R. Martineau & P. Benoit - Phytoprotection 54(1): 23-32 (1973).
[4]A.P. Randall - Can. For. Serv. Bimonthly Res. Notes V36(5): 23 (1980).

budworm must be accurately timed if it is to be effective. With viruses this timing is most critical because the insect is accessible for only a short period prior to mining and the virus tends to be quickly deactivated. It thus appears that early application of NPV should be considered as a viable strategy only after a better understanding of how the weather influences the emergence and dispersal of L_2 and L_3 larvae has been achieved.

The more conventional double application with high dosages of NPV also appeared to fail to control the budworm population. In essence this was a single application since the first spray - an early one - could not be considered a viable strategy. The second application failed to achieve any success possibly due to sub-optimal spray deposits. Indications are that the droplets might be generally <100 μm in diameter and while these might be optimally sized for chemical insecticides the evidence emerging from this study is that these small droplets might not have sufficient PIBs to be very effective against spruce budworms.

Table 1. Viral Application and spruce budworm population data (St. Eugene, Quebec 1983)

Block	APPLICATION					DEPOSIT[1]	BUDWORM LARVAE (Sampling Dates) No./branch				
	Date (1983)	Temp. (°C)	% R.H.	Windspeed ($\bar{X}$-km/h)	Dosage (PIBx10^{12}/ha)	Drops/cm^2	(13/5)*	(4/6)*	(11/6)†	(16/6)†	(30/6)†
1	1st 14/5	13	77	2	1.15	28	110	93	34	27	11
2	1st 14/5	16	67	5	3.44	13	100	112	32	13	14
	2nd 9/6	12	68	1.5	2.30	5					
Check	N/A					N/A	93	104	29	19	16

[1] recorded on Kromekote Cards at ground level.

*per 90 cm branch; †per 45 cm branch and not weighted accordingly.

At the time of this writing, detailed analyses of spray deposit, budworm population and host tree defoliation have not been completed - thus THESE DATA ARE VERY PRELIMINARY.

Study No. 2

Aerial Characterization of a New Sumithion Flowable Insecticide: A Summary

by

B.L. Cadogan, B.F. Zylstra, C. Nystrom,
L.B. Pollock and P. Ebling
(FP-51)

(Report to the 11th Annual Pest Control Forum)

The program of the Forest Pest Management Institute is devoted almost exclusively to the development of new and/or improved pest control products and strategies which will assist forest managers in achieving management objectives without jeopardising public health or environmental quality.

At present only a few insecticides are registered for aerial application in forests and fewer still can be said to be efficacious against the spruce budworm *Choristoneura fumiferana* (Clem.) which is considered to be the major defoliators of Eastern conifers.

A new flowable formulation of Fenitrothion currently being developed appears as a promising prospect to be added to the small arsenal of compounds which can be sprayed aerially to control budworm. Our task was to examine the spray characteristics of the new Sumithion F20 flowable insecticide.

A series of trials was conducted during July 1983 near Aubrey Falls, Ontario. The formulation was mixed in water and Rhodamine® W.T. red liquid dye was added as a tracer. The tank mix was applied at 210g AI/ha using a Cessna Ag truck® fitted with 4 Micronair® AU3000 rotary atomizers. Three volumes (1.0, 1.5 and 4.7ℓ/ha) were applied as single swaths with the atomizers operating at three different blade angle settings (25, 30 and 35°). The aircraft flew approximately 15m above the ground at 160 km and sprayed under stable weather conditions with light (1-8 km/L) crosswinds. The assessment criteria were (I) Absolute observed swath in relation to the theoretical swath (II) Effective swath based on a given droplet density and (III) Swath spectrum.

Discussions

At the time of this writing no analysis of the data was conducted. However preliminary examinations indicate that the formulation atomised satisfactorily. Deposit from trials using 1.0ℓ/ha was consistently the lightest and that from those using 4.7ℓ/ha the most dense.

Study No. 3

Spray Characterization of Aerially Applied Volumes Specifically for Vegetation Management and a Comparison of Micronair® AU3000 and AU5000 Rotary Atomizers: A Summary

A Joint Cooperative Program

by

B.L. Cadogan et al. (FP-51)

S.A. Nicholson and C. Hope
(Ontario Ministry of Natural Resources, Maple)

(Report to the 11th Annual Pest Control Forum)

During September 1983 experimental trials were conducted at Thessalon airport, Ontario to determine and compare the spray characteristics of 4-Micronair® AU3000 standard rotary atomizers, 8-Micronair AU5000 mini atomizers and boom and nozzle systems. These delivery systems were fitted to Cessna® 188 Ag-truck aircraft which flew single swaths approximately 15m above the ground at 160 km/h. The trials were conducted under stable weather conditions using water with Rhodamine 'B' dye added to act as tracer for deposit analysis. The swaths were applied with winds blowing generally across the aircraft's flight path or approximately parallel to the sample layout. Sample units comprising of 10x10 cm Kromekote® cards and glass slides were spaced 10 m apart and extended to 500 m downwind of the flight path. The samples were placed horizontally on aluminum stakes about 18 cm above ground level.

Volumes Specifically for Herbicide Applications

The maximum output achieved with the 8-AU5000 was 166 ℓ/mm (31.3ℓ/ha) and this volume was atomized using 4 blade angle settings (65, 55, 45 and 35°).

Both the AU5000's and AU3000's were operated at 96 ℓ/min (18 ℓ/ha) the former system using 55, 45 and 35° blade settings and the latter at 35, 30 and 25°. Although the standard Micronairs are reportedly not recommended for herbicide application these trials should provide basic data on which to compare other systems. Five different configurations of nozzles (D 6 without tips, D 6-46, D 6-56, D 10-45, and 6510 T-Jets) were tested at 166 ℓ/min.

Comparison of Micronairs

Trials to compare the two Micronair systems were conducted primarily at volumes more suited to insecticide application. Both systems were tested at outputs of 1.5, 3.0 and 4.5 ℓ/ha with the AU5000 operating at 55, 45 and 35° and the AU3000 at 35, 30 and 25°.

Discussions

No results from these trials are as yet available but it is anticipated that these initial trials will provide (I) a basis on which to build sound aerial application strategies for vegetation management in forests and (II) data which will enable cross-referencing and ultimately interchangeability of the standard and Mini Micronair systems on a variety of small aircraft.

SPRAY DEPOSIT EVALUATION OF PERMETHRIN

Study Ref. FP-23, 50, 53, 61, 62, 70 and 71

Report to the Annual Forest Pest Control Forum

by

P. de Groot (Project Co-ordinator)

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P6A 5M7

SUMMARY

A field investigation of the spray deposit of Permethrin for the purpose of establishing buffer zone dimensions around productive bodies of water has been initiated at FPMI. To date two trials have been conducted, primarily to develop and calibrate sensitive bioassays and deposit assessment techniques. A brief summary of the work conducted to date and future plans are presented here.

INTRODUCTION

A long-term study has been initiated at FPMI to investigate the spray deposit characteristics of Permethrin. Permethrin has excellent potential for control of a variety of important forest insect pests. It is highly toxic to fish and aquatic invertebrates. To ensure that significant undesirable impacts or aquatic ecosystems from its use do not occur, buffer zones around productive bodies of water need to be established. At present there is insufficient data to establish buffer zone dimensions for the range of pesticide use patterns in forest pest management.

This study is aimed at determining, through field research and testing, buffer zone dimensions that will increase forest manager's flexibility in the responsible use of this pesticide while ensuring that significant biological impact on aquatic ecosystems will be very unlikely from such use.

PROJECT PARTICIPANTS

The study of spray deposit requires an interdisciplinary approach. The team undertaking this study at FPMI involves the following projects: Insecticide Toxicity - B.V. Helson; Environmental Impact - P.D. Kingsbury; High-Value Stand Protection - P. de Groot; Chemical Accountability - K.M.S. Sundaram; Pesticide Formulations - A. Sundaram; Spray Cloud Behaviour - N. Payne; and Biological Systems Analysis - R. Fleming. Participation from other agencies or establishments is expected as the project progresses.

EXPERIMENTAL DESIGN AND PROGRESS TO DATE

In the study of spray deposit there are a number of variables and their interaction that must be considered. Included among these are droplet size and density emitted, meteorological conditions at time of spray, equipment type, forest stand characteristics such as species, height, crown and tree density and formulation. Our first priority was the development and calibration of bioassay and physio-chemical analysis techniques. To this end two trials were conducted in September of this year. At this point in time, analysis of the data is incomplete but a brief summary of techniques, layout and equipment used is presented here by the project staff involved.

A. Plot layout

Both trials were conducted in a young white spruce, *Picea glauca*, plantation. Mean tree height and stocking was estimated to be <1.5m and <70%, respectively. Crown closure had not occurred, the topography was flat and species competition was limited to low lying herbaceous cover.

Meteorological conditions (wind speed and direction, RH, temperature gradient) were monitored before, during and after the spray.

A Solo® Port 423, back pack mistblower calibrated at a delivery rate of 2 ℓ/min was used to emit 35 gai/ha of Permethrin (Ambush® 500 EC) at 25 ℓ tank mix/ha along a single spray line measuring 140m. The spray line was oriented at right angle to the direction of the prevailing wind with the spray nozzle directed downwind and parallel to wind flow (see Fig. 1).

The first trial was conducted on September 13, 1983 at 11:10 hrs. Mean wind speed during emission time was 9.4 km/hr and a RH reading of 80% was observed. The second trial was done on September 27, 1983 at 12:02 hrs. Mean wind speed was 8.0 km/hr and RH was 52.5%. Assuming uniform distribution of Permethrin in the spray mix, actual dosage emitted was calculated to be 33.5 and 33.1 g AI/ha for trials 1 and 2 respectively. Calculations were based on a swath width of 10m.

B. Bioassay analysis undertaken by B.V. Helson and P.D. Kingsbury

Two aquatic invertebrates, *Aedes aegypti*, mosquito larvae, and *Grammarus pseudolimnaeus* (Amphipoda), which are common freshwater crustaceans, were used for the bioassays. A colony of *Aedes aegypti* was established at FPMI and the necessary numbers of larvae were reared for each trial. The amphipods for each trial were collected from the field.

Two bioassay techniques were used in this study; a wading pool technique and a plastic bucket or mason jar technique.

Wading Pool Technique

Twenty-five children's, inflatable, plastic wading pools, ca 0.8m in internal diameter were set up in the treated area. The pools were placed 20m apart along 5 lines, also 20m apart such that 5 pools would be situated 10m, 30m, 50m, 70m and 90m downwind from the spray line (see Fig. 1). The pools were lined with 6 mil clear plastic sheeting and filled with 50 ℓ of water from a nearby stream.

Immediately after the spray, 20, 3rd instar mosquito larvae and 10 amphipods were placed in separate cages in each pool. The cages were made from 1 ℓ plastic containers. The bottom and two, 5 x 10 cm pieces from opposite sides of the container were removed and covered with fine mesh cloth screening. Mortality was determined daily for 2 or 3 days after treatment and also at later times in the case of amphipods.

In addition to the above pools, another group of 22-23 pools was set up several kilometres from the treated area. These pools were used as untreated controls and also as treated standards to obtain dose-response relationships in each trial. Within 2 hours after the mist-blower application, these standard pools were treated with a series of permethrin concentrations ranging from 0.05 to 16.0 ppb. Mosquito larvae and amphipods were then placed in all pools as above and mortality was determined on the same days as above.

Water samples for chemical analyses were taken from each pool 1/2 hr after the sprays and treatments.

Plastic Bucket (Mason Jar) Techniques

In the first trial, plastic buckets (1 kg honey containers) containing 600 ml of distilled water were placed out in the treated area immediately before the spray. They were placed along the 5 lines of pools at 5m intervals for the first 60m, 10m intervals up to 100m and also at 120 and 150m downwind from the spray line (see Fig. 1). One half-hour after the spray these buckets were picked up, capped and then returned to the laboratory where 20 mosquito larvae were placed in each bucket. In addition another series of buckets was treated with known permethrin concentrations shortly after the spray to serve as standards and a group was left untreated to serve as controls. All buckets were held in a controlled environment chamber at 20°C. Mortality counts were performed daily for 3 days after treatment.

In the second trial, 500 ml Mason jars were used instead of plastic buckets to reduce possible problems with permethrin adsorption to the plastic buckets. These were set out in triplicate at each station. In the first trial, 1 bucket was placed at each station. A set of 3 jars for mosquito bioassays was placed at each of the 25 pool sites in the second trial. Sets of 3 jars for amphipod bioassays were also placed at 10m intervals up to 100m and at 120 and 150m along the centre line of pools in this trial. Other methods were similar to those used with the plastic buckets in the first trial.

Bioassay data analysis is incomplete at this time, however the range of concentrations providing 0-100% mortality at 48 hours often treatment has been calculated to demonstrate the sensitivity of the bioassay.

First trial:	Amphipods in Pools	<0.1 - 4.0 ppb,
	Mosquitoes in Pools	0.25 - >16.0 ppb,
	Mosquitoes in Buckets	0.8 - >12.8 ppb.
Second trial:	Amphipods in pools	0.1 - 1.0 ppb,
	Mosquitoes in pools	0.25 - 2.0 ppb,
	Amphipods in jars	0.2 - 0.8 ppb,
	Mosquitoes in jars	0.2 - 6.4 ppb.

C. Physical and Chemical Analysis

i) Analysis undertaken by K.M.S. Sundaram, A. Sundaram and N. Payne

Sampling stations were positioned at 10, 20, 30, 50, 70, 90, 120 and 150 meters downwind from the spray line along 3 lines located 50, 70 and 90 meters from application starting position (see Fig. 2). Two sampling stations were located 30 meters upwind from the spray line at 60 and 80 meters from the starting position. The total number of stations established was 26. At each station the following sampling units were used.

Air sampler containing toluene (150 filled ml) fritted glass bubblers operating at 1 L/min for 30 min with battery or generator powered pump to quantify the airborne permethrin.

Aluminum tray (15 cm x 21 cm x 1.6 cm) containing 0.5L of distilled water to determine permethrin deposited on water surface (1.6 cm depth) during spray.

Two (20 cm x 20 cm) glass plates kept 25 cm above forest floor to estimate approximately the level of permethrin deposited on forest floor and if possible to correlate with the concentration in water.

Five bronze rods (0.25 cm diam., 44 cm length) mounted on a wooden stick, at a height of 50 cm above ground to study (i) the collection efficiency of a cylinderical surface vs a flat one (glass plates) and (ii) correlate the concentration of permethrin in air (measured by the air samplers) with permethrin deposited on the rods.

Two Kromekote cards (10 cm x 10 cm), one placed horizontally at 25 cm above the forest floor and another vertically at 45 cm above the ground. Both the cards would give droplet density and spectra in horizontal and vertical directions which could be correlated with concentrations found in air samplers, glass plates and bronze rods kept at each sampling station.

Pre- and post-spray (except K cards) samples were collected. Water samples (700 ml) from wading pool to determine concentration (in ppb) of permethrin.

Glass plates and bronze rods were thoroughly eluted with methanol and hexane respectively. Eluates were transferred quantitatively to amber coloured bottles and stored in a freezer to prevent possible degradation of the A.I. Toluene samples from each bubbler were transferred quantitatively to brown bottles, sealed and stored in the freezer. Water samples were put in air-tight Teflon bottles and stored as above. In the laboratory, they were extracted repeatedly with hexane, the organic phase was dried by passing over a column of Na_2SO_4, flash-evaporated and stored in the freezer until analysis.

All samples will be processed according to established methods and will be analysed by (1) EC-GLC and (2) HPLC using UV and fluorescence detectors.

Concentration levels in each sampling site will be compared wherever applicable. Concentration (c) vs distance downwind (d) and log c vs d will be plotted to evaluate the drift potential of permethrin under the operational conditions existing during the spray application. Additional analysis will also be undertaken.

ii) Analysis undertaken by P. de Groot

Deposit sampling stations were located 3, 5, 10, 15, 20, 30, 40, 50, 70 and 90 meters downwind from the spray line for a total of 10 stations per sample line (see Fig. 2). Sample lines were perpendicular to the spray line and were located 30, 50, 70, 90 and 110 m from the starting position of the spray line. One Kromekote card (10 cm x 10 cm) and two glass slides (50 x 75 mm) were placed in a vertical position at approx. 1, 2 and 3 meters above ground and in a horizontal position approx 25 cm above ground.

Analyses of VMD, NMD, droplet density/cm^2 and colorimetric analysis of insecticide deposit (vol/ha) will be undertaken.

FUTURE WORK

Although analysis of data is incomplete at this time, considerable insight has been gained in the selection of a suitable experimental design. Bioassay and water sample analysis will be completed by year end.

As mentioned earlier, there are numerous combinations and permutations of parameters that can be investigated. Although bioassay calibration is largely complete, further refinement is likely necessary. Furthermore a refinement of the problem analysis is needed to clearly define the scope and limitations to this study and help set priorities and direction for the subsequent field trials. This indepth problem analysis will be undertaken in late November of this year.

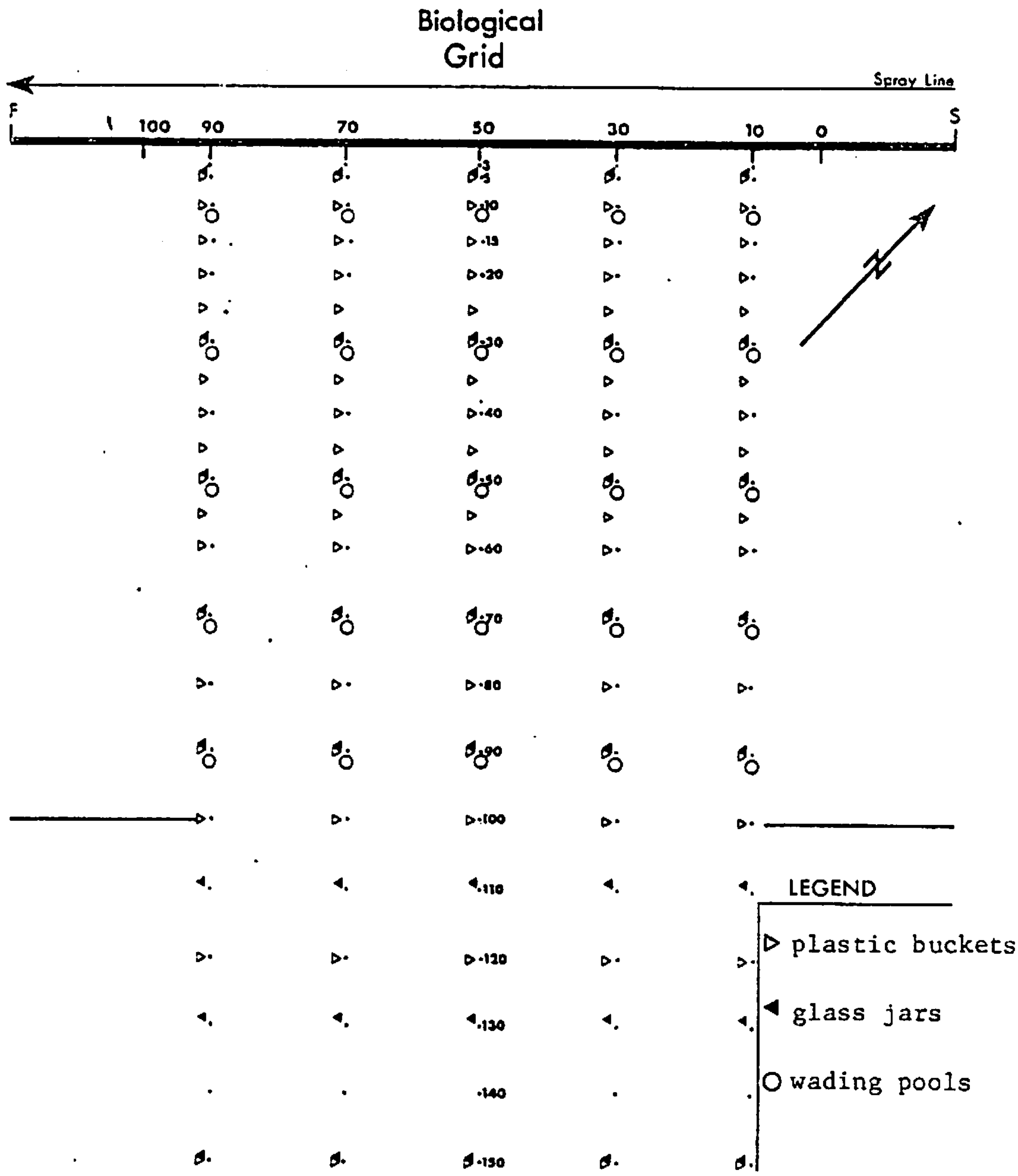

Fig. 1. Location of bioassay sampling stations.

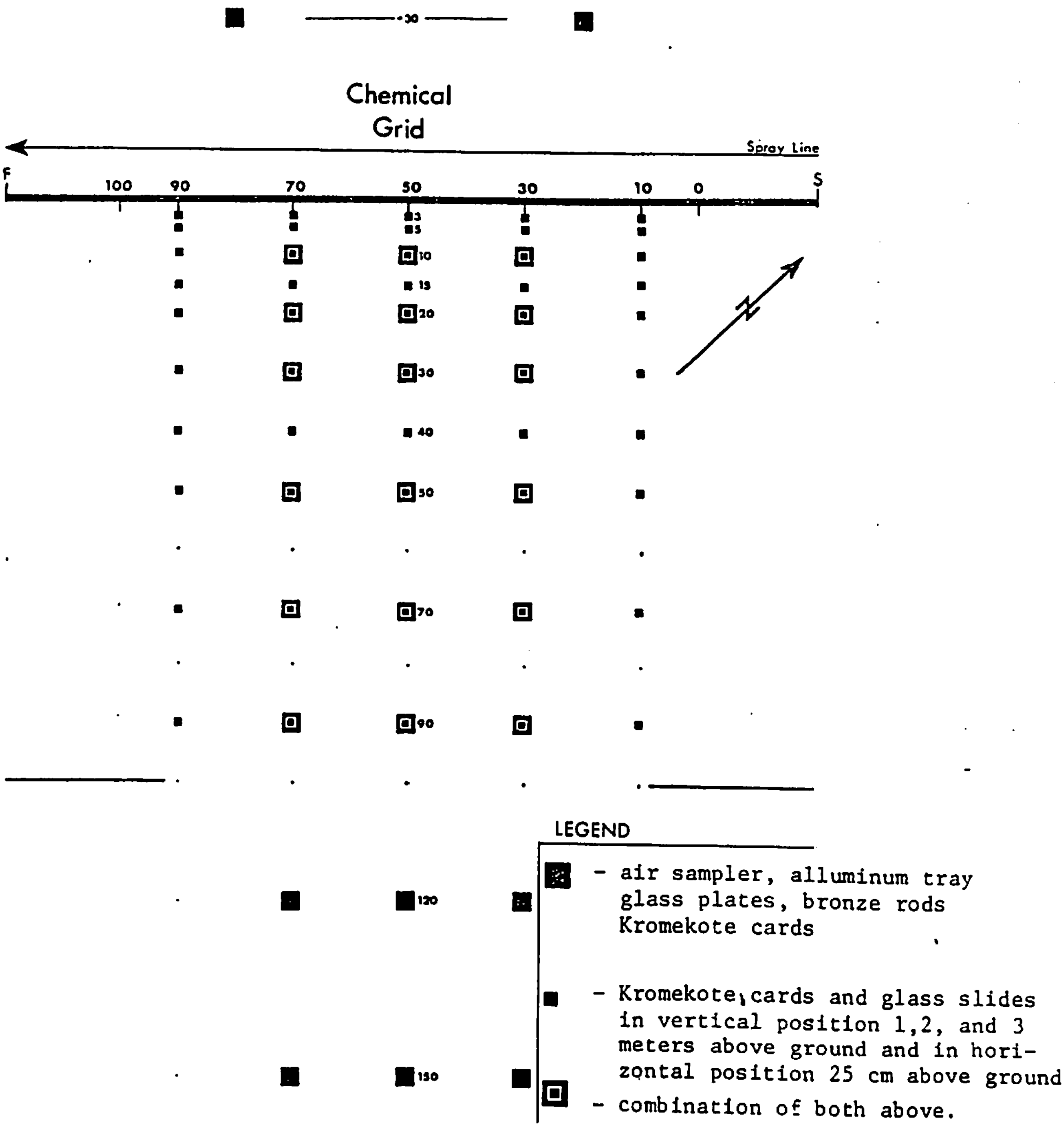

Fig. 2. Location of sampling stations for physical and chemical analysis of Permethrin deposit.

Summary of the 1983 Field Research on the Spruce Budmoth, *Zeiraphera canadensis* (Lepidoptera: Olethreutidae)

(Study Ref. No. FP-52)

Report to the Annual Forest Pest Control Forum

Jean Turgeon

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Sault Ste. Marie, Ontario
P6A 5M7

November 1983

SUMMARY

During the winter period of 1983 we were able to determine the duration of the spruce budmoth (Sbm), *Zeiraphera canadensis* (Mut. Free.) diapause and subsequently rear the larvae up to the adult stage. The development or Sbm at 8 different temperatures was also studied.

In the spring, studies on the life history and seasonal history were resumed and carried out simultaneously in Bathurst and St. Quentin (N.B.). We completed more behavioral studies and obtained information on the:

1) duration of the hatching period,
2) time of day hatching takes place,
3) length of time 1st instar larvae take to cover the distance between the scales (hatching site) and the buds (feeding site).

A preliminary test on the susceptibility of 1st instar Sbm to infection by the nematode *Heterorhabditis heliothidis* was performed under laboratory conditions.

The flight period of males was determined using Z9-14:Ac, an attractant for Sbm. More complete pheromone trials were carried out concurrently.

The study on the distribution of Sbm infestations in plantations of different ages was continued.

RESULTS

Eggs transferred to 20 C after 14-16 weeks of cold storage at 0.5 C will take a mean of 11 days to hatch. A model of Sbm phenology should be available at the end of 1983.

Under the field conditions that prevailed during the spring of 1983, the hatching period lasted approximately 10 days. However, more than 90% of the larvae hatched within a period of 3-4 days. Larvae generally hatch at the end of the day (1700 and 2000 h). This hatching period will happen earlier or later in the day depending on daily temperatures. Larvae placed mechanically under the scales during the daily hatching period will take approximately 15 min to reach a suitable bud.

Trichogramma minutum was the only egg parasite found. Parasitism levels varied between 15 and 28%, depending on the site. In 1983 the larval parasite collection was increased. However, levels remained very low, varying from 0-13%, depending on the site and the plot. Specimens were sent to Ottawa for identification. Field-collected larvae are at present being dissected for the presence of any virus or disease.

Z. canadensis larvae feeding on foliage can successfully be infected by *H. heliothidis*. After only 6 days of close contact with the nematode nearly 100% of the larvae become infected and die.

The compound identified last year as a potential attractant, Z9-14:Ac, enabled us to successfully monitor the flight period of *Z. canadensis* adult males, which lasted approximately 15 days. However, other field trials conducted during that flight period emphasized the lack of competitiveness with the control treatment during peak emergence indicating that an important component is missing. More screening tests will be needed before the establishment of an efficient monitoring system for this white spruce pest.

Results of studies on Sbm damage in plantations of different ages confirm those obtained last year and show that trees between 14 and 19 years old are the most heavily infested.

Herbicides R & D Program at Forest Pest Management Institute for 1983

Report to the Annual Forest Pest Control Forum, Ottawa

Phillip Reynolds

Raj Prasad

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Forest Pest Management Institute

Canadian Forestry Service

Sault Ste. Marie, Ontario

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During 1983 a number of developments have occurred to strengthen and expand the activities of the Herbicide R&D Project at the FPMI in Sault Ste. Marie. These include expansion of staff, acquisition of new research facilities, initiation of university research contracts, collaborative participation in on-going registration research, expansion of current research effort, and a national problem analysis of future herbicide R&D needs throughout Canada

Expansion of Staff

In May 1983, a silviculturist (Dr. Phillip Reynolds) with field experience in herbicide applications testing (aerial and ground) was hired to coordinate the Herbicides R&D Project and conduct a national problem analysis aimed at determining future herbicides R&D needs and the capabilities within CFS to address the needs. In June 1983, a herbicide chemist (Mr. Joseph Feng) was added to the Herbicide R&D staff to establish a herbicides residue laboratory at FPMI. Plans are progressing to employ an additional technician to work in this laboratory by the end of 1983. Early in 1984, a technician will be hired to assist in the field applications program. New herbicides R&D staff at FPMI will complement previous research personnel (Dr. Raj Prasad, Mr. Dal Travnick) whose work has focussed on plant physiological problems pertaining to herbicide use and development. With the addition of new personnel, the Herbicides R&D staff at FPMI will consist of six persons, and hopefully serve as a nucleus for coordinating herbicides R&D within other regional CFS research centres.

Acquisition of New Research Facilities

Major capital expenditures have been made in 1983 at FPMI in support of herbicides R&D. Chief among these expenditures is the establishment of a new herbicide residues laboratory. The laboratory facility is being developed with the intent of addressing the fate of new forest herbicides in the Canadian environment. Initially the facility will focus on the herbicides, Roundup (glyphosate), Velpar (hexazinone) and Garlon (triclopyr) and will consider accumulation, leaching, persistence and degradation of these herbicides in forest soils, forest watersheds and animal tissues. New equipment essential for running a residues laboratory, including a gas chromatograph (GC) and a high pressure liquid chromatograph (HPLC), have been purchased and will be available at FPMI by the end of 1983. Mr. Feng has visited similar residue laboratories at Dow Chemical, DuPont and Monsanto to ensure that the new FPMI laboratory is set up in accordance with currently recognized procedures for analysis of Garlon, Velpar and Roundup.

To further bolster FPMI's capability to conduct plant physiological research pertinent to herbicides R&D, a modern greenhouse facility has been dedicated to herbicide research at FPMI. The facility is being equipped with a modern spray chamber which will be used to expose crop trees or weed species to various herbicide formulations using a variety of nozzle types. Results from these studies should provide much needed information pertaining to (1) efficacy of new herbicide formulations, (2) crop injury resulting from herbicide exposure, (3) the potential effects of adjuvants on efficacy or crop injury and (4) the influence of nozzle type on spray deposition, efficacy or crop injury.

Additional ground and aerial application equipment will be purchased in 1984 for use in the field applications/testing program.

Initiation of University Research Contracts

During the summer of 1983, the Herbicides R&D project was instrumental in negotiating three university research contracts to study the leachability, persistence and lateral movement of Garlon, Velpar and Roundup in selected Canadian forest soils. PRUF (Program of Research by Universities in Forestry) funds (approximately $138,000) have been awarded to the Universities of Guelph and Toronto to undertake the research.

Research on Garlon will be conducted at the University of Guelph under the direction of Drs. Gerry Stephenson and Keith Solomon; research on Velpar and Roundup will be performed at the University of Toronto under the direction of Dr. D.N. Roy. All three studies will focus on northern Ontario soils and will be conducted in phases over the next 2-3 years with guidance and periodic review by FPMI and other external researchers. The latter will include inputs from provincial researchers such as Ontario Ministry of Natural Resources (OMNR, Dr. Robert Campbell), governmental agencies concerned with forestry herbicide registration, and chemical company R&D representatives concerned with obtaining forestry registrations.

During October 1983, phase 1 for all three herbicide studies was launched with site selection and initial soil sampling. Soil samples were collected for laboratory analysis and preliminary soil column leaching studies. All soil sites were selected near Matheson, Ontario on crown lands. The sites are in close proximity to previously established Roundup and Velpar field trials. Both organic clay and sandy soil sites were selected. These will afford an opportunity to monitor both vertical and lateral leaching of the three herbicides in two differing soil types. Phase 2 research will commence in June 1984 when the three herbicides are applied to the chosen sites and continue into late 1984 as various soil samples are collected for residue analysis. Phase 3 will involve residue analysis of the various field samples.

The intent of the PRUF grants is to augment residue research which will be performed by the new herbicide residue laboratory established at FPMI. In addition, the grants are designed to develop residue research capability in various forestry school programs within Canada and to cultivate a future supply of forestry researchers capable of addressing the environmental fate of forestry herbicides used in Canada.

Collaborative Participation in On-going Registration Research

To assist in obtaining environmental fate data needed for registration of forestry herbicides, FPMI's herbicide residue laboratory is working cooperatively with various provincial researchers and chemical company R&D representatives. Velpar, Garlon and Roundup soil samples obtained after aerial spraying in northern Ontario have been collected for analysis at FPMI. In addition, soil samples collected following an aerial Garlon trial in B.C. this September may be analyzed at FPMI. The various soil samples consist of samples collected at varying soil depths and time periods following aerial spraying. Analysis of the samples will provide needed data on persistence, leaching and rate of breakdown of the herbicides in the Canadian environment. Examination of samples of the same herbicide collected in different geographic locations will allow for an assessment of variable climatic and soil conditions on these processes.

A breakdown of the various soil residue samples collected to date includes the following:

(1) Velpar samples resulting from aerial spraying near Matheson, Ontario in May 1983; spraying performed by OMNR under the direction of Dr. Robert Campbell; soil sampling performed by OMNR.

(2) Garlon samples resulting from aerial spraying near Nipigon, Ontario in August 1983; spraying performed by OMNR in cooperation with Dow Chemical Canada (Ms. Monique MacKasey); soil sampling performed by FPMI personnel.

(3) Roundup samples resulting from aerial spraying near Nipigon, Ontario in August 1983; spraying performed by OMNR in cooperation with Dr. John Jeglum of Great Lakes Forest Research Center (GLFRC); soil sampling performed by FPMI personnel.

(4) Garlon samples resulting from aerial spraying near Chilliwack, B.C. in September 1983; spraying performed by B.C. Forest Service (BCMF) in cooperation with Dow Chemical Co.; soil samples collected under the direction of Mr. Mel Scott (BCMF).

(5) Velpar samples resulting from ground spot-gun application near Nipigon, Ontario in July 1983; application performed by Dr. Raj Prasad, Mr. Dal Travnick and Mr. Joe Feng of FPMI in cooperation with Dr. John Jeglum (GLFRC) and DuPont Canada (Mr. Ian Parsons); soil sampling performed by FPMI personnel.

As part of a further effort to advance registration of forestry herbicides, Dr. Reynolds participated in the collection of efficacy registration data in N.B. (Garlon) and in Ontario (Velpar) during the summer of 1983. The opportunity to work cooperatively with Dow Chemical and DuPont researchers helped to provide much needed manpower in data acquisition while allowing for an assessment and familiarization with research protocols used by the two companies.

Expansion of Current Research Effort

The preceding section details much of this expansion. Of particular notability, however, is the Velpar spot-gun research undertaken near Nipigon, Ontario. FPMI personnel from the Herbicides R&D Project working with Dr. John Jeglum of GLFRC were instrumental in establishing the research site.

The spot-gun treatment is located on a black spruce site characterized by some jack pine regeneration. During the summer of 1984, vegetation on the site will be evaluated for herbicide efficacy and effects on crop tree growth. Residue analysis of soil samples collected during 1983 should be complete sometime in 1984.

In late October 1983, researchers at FPMI working cooperatively with J.D. Irving in N.B. and Waldrum Specialties, Inc. (near Philadelphia), launched preliminary testing of a new boom for use on fixed-wing aircraft or helicopters. The new boom, known as a thru-valve boom (TVB) was supplied by Waldrum Specialties for testing on a Turbo-thrush owned by J.D. Irving. The new boom has been designed to achieve significant drift control on fixed-wing aircraft flying at speeds of 100-120 mph. Mechanical drift control with the boom is believed to be similar to that achieved with the MICROFOIL BOOM* used on helicopters flying at pesticide application speeds usually half that for fixed-wing aircraft. The

*Registered trademark of Union Carbide Agricultural Products Co., Inc.

MICROFOIL BOOM is generally regarded as the ultimate mechanical device for control of aerial spray drift.

Preliminary drift tests of the TVB were conducted by several FPMI researchers (Drs. N. Payne, L. Cadogan, A. Sundaram and S. Sundaram) working cooperatively with Mr. Arthur Schneider (representing Waldrum Specialties, Inc.) and Mr. Pat Marceau (representing J.D. Irving). Preliminary drift data for the TVB will be compared with similar drift data for an Irving turbo-thrush equipped with conventional nozzles. Results of the drift study will hopefully be available early in 1984.

National Problem Analysis of Future Herbicides R&D Needs

In order to better assess future herbicides R&D requirements throughout Canada, members of the FPMI herbicides research team (in particular, Dr. Phillip Reynolds) traveled extensively throughout Canada and the U.S. in 1983. Several provinces were visited to see first-hand existing forestry problems requiring herbicide use and to identify probable future forestry herbicide use patterns. Provinces visited in 1983 included Ontario, B.C., N.B., N.S. and P.E.I. Plans exist to visit Quebec, Newfoundland and Alberta in 1984. In addition, cooperation with the U.S. Forest Service resulted in trips to Michigan, Wisconsin, Minnesota and Oregon to view herbicide use patterns in these States both on private forestry lands and on four National Forests. Visits were also made to private forestry lands in Maine.

In all instances, people concerned with herbicide R&D and herbicide use at federal, provincial, forest industry, pesticide industry and university levels were consulted. Time spent in Ontario and N.B. included assisting provincial and chemical researchers in establishing

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or assessing herbicide trials for purposes of gathering registration data and in evaluating experimental protocol used by these researchers in collecting this data. The intent of this extensive travel has been to gain a fuller appreciation of the herbicide problem in Canada (i.e., to identify existing registration testing and data gaps) which is required for the development of a comprehensive problem analysis. It is hoped that this problem analysis will guide the development of a herbicides R&D project at FPMI and suggest required interfaces and cooperative approaches with CFS regional centres, provincial forest agencies, chemical company researchers, regulatory agencies and other potential cooperators. Information gathered in the problem analysis will serve to define 1984 and 1985 field research throughout Canada and recommend regional CFS roles for participation in this research.

SUMMARY REPORT ON STUDIES OF THE USE OF HERBICIDES IN CANADIAN FORESTS

REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

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INTRODUCTION

The forest resource is not endless as it seemed to be; we are approaching or exceeding annual allowable cut in many parts of the country, and we are also falling behind in the effective regeneration of cut-over lands. Therefore, in order to meet the very significant demand in our fibre resource that will occur in the 21st century, we must embark upon a vital program of intensive management of coniferous forests that will include active and complete regeneration of cut-over forest land (including the backlog) and a significant shortening of rotation age. These goals can be achieved only by intelligent use of effective, economical and environmentally acceptable herbicides. At present, there are only 2 herbicides (2,4-D and 2,4 5-T) registered for forestry use in Canada, and unfortunately because of some precipitous political reaction to their alleged public health problems (dioxins), some provinces are banning the continued use of 2,4, 5-T. Thus, there is a great dearth of forest herbicides for conifer release and site preparation, and therefore, a program of evaluation of newer products for this purpose was initiated.

Evaluation of Herbicides for Forestry Use

The screening of herbicides for conifer release and site preparation was carried out in three steps:

(a) Rapid and quick evaluation of scores of compounds by using a seed bioassay technique under the laboratory conditions. This procedure rapidly identified compounds active against coniferous or deciduous (weed) tree spp.;

(b) Further evaluation of some promising candidates in the greenhouse by using the seedlings of trees of pest and the crop spp.; and,

(c) Final evaluation of the selected candidates against the pest spp. under nursery and field conditions (so as to determine the effects of weather parameters on the efficacy of the selected compounds).

To begin with, 21 compounds of varying chemical structure and biological activity, were obtained from the chemical companies and subjected to the screening procedure described above. Five herbicides (Garlon, glyphosate, Herbec-20, Spike-80W and Velpar) were found most promising for site preparation and conifer release and were accordingly tested under small field plot conditions in Thessalon and Searchmont, Ont. The results are presented in Table II. Some concern was expressed for screening of herbicides against western weed and crop species and therefore a preliminary greenhouse experiment was carried to test two promising herbicides (Garlon and glyphosate) against thimbleberry and Sitka spruce. Table I presents results from a thimbleberry trial and shows that these two herbicides are efficacious and selective against thimbleberry. Further field testings under western (B.C.) conditions are necessary before any firm conclusion can be drawn.

Evaluation of New Herbicides Against Thimbleberry Under Greenhouse Conditions

Thimbleberry (*Rubus parviflorus* Nutt.) is a serious pest of conifer plantations in western Canada (B.C.) and new herbicides are required to manage this weed species. Because there is a dearth of herbicides for forestry use, a national program on screening and field testing of several herbicides for the control of forest weeds, was initiated at this Institute in 1981. The present findings are a summary of results obtained under greenhouse conditions at Sault Ste. Marie, Ontario, on the influence of two prominent herbicides (glyphosate and triclopyr) on thimbleberry. Seedlings (6 month-old) were raised in the greenhouse under controlled conditions of light, temp. and nutrition and treated with varying concentrations of commercial formulations of glyphosate (Roundup) and triclopyr (Garlon). All seedlings were sprayed in a controlied spray chamber and replicated 10 fold to minimize the variation in their response to herbicide treatments. After treatments, the seedlings were moved to another compartment of the greenhouse and the effects were observed for 3 weeks.

TABLE I. Effects of Glyphosate and Garlon on Thimbleberry

Treatment (herbicides)	Concentration (ppm)	Phytotoxicity Rating (0-9)*
Glyphosate (35 9 gm AI/L)	0	0
	1,000	2.7
	2,500	4.5
	5,000	7.2
	12,500	8.9
	25,000	9.0
	50,000	9.0
Triclopyr (4 lbs. AI/gallon)	0	0
	1,000	6.8
	2,500	8.1
	5,000	9.0
	12,500	9.0
	25,000	9.0
	50,000	9.0

*No control = 0; complete control = 9.0.

Both herbicides (glyphosate and triclopyr) seemed to be very effective against the thimbleberry. No resprouting after treatments was evident. Cultivation of thimbleberry in the greenhouse presents problems and further evaluation should be carried under its natural (environmental) conditions in the west. The author is grateful to B.C. Ministry of Forests and Dr. J. Manville, CFS, Victoria, B.C. for supplying thimbleberry samples.

Evaluation of Glyphosate and Garlon Against Sitka Spruce Under Greenhouse Conditions

Sitka spruce (10 months old) were treated with glyphosate and triclopyr at the same concentrations as thimbleberry. 0-25,000 ppm had no effect on Sitka spruce, but concentrations over 50,000 ppm reduced the growth and caused mortality of many seedlings. Thus these experiments demonstrate that conifer (sitka spruce) species have greater tolerance to these herbicides than the pest species (thimbleberry).

Evaluation of Some Herbicides for Weed Control in Red Pine Plantations Under Field Conditions

Six herbicides and a hand cutting method were employed to investigate control of weeds (eastern alders, aspen and grasses) in a 7 year-old red pine plantation in Algoma district of northern Ontario. A field experiment with randomised block layout and with 3 replications (plot size - 5x5 m) was designed. Some herbicides (Garlon, glyphosate, 2,4-D) were applied to foliage by a knapsack sprayer and some others (Velpar, Herbec-20 and Spike-80W) were applied through soil. Treatments were made in the middle of August 1982 when conifer needles were completely "hardened off". Observations on phytotoxicity and weed control were made in the following year (Aug./83). Garlon, Roundup, Herbec-20, Spike-80W were most effective against aspen while 2,4-D, Roundup, Garlon, Spike-80W were effective against eastern alder (*Alnus rugosa* Spreng.). Grasses were best controlled by Roundup, Spike-80W and Velpar. However, both Herbec-20 and Spike-80W were extremely phytotoxic to red pine and seemed more suited for site preparation. Even though Herbec-20 was very efficacious against aspen, it did not completely kill the alders. Profuse coppicing of alder stumps was visible in plots cut manually; similarly aspen resprouted

TABLE II. Effects of Herbicides and Manual Method of Cutting on Weed Control and Crop Tolerance

Treatment	Rate (per hectare)	Method of treatment*	Weed Control* (0-9)			Crop tolerance (0-9)*
			Alder	Aspen	Grasses	
Check	-	F.S.	0.0	0.0	0.0	9.0
Esteron 600 (2,4-D amine)	6L	" "	7.8	6.2	0.0	9.0
Garlon (triclopyr)	6.5L	" "	7.9	8.9	0.0	9.0
Roundup (glyphosate)	5L	" "	9.0	8.9	8.3	9.0
Herbec-20 (tebuthiuron)	14kg	S.A.	1.1	8.9	1.4	0.0
Spike-80W (tebuthiuron)	8kg	" "	8.4	9	6.1	0.0
Velpar (hexazinone)	10L	" "	1.5	8.9	3.9	9.0
Manual cutting	-	- -	2.0	2.0	0.0	9.0

0 = no control and/or tolerance, 9 = complete control and/or tolerance*
F.S. - foliar spray
S.A. - soil application

heavily in plots cut manually. Garlon, Roundup and Velpar seemed quite promising for weed control in red pine plantations. Red pine seems more resistant to Velpar than jack pine and further experiments are underway to study the causes of this selectivity.

<u>Evaluation and Efficacy Trials of Selected Herbicides Under Semi-Operational (Field) Conditions</u>

Because Garlon, glyphosate and Velpar showed excellent promise under laboratory, greenhouse and small field plot conditions, they were finally tested under field conditions (ca. 50 hectare blocks of black spruce plantations) in cooperation with the Ontario Ministry of Natural Resources (OMNR) at Nipigon, Thunder Bay, Ontario. Garlon and glyphosate were sprayed aerially with a fixed-wing aircraft while Velpar was applied by the "shot-gun" method at dosages recommended commercially for these herbicides. All treatments were made in late August. Preliminary observations indicate that all three herbicides were effective in suppressing the brush vegetation without causing any apparent damage to the crop (black spruce) species. Further follow-up studies are planned for next year.

Effect of Time of Application of Glyphosate on Brush Control and Crop Tolerance in Nurseries

Because glyphosate showed great promise for brush and grass control in forests, it was necessary to determine the optimum time of its application. Also, because scattered evidence suggested considerable injury to conifers following glyphosate applications in spring, a nursery experiment involving five brush and four conifer species were laid out at the Insectary (G.L.F.R.C.-Sault Ste. Marie) in 1982. The conifer species were ca. 3 yr old and the brush species were propagated from cuttings or suckers and were ca. 2 yr old "seedlings". They were planted in the nursery in 1982 and sprayed with one concentration of glyphosate (0.25 kg A.I./ha) during June, July, August and September 1983 with the aid of a knapsack sprayer to the point of drip-off. Observations for phytotoxicity to brush and conifer species were made 3-4 weeks after spraying and finally at the end of the experiment in October. Preliminary results (Table III) suggested that July and August would be the optimum time of application under these nursery conditions. Early spraying in June caused some injuries to conifers probably because they were not completely "hardened-off" and late application in September also brought about some phytotoxicity to balsam fir and red pine because of "reflushing" of buds under the nursery condition which was fertilized and irrigated by natural rainfall. Different brush species react differently to glyphosate treatment but poplar and to a lesser degree pincherry and raspberry, showed very good control. The residual effects of these treatments would be monitored in Spring 1984 to ascertain the systemic effects of glyphosate.

TABLE III. Effects of Time of Applications of Glyphosate (Roundup) at the Nursery (1983)

Species	Phytotoxicity Rating (percentage damage)*				
	Application Date				
	June	July	August	September	Controls
Dagwood	35	34.2	2.5	21.6	0
Balsam Fir	1.6	0.8	0.0	10.0	0
Raspberry	50	53.3	70.0	3.3	0
Red Pine	0	0	0	5.0	0
Green Ash	3.3	35.0	5.0	20.0	0
White Spruce	0	0	0	0	0
Pin Cherry	63.3	50.0	100.0	33.3	0
Jack Pine	8.3	0	1.7	0	0
Poplar	16.6	100.0	93.0	90	0

*Mean values of 3 replicates; 0 = no control and complete tolerance

100 = complete control and no tolerance

Conifer Release of Red Pine with Velpar

Velpar seems to be a quite effective herbicide for red pine plantations in the Great Lakes Region, U.S.A. Because of light sandy soils and other environmental factors, red pine is being planted in large acreage in these regions and seems to thrive very well under these conditions. Red pine also seems to be more tolerant to Velpar than jackpine in these soils and therefore 3 experiments were carried out in these plantations (ca. 10 ha each) in collaboration with the Ontario Ministry of Natural Resources, Blind River, Ont. Red pine plantations (aged 3-6 yrs) were treated with Velpar (10 L/ha) by the "hand-gun" method in three locations - Martel, Parkinson and Timbrell Townships, Ont. during late July and August. Since aspen and to a lesser degree, pincherry were the major brush species, treatments (2 c.c. Velpar/spot) were directed at the base of their clumps. Observations on weed control, and conifer release (volume and height growth of red pine) were also made at these three sites. Preliminary results (Table IV) suggested that some phytotoxicity to brush species was apparent in Sept.-Oct. but no comparable injury to crop species was evident at that time of observation. Further observations would be made next spring, summer and autumn to discern the full effectiveness of Velpar.

TABLE IV. Effects of Velpar on Phytotoxicity of Aspen in Red Pine Plantations

Sites	Date of Treatment	Phytotoxicity Rating*
Martel	August 25/83	5-10%
Parkinson	July 26/83	70-80%
Timbrel	August 18/83	10-20%

*Mean of 3 plots at each site; observations taken on Sept. 15/83; o = no browning 100% = complete browning.

Pesticide Formulation Research for Pest Control Programs in 1983

(Study Ref. No. FP-61)

Report to the Annual Forest Pest Control Forum

by

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INTRODUCTION

During 1983, the Pesticide Formulations Section at FPMI undertook a number of laboratory and field studies related to forest spray activities. The major areas of research are grouped under two major headings:

A. Laboratory Studies

A(i) Herbicides

A(i) 1. Spray Adjuvants for Drift Control of Herbicide Droplets

Thickening agents that alter the viscosity and evaporation rate of spray mixes are known to reduce the proportion of small droplets in the spray cloud and are therefore widely used for drift control in herbicide spraying. However, the relative importance of physical and chemical properties of spray formulations has not been investigated under controlled conditions in order to optimize the role of formulation ingredients. In this study the influence of physical and chemical properties on spray droplet spectra of glyphosate formulations was investigated with and without altering their viscosity and evaporation rate values. The Institute's spray chamber was used for spray generation and the Kromekote® card for droplet collection.

Results indicate that certain polymeric components can dramatically alter the droplet spectrum without altering the viscosity and evaporation values of spray mixes. However, other thickening agents, which altered the viscosities and evaporation rates significantly, failed to provide marked influences on spray droplet spectra. This study clearly points out the need to investigate every spray mix thoroughly before embarking on large scale field trials.

A(i) 2. Droplet Impaction, Retention and Dissipation Characteristics of Four Glyphosate Formulations on Non-target Conifer Needles

The objective of this study is to find out whether formulation ingredients have any influence on the droplet impaction, retention and dissipation characteristics on non-target conifer needles. Glyphosate was formulated in four liquid media containing different additives. These were sprayed in the spray chamber at the rate of 1.8 kg AI in 50 L/ha using a twin-fluid atomizer. Spray droplets were collected on young and mature balsam fir needles and on Kromekote® cards. Following impingement, their retention, spreading and dissipation characteristics were studied by microscopic examination of the droplets. Droplets on Kromekote® cards were analysed for size spectra and number median diameter. Results indicated that formulation ingredients had a marked influence on droplet sizes on target surfaces. The physicochemical properties of additives and of the end-use mixtures both affected the droplet/non-target interactions at the conifer leaf surface. However, no phytotoxicity was observed on young and mature needles with all formulations.

A(i) 3. The Effect of Droplet Dissipation Rates of Three Glyphosate Formulations on Herbicidal Activity on Alder, Poplar and White Birch Seedlings (A Co-operative Study with FP-54)

Glyphosate was formulated with three different amounts of Triton® X-114 emulsifier, 0.5, 1.0 and 5.0% (v/v), and sprayed onto the above-mentioned seedlings. Droplet retention and dissipation characteristics were studied using a microscope. Phytotoxicity and herbicidal activity were evaluated at 1, 2 and 3 weeks after spray application. Results are being put together to understand the correlation between the rate of droplet dissipation and plant response.

A(i) 4. The Role of Droplet Size on Herbicidal Activity of Glyphosate Formulations on Alder, Poplar and White Birch Seedlings (A Co-operative study with FP-54)

It is known that the antidrift agent Nalco-Trol® alters the spray droplet spectrum of a herbicide formulation. However, whether such increases in drop sizes alters the herbicidal activity is not known. In the present study, glyphosate was formulated with and without Nalco-Trol® and was sprayed over alder, poplar and white birch seedlings at the rate of 50L/ha. Droplet measurements were carried on foliage by microscopy under 40X and 100X magnification. Results indicated a significant increase in droplet sizes with Nalco-Trol®. However, whether such increases were followed by marked increases in herbicidal activity is yet to be evaluated. Results are being put together to carry out the correlation.

A(ii) Biorationals

A(ii) 1. Droplet Impaction Characteristics of Three B.t. Formulations on New and Mature Conifer Needles

Thuricide 32B, Thuricide 32LV and Dipel 88 were sprayed in the Institute's spray chamber at the rate of 30 BIU/4.7 L/ha, about 3 m above the canopy of potted seedlings of spruce and balsam fir. Following impingement, the droplets on both young and mature needles were counted by microscopy. Surface area of both young and mature needles were assessed and droplets per unit area of foliage were evaluated. With both spruce and balsam fir needles, the young ones received more droplets than the mature ones with all formulations. The results are now being written and will be put together as a report in the near future.

A(ii) 2. Rainfastness of Droplets of a B.t. Formulation on Conifer Needles With and Without the Rhoplex Sticker

Thuricide 32B was sprayed (with a tracer dye) with and without the Rhoplex sticker on potted balsam fir and spruce seedlings, at the rate of 30 BIU/4.7 L/ha, using the Mini ULVA spinning disc nozzle (Micron Corporation) in the Institute's spray chamber. Following droplet impingement, the needles were examined by microscopy for droplet density. At 2 to 3 hr after spraying, the seedlings were exposed to two different intensities of natural rain for specified time periods. The needles were again examined for droplet density. Results indicated that, with the Rhoplex sticker about 70 to 75% of the number of droplets were washed off in both the light and heavy rain. However when no sticker was used, all droplets were washed off from the spruce and balsam fir needles, indicating the need for adding a sticker for the Thuricide 32B formulation. However the experiment should be carried out again after allowing the B.t. droplets on the needles to dry out for 24 to 48 hr, before exposing the plants to the rainy weather.

A(ii) 3. Formulation Properties, Stability Studies with Erio Acid Red, Spray Atomization Characteristics and Droplet Adhesion on Conifer Needles: A Study with Novabac 3 Formulation. (A Cooperative Study with FP-10, MFRC and RPC of New Brunswick)

This study is part of a large scale field study funded by CANUSA. Physical properties of the tank mix formulations, droplet evaporation and spray atomizability were carried out in the laboratory in the Institute's spray chamber. Compatibility and stability studies were carried out with Erio Acid Red dye. Results indicated good performance characteristics of Novabac 3 tank mix formulation, except the adhesion of spray droplets on spruce and balsam fir needles. The adhestion was poor indicating the need to add a sticker to the tank mix.

A(iii) Insecticides

A(iii) 1. Droplet Spectra and Deposition Pattern of Two Fenitrothion Formulations Following Simulated Aerial Application Using Different Volume Rates

The fenitrothion formulations sprayed were: the Atlox-based formulation used in New Brunswick and the oil-based formulation used in Quebec. The Institute's spray chamber was used to generate the spray cloud. For the 1.5 L/ha application rate, the spray mixes were used undiluted. For the 3.0 L/ha on the other hand, the formulation was diluted with the same diluent used in the field to provide the concentration of 210 g AI/ha Kromekote® cards were used for droplet collection and analysis of spectra. Results indicated a consistent increase in the droplet sizes when the volume rate was increased, but the droplet numbers were not as high as expected. This study pointed out the need for optimization of volume rates for every spray formulation and application equipment.

A(iii) 2. Development of a Rapid Spectrofluorometric Technique for Estimating Foliar Pesticide Residues Following Ground Application

Fluorescent tracer dyes have been used in pesticide formulations by previous researchers to estimate foliar spray deposits following solvent extraction. Such extraction techniques inevitably dissolved the chlorophyll components which interfered in the spectrofluorometric analysis of the tracer dye. To overcome this interference, a micro-column cleanup procedure was developed in the present study to get rid of the unwanted chlorophyll components. This method is fast and sensitive enough for high foliar deposits which are encountered in ground applications. However this method is not sensitive enough for low foliar residues which are generally observed in aerial applications over conifer forests.

A(iii) 3. Development of a Formulation Mimic for the Permethrin® Drift Study

Triethyl phosphate, a non-insecticide chemical that is quantifiable by GC, was used to formulate the mimic for the Permethrin® emulsifiable formulation. Atlox 3409F was used at 0.25% level. Physical properties and spray atomization characteristics were studied for both Permethrin® and Triethyl phosphate formulations before optimizing the quantities of ingredients.

A(iii) 4. Development of a Formulation Mimic for the Herbicide Drift Study in New Brunswick

Fenitrothion was chosen to prepare the herbicide mimic formulation with diesel oil, Cyclosol® 63 and Triton® X-114 emulsifier. Stability and physical properties were studied at various temperatures.

A(iii) 5. Development of a New Fenitrothion Formulation (Sumithion® Flowable) for Operational Spray Programs: Stability Considerations, Physical Properties and Spray Atomization Characteristics

The Sumitomo Chemical Company has developed a new fenitrothion formulation containing no traditional emulsifier. This was tested in the Pesticide Formulation Section for field suitability. Stability of the flowable concentrate (or the basic formulation) and of the tank mix formulations was evaluated along with a variety of diluents for field use. Physical properties of the basic formulation and tank mixes were studied including droplet evaporation and spray droplet spectra using three types of atomizers. In addition spray droplet impaction, retention and dissipation characteristics were studied.

Results indicate that this formulation had a freezing and pour points below -3°C. It had excellent stability, optimum viscosity and evaporation rates. With respect to spray atomization characteristics, the tank mix formulation produced a more desirable droplet spectrum than the conventional Atlox-based fenitrothion formulation, since it produced a relatively smaller proportion of droplets <20 µm. This formulation will probably have a great potential for drift control if delivered by the appropriate spray delivery systems. For enhanced droplet adhestion purposes about 2.5% canola oil may be added to the tank mix during the addition of water to the basic formulation. Results of this extensive study are being written in the form of a report.

A(iii) 6. Formulation Properties of the Matacil® 180 F (flowable), With Specific Reference to Shelf Life, Stability, Flowability and Agglomeration Characteristics of Particulate Ingredients (A Cooperative Study with FP-71)

In order to minimize the toxicity of Matacil® 180D to aquatics, The Chemagro Chemical Company has developed and registered a flowable suspension of milled aminocarb particles (about 2 to 3 µm in diameter) in oil along with solid/liquid dispersing and stabilizing agents. It is a heterogeneous system compared to the Matacil® 180D which is a homogeneous solution. Settling, agglomeration and caking can be a problem for flowable pesticide formulations as well as for tank mixes. This formulation was subjected to rigorous test procedures in the Pesticide Formulations Project of the Institute. Stability studies were carried out at various temperatures. Extensive studies on various physical properties, droplet evaporation rates and settling characteristics of the end-use mixtures were carried out. Quality control for the AI concentration was evaluated for four batch samples.

Results indicate that the AI concentration varied from batch to batch indicating the need for quality control. In stability studies, the formulation tested demonstrated settling, agglomeration and caking after storage of 3 months. This occurred with the inert formulation components and also with the active ingredient (as evidenced by GC measurements of samples collected at different levels of the suspension concentrate). Once agglomeration occurred, the resuspendibility of the cake formed was extremely difficult. With respect to stability of the tank mixes, phase separation was apparent if the tank mixes were stored for about 6 hr. Re-emulsifiability depended on the nature of the emulsifier used.

In summary, phase separation, agglomeration of the inert particles and AI, and caking of Matacil 180 F can occur during storage. It is therefore not advisable to store this formulation for longer than about 12 weeks. Extended storage is discouraged. Even with fresh samples, the drum material should be agitated well before pumping out the concentrate for preparing the tank mixes.

A(iii) 7. Development of New Formulations of Zectran® for Operational Spray Programs: Assessment of Stability and Physical Properties

The Union Carbide Chemical Company is in the process of introducing new formulations of mexacarbate (Zectran®) and these formulations have been tested for Canadian field weather suitability. Three formulations were evaluated by studying their physical properties, freezing point, pour point and crystallization phenomenon. Some modifications were recommended to the company based on observations made in the Formulation Section of the Institute. These modifications may be introduced for field testing in 1984.

A(iii) 8. Development of New Fenitrothion Formulations for Operational Spray Programs: Assessment of Stability, Physical Properties and Spray Atomization Characteristics

Four new spray mixes were prepared:

i) Fenitrothion 22.0/Cyclosol® 63 78.0 (v/v)

ii) Fenitrothion 11.0/Atlox 3409F 1.5/Cyclosol® 63 1.5/water 86.0 (v/v)

iii) Fenitrothion 11.0/Atlox 3409F 1.5/Cyclosol® 63 4.0/water 83.5 (v/v)

iv) Fenitrothion 11.0/Atlox 3409F 1.5/Dowanol TPM 4.0/water 83.5 (v/v)

Their stability was studied under various temperatures and with water of variable pH and hardness. Their physical properties were evaluated including rate of droplet evaporation and spreading characteristics on Kromekote® cards. Spray atomizability was also studied in the Institute's spray chamber, using the Mini ULVA spinning disc nozzle and spray droplets were collected on Kromekote® cards, for evaluating droplet spectra, NMD, VMD, D_{max} and spray volume deposit. Results have been tabulated and a report is being prepared. This report will form a supportive document for registration of the above formulations.

A(iii) 9. Use of a Laser Doppler Velocimeter to Study the Influence of Formulation Additives on the Droplet Spectra Produced by a Twin-Fluid Atomizer. (A Co-operative Study Under Contract with Prof. Brain Kaye of The Laurentian University)

Droplet size measurements are subject to variations depending on the method used, and different collection units have different collection efficiencies depending on their geometry and surface properties. Because of this, measurements of droplets in air provide one of the truest representatives of droplet spectra produced during spray atomization. The Laser Doppler Velocimeter is most useful to measure droplet spectra in air, produced in the vicinity of a nozzle, and would provide means of comparing spray atomization characteristics of different formulations. Formulations studied were:

i) Fenitrothion/Atlox/Dowanol/water
ii) Fenitrothion/Cyclosol® 63/ID 585
iii) Fenitrothion/Triton® X-114/water
iv) Glyphosate formulation with and without Nalco-Trol®

Results indicate that formulation additives have a marked influence on droplet spectra produced. Results are being put together in the form of a report and will also be available for journal publication.

A(iii) 10. The Influence of Simulated Aerial Sprays of The Atlox-Based Fenitrothion Formulation on Health Effects of Song Birds (A Cooperative Study with FP-71 and CWS at Ottawa and Fredericton)

The formulation currently used in New Brunswick (fenitrothion/Atlox/Dowanol/water) was sprayed in the Institute's spray chamber at the rates of 1/2, 1, 2 and 5 times the normal application rate (210 g AI per ha) to study the health effects of Zebra finches after one hour exposure at each dosage rate. Spray droplets were collected on the conventional Kromekote® card-glass plate units. Droplet spectra and volume deposit per unit area were evaluated. Detailed experimental procedures and the results are being put together under the Project FP-71, and a report is being prepared by Mr. Pierre Mineau of CWS, who coordinated the study.

B. Field Studies

B(i) Herbicides

B(i) 1. Assessment of Spray Droplet Spectra of Glyphosate Formulation Following Helicopter Application (A Co-operative Preliminary Trial With USDA Forestry Service in Duluth, Minnesota and FP-54)

Raindrop nozzles are supposed to minimize the proportion of driftable small droplets in the spray cloud. This was investigated in a cooperative spray trial in Duluth, Minnesota. Glyphosate formulation was sprayed over a cut area of the forest containing tall grass species and other weeds, using a helicopter flying at 45 mph. Several Raindrop nozzles were mounted on a spray boom of length not more than 3/4 of the main rotor length of the aircraft. The application rate was 0.75 lbs AI in 10 gallons per acre at a nozzle pressure of 35 p.s.i. Spray droplets were collected on water-sensitive cards and on 3M paper for droplet analysis. There were significant numbers of driftable small droplets on the card. The large droplets were in the order of several millimeters in diameter and were not ciruclar. Therefore accurate droplet sizing was not possible. However droplet stains less than 400 um were all circular and accurate measurements could be made by microscopy. Results indicated significant amounts of droplets <30 μm diameter in the spray cloud, which are highly susceptible to environmental drift if sprayed under high wind conditions. The conclusion is that even with the rain drop nozzles the off-target drift is not totally eliminated.

B(ii) Insecticides

B(ii) 1. Spray Droplet Spectra and Drift Characteristics of Permethrin Formulation (A Cooperative Study with Many Projects)

Spray cards were placed in the off-target region of the spray cloud, at vertical and horizontal positions. Droplet analysis was made by microscopy and by the Flying Spot Scanner of NRC. Droplet spectra was evaluated in terms of NMD, VMD and D_{max}. The details of experimental design and summary of results are being put together under a separate heading by the coordinator of the study.

B(ii) 2. Spray Distribution and Deposition on Young Spruce Trees in a Plantation Forest (A Cooperative Study with FP-53)

This study is part of the spray trial for Zeiraphera control carried out in the J.D. Irving's plantation in New Brunswick. Fenitrothion/Triton® X-113/water formulation was used and spray was applied using the Mini ULVA (or Flak) of Micron Corporation. Conifer branch tips were collected after spray application, the unopened buds were separated and the mature needles were removed from the stem using a pair of forceps. The buds, needles and the stem were extracted with methanol to remove the spray deposits containing the tracer dye. These extracts were pale green in colour because of the chlorophyll component of the spruce foliage, and were therefore subject to microcolumn clean-up procedures. The cleaned extracts were made up to a known volume and the dye residues were quantitated in a spectrofluorometer. Results indicated consistently low residues in the buds and stems, but the needles contained significantly higher dye concentrations.

B(ii) 3. The Role of Surface Area of Spruce Needles, Stems and Buds on Droplet Capture Efficiency (A Co-operative Study with FP-53)

This is also part of the spray trial for the Zeiraphera control in New Brunswick. As mentioned in the study B2, foliar residues of the tracer dye were estimated spectrofluorometrically. The surface area of needles, buds and stems were estimated by microscopic measurements. The concentration of pesticides per gram of the plant components was expressed in terms of surface area of the plant components. Results are being written as a report.

SUMMARY REPORT ON STUDIES OF THE IMPACT OF INSECTICIDES ON FOREST ECOSYSTEMS

(Study Ref. FP-15)

Report to the 1983 Forest Pest Control Forum

Environmental Impact Section

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INTRODUCTION

Field studies carried out by the Environmental Impact Section of the Forest Pest Management Institute in 1983 were primarily focused on intensified aquatic and terrestrial sampling activities in the Icewater Creek research area where in-depth environmental impact research has been conducted since 1980. A study was also carried out to examine forest songbird responses to timber stand alterations in Eastern Canada caused by spruce budworm damage over the past decade. The environmental impact section also participated in interdisciplinary permethrin drift studies reported on seperately to this forum.

SONGBIRD RESPONSES TO SPRUCE BUDWORM IMPACTS

In June of 1983, a total of 152 bird and 32 associated vegetation surveys were carried out in Nova Scotia, New Brunswick and Quebec in an attempt to compare bird density and diversity in various forest stands unaffected, damaged, or killed by previous or current spruce budworm infestations. Censuses were carried out in Fundy National Park, New Brunswick, where budworm related mortality occurred primarily about a decade ago; in recently killed stands in Cape Breton Highlands National Park and Crowdis Mountain area on Cape Breton Island, Nova Scotia; in virtually dead 98% defoliated stands within Chequecto Management Area, Nova Scotia; in recently defoliated (40-60%) stands within Parc Gaspésie, Quebec; and in adjacent undamaged conifer and deciduous stands where available. Although songbird responses to habitat changes are very complex and the present study is limited both in scope and in the extent to which the data have been analyzed at this time, some gen-eralized conclusions can be made as follows:

(1) Songbird diversity in conifer stands which have suffered recent massive budworm caused defoliation and/or tree mortality is similar to that in nearby undamaged stands, but songbird density is only about half that in adjacent undamaged areas.

(2) In areas where the budworm-killed conifer component is being replaced by a new forest growth, songbird density is comparable to that in adjacent undamaged stands, but songbird diversity is considerably lower (about one half the number of families and two-thirds the number of species) than in nearby unaffected stands.

ICEWATER CREEK STUDIES

In 1980, the Environmental Impact Section of FPMI, through the co-operation of the Sault Ste. Marie District Office of the Ontario Ministry of Natural Resources, set up an ongoing research program in the Icewater Creek watershed about 50 km north of Sault Ste. Marie, Ontario. The objective of this programme is: To examine in depth a number of aquatic and terrestrial habitats and micro-habitats and their resident animal populations to determine: (1) the nature and degree of inherent risk, (2) the level of actual exposure, and (3) actual response to forest pest management strategies involving aerial applications of pest control agents.

The program will have three distinct phases designed to generate information on three aspects of the effects of forest pest control activities on the environment: (1) potential risk (2) actual exposure and (3) actual response. In general, the actual impact on each part of the environment is primarily a factor of the susceptibility of that portion of the ecosystem to the particular pest control procedure and its level of exposure to the pest control agent used, i.e., Risk + Exposure = Response. To this extent, part of the objective of the first two portions of the program will be to help predict potential hazards of any suggested pest control action. The third portion of the program will test actual responses and elucidate the nature of and ecosystem responses to actual impacts. This will involve relating impacts at lower trophic levels or among specific groups of organisms to secondary impacts on higher trophic levels and changes within the ecosystem (e.g., altered food supply, changes in basic processes such as predation or pollination, etc.).

Extensive studies were carried out in 1983 in a number of fields.

Songbird Studies

Netting-marking studies. A variety of study techniques were applied to identify and evaluate seasonal changes in songbird biology at the indicator species level which change or influence their risk of impact from aerially applied pes-ticides. Over 300 individuals of thirteen selected species were colour-banded and released after capture in mist nets. Attempts were made to make observations on individuals of these species to indicate their suitability for intensive study of marked individuals. Results suggest that the chestnut-sided warbler, white-throated sparrow and magnolia warbler might be species most suited for study by this method. Time-budget studies were attempted on several species to observe the proportion of time spent engaged in various activities and locations and how these change with time of day or season. From this type of data, the risk to aerially applied pesticides via various exposure routes can be more accurately assessed. Other data collected during the program included migrations, local movements, changes in breeding conditions, nesting and fledging times and weights at fledging of various resident bird species in the study area.

Brain cholinesterase studies. White-throated sparrows were shot at weekly intervals over the breeding season from a clear-cut approximately 5 km north of the Icewater Creek research area to look for any seasonal changes in brain cholinesterase levels which might reflect changes in breeding condition, activity, or other factors. A total of 41 adult males were sampled between 31 May and 22 July. The cholinesterase activity of these birds averaged 34.68 ± 4.71 Micromoles/min/g of brain tissue and did not change significantly over the sampling period. Small numbers of other bird species were collected by shooting or mist netting to provide baseline data for future work in the Icewater Creek research area and facilitate analytical methodology development.

Aquatic Studies

Brook-trout studies. Extensive brook trout density, growth and movement data were collected from Icewater Creek in 1983 by extensive electro-shocking combined with branding individual fish. Data from over a thousand brook trout were collected between May and November. Over five hundred individuals greater than 95 mm in length were branded for individual recognition, and close to 150 recaptures of marked fish were made at later sampling periods. Over three hundred small (< 95 mm) young-of-the-year and yearling fish were also caught and marked with an adipose fin clip. Recapture data to-date suggests that brook trout are generally stationary in their area of residence over the summer in Icewater Creek, although there are more movements in and out of some portions of the watershed than others.

Aquatic invertebrate studies. Benthos sampling was continued in Icewater Creek in 1983 using artificial substrate samplers. Emerging adult aquatic insects were captured at three sites for taxonomic evaluation to provide further information relevant to taxonomy and life history studies of the Icewater Creek aquatic insect fauna. An artificial channel was set up along-side the stream for captive aquatic invertebrate studies. In 1984 and 1985 *in situ* bioassays of forestry insecticides on selected Icewater Creek aquatic invertebrates will be carried out by researchers from the University of Guelph under the CFS Program of Research by Universities in Forestry.

Terrestrial Anthropod Studies

Pollinator studies. In 1983 honeybee colonies were excluded from the Icewater Creek area and field studies focused on wild pollinator activity in the absence of honeybees. Visitation by wild pollinators was censused on 26 species of wildflowers, shrubs and trees over the season, and representative collections of the pollinator complex were made for identification beyond that possible in the field. Pollinator activity was also assessed periodically on a 1 km roadside transect. With the co-operation and active input of FPMI's Insect Toxicology Section, topical application toxicity tests with fenitrothion and aminocarb were carried out on andrenid bees and bumble bees from the Icewater Creek area, as well as domestic honeybees, in order to provide relative toxicity data for assessing hazard of these insecticides to different pollinators.

Ground insect studies. Pitfall trap sampling was again conducted on two sites throughout the year to document ground insect fauna and activity patterns. Preliminary toxicity studies on ground beetles were initiated with the co-operation of the Insect Toxicology Section, utilizing both topical application and contaminated diet studies.

CHEMICAL ACCOUNTABILITY OF FOREST PEST CONTROL PRODUCTS

(Study Ref. No. FP-71)

Report to the Annual Forest Pest Control Forum

by

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INTRODUCTION

During the current year, the Chemical Accountability Section at FPMI undertook a number of laboratory and field studies related to forest spray activities. The major areas of interest were:

1. Analytical chemistry of pest control products at residue levels.
2. Persistence of fenitrothion in forestry substrates.
3. Penetration and metabolism of topically applied aminocarb and fenitrothion formulations in spruce budworm (*Choristoneura fumiferana*, Clem.).
4. Simulated aerial application study to understand the physical (behavioral pattern) and biological (enzyme inhibition) effects of fenitrothion exposure to birds using Zebra finch (*Taeniopygia guttata*) as indicator species (a cooperative program beween the scientists of FPMI and CWS coordinated by Mr. Pierre Mineau of CWS in Ottawa).
5. Model ecosystem and related field studies to understand the mobility and persistence of aminocarb and fenitrothion.
6. Collaborative research projects undertaken jointly with other scientists at FPMI to investigate the:
   (i) drift of permethrin in plantation spray and
   (ii) storage stability and suspendability of newly introduced Matacil® 180F formulation.

This report summarizes some of the advances made in the above studies. The progress report on the last item will be presented separately by the respective coordinators, viz., Mr. P. deGroot on permethrin drift and Dr. A. Sundaram on Matacil 180F formulation.

1. Methodology research

a) Permethrin analysis: Distilled and natural water samples were fortified with known amounts of permethrin standard. Separate aliquots were extracted with CH_2Cl_2 and hexane, dried over Na_2SO_4 and analyzed by EC-GLC and HPLC (UV) techniques. Recoveries from distilled water were quantitative. Further research is necessary to improve the extraction efficiency of the chemical from natural waters. Very likely pH adjustments followed by exhaustive extraction methods are necessary to remove the adsorbed permethrin from particulates present in natural water. Compared to the EC-GLC, HPLC (UV-variableλ) gave a better separation of the cis and trans isomers of the insecticide. Currently, attempts are made to use the HPLC technique (fluorescence detector) and compare it with the EC-GLC in detecting the permethrin present in various samples (air, water, glass plates, cylinderical bronze rods used as collectors of spray droplets) collected during a recently conducted drift study. GC/MS studies to supplement the identification and quantification of permethrin are also in progress.

b) Mass spectrometry of forestry insecticides: Mass spectrometry studies of forestry insecticides using EI techniques provided a variety of useful information on their thermal stability, GC on-column decomposition and structural aspects of the parent and fragmented moieties. Recent studies confirmed the long suspected GC on-column decomposition of some N-methylcarbamates such as aminocarb and mexacarbate and their metabolites. Judicious selection of GC parameters (column type and loading, column temp., injection port temp., etc.) are vital for the direct GC analysis of this class of compounds in order to establish accuracy, reproducibility and reliability in residue analysis. Such thermal instabilities were not encountered in other classes of forestry insecticides such as OPs and OCs including permethrin. Using the GC/MS, computer program tapes and reference spectra on currently used insecticides have been prepared to serve as a nucleus for the planned atlas of GC/MS reference data on forestry insecticides.

c) Micro-column cleanup studies: As an on-going project in developing simplified analytical techniques for the analysis of forestry substrates, micro-column cleanup techniques for the residues of mexacarbate and carbaryl in balsam fir foliage was investigated. Different chromatographic absorbents and eluting solvents including coagulation coupled with solvent partitioning techniques were investigated. Quantitative recovery for carbaryl was obtained by using acid-washed 15% Nuchar® SN charcoal in cellulose with ethyl acetate as eluting solvent. The maxacarbate had its highest recovery when the coagulation followed by liquid/

liquid partitioning technique was used. A double micro-column system consisting of activated Florisil/Nuchar® SN in cellulose developed earlier has been extended to clean tissues of birds exposed to fenitrothion spray. The method was found be be useful.

d) Formulation analysis: As part of CFS/FPMI Action Plan of 1982 on new formulation development for fenitrothion and aminocarb, reliable analytical techniques were developed for the analysis of formulation mixes containing Triton® series of emulsifiers and the conventional Atlox® emulsifier. Using the technique, assisted the Bio-Research Laboratories of Montreal in analysing nearly 100 of their formulations used in various toxicity studies. The participation not only helped the Bio-Research to generate reliable toxicity data on various formulation mixes but also served as a measure of quality control on the Company to improve their overall toxicity studies.

e.) FICP Check Sample Program: As active participant and coordinator of the forestry program, the accomplishments during the year unfortunately has been minimal, because of other priorities and staff changes. The only meaningful contribution to the program during this year has been the processing of data and evaluation of the aminocarb study initiated last year. Should we anticipate national acclaim and credibility, we should strive to put more effort in future in this area.

2. Persistence of fenitrothion in forestry substrates from New Brunswick

During the past many years, it has been reported that fenitrothion has the tendency to persist in certain components of the forest environment due to its high lipophilicity ($K_{o/w}$ 2,380), high b.p. [140-145° (decomp.)/13.3 Pa], low v.p. (8 x 10^{-4} Pa) (poor volatility), rapid absorption and adsorption by forest matrices and poor biodegradability while present as a solute in lipoidal materials. Our last year (1982 May/June) sampling done in the FPMI experimental plots during the peak period of fenitrothion operation in N.B. and subsequent analysis indicated that the chemical was present in most of the aquatic and terrestrial substrates studied. This, as we suspected, could be due to drift rather than the inherent properties of the chemical. To validate our earlier observations and also to meet the recommendations of FPMI, an intensive field monitoring program had been undertaken during the early part of May 1983, that is much earlier to any kind of spray operation undertaken by the province, to examine the residue levels of fenitrothion present in similar substrates collected from the same FPMI experimental spray blocks used in 1982. Results are given in Table 1. For comparative purposes, results obtained in the 1982 study are given in Table 2.

By comparing the residue levels (Tables 1 and 2), it is apparent that most of the samples collected in 1982 were, as suspected, contaminated with fenitrothion due to drift from the neighbouring operational spray blocks. But the 1983 data did show conclusively that fenitrothion appears to have a tendency to persist in measurable levels in balsam fir foliage. Apparently the foliage has acted as a reservoir or sink for the residual chemical through gradual absorption and dissolution of it in cuticular waxes and transportation of the resulting liquid/solid solution through cuticular pores to the cutin layer for storage where one could expect little physical and metabolic processes to occur apart from dilution. It is likely that trace levels of the insecticide found in the litter/soil strata and the aquatic environment could be due to the foliar leaching and runoff during rain and litterfall of needles and twigs.

Extensive and continuing use of fenitrothion would probably warrant the need for a more comprehensive study of its persistence and metabolic fate in various components of the forest environments so that we can correlate and understand fully its possible detrimental effects vis-a-vis subtle ecological implications and accompanying impact on the ecosystem. In addition we must also strive to elucidate and improve our knowledge on the ecotoxicity of this chemical and its transformation products especially when they move and persist at near trace levels in various environmental compartments as we have seen in this study.

3. <u>Penetration, persistence and metabolism of topically applied aminocarb and fenitrothion formulations in spruce budworm larvae</u>

Studies on the penetration, persistence and metabolism of topically applied aminocarb and fenitrothion in organic solvents admixed with different concentrations of surfactants and/or petroleum oils to L5 SBW have been initiated to understand the role of formulation additives in cuticular penetration. Knowledge gained would assist in developing suitable spray mixes to enhance cuticular penetration and if possible to correlate it with observable physical parameters.

Microapplicator calibration and delivery of optimum droplet size (0.5 µl) to the L5 larvae have been accomplished by using a radio-tracer technique. Insect interaction and response to pure solvent and fenitrothion solution at one concentration level (0.015 µg/insect) have been completed. Some preliminary data on the rate of penetration and persistence have been gathered and analysed. Further work is planned after Christmas.

4. <u>Studies on the physical and biological effects of fenitrothion sprays to birds under controlled conditions (FPMI-CWS collaborative study)</u>

In this collaborative research study on avian toxicology, Zebra finch *(Taeniopygia guttata)* was used as an indicator species. The objective was to study the behavioral pattern and ChE levels of birds exposed to fenitrothion spray under controlled (spray chamber) conditions. Two types of studies were conducted using the water-based formulation of fenitrothion containing Atlox and Dowanol . In the exposure study, birds were sprayed with 4 dosage rates of fenitrothion in the FPMI spray chamber. Similarily in the gastric intubation study 4 dose groups were used. All birds were observed for behavioral abnormalities during the 12 h post-exposure period, after that time all were euthanized to determine brain, blood and liver ChE levels and blood, liver and tissue residues including feathers. The control group of birds were also studied in the same manner. In the spray exposure study, spray deposits, droplet spectra and air-borne concentrations of fenitrothion were also determined to correlate with the behavior and toxic effects observed. The results are gathered now and eventually will appear as a journal publication.

5. Studies on the mobility and persistence of aminocarb and fenitrothion in aquatic model and field studies

The environmental behavior of forestry insecticides, aminocarb and fenitrothion, in aquatic systems were studied, (1) under controlled conditions using laboratory model ecosystems and (2) in dynamic systems such as forest streams following operational spray programs. In aquatic model systems consisting of forest soil and natural water, the mobility of the chemicals usually were from water to soil even though the insecticides studied were very different in chemical structure. The results indicated that adsorbed insecticides were lost primarily due to microbial action and the half-lives in the substrates varied according to the insecticide. Studies in the stream ecosystem showed that distribution, dissipation, adsorption, desorption and mobility of the insecticides varied depending to a large extent on the physicochemical properties of the material, type of additives present in the formulation, dosage, mode of application, rates of discharge of water, meteorological conditions, etc. which existed during the period of study. Loss of the chemicals from water surface was rapid due to various interrelated physical and environmental factors. Penetration of the insecticides into the stream bottom was slow and the adsorbed materials were lost rapidly by degradation, convective transport and dispersion. Fish samples and aquatic plants did accumulate detectable levels of the insecticides but the rate of disappearance from the substrates was rapid. Neither fish mortality nor any significant behavioral changes were observed in them. Under operational spray conditions in forestry, the residue levels in various aquatic substrates were below the toxic levels and were rapidly lost by various physical and biological factors.

Table 1. Average prespray concentrations of fenitrothion in various forestry samples collected in May 1983 from the 1982 experimental spray blocks in New Brunswick

Sample type	Block No. IB*	IIB*	IIIB*	1C+	2C+	3C+	82**	86**
Air (ng/m^3)[1]	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Water (stream) (ppb)[2]	T	T	T	T	N.D.	T	T	T
(pond) (ppb)[2]					T			
Sediment (stream) (ppb)[3]	N.D.	T	2.6 ± 0.5 (6.0 ± 1.0)	T	N.D.	2.3 ± 0.5 (4.6 ± 1.0)	T	1.0 ± 0.5 (1.4 ± 0.8)
(pond) (ppb)[3]					5.4 ± 0.5 (8.7 ± 1.5)			
Water cress (ppb)[3]								2.5 ± 0.5 (3.7 ± 0.8)
Moss (ppb)[3]	4.1 ± 0.5 (14.0 ± 1.0)	6.0 ± 1.0 (17.0 ± 3.0)	3.3 ± 0.5 (7.4 ± 0.9)		4.8 ± 0.5 (11.2 ± 1.5)	6.6 ± 0.5 (16.2 ± 1.0)	7.4 ± 0.5 (21.1 ± 1.5)	2.4 ± 0.5 (6.0 ± 1.0)
Fish (ppb)[3] (brook trout)							T	T
Aquatic insects (ppb)[3] (water striders)	N.D.						N.D.	N.D.
Foliage (b.f.) (ppb)[4] (old)[5]	445 ± 40 (750 ± 70)	560 ± 50 (1000 ± 90)	450 ± 40 (790 ± 70)	615 ± 50 (1110 ± 90)	395 ± 40 (705 ± 70)	1160 ± 110 (2100 ± 180)	515 ± 50 (915 ± 90)	315 ± 40 (550 ± 70)
(new)[6]	575 ± 50 (985 ± 90)	630 ± 60 (1095 ± 110)	420 ± 40 (690 ± 70)	800 ± 80 (1315 ± 130)	150 ± 30 (265 ± 50)	670 ± 70 (1165 ± 120)	1000 ± 250 (1730 ± 430)	118 ± 30 (231 ± 42)
Litter (ppb)[7]	T	14.2 ± 1.1 (51.0 ± 2.2)	T	T	T	T	T	T
Soil (ppb)[7]	N.D.	T	N.D.	T	N.D.	T	N.D.	N.D.

* Bathurst blocks; +Charlo blocks; ** Blocks near Fredericton.
1 Minimum detection limit (MDL) = 10 ng/m^3.
2 MDL = 0.01 ppb, T (traces) = 0.007 - 0.009 ppb; N.D. (not detected) <0.007 ppb.
3 MDL = 1 ppb; T = 0.5 - 0.9 ppb; N.D. <0.5 ppb.
4 MDL = 50 ppb.
5 Foliage prior to 1982.
6 1982 foliage.
7 MDL = 10 ppb, T = 5-9 ppb, N.D. <5 ppb.

Residue values without parentheses = residues in terms of wet weight.
Residue values with parentheses = residues in terms of oven-dry weight [105°C for 16 hrs in a thermostatic oven (AOAC 1955)]

<u>Formulation used in 1982 (v%)</u>

IB and 2C - Matacil® 180F 26, Triton® X-100 3, water 71.
IIB and 3C - Fenitrothion 10.9, Triton® X-100 10.7, water 78.4.
IIIB and 1C - Fenitrothion 10.9, Triton® X-100 3, Cyclosol 24, water 62.1.
82 - Matacil® 180F 26, I.D. 585 74.
86 - Matacil® 180F 26, Atlox® 1.3, water 72.7.

Table 2. Average prespray concentrations of fenitrothion in various forestry samples collected during the 1982 spray program in New Brunswick.**

Sample type	Block No. and formulation	IB A/W	IIB F/W	IIIB F/O	1C F/O	2C A/W	3C F/W	82* A/O	86* A/W
Air (ng/m^3)[a]	1st				90	68	89	58	52
	2nd				72	59	70	66	59
Glass plates (g/ha)[b]	1st				0.18	0.13	0.12	0.06	0.04
	2nd				0.11	0.08	0.10	0.05	0.07
Water (stream) (ppb)		0.01	0.04	0.07				0.02	0.02
Sediment (ppb)[c]	1st A.S.							64	110
	1st O.D.							82	160
	2nd A.S.							96	190
	2nd O.D.							155	260
Water cress (ppb)	1st A.S.								140
	1st O.D.								640
	2nd A.S.								220
	2nd O.D.								1040
Moss (ppb)	1st A.S.	29	62	128				3	3
	1st O.D.	103	179	579				7	9
	2nd A.S.	89	100	176				4	5
	2nd O.D.	317	354	646				12	13
Fish (ppb)	1st	6						7	4
	2nd	5						5	4
Foliage (ppb)[d]	1st A.S.				431	270	1057	475	352
	1st O.D.				844	537	2073	781	659
	2nd A.S.					399		521	464
	2nd O.D.					685		805	721
Soil (ppb)	1st A.S.				11	115	201	110	95
	1st O.D.				16	163	286	192	139
	2nd A.S.					124		88	81
	2nd O.D.					190		119	122
Litter (ppb)	1st A.S.				24	66	540	77	108
	1st O.D.				98	98	993	121	167
	2nd A.S.					54		67	96
	2nd O.D.					87		118	159
Insects (ppb)	SBW 2nd							N.D.	N.D.
	TCP 2nd							N.D.	10

B = Bathurst; C = Charlo; * = Near Fredericton; A/W = Aminocarb in water; F/W = Fenitrothion in water; F/O = Fenitrothion in oil; A/O = Aminocarb in oil; A.S. = As sampled; O.D. = oven-dry (105°C for 16 hr; AOAC 1955); SWB = Spruce budworm; TCP = Tent caterpillar.

[a] Using density of dry air at 1 atm and 15°C as 12.255 x 10^{-4} g/ml (Lange's Handbook of Chemistry, 11 Edn. p. 10-146), these values range from 0.05 ppb to 0.08 ppb. Density of air depends upon R.H., P and T.

[b] One hr exposure at ground level.

[c] Petri dishes with sediment at stream bottom.

[d] Needles only (balsam fir).

** Operational spraying was on during sampling.

Demonstration and recommendations for the operational use of Futura (*Bacillus thuringiensis*) against spruce budworm

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Introduction

Among the various options proposed for the control of the spruce budworm, the use of _B. thuringiensis_ correspond the most to the different preoccupations determined by this problem, i.e. efficacy, possibilities of operational use, economy and safety. On this topic, the research and aerial dispersions of _B. thuringiensis_ made at the beginning of the 70's by the Laurentian Forest Research Centre had showed that _B. thuringiensis_ can be applied efficiently against the spruce budworm, this at a 20×10^9 International Units/ha (8 B.I.U./acre) (Smirnoff 1971, 1972; Smirnoff _et al_ 1973, 1974). However, it was necessary to render operational and profitable the use of this entomopathogen. The research were then continued so as to realize _B. thuringiensis_ preparations enabling to apply the required dosage in a final low-volume/ha.

Fundamental research and both experimental and aerial dispersions with Bacillus thuringiensis carried out by the Insect Pathology Unit of the Laurentian Forest Research Centre during the last 10 years revealed the feasibility of using this microorganism for an operational control of spruce budworm (Smirnoff et al. 1973, 1982, Smirnoff-Hardy 1978, Smirnoff 1979, 1980 a). However, potential users questioned some aspects relevant to the operational use of B. thuringiensis such as its efficiency, particularly with high populations, operational considerations, such as complex mixing on the site, large volume to be dispersed etc..., its higher cost compare to chemical insecticides currently used against spruce budworm, and even its safety.

It was felt, based on experience with B. thuringiensis and on results of research carried out since 1971, that development of a compact and low-volume dispersion formula would respond to most of these questions.In 1979 a new B. thuringiensis formula Futura, providing dispersion of 20 X 10^9 international units of B. thuringiensis/ha required for spruce budworm in a volume of 2.5 L/ha (35 ounces/acre) was developed (Smirnoff 1981). The formula was used for calibration tests in 1979 (Smirnoff 1980 b) and was field tested in 1980, 1981, 1982,and 1983. Results of these tests are presented.

The Futura formula is composed of:

15% Bacillus thuringiensis primary powder(80 000 international units/mg)

44.8% sorbo (a 70% aqueous solution of sorbitol)

33.7% water

6.5% inert natural ingredients

The material is delivered to the airport as a paste concentrate alleviating transportation of large quantities of water. Then, for each hectare to be treated, 1.5L of the concentrate is added to 1.0 L of unchlorinated water + 1.56 mL of Chevron sticker. If transportation costs is not significative or if no mixing facilities exist, Futura can be delivered "READY TO USE". Ten thousands nephelometric units of chitinase/ha (optional) can be added to Futura. The chitinase is an enzyme which increases B. thuringiensis activity on spruce budworm and its use is recommended in colder regions.

A Grumman AgCat aircraft was used for tests over 40 ha blocks. Blocks or stands were mainly composed of balsam fir. A DC-4G and a Super Constellation L 749 aircraft were used over large blocks, 3000 ha and over, to confirm the possibility of using Futura over vast areas. The spray system on the Grumman AgCat was composed of booms and flat fan (T 8004) nozzles. Booms and open-type nozzles were used on the DC-4G and Super Constellation. Standard methods for determining spruce budworm population, previous to spraying were used. The method of Smirnoff (1982) assessed deposit. This method requires containers with peptonized water to be distributed in the field instead of petri dishes or other devices and it is the only one determining the quantity of active material (viable spores of B. thuringiensis)deposited. Defoliation was assessed using the methods of Fettes (1950) and Dorais and Hardy (1976). Also, the current year growth mass evaluation method was used to evaluate results of B. thuringiensis treatments in terms of global mass of foliage saved (submitted for publication in the Can. J. of For. Res.).

FIELD TESTS:

1980

In 1980 spruce budworm populations in the region of the field station, Chicoutimi, Quebec, were rather low and tests aimed mainly at comparing Futura with the Thuricide + sorbitol formula used at 4.7 L/ha in large field tests.

Results revealed that deposit with Futura was good with 348 756 viable spores/cm^2 over a theorical emission of 45 000 viable spores/cm^2 meaning that 80% of emitted number of spores were deposited at ground level. Larval mortality was 72.2% and defoliation 7.45%. These figures compared advantageously with results given by the Thuricide + sorbitol formula and were of course much better than those obtained in untreated plots. Futura dispersed well, provoked a suitable larval mortality and protected foliage sufficiently. The next step was to test it in severely infested stands supporting various degrees of defoliation.

1981

In 1981 three series of field tests were carried out. The first treated 7 X 40 ha plots with Futura at 2.5 L/ha (20 X 10^9 I.U./ha) using a Grumman Ag Cat aircraft. The second test treated 895 ha with Futura at 2.35 L/ha (18.8 X 10^9 I.U./ha) by means of a Super Constellation L-749 aircraft. The third test, carried out simultaneously with the first test as a compagnion, involved treatments using Thuricide 32B/sorbo/water/chitinase/Chevron (20 X 10^9 I.U./ha in a final volume of 4.7 L/ha) by means of a Grumman AgCat airfraft. Results are summarized in Table 1. They show that Futura dispersed by the Grumman AgCat was able to yield a good larval mortality and foliage protection. Larval mortality 10 days after treatment was 72.0%, dispersed at 2.5 L/ha compared to 70.3% with Thuricide + sorbitol, dispersed at 4.7 L/ha. Defoliation with Futura averaged 71.6%, but some of the blocks were in a desesperate situation after several years of severe defoliation. Thuricide + sorbitol yielded a 67.0% defoliation for a stand in an acceptable condition (Table 1).

Dispersion of Futura by means of the Super Constellation aircraft at 2.5 L/ha yielded a 75.0 to 96.9% larval mortality for a pretreatment population averaging 27.5 larvae/45 cm with a peak at 46.2 larvae/45cm (Table 1). Defoliation was 25 to 40% in plots with 10 to 20 larvae/45cm avel 50 to 60% in plots with 25 to 35 larvae/45cm.

Finally, foliage potential (buds formed in the fall) increased in all treated plots and decreased in untreated plots (Table 1). At the end of the 1981 field season it was concluded that Futura was able to kill spruce budworm and protect foliage with half of the volume of the *B. thuringiensis* formulas used preceedingly, 2.5 L/ha instead of 4.7 L/ha.

1982

Five 40 ha blocks were treated with Futura (20 X 10^9 I.U. in 2.5 L/ha). One 40 ha block with Thuricide 48B (20 X 10^9 I.U. in 2.5 L/ha). Another 40 ha block with Futura (30 X 10^9 I.U. in 3.75 L/ha) and one more with Thuricide 48 LV (30 X 10^9 I.U. in 4.7 L/ha). The aim was to determine the efficiency of Futura in different conditions of stand deterioration and population levels and compared it with higher dosage of an other formula. Results are summarized in Table 2. Also, a 3500 ha block was treated with Futura by means of a DC-4G aircraft.

The number of *B. thuringiensis* viable spores initially emitted was 445 000/cm^2 for a dosage of 20 X 10^9 I.U./ha and 667 500/cm^2 for a dosage of 30 X 10^9 I.U./ha. In blocks treated with Futura at 2.5 L/ha for a dosage of 20 X 10^9 I.U., the number of viable spores deposited varied from 269 830 to 406 821 spores/cm^2 and averaged 351 848/cm^2. Deposit was 268 862 spores/cm^2

with Thuricide 48B. In blocks treated with a dosage of 30 X 10^9 I.U./ha, deposit was 520300, for Futura (3.75 L/ha) and for Thuricide 48LV (4.7 L/ha) 608 388 spores/cm^2. Deposit with Futura dispersed with a DC-4G was 222 400 viables spores/cm^2 (Table 2). Deposit varied from 60 to 90% of the emitted number of spores during treatment with the Grumman AgCat aircraft.

Larval mortality established 10 days after treatment averaged 91.5% in blocks treated at 20 X 10^9 I.U./ha compared with 95.3% in blocks treated at 30 X 10^9 I.U./ha showing that higher dosage has little effect on spruce budworm mortality.

Defoliation of current year shoots averaged 14.3% in blocks treated at 20 X 10^9 I.U./ha and was 24.7% in blocks treated at 30 X 10^9 I.U./ha. Therefore why use 10 X 10^9 I.U./ha more to obtain 10.4% less protection? In untreated areas defoliation was 100% (Table 2).

The current year growth mass also indicates the valuable protection resulting from the use of Futura at 20 X 10^9 I.U./ha. Per 100 cm branch 49.0 g of current year shoots were protected while only 1.2 g were protected in untreated plots (Table 2). Results using the DC-4G were satisfying (Table 2). Also, calibration tests conducted in the fall of 1982 with the DC-4G aircraft revealed that an increase of 50% in deposit of B. thuringiensis can be obtained distributing the 110 nozzles on the DC-4G close to fuselage, 55 on each side.

1983

The 1983 field tests were aimed at determining the theoritical minimum dosage that can be used with Futura. Thus, Futura was dispersed at 2.50, 2.14, 2.00, 1.43 and 0.71 L/ha (35.0, 30.0, 27.5, 20.0 and 10.0 ounces/acre). Also, a new device call "pyramid" was developed to determine spreading of the _B. thuringiensis_ dispersion in a tree for each of the dosage tested and for each flight. Petri dishes with nutrient agar medium and containers with peptonized water (Smirnoff 1982) were placed at different levels and depth in the tree crown and under it. Some 2000 analyses were carried out and preliminary results reveal:

- there is no relation between the number of viable spores/cm^2 and the number of droplets/cm^2.
- evaluation of the number of viable spores dispersed is the only valuable figure for deposit assessment..
- deposit at different levels in the tree varied with height of dispersion (flight altitude).

Results of field tests are just being analysed and some of them are reported in Table 3. It can only be said at this time that it seems possible to reduce the volume of Futura provided that purer _B. thuringiensis_ concentrates be obtained, i.e. concentrates with less inert material. This would permit droplets with a larger number of spores, but still provide the 20 X 10^9 I.U./ha required for spruce budworm control.

Also, a 3500 ha block was treated with Futura at 2.5 L/ha by means of a DC-4G aircraft. The test was carried out by the Department of Energy and

Resources, Quebec, and results are not available yet. However, indications are that results are satisfactory, defoliation determined visually, is about 40% throughout the treated area.

Conclusions

Analyses of the above-mentioned results revealed that Futura is responding to questions on efficiency, operational considerations, cost and environmental constraints.

1. Deposit. Larval mortality and foliage protection are equivalent or higher than with B. thuringiensis formulas previously used at 4.7 L/ha, and than with chemical insecticides presently used against spruce budworm.

Results of 1981 and 1982 were particularly significative of the successful use of Futura to restore stands in a pre-death condition. Over this two year treatment sequence trees with less than 40% foliage potential in the spring of 1981 showed over 75% foliage potential after treatment in the spring of 1983.

The Department of Energy and Resources, Quebec, mentioned in its annual reports of 1981 and 1982 that B. thuringiensis offered the same type of protection that can be expected with any chemical insecticides.

2. Futura considerably simplifies the use of B. thuringiensis:
   - a sole annual dispersion is required;
   - it can be stored for many years and is frost resistant up to -20^{0} C;

- it remains homogeneous (no deposit or deterioration observed after 3 years);
- the formula, ready for dispersion, is protected from spore emergence and external contamination due to the use of sorbitol as conservative.
- sorbitol equalizes the osmotic pressure of the suspension and the spores preventing spores from breaking.
- it can be delivered "ready to use" avoiding installation of a mix plant at the airport.

3. Futura responds to cost objections;

- the dosage used is almost the same amount as that used with chemical insecticides (2.5 L/ha for Futura compared with 2.8 L/ha for chemical insecticides) but with chemical insecticides two dispersions (1.4 L/ha each) per year are required while the 2.5 L/ha of Futura are dispersed in one application.
- as mentioned above it reduces mixing cost as it is ready to use
- it reduces transportation costs by avoiding transportation of excess material or water. A cost benefit analysis is possible between cost of transportation of ready to use material or transportation of the concentrate only, without water, and establishment of a small mix plant, just to add water. Also, Futura can be transported in heavy polyethylene bags avoiding use of the heavy and costly metal drums.
- the ratio area treated/load is the more economical of all _B. thuringiensis_ preparations available to date.

In the fall of 1982 cost of treating 1 hectare with chemical insecticide was $4.55 compared with $7.00 for Futura. However, the price of the chemical insecticide was based on negotiations for more than 3 000 000 ha while the price for Futura was based on requirements for limited experimental use. These costs could be lowered.

4. Futura is fully safe for the environment. Needless to say that B. thuringiensis is specific for certain Lepidoptera and has abolutely no action on warm-blooded animals including man. Futura contains only human and environmentally safe ingredients, e.g. sorbitol, a comestible liquid sugar, used in soft drinks, etc... Also, Chevron sticker has all authorizations required to be used as a sticker in forestry and agriculture at the concentration used with Futura.

In conclusion, the above-mentioned results clearly show that the low-volume dispersion and compact B. thuringiensis formula, Futura, providing dispersion of the required dosage of 20 X 10^9 I.U. of B. thuringiensis for spruce budworm control, can and should be used for operational control of spruce budworm populations and foliage protection. Futura has responded favorably to almost all of the objections concerning efficiency, cost, operational consideration, and environmental constraints. B. thuringiensis should no longer be considered as a possible way for spruce budworm control, but rather as an operational method with the same "ready to use" property as all other insecticides used against this insect. Futura can be prepared by any B. thuringiensis manufacturer which is able to prepare a powder with 80 000 I.U./mg. Also, its physical properties meet all requirements for operational purpose.

Finally, results revealed that 20 X 10^9 I.U./ha is sufficient to assure an efficient control of spruce budworm. B. thuringiensis can be used with success and economically against spruce budworm provided that the above-mentioned formula and technical requirements, which we have developed, are strictly followed.

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Table 1

Results of Field Tests with <u>Bacillus thuringiensis</u> Against

the Spruce Budworm in 1981

Formulas	Dosages X 10^9 I.U./ha	Volume L/ha	Deposit Viable Spores/ cm^2	Pretreatment Populations		Current Year Growth Defoliation %	Mass of Current Year Growth/100 cm Branch g	Buds Formed (For the Next Year) %
				Larvae 45 cm Branch/Tip	Larvae/Bud			
				Grumman Ag Cat				
Futura	20.0	2.5	283 000	24.9	--	34.7	26.5	93.3
Futura	20.0	2.5	336 000	37.9	--	90.3	3.7	64.4
Futura	20.0	2.5	--	31.2	--	85.1	4.7	54.8
Futura	20.0	2.5	342 850	30.1	--	58.8	17.1	84.5
Futura	20.0	2.5	381 600	17.2	--	38.9	18.6	70.5
Average-Futura	20.0	2.5	335 863	28.2	--	61.5	14.1	73.5
Thuricide 32B/SORBO/ Eau	20.0	4.7	413 000	22.2	--	67.0	17.3	85.9
Untreated[a]	--	--	--	25.2	--	96.4	4.8	39.4
				Super constellation L-749				
Futura[b]	18.8	2.35	295 000	10-20	--	25-40	15.1	76.9
	--	--	--	25-35		50-60		
Untreated[c]	--	--	--	29.5	--	98.7	0.7	6.6

a Average for 8 sampling plots
b Average for 9 sampling plots
c Average for 5 sampling plots

Table 2

RESULTS OF FIELD TESTS WITH BACILLUS THURINGIENSIS AGAINST SPRUCE BUDWORM IN 1982

Formulas	Dosages X 10^9 I.U./ha	Volumes L/ha	Deposits Viable Spores/ cm^2	Pretreatment Populations		Current Year Growth Defoliation %	Mass of Current Year Growth/100 cm Branch g	Buds Formed (For the Next Year) %
				Larvae/ 45 cm Branch/Tip	Larvae/Bud			
				Grumman AGCAT				
Futura	20	2.5	336 380	28.0	0.14	21.9	33.4	77.8
Futura	20	2.5	384 780	17.3	0.13	12.5	46.6	77.9
Futura	20	2.5	269 830	20.2	0.19	19.6	42.9	77.8
Futura	20	2.5	406 821	24.8	0.37	12.9	67.4	81.1
Futura	20	2.5	361 427	12.2	0.13	10.3	54.7	85.3
Average Futura	--	--	351 848	20.5	0.19	13.4	49.0	79.9
Thuricide 48B	20	2.5	268 862	11.8	0.09	8.8	67.4	68.4
Futura	30	3.75	520 300	22.7	0.26	22.7	41.2	91.1
Thuricide 48LV	30	4.7	608 388	36.8	0.24	26.7	48.3	84.1
Untreated[a]	--	--	--	25.7	0.24	100.0	1.2	4.6
				DC-4G: Four engines				
Futura[b]	20	2.5	222 400	31.8	0.19	24.9	43.7	80.1
Untreated[c]	--	--	--	30.1	0.28	100.0	0.6	10.2

a Average for 8 sampling plots
b Average for 9 sampling plots
c Average for [illegible] sampling plots

Table 3

RESULTS OF FIELD TESTS WITH <u>Bacillus thuringiensis</u> AGAINST

THE SPRUCE BUDWORM IN 1983

Formulas	Dosages X 10^9 I.U./ha	Volume L/ha	Deposit Viable Spores/ cm^2	Pretreatment Populations		Current Year Growth Defoliation %	Mass of Current Year Growth/100 cm Branch g	Buds Formed (For the Next Year) %
				Larvae 45 cm Branch/Tip	Larvae/Bud			
				Grumman AGCAT				
Futura	20.0	2.50	349 841	12.3	0.08	32.8	36.0	84.2
Futura	17.0	2.14	142 000	21.1	0.24	55.9	18.6	78.5
Futura	16.3	1.43	143 456	19.9	0.19	54.8	12.4	73.4
Futura	8.0	0.71	135 475	18.8	0.19	49.8	22.1	79.7
Untreated[a]	--	--	--	20.9	0.28	93.1	2.7	33.2

a Average for 8 sampling plots

NATIONAL RESEARCH COUNCIL PUBLICATIONS REPORT

ASSOCIATE COMMITTEE ON SCIENTIFIC CRITERIA FOR ENVIRONMENTAL QUALITY

SUBCOMMITTEE ON PESTICIDES AND INDUSTRIAL ORGANIC CHEMICALS

ENVIRONMENTAL SECRETARIAT

RECENT OR CURRENT PROJECTS:

1. Aminocarb: The effects of its use on the forest and the human environment. NRCC No. 18979.

   This document was published in 1982 and contains a computer-model that estimates bystander exposure and drift potential.

2. 2,4-D: Some Current Issues. NRCC No. 20647.

   This document is currently at the printers and should be published before Christmas. A computer-model is again used to estimate exposure and drift potential and the document examines the differences between exposure from forest insecticides and herbicides, using aminocarb and 2,4-D as the respective examples. The exposure from aminocarb was found to be approximately two orders of magnitude higher, at least within the context of this model.

3. Update of all NRCC documents that contain IBT data.

   These updates will consist of short critiques of the toxicology of the relevant compounds, with particular attention being paid to changes or parallels in data. Each update will be published separately; the first one, which is on fenitrothion, should be out in the next few months. The next pesticide to be examined is *Bacillus thuringiensis*.

4. Criteria monograph on pyrethroids.
   This document should be published in four to five months.

5. Scientific evaluation of cost/risk/benefit assessment procedures for organic chemicals in Canada.

   This project is using pesticides as a test case and three pesticides will be taken through the complete procedures. 2,4-D and/or 2,4,5-T will be one of the three pesticides.

NOTE:

Anyone wishing to receive these documents or be put on our mailing list should contact myself or Gordon Copp, our Copy Editor, at 996-6097.

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D.A. Winston

Forestry and The Expert Committee on Weeds

Over the past decade the interest in the use of herbicides in forest management has risen dramatically. The Canadian Forestry Service (C.F.S.), several provincial agencies and several members of the forest industry have initiated research and operational trials to test the efficacy of several herbicides, including those already registered for forestry use (2,4-D, 2,4,5-T) and those with potential (e.g. glyphosate, hexazinone). However, due to our disparate programs and locations, the forestry community has had a difficult time in gaining new registrations, and indeed in maintaining old ones. Communications have been limited to individuals, infrequently with chemical manufacturers, and has led to a misunderstanding of many procedures including the registration process and Agriculture Canada's role. To make matters worst the lack of communication and lack of coordination of effort has led to a lot of work being done without any focus and without any hope of securing registrations.

As a means of rectifying this situation, Dr. Campbell (OMNR) and I met with several CFS scientists in October 1982 to assess our various options. The one that we proposed was to establish a CCREM sponsored organization to coordinate forest herbicide research. An alternative was to more closely align ourselves with the Expert Committee on Weeds which is sponsored by the Canadian Agricultural Services Coordinating Committee (CASCC). Forestry has long been involved with this group but as a result of some early discussions we were concerned that the ECW would not welcome forestry participation in the future. This ultimately led to a proposal to CCREM for sponsorship of our own organization, and subsequently a request by CCREM to further examine our relationships with the agricultural community.

I am happy to report that we have followed up on the CCREM request and that ECW is now in general, very warm to our participation. For example, the ECW has extablished a Silviculture group in the Eastern Section, and has approved the formation of a Silviculture group in the western section.

The Expert Committee on Weeds is an organization of agricultural research scientists and chemical industry representatives that meets annually, prepares recommendations to Agriculture Canada on the registration of herbicides and provides an opportunity for the coordination of herbicide research and distribution of industry funds. In addition to agricultural specialists, non-crop specialists in fields such as hydro-right-of way and forestry have participated. The ECW has a formal structure which includes representatives from the regulatory agencies, chemical industry and Agriculture Canada.

Forestry participation in the ECW is important since it provides us with direct inputs into the recommendation process to Agriculture Canada and the other regulatory agencies; it provides a forum for discussion and coordination of research and it provides an important opportunity for contact with the chemical industry, lobbying for forestry programs and development of cooperative efforts for registration of new products.

I would like to encourage all forest agencies to consider having some staff join the ECW and attending their meetings. Membership is free in both the Eastern and Western sections. A request for inclusion on the mailing list can be sent to Dr. W. Saidak, Research Coordinator, Agriculture Canada, Sir John Carling Building, Ottawa, Ontario K1A 0C5.

An Important Unknown in Interpreting the Infestation Dynamics

of the Spruce Budworm

by

W. Lloyd Sippell

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Great Lakes Forest Research Centre
P.O. Box 490
Sault Ste. Marie, Ontario P6A 5M7

This talk is intended to provide a change of pace in the proceedings of the Forum as well as to stretch our imaginations for improving forest pest management strategies in future.

On the morning of July 12, 1969 two couples were driving home along Black Bay Road towards the town of Petawawa, Ontario when they observed a strange looking light in the sky. They stopped in a parking lot on the north end of town to observe the phenomenon more closely. They were joined there by two OPP constables, Jack McKay and Grant Chaplin, who had become suspicious over their strange actions at 5 o'clock in the morning. When interviewed, Grant Chaplin, who is now a corporal here in the Ottawa detachment, said that at first he thought that somebody must have been looking through the bottom of empty beer bottles. However, when it was explained, the constables, too, saw the strange lighted figure to the northwest in an otherwise clear sky.

At much the same time, three military police on duty at Canadian Forces Base Petawawa, which is located north of the town, sited what they described as a cylindrical, bright object in the sky which they could neither identify nor explain. A local Pembroke reporter heard about these sitings of July 12 and a Canadian Press story appeared in many Canadian newspapers on July 14. The following appeared in the Sault Star, the daily newspaper in Sault Ste. Marie, Ontario.

Police Spot UFO Near Base

July 14/69

PEMBROKE (CP) — Two police constables and several other persons reported sighting an unidentified flying object near here early Saturday.

"It was just like a large star . . . no body, no form, just a light about 1,500 feet in the sky," said Constable Jack McKay of the Pembroke OPP detachment.

The object was described as a "cylindrical-shaped brilliant light in the sky over Petawawa," a town 10 miles north of Pembroke. Constable McKay, his patrol partner Constable Grant Chaplin, and several others, including three military policemen at the nearby Canadian forces base, reported seeing the phenomenon at about 5 a.m. Saturday.

The Canadian forces radar station at North Bay reported Sunday it is checking the incident.

It so happened that the Forest Insect and Disease Survey (FIDS) of the Great Lakes Forest Research Centre (GLFRC) was operating a black light insect trap at the then Petawawa Forest Experiment Station, now the Petawawa National Forestry Institute (PNFI). Trapping results showed a dramatic surge in numbers of spruce budworm moths on July 12, compared to the small numbers which were being captured in the trap beginning July 5. According to the FIDS technician, the number of spruce budworm moths attracted to the black light exceeded the capacity of the trap following July 12. On July 12 and for 10 subsequent nights the number of spruce budworm moths trapped exceeded 200+, the maximum number that can be recorded on the form. Apparently the volume of moths removed each morning exceeded the amount that the survey field technician could handle properly because on July 21 an irate call was received at GLFRC from the Sault Ste. Marie postmaster requesting that a large parcel which had arrived overnight be picked up immediately because of the extremely foul odor it was emitting. The large package contained the partially putrefied remains of spruce budworm moths from 4 nights of light trap operation. Little could be done with this material owing to the foul smell, however, a sample taken from the returns of July 12 contained 181 and 217 spruce budworm like moths. All moths showed evidence of severe battering in that no scales or wing pattern whatever remained. Identification of the moths in a subsample using genitalia confirmed that they were *Choristoneura fumiferana* (Clem.).

The trapping results came as no surprise to the technician because spruce budworm moths "were everywhere". On July 12 and 13 the grounds and buildings near artifical lights at PNFI were literally covered with moths and between two greenhouses with continuous lighting, moths were piled 13 cm (5 in.) deep. Around the cafeteria building of Atomic Energy of Canada Limited 47 205-L (45 gal.) drums of moths were swept and shovelled up for disposal (Sippell et al. 1970).

Quite an anecdote! Remember, this was 1969 before the concentrated radar work of 1973-1976 was begun in New Brunswick. Numerous similar, though somewhat less spectacular, events had been observed by the field staff of FIDS over many years, in which the evidence of moth flights was at best empirical but more often circumstantial or conjectural. These events were often discussed and sometimes even cautiously reported; however, the eventual conclusion that moth movement was a vitally important component of infestation dynamics emerged gradually but persistently over time on the basis of numerous pieces of evidence rather than on scientific proof.

All that, of course, changed with the publication of Greenbank et. al. (1980) on spruce budworm moth flight and dispersal. They showed that spruce budworm moths regularly make vertical exits from heavily damaged and heavily infested stands and that under a fairly wide range of temperature and wind conditions beginning about 1800 hours and reaching a peak about 2100 hours each evening moths makes their exodus. Above the tree canopy moths are oriented downwind and at a combined flight and wind speed often equalling 30 km/hr or more, moths disperse over distances of 40-80 km in a few hours. But it was the description of a radar-recorded 6-hr moth flight overnight at Renous, New Brunswick that jolted me into associating the reported UFO with the dramatic and coincident influx of moths near Petawawa.

Conventional weather data and summaries of hourly recorded wind directions and speeds obtained from the Weather Archives, Atmospheric Environment Services, Dept. of the Environment, Downsview, Ontario were examined. During the night of July 11-12 at Chalk River, located some 18 km northwest of the town of Petawawa, a light to moderate breeze from the southeast was recorded, changing direction to the north and west a few hours before dawn (Table 1). The weather chart for 2000 hours on July 11, 1969 (Fig. 1) shows that these conditions were being influenced by a weak low pressure air mass centered in northeastern Ontario If a flying speed of 7 km/hr is used for moths and an approximate wind speed

Table 1. Wind direction and speed (km/hr) recorded at Chalk River, Ontario during the night of July 11/12, 1969.

Date	Hour											
	01	02	03	04	05	06	19	20	21	22	23	24
							SE	SE	SE	SE	SE	SE
July 11							11.3	8.0	6.4	6.4	6.4	3.2
	SE	SE	NW	N	W	W						
July 12	8.0	3.2	3.2	3.2	3.2	4.8						

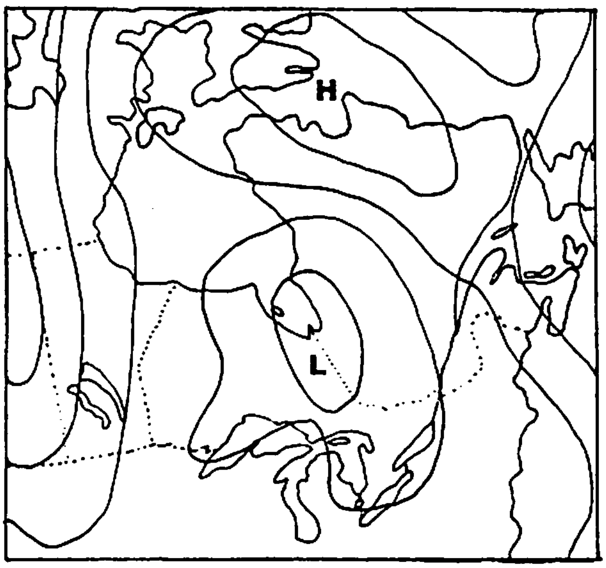

Figure 1. Weather chart for 2000 hours EDT, July 11, 1969.

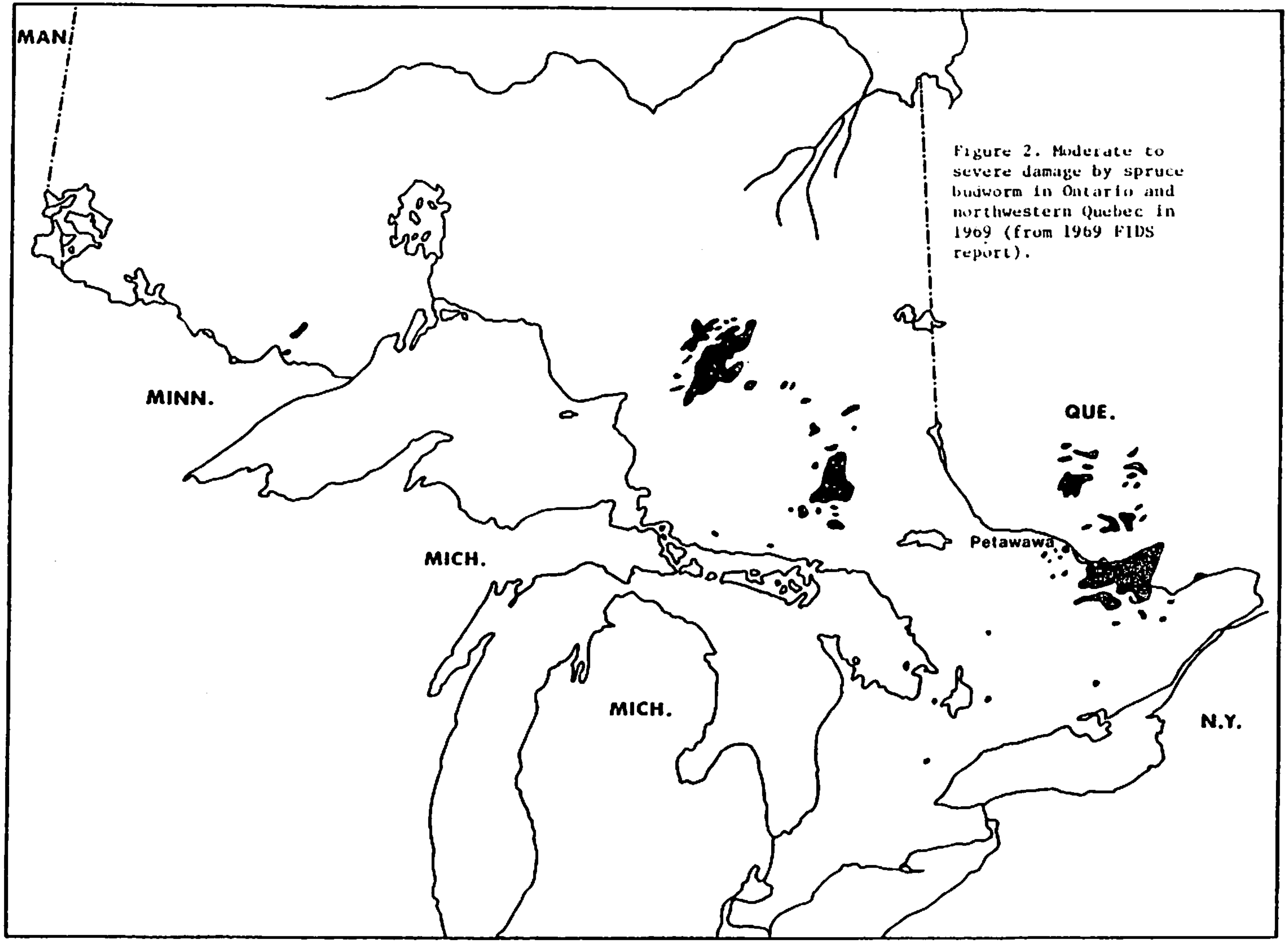

Figure 2. Moderate to severe damage by spruce budworm in Ontario and northwestern Quebec in 1969 (from 1969 FIDS report).

of 5 km/hr, for a total of 12 km/hr over an extended period during the night, it could be assumed from the 1969 infestation map (Fig. 2) that the source of dispersing moths was the extensive infestation located from 20 to 150 km to the southeast beginning south of Pembroke and extending into the adjoining lower Gatineau area of Quebec. Weather data from other stations supported the evidence that similar winds moved to the northwest during the night. Apparently some of the moths had become concentrated as they do in zones of wind convergence (Greenbank et al. 1980) and I believe the Petawawa UFO turned out to be one of those concentrations that caught the first rays of the sun at dawn on July 12, 1969.

A comparison of the 1969 and 1970 infestation maps for the Ottawa Valley (Fig. 3 and 4) reveals that the boundary of continuous moderate to severe infestation in 1970 extended 95 km (59 mi.) to the northwest of the 1969 border, and resulted in an expansion of over 1500 km^2 (580 sq. mi.) of new infestation. Furthermore, the intensity of damage in the Chalk River-Deep River area, where the mass influx of moths occurred, increased from barely detectable levels in 1969 to "consistently severe on all host trees" in 1970.

Temperatures and wind conditions in the Ottawa Valley were similar on the previous night, July 10-11 (Table 2) with conditions being influenced by a smaller low pressure air mass centered in southwestern Ontario (Fig. 5). It is reasonable to assume that another wave of moths had dispersed up the Ottawa Valley one evening previous to the Petawawa incident. Weather data suggest a more rapid dispersal pattern owing to higher wind velocities before midnight, but an abbreviated one owing to

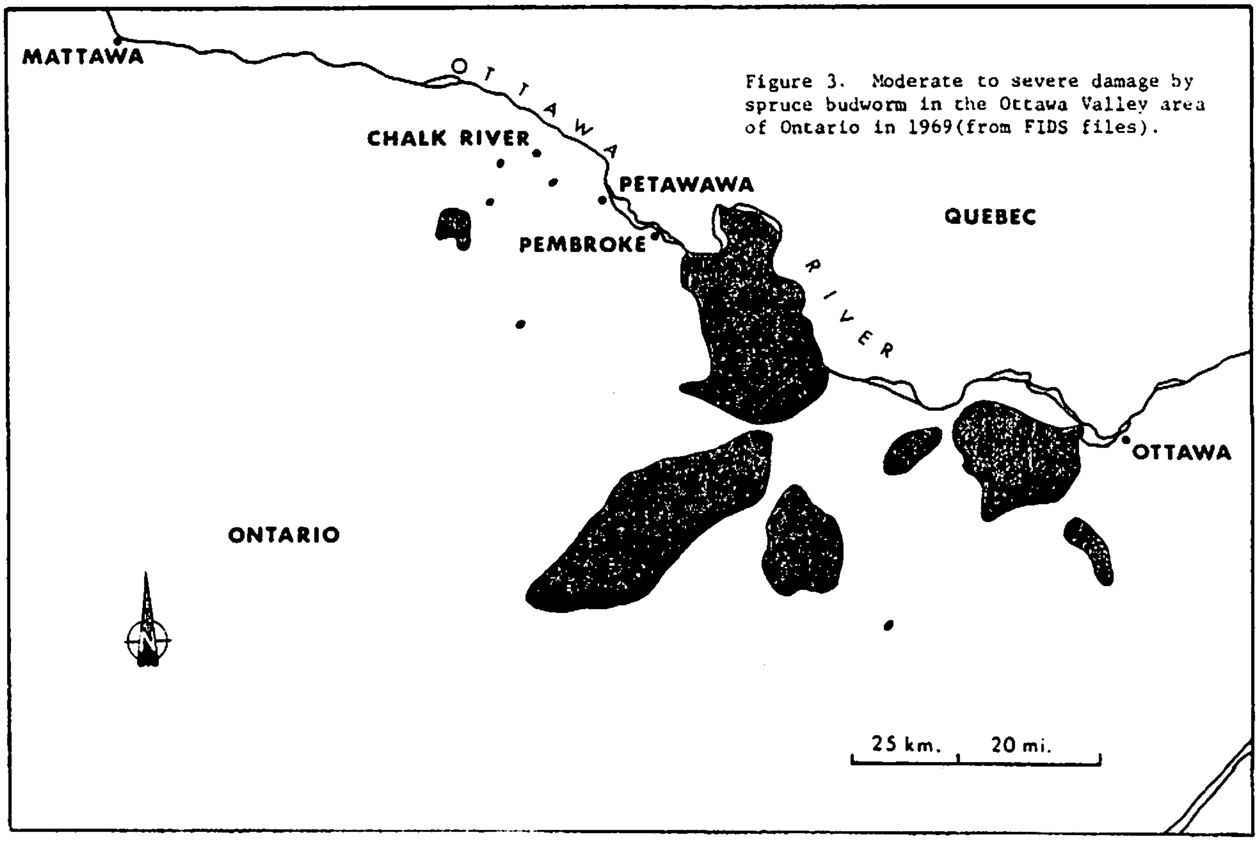

Figure 3. Moderate to severe damage by spruce budworm in the Ottawa Valley area of Ontario in 1969(from FIDS files).

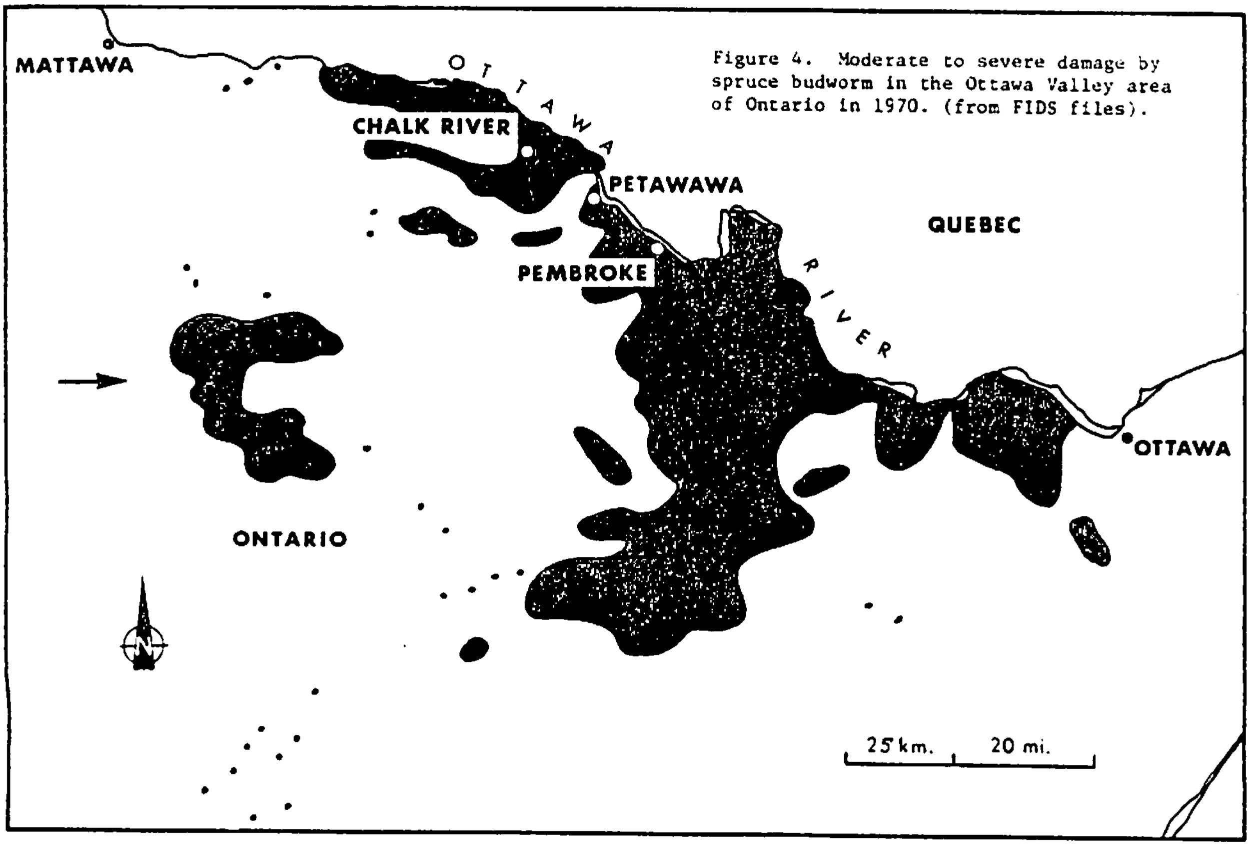

Figure 4. Moderate to severe damage by spruce budworm in the Ottawa Valley area of Ontario in 1970. (from FIDS files).

Table 2. Wind direction and speed (km/hr) recorded at Chalk River, Ontario during the night of July 10/11, 1969.

Date	Hour											
	01	02	03	04	05	06	19	20	21	22	23	24
July 10							SE 11.3	SE 16.1	SE 8.0	SE 8.0	SE 8.0	SE 6.4
July 11	SE 3.2	S 6.4	SW 1.6	SW 3.2	W 6.4	W 4.8						

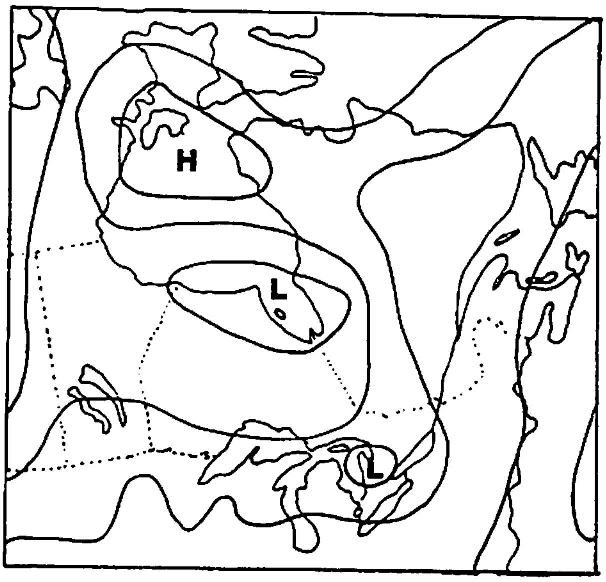

Figure 5. Weather chart for 2000 hours EDT, July 10, 1969.

dropping temperatures which, during the morning of July 11, fell to a minimum of 10°C when dispersal ceases. Dispersal to locations farther from the source than occurred on July 11-12, and in a more direct northwestern direction is suggested. The eruption of a large new infestation in Algonquin Provincial Park in 1970 (Fig. 4) (→) has these precise traits, but here the evidence is circumstantial.

At Petawawa, the precise time of moth dispersal became known through an incidental observation. Usually the exact dates of night-time dispersal are unknown. Without more detailed information, little can be learned either generally or specifically about the influence moth dispersal has on infestation change. More operational information on dispersal patterns and associated winds must be obtained. The usefulness of existing radar equipment such as the new weather radar stations which AES has recently brought on line at Toronto, North Bay and Thunder Bay (and will soon set up as Sault Ste. Marie) should be investigated. Some rather superficial and preliminary trials were made in 1983 without success. Alternatively if present operational equipment cannot be utilized, more suitable radar equipment will berequired.

Research on the spruce budworm responds to the highest demands and takes the path of greatest immediate productivity. The early concept of "controlling epicenters", once regarded as an inspirational goal among early Canadian entomologists, has been largely abandoned. The CFS Spruce Budworm Task Force report, for example, suitable and excellent as it is for identifying research needs as perceived by forest management, fails to mention the concept of outbreak control.

In September I presented a paper at a CANUSA workshop in Burlington, Vermont entitled "Planning now to reduce, postpone or prevent the next spruce budworm outbreak". In it were developed 10 general characteristics of infestation in Ontario and a proposal was advanced for disrupting the initiation of the next outbreak. The proposal recognizes the full potential of moth dispersal and calls simply for the manipulation of residual infestations in the western range of the spruce budworm at a time when infestations are limited, reducing them and maintaining them below levels at which moth dispersal would occur (see Sanders [1979]). Historical evidence suggests that such action would result in the removal of the potential outbreak source.

It would be ludicrous to suggest that such a proposal be initiated now because the present outbreak continues to expand in some critical areas such as northwestern Ontario and seems destined to continue ad infinitum in other parts of the range. But the concept does provide the basis for a truly regional Integrated Pest Management program in Canada as well as the United States. The number and diversity of management objectives mitigate against a rapid "meeting of minds" that would be necessary to implement such an international approach to outbreak prevention, yet I consider that the strategy holds rich long-term promise for eventual outbreak containment.

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EASTERN SPRUCE BUDWORM COUNCIL
CONSEIL DE L'EST SUR LA TORDEUSE D'EPINETTE

REPORT FROM THE EASTERN SPRUCE BUDWORM COUNCIL (*)

The Eastern Spruce Budworm Council is a joint body made up of representatives from the various jurisdictions in northeastern North America for the purposes of sharing their knowledge and experience of the spruce budworm problem and studying and collaborating in programs related to the various aspects of the problem. It was officially established in January 1979 by the signature of a Memorandum of Understanding. As provided in this document, the four signatory Provinces of Quebec, New Brunswick, Nova Scotia and Newfoundland are full members of the Council. It is also provided in the Memorandum that the Council may invite the participation of jurisdictions other than the signatories as associate members. The Province of Ontario, the Canadian Forestry Service and the State of Maine were accepted as associate members at a Council meeting held in Quebec City in April 1979. The USDA Forest Service was likewise accepted as associate member at a Council meeting held in

(*) Presented at the Eleventh Annual Forest Pest Control Forum, held in Ottawa on November 15-17, 1983

Fredericton in April 1982. As it now stands, the membership of the Council is therefore made up of eight members, i.e. four full members and four associate members.

Two Council meetings were held in 1983, a spring meeting on April 12-13 in Halifax and a fall meeting on November 9-10 in Toronto. The Council has also been active in 1983 through its four working committees on (a) spray technology, (b) environmental monitoring, (c) human health issues, and (d) the standardization of survey and assessment techniques.

The committee for the standardization of survey and assessment techniques has published this year a reference manual of survey and assessment techniques used in spruce budworm surveys and in the assessment of operational spray programs. Again this year, the same committee has been working on the preparation of maps depicting the overall spruce budworm situation in northeastern North America. These maps will be presented by Mr. E. G. Kettela, the Canadian Forestry Service representative on the committee.

Gerard Paquet

Executive Secretary
Eastern Spruce Budworm Council

INFORMATION ON NEWFOUNDLAND'S 1983 SPRAY PROGRAM *

1. Original area selected for treatment:

Matacil (1.8D)	84 571.8 ha
Bt (Thuricide 16B)	1 453.4 ha
Total	86 025.2 ha

2. Modifications based on pre-spray sampling:

Additions	5 182.0 ha
Deletions	-17 826.9 ha (incl. 1 453.4 ha Bt)
Net Deduction	-12 644.9 ha (14.7%)

Revised Program = 73 380.3 ha

3. 99.2% of area received double application with Matacil as prescribed.

4. Insecticides/Dosage Rates:

Matacil 1.8D	2 x 70g/1.46L/ha	(63 961.9 ha)
Matacil 180 Flowable	"	(9 418.4 ha)

5. Formulations (% by volume):

Matacil (either)	26.6%
Insecticide Diluent 585	73.4%

6. Number/Type of spray planes:

   1 DC-6 (Conair Aviation, B.C.)
   4 AgCats (Kanata Aviation, P.E.I.)

7. Guidance/Supervision

The DC-6 used a Litton LTN-72 Inertial Navigation System and 1:50,000 Topographic maps.

The AgCats were led by navigator using 1:50,000 topographic maps in a Bell Jet Ranger 206B helicopter.

Aerial supervisors used a twin-engine Piper Aerostar 601P for the DC-6 operation and a twin-engine Cessna 337 for the AgCat operation.

8. Swath:

The nominal swath for the DC-6 was 610 m, and 76m/aircraft for the AgCats.

*Prepared by N. Carter for Annual Forest Pest Control Forum, 1983. Full report available from: Dept. Forest Resources and Lands; Bldg. 810, Pleasantville; St. John's, NF A1A 1P9

9. Payload:

The DC-6 carried up to 13 600 L of Matacil formulation and could treat up to 9 250 ha per trip.

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Each AgCat was equipped with a Micronair Digital Flow Meter that displayed the rate of flow and volume of spray used.

11. Duration of Program:

Spraying began on the evening of June 6 and was finished on the evening of June 26. Spray conditions were exceptionally favourable with most blocks being treated within 24 hours of opening (both treatments). In some instances spraying was delayed to wait the minimum 5-day interval between applications and in a few cases to allow more favourable shoot development.

12. Pre-spray Population Levels (Table 1):

Populations were again extremely variable as expected. Although some deletions were made for 'zero' and very low counts, some plots produced counts as high as 40-70 larvae per 45-cm branch. Fortunately these plots were not widely distributed.

13. Larval Mortality (Table 1):

For analysis, plots were classed as Low, Moderate, or Severe. Corrected mortality ranged from 73 to 100 percent with no great difference between values from plots from DC-6 or AgCat blocks.

14. Foliage Protection (Table 1):

Based on branch defoliation estimates overall average foliage protection ranged from 15 to 44 percent, with great variability.

15. Aerial Defoliation Assessment:

An aerial defoliation assessment revealed that 89% of the area was classed Light; 10% was classed Moderate; and only 1% was classed Severe.

Table 1. Summary of data obtained from plots in treated blocks and untreated check areas.

	Avg. pre-spray 1/45 cm	sh/l	Avg. Obs. Def. (%)	Foliage[a] Prot. (%)	Avg. Obs. Mort. %	Corr.[b] Mort. %	No. Plots
LOW							
AgCat	2.13 (1.19)[c]	42.16 (24.56)	6.44 (10.22)	35	100.00 (0.00)	100	18
DC-6	1.88 (0.87)	40.55 (21.58)	6.42 (6.75)	35	99.08 (3.26)	85	38
Check	1.93 (1.06)	46.14 (24.33)	9.91 (14.23)		93.79 (18.16)		43
MODERATE							
AgCat	7.92 (3.42)	10.08 (3.17)	23.05 (26.92)	40	98.11 (7.54)	84	19
DC-6	6.34 (5.08)	12.23 (2.94)	21.71 (24.57)	44	96.76 (7.76)	73	21
Check	6.41 (3.37)	11.59 (3.92)	38.58 (36.89)		87.89 (21.44)		19
SEVERE							
AgCat	23.53 (15.20)	4.01 (1.39)	62.00 (31.73)	15	97.00	77	9
DC-6	28.55 (20.68)	3.85 (1.43)	54.00 (33.72)	26	97.36 (6.17)	80	11
Check	20.25 (12.82)	3.53 (1.16)	73.13 (24.54)		87.00 (14.24)		8

a - Foliage Protection (%) = $\frac{\text{Obs. Def. (Check)} - \text{Obs. Def. (Spray)}}{\text{Obs. Def. (Check)}} \times 100\%$

b - Corrected Mortality (%) = $\frac{\text{Obs. Mort. (Spray)} - \text{Obs. Mort. (Check)}}{100 - \text{Mortality (Check)}} \times 100\%$

c - (   ) Standard Deviation

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Each AgCat was equipped with a Micronair Digital Flow Meter that displayed the rate of flow and volume of spray used.

11. Duration of Program:

Spraying began on the evening of June 6 and was finished on the evening of June 26. Spray conditions were exceptionally favourable with most blocks being treated within 24 hours of opening (both treatments). In some instances spraying was delayed to wait the minimum 5-day interval between applications and in a few cases to allow more favourable shoot development.

12. Pre-spray Population Levels (Table 1):

Populations were again extremely variable as expected. Although some deletions were made for 'zero' and very low counts, some plots produced counts as high as 40-70 larvae per 45-cm branch. Fortunately these plots were not widely distributed.

13. Larval Mortality (Table 1):

For analysis, plots were classed as Low, Moderate, or Severe. Corrected mortality ranged from 73 to 100 percent with no great difference between values from plots from DC-6 or AgCat blocks.

14. Foliage Protection (Table 1):

Based on branch defoliation estimates overall average foliage protection ranged from 15 to 44 percent, with great variability.

15. Aerial Defoliation Assessment:

An aerial defoliation assessment revealed that 89% of the area was classed Light; 10% was classed Moderate; and only 1% was classed Severe.

Table 1. Summary of data obtained from plots in treated blocks and untreated check areas.

	Avg. pre-spray 1/45 cm	Avg. pre-spray sh/1	Avg. Obs. Def. (%)	Foliage[a] Prot. (%)	Avg. Obs. Mort. %	Corr.[b] Mort. %	No. Plots
LOW							
AgCat	2.13 (1.19)[c]	42.16 (24.56)	6.44 (10.22)	35	100.00 (0.00)	100	18
DC-6	1.88 (0.87)	40.55 (21.58)	6.42 (6.75)	35	99.08 (3.26)	85	38
Check	1.93 (1.06)	46.14 (24.33)	9.91 (14.23)		93.79 (18.16)		43
MODERATE							
AgCat	7.92 (3.42)	10.08 (3.17)	23.05 (26.92)	40	98.11 (7.54)	84	19
DC-6	6.34 (5.08)	12.23 (2.94)	21.71 (24.57)	44	96.76 (7.76)	73	21
Check	6.41 (3.37)	11.59 (3.92)	38.58 (36.89)		87.89 (21.44)		19
SEVERE							
AgCat	23.53 (15.20)	4.01 (1.39)	62.00 (31.73)	15	97.00	77	9
DC-6	28.55 (20.68)	3.85 (1.43)	54.00 (33.72)	26	97.36 (6.17)	80	11
Check	20.25 (12.82)	3.53 (1.16)	73.13 (24.54)		87.00 (14.24)		8

a - Foliage Protection (%) = $\frac{\text{Obs. Def. (Check)} - \text{Obs. Def. (Spray)}}{\text{Obs. Def. (Check)}} \times 100\%$

b - Corrected Mortality (%) = $\frac{\text{Obs. Mort. (Spray)} - \text{Obs. Mort. (Check)}}{100 - \text{Mortality (Check)}} \times 100\%$

c - ( ) Standard Deviation

THE SPRUCE BUDWORM IN NEWFOUNDLAND IN 1983

Report prepared for the Eleventh Annual Forest
Pest Control Forum, Ottawa
15-17 November 1983

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10 November 1983

THE SPRUCE BUDWORM IN NEWFOUNDLAND AND LABRADOR IN 1983

Larval Development and Defoliation

Results of the larval sampling and egg mass surveys in 1982 indicated that moderate and severe defoliation would occur in 110 000 ha distributed from South Branch to the Humber Canal near Deer Lake in western Newfoundland and along a section of the Noel Paul's Brook in central Newfoundland. In Labrador the infestation was expected to be about 1000 ha along Beaver River.

In 1983 warm and dry weather conditions prevailed throughout the Island from April to mid-July pushing insect and tree development about three weeks ahead of last year. Larval development progressed rapidly, defoliation was complete by July 15 and local moths were trapped as early as July 4. However, from mid-July to late August record rainfall occurred. The weather for the remainder of the season was above normal, dry and warm. In Labrador weather conditions were near normal during the summer except for heavy rainfall in mid-July.

Ground and aerial surveys showed that although budworm defoliation was more widely distributed in 1983 it had only increased from 90 000 ha in 1982 to 100 000 ha in 1983 (Table 1, Fig. 1). The increase in distribution of larvae occurred along the north side of Bay of Islands, the Northern and Baie Verte Peninsulas, the Noel Paul's Brook area and the Bonavista Peninsula.

A decrease in defoliation was recorded in the Stephenville - Port au Port area, and near Glide Lake (Fig. 1). However, moderate and severe defoliation increased significantly from 42 000 ha in 1982 to 68 000 ha in 1983. In Labrador the two small infestations near Goose Point and Beaver River decreased from a total of 700 ha in 1982 to 360 ha in 1983.

Biological Control Factors

In 1983, weekly samples of spruce budworm were collected from eight permanent sampling areas. The major larval parasites were *Apanteles fumiferanae* and *Glypta fumiferanae*. The only pupal parasite reared and recovered was a tachinid species. About 10% of spruce budworm reared were parasitized.

Fungal diseases caused less than 1% mortality of the reared budworm samples. The major fungal pathogen was *Zoophthora radicans*. Incidence of microsporidian disease, caused by *Nosema fumiferanae*, was about 3%.

Damage Assessment

Ground and aerial surveys were conducted jointly with the Inventory Section of the Provincial Department of Forest Resources and Lands to determine the area of tree mortality in the productive forests. The surveys included all productive areas but sampling was concentrated in the predominantly black spruce stands of central Newfoundland where general deterioration and much increased tree mortality commenced in 1982. The methods were similar to those initiated in 1982 with the goal of producing maps in 1:30,000, 1:50,000 and 1:250,000 scale to show tree mortality separately for balsam fir and black spruce stands in five damage classes (1-10%, 11-25%, 26-50%, 51-75% and 76-100%).

The comprehensive analysis of the 1983 damage assessment has not been completed but preliminary results indicate that the area of merchantable balsam fir stands did not increase appreciably from 1982 (Fig. 3). However, the proportion of tree mortality in predominantly fir stands increased from 18 300 000 m^3 to 19 150 000 m^3 and the proportion of dying trees from 1 119 000 m^3 to 1 984 000 m^3. The total volume of these stands was estimated at 37 685 000 m^3 (Table 2).

The general deterioration and increased tree mortality that commenced in 1982 in predominantly black spruce stands of central Newfoundland continued in 1983 (Figs. 3, 4). The most noticeable increase occurred in the Halls Bay and Twin Lakes region where isolated areas of mortality coalesced. The areas of tree mortality also increased and coalesced in the Northwest Gander River Valley. The area of black spruce stands with more than 10% dead and dying trees increased from 80 500 ha in 1982 to about 95 700 ha in 1983 (Table 2). The volume of dead trees increased from about 2 000 000 m^3 to 3 194 000 m^3 and the volume of dying trees from 464 000 m^3 to about 915 000 m^3. The total volume of these stands was estimated at 8 200 000 m^3 in 1982 and about 10 300 000 m^3 in 1983. In addition dead and dying trees comprising less than 10% of the stand volume was recorded on 100 000 ha in 1983 (Fig. 4). Assuming an average volume of 100 m^3/ha the total volume of these stands is estimated at 10 000 000 m^3.

In summary the combined volume of balsam fir stands and black spruce stands with more than 10% mortality increased from 45 918 200 m^3 in 1982 to 48 007 500 m^3 in 1983 (Table 2). The volume of dead and dying trees at 25 243 400 m^3 comprise more than 50% of the volume of these stands.

Causal Factors of Black Spruce Mortality

All black spruce stands with tree mortality in central Newfoundland had been severely defoliated by the spruce budworm for several years prior to 1980 which resulted in some tree mortality and widespread top kill. However, following the decline of budworm populations most of the stands showed good recovery for two to three years until 1982 when the general stand deterioration commenced. In addition to the analysis of the history of budworm damage work was initiated in 1983 to investigate the role of other factors in black spruce mortality. This work included; 1) establishment of new permanent plots; 2) comprehensive soil and site description with biological, physical and chemical analysis; 3) tree growth data from branch samples and stem analysis; 4) chemical analysis of foliage and ground vegetation for possible role of acid rain; 5) investigations of bark beetles, and 6) sampling for rootlet mortality and Armillaria root rot. Most of the above work is still in progress but preliminary results on bark beetles and shoot growth and root rot and Hylobius weevils are summarized below.

The Four-Eyed Spruce Bark Beetle in Black Spruce - Studies of the biology of the four-eyed spruce beetle, *Polygraphus rufipennis*, showed one generation and three broods per year. Most new attacks in June were confined to trees with green foliage.

The beetle was active in all permanent plots established to monitor spruce mortality and stand conditions (Table 3). Most trees dead by 1982 had evidence of previous beetle attack and practically all trees that died in 1983 had been invaded by this bark beetle.

Bark beetles successfully attacked and killed trees with all degrees of foliage loss (Table 4). However, nearly half of the 204 trees attacked in 1983 and subsequently died had been classed as 100% defoliated (usually live) in October of 1982. Another 70 trees had been 80% or more defoliated. The remainder of the defoliation classes were about equally attacked except for the 40% and 50% defoliation classes. One obvious pattern in the data (Table 4) is that the lower defoliation classes were more frequently attacked in stands classed as "severely damaged". This could be caused by either higher beetle populations present in these stands, or by the increased susceptibility of trees in stands having had received more budworm damage in the late 1970's.

Elongation by terminal shoots of mid-crown branches occurred in all stands in all years back to 1975 (Fig. 5). Shoot length was about 35 to 40 mm per year in the mature trees for all years except 1981 and 1982. For these two years, when the recovery occurred, shoot elongation was decidedly higher at about 50 to 70 mm per year. In the young stand shoot elongation was greater but followed the same pattern: about 70 mm for the two years of recovery, and about 50 to 55 mm in other years.

In summary, mortality of spruce continued in the plots in 1983: an additional 10% of the trees died in moderate and severe stands and about 5% in light and young stands. About 60% of the trees that died in 1983 had green foliage at the beginning of 1983 and about 25% had more than half of their foliage component. The degree of shoot elongation per year for the years 1975 to 1983 did not indicate a gradual decline of vigor in the stands sampled. Therefore, the beetle is able to kill trees that appear capable of complete recovery from spruce budworm damage - as judged by foliage condition.

Armillaria Root Rot and Hylobius Weevils in Black Spruce - The root system of 192 black spruce trees were exposed by washing away the soil and were examined for the presence and severity of Armillaria root rot and Hylobius weevil damage. Equal number of trees were sampled from black spruce stands with light, moderate and severe budworm damage at Halls Bay and Northwest Gander River (Table 5).

The percentage of trees infected with *Armillaria mellea*, the causal organism of Armillaria root rot, increased with the severity of total budworm defoliation and reached an overall average of about 85% in the 81-100% defoliation class. The incidence of the root rot also increased with the severity of average budworm damage in the stand from light to severe. Analysis of data on the intensity of infections has not been completed but the general increase in infections with defoliation indicates that Armillaria root rot contributes to the mortality of black spruce stands.

The incidence of Hylobius weevil damage also had a tendency to increase with defoliation. However, observations on the severity of damage indicated that this weevil did not contribute significantly to black spruce mortality.

Forecast for 1984

In addition to egg mass samples spruce budworm pheromone traps were placed in western and central Newfoundland. These traps caught numerous moths in areas of defoliation. However, traps away from defoliated areas, especially in central Newfoundland, caught only one to two moths, indicating low population levels.

The egg mass survey was conducted in over 600 sample points across the Island and 15 points in Labrador. The area of light, moderate and severe defoliation for the Province in 1984 is forecast to be about 89 000 ha (Table 6). Moderate and severe defoliation on the Island is expected to be about 43 000 ha distributed along the North Branch of the Codroy River, near Corner Brook, Hughest Brook, Pasadena - Grand Lake and Noel Paul's Brook (Figure 6). Light defoliation is forecast to occur on 45 000 ha on the Island near Mummichog Provincial Park, throughout the Codroy Valley to Robinson's River, near Glenburnie, St. Paul's Inlet, Parsons Pond, Sandy Lake to Birchy Basin, Middle Arm to Wild Cove, Harbour Round Pond (Red Indian Lake) and Exploits River near the mouth of Noel Paul's Brook (Table 6, Fig. 6).

In Labrador total area of defoliation is forecast to be about 1500 ha. Moderate and severe defoliation is expected to occur in 1000 ha along the Beaver River and about 500 ha of light defoliation near Goose Point (Table 6, Fig. 6).

Moderate to high hazard, based on tree condition and expected defoliation, is forecast to be about 66 000 ha for the Island and 1500 for Labrador (Table 6, Fig. 7).

Preliminary results from hibernacula surveys indicate that the forecast of the extent and severity of the infestation for the Island will need to be increased.

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10 November 1983

Table 1. Area (ha) of defoliation caused by the spruce budworm in productive forests of Newfoundland in 1983.

Management[1] Unit No.	Defoliation Class[2]			Total
	Light	Moderate	Severe	
2	272	-	-	272
9	2 569	-	2 171	4 740
10	286	-	-	286
11	-	-	194	194
12	1 679	-	4 236	5 915
14	11 706	2 660	34 090	48 456
15	15 486	1 435	22 419	39 340
16	2 151	-	194	2 345
17	224	-	-	224
18	1 334	-	-	1 334
	35 707	4 095	63 304	103 106
Labrador	68	-	297	365

[1]See Figure 2.

[2]Light: 1-25%.
Moderate: 26-75%.
Severe: 76-100%.

Table 2. Cumulative balsam fir and black spruce mortality and damage following spruce budworm defoliation in Newfoundland.

Merchantable balsam fir stands

	1982	1983 (estimate)
Total area, ha	361 900	361 900
Dead, vol. m^3	18 319 500	19 150 400
Dying, vol. m^3	1 119 500	1 984 000
Total stand, vol. m^3	37 685 200	37 685 200

Merchantable black spruce stands

	1982	1983 (estimate)*
Total area, ha	80 500	95 700
Dead, vol. m^3	2 002 000	3 194 200
Dying, vol. m^3	464 000	914 800
Total stand, vol. m^3	8 233 000	10 322 300

Merchantable balsam fir stands and black spruce stands combined

	1982	1983 (estimate)*
Total area, ha	442 400	457 600
Dead, vol. m^3	20 321 500	22 344 600
Dying, vol. m^3	1 583 500	2 898 800
Total stand, vol. m^3	45 918 200	48 007 500

*Data do not include 100 000 ha of black spruce stands with less than 10% mortality recorded in 1983.

Table 3. Summary of four-eyed spruce bark beetle infestation in black spruce mortality plots in 1983 in Newfoundland.

Damage class	Locality	No. black spruce (n)	% Living	% Dead ≤ 1982 With bb	% Dead ≤ 1982 Without bb	% Dead 1983 With bb
Light	Halls Bay	336	86	8	1	5
	NW Gander	329	95	2	1	2
	Total/Avg.	665	91	5	1	3
Moderate	Halls Bay	367	52	13	12	23
	NW Gander	298	92	5	2	1
	Total/Avg.	665	70	10	7	13
Severe	Halls Bay	555	13	70	10	7
	NW Gander	456	12	75	1	12
	Total/Avg.	1011	12	72	6	10
Young stands	Rattling Brook	2157	80	(15	)	5

Table 4. Number of black spruce trees with bark beetle attack that died in 1983 by 1982 defoliation classes.

Damage class	Locality	Total Defoliation Class in 1982										Total No. trees
		10	20	30	40	50	60	70	80	90	100	
Light	Halls Bay	2	0	1	0	0	0	1	4	5	2	15
	NW Gander	1	0	1	0	0	0	0	1	2	1	6
	Total	3	0	2	0	0	0	1	5	7	3	21
Moderate	Halls Bay	0	0	0	0	1	3	1	10	26	43	84
	NW Gander	0	0	0	0	0	0	0	1	2	1	4
	Total	0	0	0	0	1	3	1	11	28	44	88
Severe	Halls Bay	2	3	0	2	0	1	1	1	7	22	39
	NW Gander	0	2	3	7	9	1	3	6	5	20	56
	Total	2	5	3	9	9	2	4	7	12	42	95
GRAND TOTAL		5	5	5	9	10	5	6	23	47	89	204

Table 5. Percent defoliation of black spruce trees in light, moderate and severe budwrom damage classes and percent trees with Armillaria root rot and Hylobius weevils.

Location	% defoliation	Number of trees: Light	Moderate	Severe	Total	% trees with *A. mellea*	% trees with *Hylobius*
NW Gander	0-20	15	4	1	20	20.0	45.0
	21-40	10	11	1	22	27.3	45.5
	41-60	4	8	4	16	25.0	62.5
	61-80	3	4	12	19	26.3	73.7
	81-100	0	5	14	19	89.5	57.9
Halls Bay	0-20	28	10	0	38	2.6	7.9
	21-40	4	10	0	14	7.1	21.4
	41-60	0	10	11	21	33.3	28.6
	61-80	0	1	8	9	22.2	22.2
	81-100	0	1	13	14	78.6	14.3
NW Gander and Halls Bay	0-20	43	14	1	58	8.6	20.7
	21-40	14	21	1	36	19.4	36.1
	41-60	4	18	15	37	29.7	43.2
	61-80	3	5	20	28	25.0	57.1
	81-100	0	6	27	33	84.8	39.4

Table 6. Areas (ha) of light, moderate and severe defoliation caused by the spruce budworm and moderate to high hazard forecast in productive forests of Newfoundland in 1984.

Management Unit No.	Ownership	[1]Light defoliation	Moderate and severe defoliation	Totals	Moderate to high hazard
9	Bowater	6397	-	6397	-
12	Abitibi-Price	1754	9462	11216	9462
14	Crown	1776	-	1776	1776
14	Bowater	21606	1799	23405	23405
15	Crown	-	9955	9955	9955
15	Bowater	-	21511	21511	21511
16	Bowater	7290	-	7290	-
17	Crown	2313	-	2313	-
	GMNP	3236	-	3236	-
All	Crown	4089	9955	14044	11731
	Bowater	35293	23310	58603	44916
	Abitibi-Price	1754	9462	11216	9462
	GMNP	3236	-	3236	-
TOTAL Island		44372	42727	87099	66109
TOTAL Labrador		473	1061	1534	1534
TOTAL Province		44845	43788	88633	67643

[1]Light 1-25%
Moderate 26-75%
Severe 76-100%

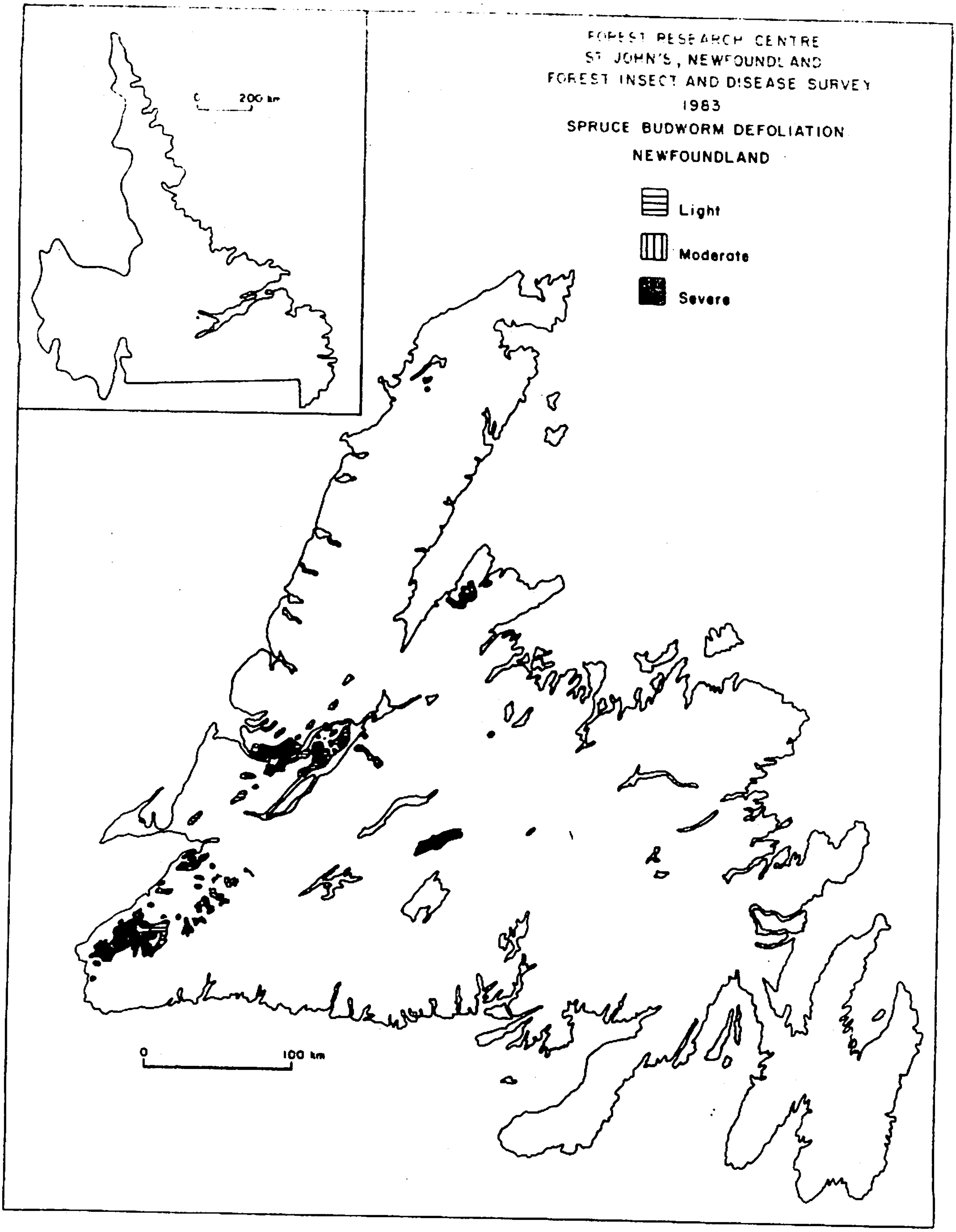

Figure 1. Areas of light, moderate and severe defoliation by the spruce budworm in Newfoundland in 1983.

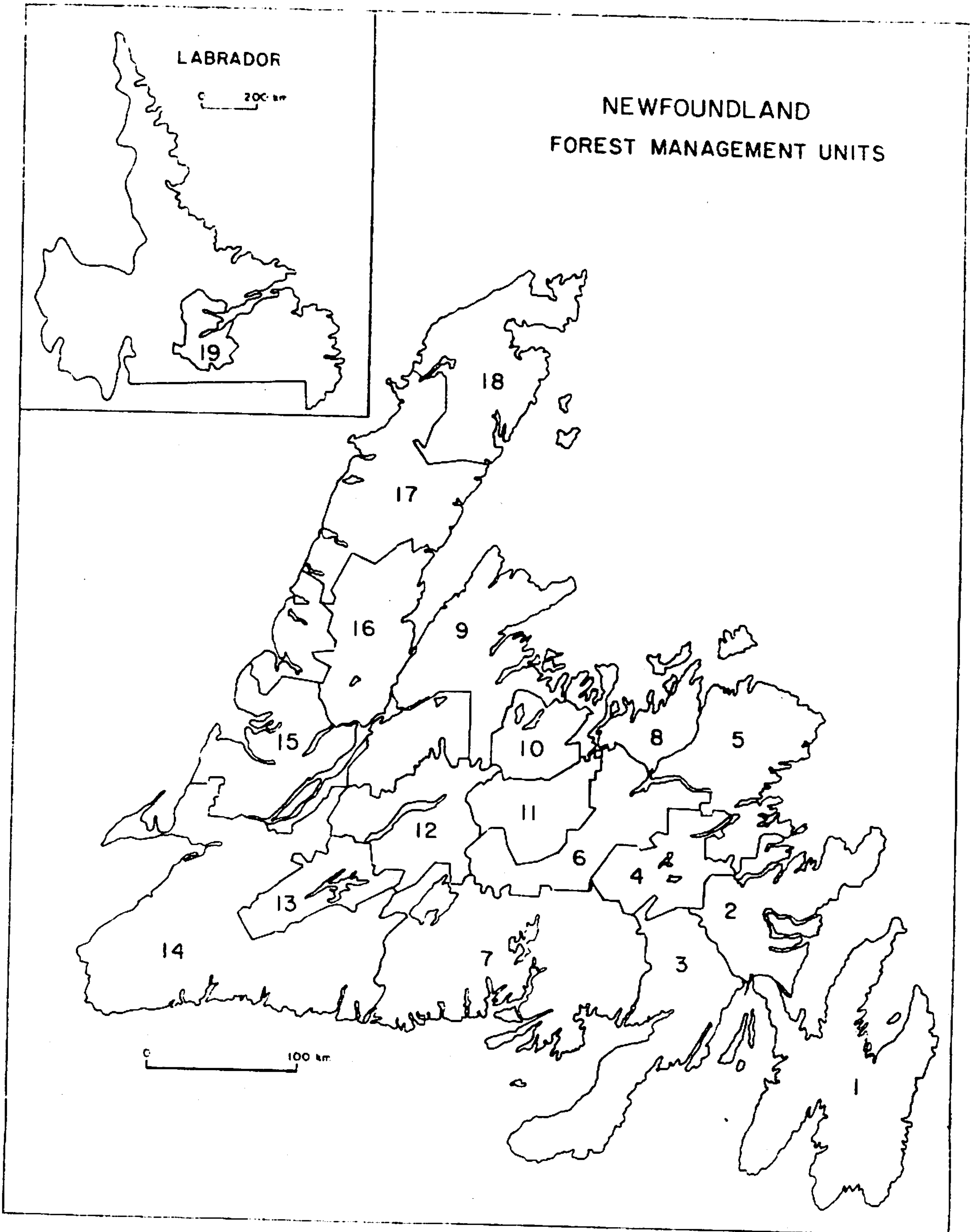

Figure 2. Forest Management Units of Newfoundland.

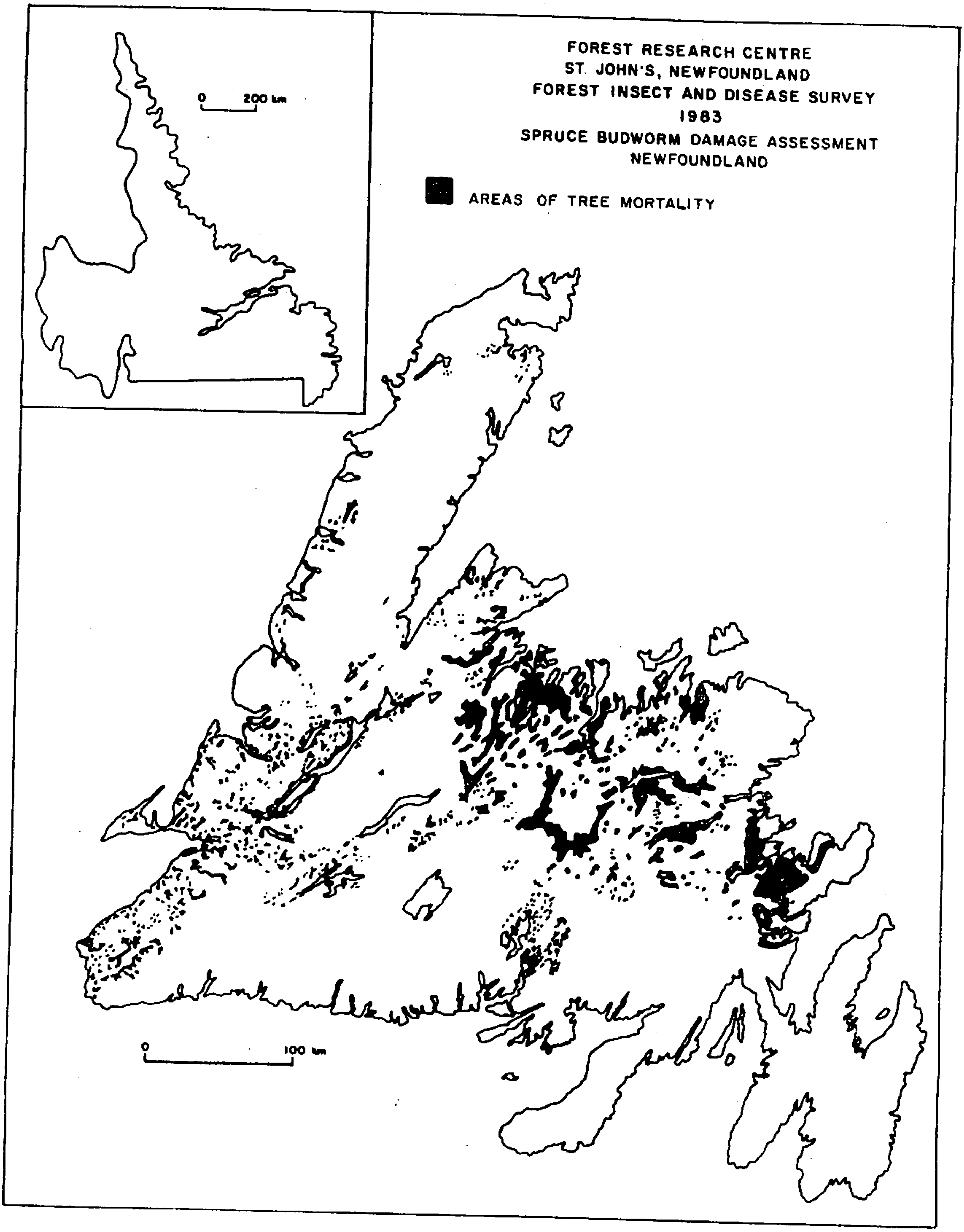

Figure 3. Areas of tree mortality following spruce budworm damage in Newfoundland in 1983.

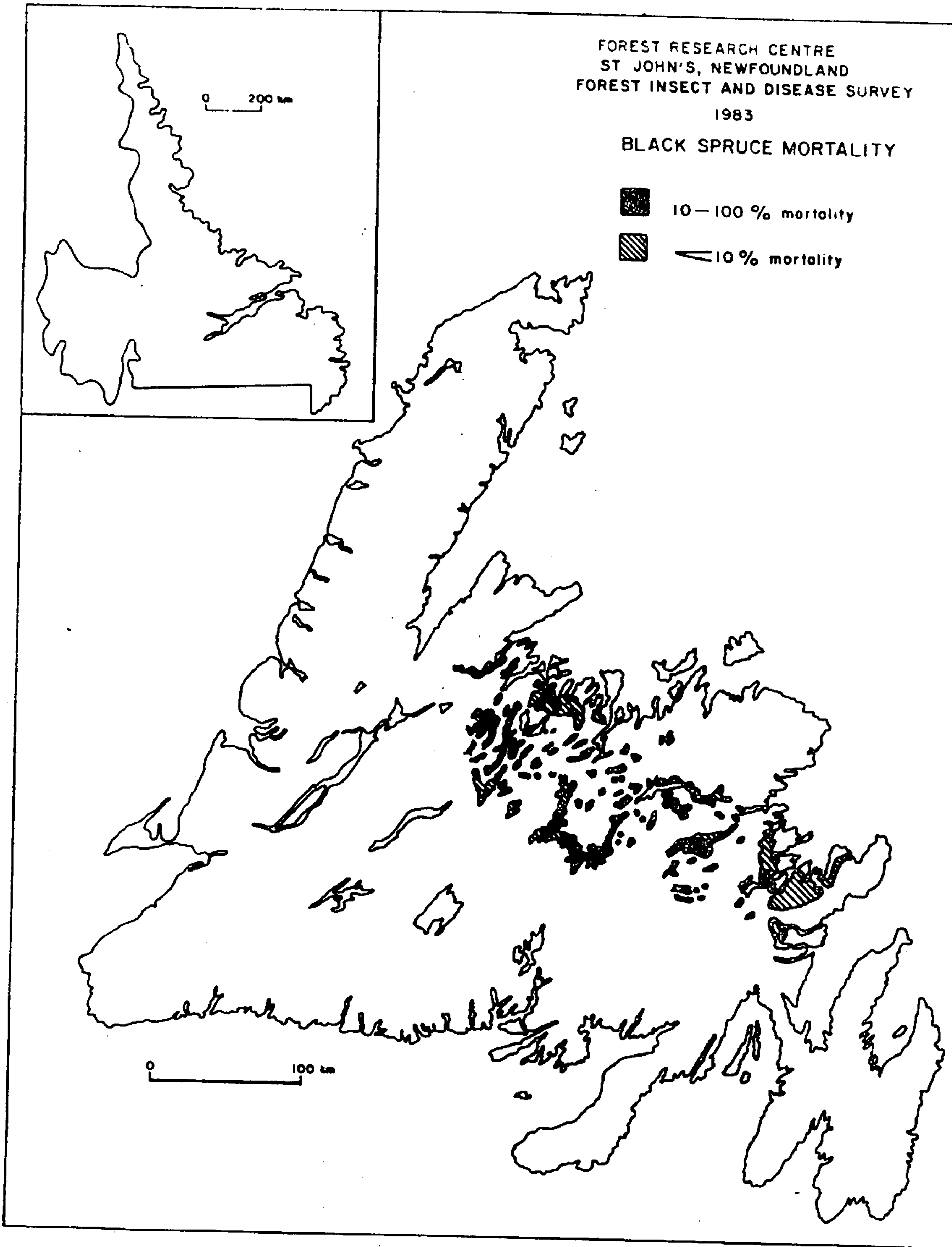

Figure 4. Areas of black spruce mortality following spruce budworm damage and attack by other pests in Newfoundland in 1983.

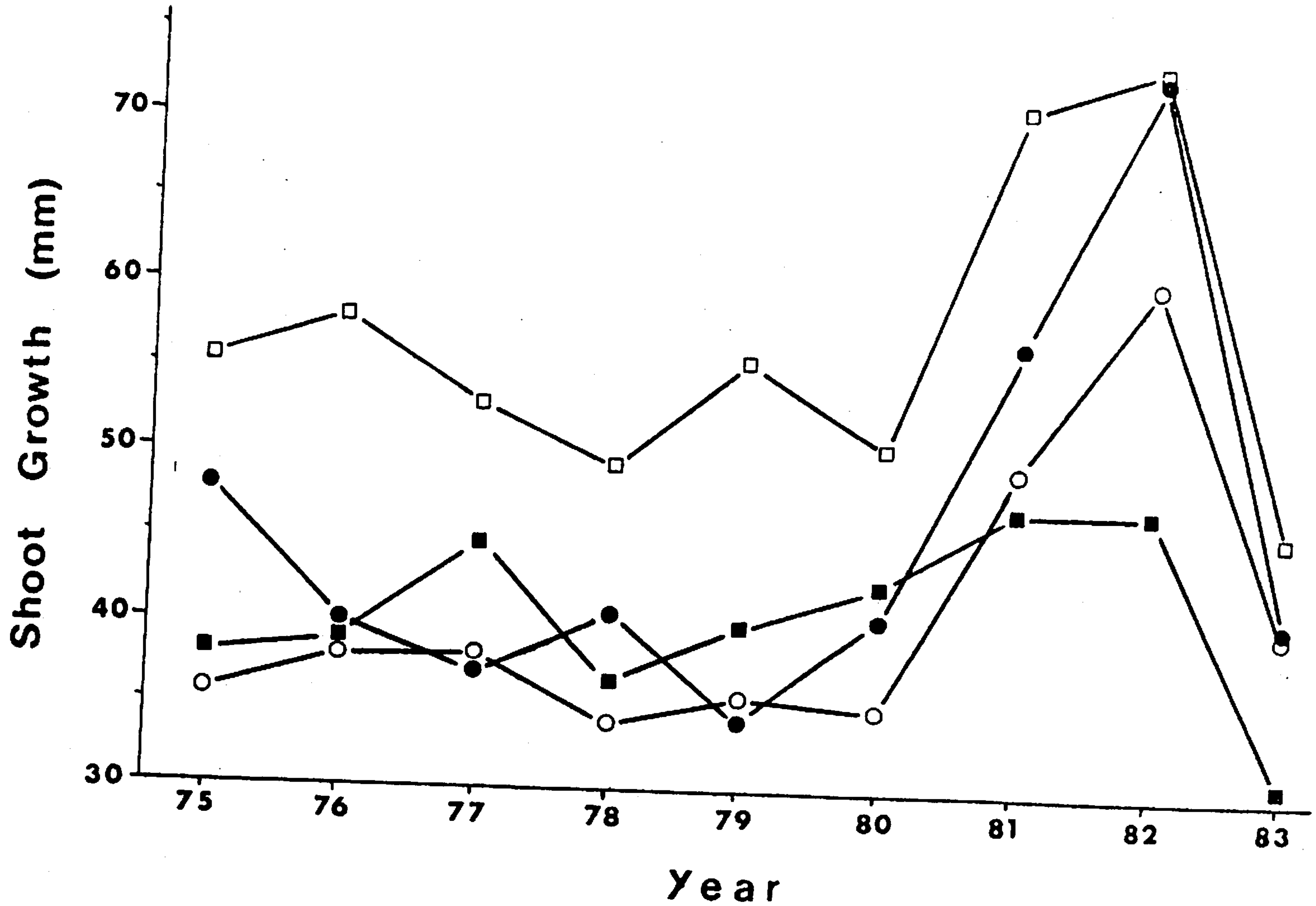

Figure 5. Average annual terminal shoot growth in mm of mid-crown branches in black spruce plots in Newfoundland. ○ = Light damage, ● = Moderate damage, ■ = Severe damage, □ = Young stands.

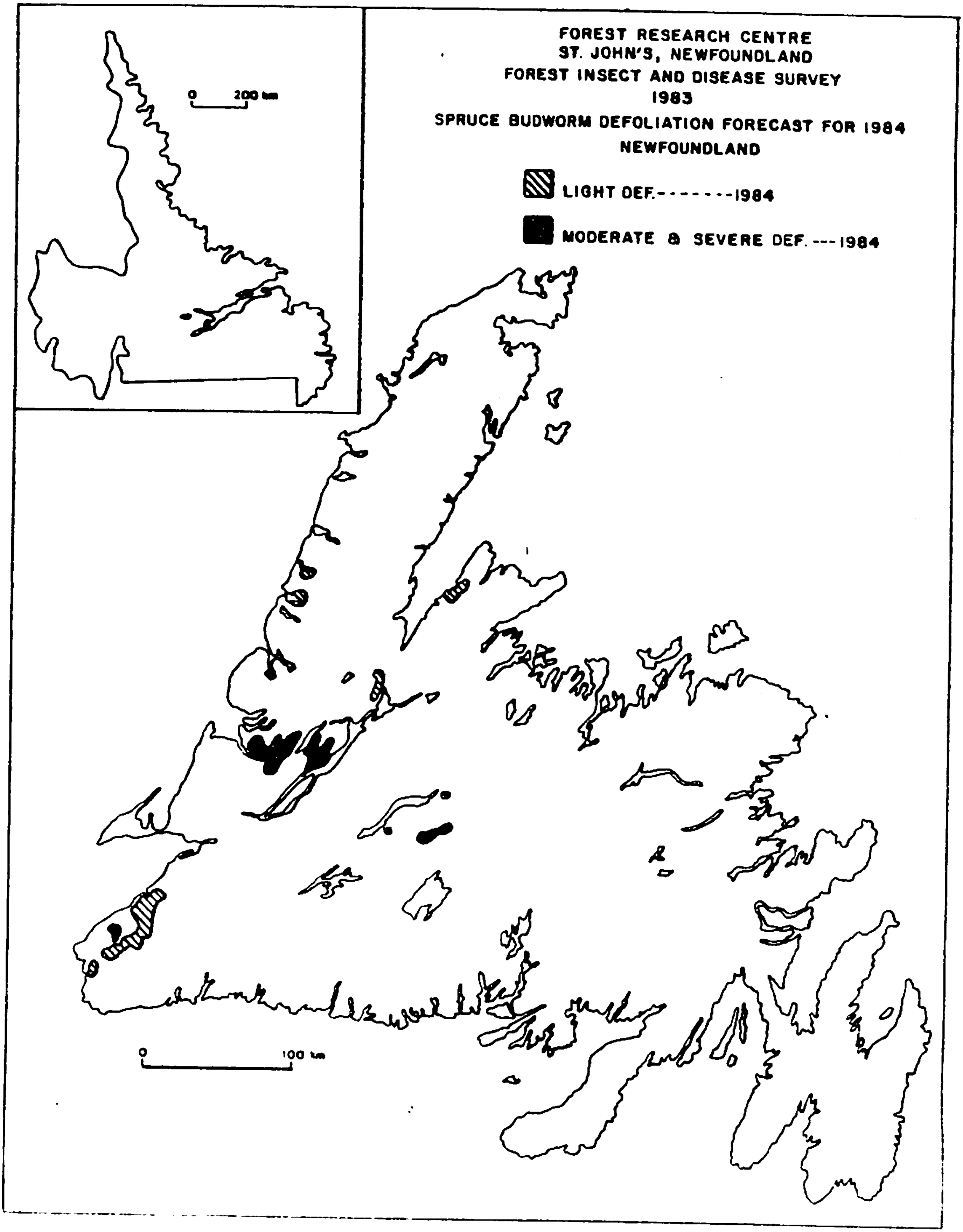

Figure 6. Areas of light, moderate and severe defoliation by the spruce budworm forecast in Newfoundland for 1984.

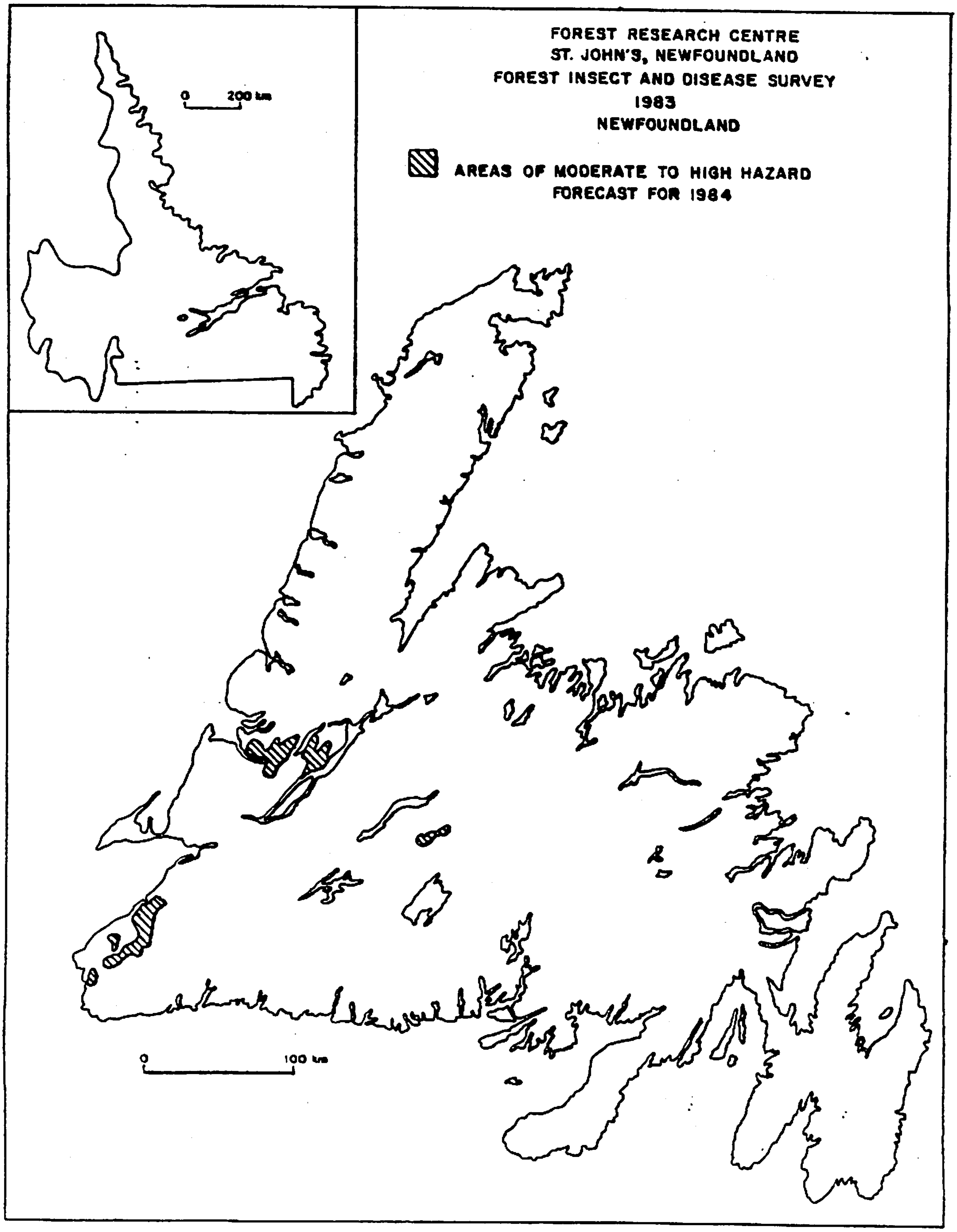

Figure 7. Areas of moderate and high spruce budworm hazard forecast in Newfoundland for 1984.

Department of Fisheries and Oceans' Experiment to Determine the Long-term Effects of Matacil on an Aquatic Ecosystem in Central Newfoundland

Report to the Eleventh Annual Forest Pest Control Forum

Ottawa, Ontario, November 1983

by

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PURPOSE

The purpose of the project has been to determine the long-term effects of aerially applied pesticides on aquatic ecosystems. However, the project is being modified.

We have been considering a long-term effect to be a direct or indirect effect of spraying which is not apparent immediately after spraying or that is immediately apparent and persists in the long term. Special consideration was given to effects changing the value of the fishery resource.

In order to attain the objective two major experimental approaches were planned.

EXPERIMENTAL DESIGN

The first approach was the collection of biological data on Spruce Pond and its three streams for a number of years prior to a spray and a number of years during which the area was to be experimentally sprayed. Spruce Pond is a brown-water pond of 36 ha with an average depth of about 1 m situated about halfway down the Bay D'Espoir Highway on the headwaters of the Northwest Gander River. The sixth year of data collection on the Spruce Pond system was 1982, except that an additional set of fish population estimates were obtained in 1983. It was hoped that a comparison of pre-spray to post-spray data would reveal any changes occurring as a result of the proposed experimental spray.

The second approach was the collection of biological data on the Spruce Pond and Headwater Pond systems during which time Spruce Pond was to be experimentally sprayed and Headwater Pond was to be a control. Headwater Pond is a brown-water pond of 78 ha with an average depth of about 1 m situated about 4 km upstream from Spruce Pond. It has two tributary streams. The fourth year of data collection on the Headwater Pond system was 1982, except that an additional set of fish population estimates were obtained in 1983. It was intended that an understanding of the similarities and differences between the two systems be had prior to experimental spraying. It was hoped that a comparison of the sprayed system to the unsprayed system would reveal changes caused by the proposed experimental spray.

DATA COLLECTED TO DATE

Data were collected on both pond systems from the last week in May to the first week in October. Stream counting fences were installed adjacent to the ponds and the kinds and numbers of migrating fish were monitored. Present in the ponds are brook trout, Atlantic salmon, American eels, and threespine sticklebacks. Population estimates of trout and salmon were conducted each spring and fall and growth rate and production data were obtained for each species except eels. Stream invertebrates were sampled twice monthly with Surber samplers and drift nets. Artificial substrates were harvested in September. Every 2 weeks, samples of phytoplankton, zooplankton, and bottom invertebrates were collected from the ponds and primary production was measured using the light and dark bottle Winkler method. Bottom invertebrates from each pond were also collected from 50 sq. ft. of Ekman dredge samples in July and from artificial substrates in September. Physical and chemical water quality were routinely monitored.

STATUS OF THE PROJECT AND FUTURE ACTIVITIES

In January, 1983, the Management Committee of the Fisheries Research Branch, Newfoundland Region, appointed a review team to examine this project. In March, 1983, the review team completed their review of the project and results obtained up to that time.

It was recognized that there was ample evidence to indicate that aquatic impacts of operational spraying with Matacil flowable would be subtle. The review team concluded that the project would not produce predictive models of sufficient precision to allow for the assessment of such subtle disturbances. The review team recommended that data collection cease.

The Management Committee decided that 1983 data collection would be confined to fish population estimates and that no data were to be collected in 1984. Thus, it is unlikely that the experiment will continue as originally planned. If an experimental modification of the study area is conducted in the future, or if long-term environmental changes occur, information collected during this study may provide useful comparative data.

Processing and analyses of data from the study are continuing. Over 147,000 animals from benthic and drift net sampling have been identified and counted. Stored in computer files are over 54,000 records from over 5,900 samples of algae and invertebrates and data from 541 water quality samples. All age and growth data from fish obtained prior to 1983 have been computerized. Information from these data will be of use to other studies. Reports arising from the experiment to date are:

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Ryan, P.M. 1982. Species composition and seasonal abundance of zooplankton in the Experimental Ponds Area, central Newfoundland, 1977-80. Can. Data Rep. Fish. Aquat. Sci. 318:iv + 85p.

Ryan, P.M. 1983. Computer code for freshwater life forms of Newfoundland: Part 1 - Animals. Can. MS Rep. Fish. Aquat. Sci. 1729:iv + 156p.

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Ryan, P.M., L.J. Cole, D.P. Riche, and D. Wakeham. 1981. Age and growth of salmonids in the Experimental Ponds Area, central Newfoundland, 1977-80. Can. Data. Rep. Fish. Aquat. Sci. 304:iv + 284p.

Technical Note on the Spraying of *Bacillus thuringiensis kurstaki* for the suppression of spruce budworm larvae (*Choristoneura fumiferana* (Clemens, 1865)) in selected areas of Nova Scotia, 1983.

by

Dr. T. D. Smith
October 4, 1983

Introduction

The spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) is the foremost insect pest species in Canada. Its preferred hosts are balsam fir (*Abies balsamea* and spruce species (*Picea* spp.). The infestation of spruce budworm has persisted in Mainland Nova Scotia since 1969. This report is to provide a synopsis of the results of the aerial application of a microbiological biocide (*Bacillus thuringiensis kurstaki* (*B.t.k.*)) to reduce population densities of spruce budworm larvae in selected high value areas of spruce and/or balsam fir in Nova Scotia in 1983.

Objective

The objective of the 1983 *B.t.k.* program was to reduce current foliage consumption by spruce budworm larvae to fifty percent or less.

Treatment

The spruce budworm infestation continued to persist on the Mainland and additional areas, Blomidon, Sand River and Chignecto were added to the program in 1983 (Figure 1). The population density of spruce budworm did not increase significantly in previously treated areas in Cape Breton except in one silviculturally enhanced area, Highland. The cone production and this enhanced area were included in the 1983 program (Figure 2).

Aircraft

A Hughes 500 helicopter accompanied by a guidance aircraft was used to spray the proposed treatment areas (496 ha) on Cape Breton.

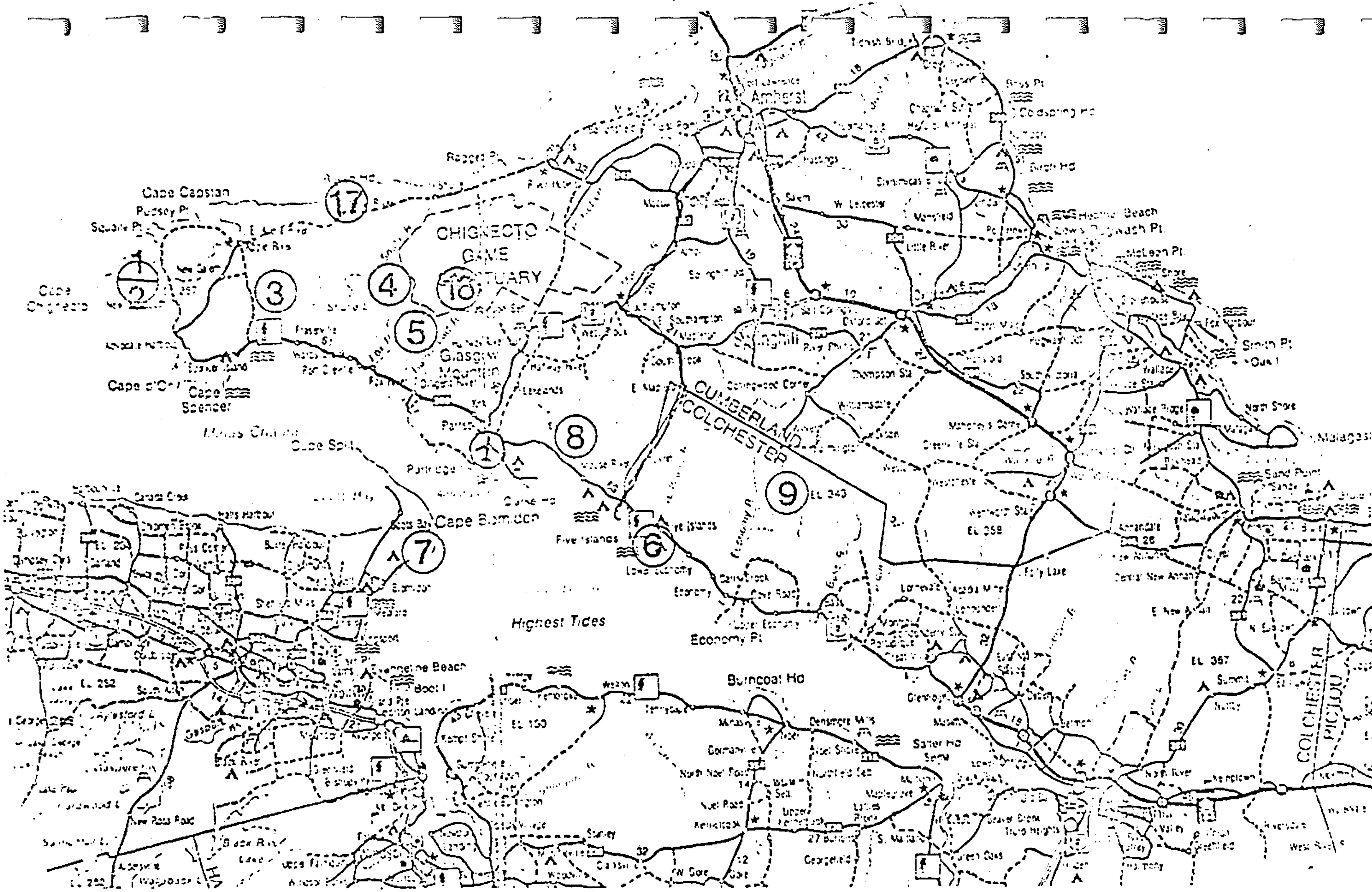

Figure 1. Proposed areas to be treated with *Bacillus thuringiensis kurstaki* (20 BIU.ha^{-1}) to suppress spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) larvae, Mainland, Nova Scotia, 1983. (1) Eatonville North, (2) Eatonville South, (3) Advocate, (4) Shulie, (5) Welton, (6) Five Islands, (7) Blomidon, (8) Moose River, (9) Economy, (16) Chignecto, (17) Sand River. Scale 1:633 600.

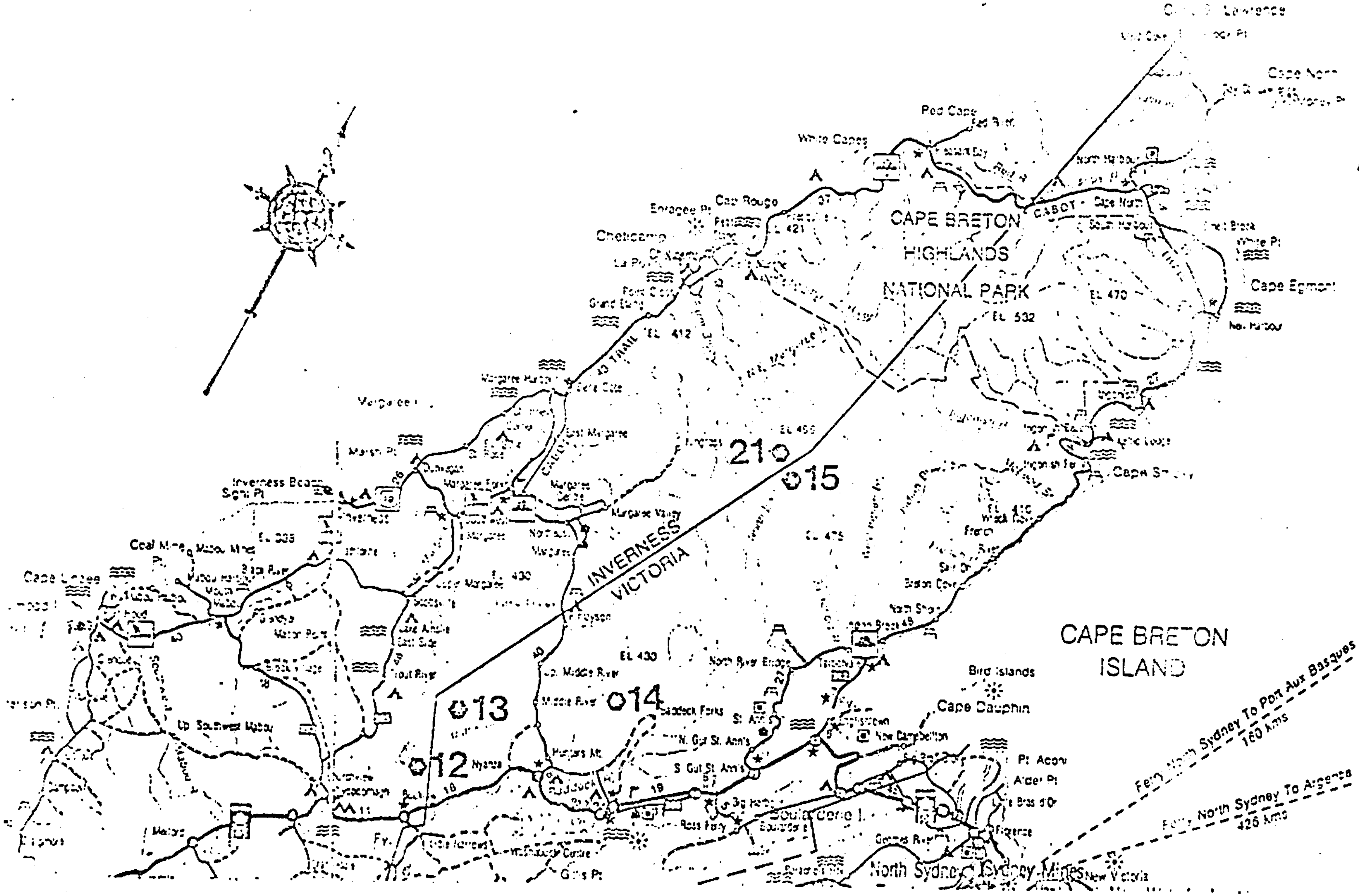

Figure 2. Proposed cone production areas and one spaced area to be treated with Bacillus thuringiensis kurstaki (20 BIU ha^{-1}) to suppress spruce budworm (Choristoneura fumiferana (Clemens, 1865)) larvae, Cape Breton Island, Nova Scotia 1983. Hume Rd - 25 ha; (13) Cairlock Rd - 70 ha; (15) Miner's Road North - 136 ha; spaced area (21) Highland Road - 222 ha.
Scale 1:633 600

Nine Grumman Ag-Cats®, three modified model As and six model-Bs were to spray the proposed Mainland treatment areas (26 459 ha). Five Cessna 172s were used as guidance aircraft (Table 1).

Area Flown

The total area flown was 20 726.5 ha in Nova Scotia, of this 20 239.7 ha were flown on the Mainland and 486.8 ha on Cape Breton. Only 76.9% of the program was completed as only a portion, 1 826.0 ha (27.6%) of the proposed Moose River Treatment area (6 613 ha) was sprayed (Table 2). The area flown with Futura was 109.8 ha, with Dipel 88 was 994.1 ha, with Thuricide 32 LV was 3 971.7 ha, and with Novabac-3 was 15 650.9 ha.

Biocide

Three commercial preparations and one experimental formulation of Bacillus thuringiensis kurstaki (B.t.k.) were applied at the recommended dose rate of 20 BIU·ha^{-1} (Table 3).

Monitoring

Monitoring of spruce budworm life stages population density trends, host development, time for spraying of and the efficacy of the biocide is done under the direction of personnel of the Canadian Forestry Service (Table 4). This year nine people were involved with monitoring activities which began in mid-May and ended during the last week of July.

Monitoring of weather conditions is done by Lands and Forests Personnel involved in monitoring activities under guidance of personnel of Environment Canada - Atmospheric Services.

Table 1. Comparison of Mean Flying Time for protection of red spruce species complex (*Picea rubens* sens lat.) from feeding by larvae of spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)), Nova Scotia, 1979-1983.

Time	Year 1979	1980	1981	1982	1983
Qualatative					
% spray periods used	66	89	61	81	41
% AM	62	100	90	83	64
% PM	38	0	10	17	36
Quantitative (hrs)					
Mean Flying Time	1.8	2.0	1.9	1.4	1.3
± 1 sd.	1.2	1.1	1.2	1.5	1.0
Total Flying Time	11.0	22.0	19.2	17.9	18.2
Theoretical Maximum Flying Time	31.5	56.0	91.0	132.0	120.0
% Flying Time Used	35.0	39.2	21.1	13.6	15.2
Area Flown (ha)	5 773.7	8 160.7	10 528.8	18 524.2	20 239.7
No. of Spray Aircraft	3	6	6	9	9

Table 2. Area, percent area, total area and percent total area flown for the B.t.k. program, June, 1983.

Date June	Session AM/PM	Area ha	Area %	Total Area ha	Total Area %
6	PM	162.6	0.6	162.6	0.60
8	PM	109.8	0.4	272.4	1.01
10	AM	2 581.7	9.6	2 854.1	10.60
13	AM	932.3	3.5	3 786.4	14.10
	PM	531.5	2.0	4 317.9	16.10
14	AM	1 220.1	4.5	5 538.0	20.60
15	AM	181.0	0.7	5 719.0	21.30
	PM	91.7	0.3	5 810.7	21.70
16	AM	73.1	0.2	5 883.8	21.90
	mid day	1 193.6	4.3	7 077.4	26.30
17	mid day	1 875.3	7.0	8 952.7	33.30
	PM	348.5	1.3	9 301.2	34.60
18	AM	63.8	0.2	9 364.0	34.80
21	AM	3 291.1	12.2	12 656.1	47.00
22	AM	4 081.8	15.1	16 737.9	62.10
	PM	533.6	2.0	17 217.5	64.10
25	AM	2 807.2	10.4	20 078.7	74.50
26	AM	647.8	2.4	20 726.5	76.90

Table 3. The application rate and volumes of one experimental and three commercial preparations of *Bacillus thuringiensis kurstaki* aerially applied 20 BIU·ha^{-1} to protect foliage of spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) from feeding by larvae of spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) in selected areas of Nova Scotia, 1983.

Preparation	Formulation l·ha^{-1}			Total Volume Used	
	Concent. Rate	Water	Total	l	Drums
Futura©[1]	1.50	1.00	2.50	200	1
Dipel 88®[2]	2.35	3.50	5.85	1 822.5	9
Thuricide 32 LV©[3]	2.35	3.50	5.85	9 112.5	45
Novabac-3®[1]	2.35	2.32	4.67	29 000.0	145

1. Futura-experimental, Novabac-3-commercial. Biochem Products, P.O. Box 264, Montchanin, D.E. USA 19710, 200 l per drum.

2. Dipel 88 commercial. Abbott Lab. Ltd., North Chicago, Illinois USA 60064, 202.5 l per drum.

3. Thuricide 32 LV commercial. Sandoz Inc. 480 Camino Del Rio South, San Diego, Cal. USA 92108, 202.5 l per drum.

Table 4. Percent Reduction in survival of spruce budworm (*Choristoneura fumiferana* (Clemens, 1855)) and percent foliage saved by aerially applying a microbial agent (*Bacillus thuringiensis kurstaki*) at 20·BIU·ha^{-1} in selected areas of Nova Scotia, June, 1983.

[illegible]								[illegible]							[illegible]				
Name	No.	Cover[1] type	Area flown[2] (ha)	Use	[illegible]	Treatment 20 BIU/ha	% Buds flushed	[illegible]	Pre-spray	[illegible]	Post spray	% Survival (Chk)	% Survival (Trt)	% Reduction in survival[5]	Chk %	Trt %	% Foliage saved (6)	% Foliage saved (7)	Number of [illegible]
Mainland Nova Scotia																			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Total Mainland			[illegible]												[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cape Breton																			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—	—	—	—	—	—	—	—
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Total Cape Breton			[illegible]												—	—	—	—	—
Total Nova Scotia			[illegible]																

1. Cover type use Quebec System: bF = balsam fir, wS = white spruce, bS = black spruce, rS = red spruce species complex
2. Data from navigator's reports.
3. Data not determined for Cape Breton treatment areas.
4. [illegible]
5. Chi Square; Percent Reduction in survival = [(Expected − Observed) ÷ (Expected)]·100)
6. Method 1, Absolute percentage foliage saved = Expected − Observed
7. Method 2; Percentage of foliage saved = [(Expected − Observed) ÷ (Expected)·100)

Monitoring of the effects of the biocide on non-target flora and fauna is the responsibility of Nova Scotia Department of Environment.

Weather

As in previous years, the predominant factor affecting conduct of the B.t.k. program is weather. This year fog was not as great a problem at Parrsboro Airport as in previous years. Hot and dry atmospheric conditions from 22 June to 25 June prevented the treatment of the majority of the Moose River Treatment Area. Persisting high temperatures from 22°C to 30°C from evening of 22 June to 24 effected a new larval stage every 36 hours. Those larvae in the last larval stage, 6th instar, formed pupae. From 50 to 60 percent of the larvae had pupated by noon on 24 June and spraying ceased, in this treatment area leaving 4 787 ha unprotected. Spraying continued in other areas with slower larval development.

The weather this year resulted in dissynchronization of larval development and host tree shoot growth. The hot dry weather favoured faster larval development. In the Mainland spruce budworm larvae commonly include red spruce budcaps in their feeding webs. The persistance of these budcaps provide a better feeding site, safer habitat, and less exposure to a stomach biocide.

In past years severe thunderstorm activity occurred over the treatment areas. It has been noted that high velocity winds and heavy rains removed many of the persisting red spruce budcaps thereby increasing the exposure of the internal portions of the feeding webs to biocides. The persistance of budcaps on red spruce would favour less foliage protection from a stomach biocide.

Results

Reduction in Survival (Table 4)

The reduction in survival varied with host and population density. On balsam fir there was no significant reduction in survival at a population density of 50.7 larvae per 45 cm branch tip whereas there was significant reduction in survival of 92 percent at a population density of 8.5 larvae per 45 cm branch tip.

On white spruce there was no significant reduction in survival at a population density of 68.2 larvae per 45 cm branch tip with the use of Thuricide 32 LV. There was a reduction of survival of 23 percent at a population density of 20.6 larvae per 45 cm branch tip with use of Futura.

On red spruce the reduction in survival varied from 22 percent in Chignecto to 93 percent in Eatonville. Generally the higher values of reduction in survival occurred with lower population densities.

Foliage Protection (Table 4)

Two factors that may have contributed to the lower foliage protection are:

(1) persistance of the budcaps, and

(2) the increasing dissimilarity of the control areas with the treatment areas.

In many cases the control areas are severely stressed whereas the treatment areas are increasingly vigorous.

Foliage protection is calculated in two ways: (1) absolute which is equal to the value of defoliation in the control minus the value of defoliation in the treatment area, and (2) relative which equal the value of defoliation in the control minus the value of defoliation in the treatment; this value is in turn divided by the value of defoliation in the control. The result being relative is comparable to other similar dev oped data.

Relative foliage protection for balsam fir varied from 22 to 39 percent. The higher value occurring at a population density of 50.7 larvae per 45 cm branch tip and 0 percent reduction in survival. Whereas the lower value occurred at a population density of 8.5 larvae per 45 cm branch tip and a reduction in survival of 92 percent.

Relative foliage protection on white spruce varied from 14 to 54 percent and reflected the same situation as with balsam fir.

Relative foliage protection for red spruce ranged from 0 to 62. There does not seem to be a difference among the effects from using different commercial formulations. Dipel 88 was two years old, Thuricide 32 LV was one year old, and Novabac-3 and Futura were produced in 1983.

Expenditures

The total expenditure of the B.t.k. program from 1 October, 1982 to 30 September, 1983 was $740,038.20. The cost per hectare flown was $35.22. There were 53 surplus drums of B.t.k. from previous years. The value of this material was $52,325.99. The adjusted value for the B.t.k. used was $130,572.67 which is equivalent to $6.30 per hectare flown (Table 5).

Table 5. Expenditures of the operational program to protect foliage of spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) by the aerial application of a microbiological agent *Bacillus thuringiensis kurstaki* against feeding larvae of spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) in selected areas of Nova Scotia, 1 October 1982 to 30 September 1983.

Category	$	%	$·ha flown^{-1}
Salaries	174,596.70	23.92	8.42
Travel	11,100.49	1.52	0.53
Supplies & Services	483,036.16	66.16	23.31
Biocide	78,246.68	10.72	3.77
Aircraft	363,438.23	49.78	17.54
Lodging	25,646.35	3.51	1.24
Rentals	12,626.91	1.73	0.61
Trucking	3,077.99	0.42	0.15
Equipment	7,890.62	1.08	0.38
Others	53,414.23	7.32	2.58
Totals	730,038.20	100.00	35.22

Disclaimer Statements:

The use of trade, firm, or corporation names is for the information and convenience of the reader. Such use does not constitute an official evaluation, conclusion, recommendation, endorsement or approval of any product or service to the exclusion of others which may be suitable.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does in imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate Provincial and/or Federal agencies before they can be recommended.

Acknowledgement

I wish to thank Mr. D. Doucette, Maritime Forest Research Centre, for the supervision on monitors and preparation of efficacy data.

Equivalents du Système Métrique

Conversion approximative aux unités métriques de mesure

Mesure de Longueur

1 pouce = 2.54 cm	1 mm = 0.039 po
1 pied = 0.3048 m	1 cm = 0.394 po
1 verge = 0.914 m	1 dm = 3.937 po
1 mille = 1.609 km	1 m = 3.28 pi
	1 km = 0.621 mi

Mesure de Superficie

1 pouce carré = 6.452 cm^2	1 cm^2 = 0.155 pouce carré
1 pied carré = 0.093 m^2	1 m^2 = 10.764 pied carré
1 verge carrée = 0.836 m^2	1 m^2 = 1.196 verge carrée
1 mille carré = 2.59 km^2	1 km^2 = 0.386 mille carré
1 acre = 0.405 ha	1 ha = 2.471 acre

Mesure de Volume

1 pouce cube = 16.387 cm^3	1 cm^3 = 0.061 po cu
1 pied cube = 0.028 m^3	1 m^3 = 35.315 pi cu
1 verge cube = 0.765 m^3	1 m^3 = 1.308 verge cu

Mesure de Capacité

1 once liquide = 28.413 ml	1 ℓ = 35.2 once
1 chopine = 0.568 ℓ	1 hl = 21.997 gallon
1 pinte = 1.14 ℓ	
1 gallon = 4.546 ℓ	

Mesure de Poids (Masse)

1 once = 28.349 g	1 g = 0.035 once
1 livre = 453.592 g	1 kg = 2.205 livre
1 tonne courte = 0.907 t	1 t = 1.102 tonne courte

Metric Equivalents

Approximate conversions to metric measures

Length

1 inch = 2.54 cm	1 mm = 0.039 in
1 foot = 0.3048 m	1 cm = 0.394 in
1 yard = 0.914 m	1 dm = 3.937 in
1 mile = 1.609 km	1 m = 3.28 ft
	1 km = 0.621 mile

Area

1 square inch = 6.452 cm^2	1 cm^2 = 0.155 sq in
1 square foot = 0.093 m^2	1 m^2 = 10.764 sq ft
1 square yard = 0.836 m^2	1 m^2 = 1.196 sq yd
1 square mile = 2.59 km^2	1 km^2 = 0.386 sq mile
1 acre = 0.405 ha	1 ha = 2.471 acre

Volume (Dry)

1 cubic inch = 16.387 cm^3	1 cm^3 = 0.061 cu in
1 cubic foot = 0.028 m^3	1 m^3 = 35.315 cu ft
1 cubic yard = 0.765 m^3	1 m^3 = 1.308 cu yd

Capacity

1 fluid ounce (Imp) = 28.413 ml	1 ℓ = 35.2 fl oz
1 pint = 0.568 ℓ	1 hl = 21.997 gal
1 quart = 1.14 ℓ	
1 gallon = 4.546 ℓ	

Weight (Mass)

1 ounce = 28.349 g	1 g = 0.035 oz
1 pound = 453.592 g	1 kg = 2.205 lb
1 short ton = 0.907 t	1 t = 1.102 short ton

[illegible]ercent reduction in survival of spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) and percent foliage saved by aerially applying a microbial agent (*Bacillus thuringiensis kurstaki*) at 20 BIU·ha⁻¹ in selected areas of Nova Scotia, June, 1987.

TREATMENT AREA					TREE HOST			SPRUCE BUDWORM PER 45 cm TIP							DEFOLIATION				
Name	No.	Cover Type[1]	Area Flown[2] (ha)	Use	Date Spraying June	Treatment 20 BIU·ha⁻¹	% Buds Flushed	Larval Index	Pre-Spray L3	Pupae – Post Spray Exp.	Pupae – Post Spray Obs.	% Survival P/L3 Exp.	% Survival P/L3 Obs.	% Reduction in Survival	Exp. %	Obs. %	% Foliage Saved 1[6]	% Foliage Saved 2[7]	Number of Colonies (cm²)[illegible]
Mainland Nova Scotia																			
[illegible]	1+2	rS	3 455.0	timber	25-26	Novabac	25	4.5	5.9	0.8	0.1	14	1	93	7	7	0	0	27.9
[illegible]	3	rS	1 645.8	timber	22	Novabac	25	5.3	25.9	3.2	1.2	12	5	59	29	27	2	7	25.0
[illegible]	4	rS	2 152.5	timber	21-22	Novabac	25	4.7	14.0	1.7	0.9	12	6	56	16	24	0	0	[illegible]
[illegible]	5	rS	2 222.8	timber	21-22	Novabac	25	4.8	21.2	2.6	1.5	12	7	42	23	21	2	21	27.0
[illegible] Islands	6	wS	109.8	park	8	Futura	60	3.7	20.6	2.6	2.3	13	10	23	22	19	3	14	13.4
[illegible]	7	wS	162.5	park	5	Thuricide	60	3.6	58.2	8.3	11.3	12	16	0	77	35	42	54	NM
		bF				Thuricide	60	3.1	50.7	6.3	11.3	12	22	0	57	35	22	39	NM
Moose River	8	rS	1 826.6	timber	22	Novabac	[illegible]	4.6	3.2	0.5	0.1	13	1	92	4	9	0	0	14.6
[illegible]	9	rS	2 581.7	timber	10	Dipel Thuricide	20	2.1	9.3	1.2	0.1	13	1	92	10	7	3	30	47.[illegible]
		bF		timber		Dipel Thuricide	60	3.6	5.5	1.1	0.1	13	1	92	9	7	2	22	47.[illegible]
[illegible]	16	rS	5 505.8	timber	13-17	Thuricide Novabac	60	4.2	20.2	2.6	2.3	14	11	22	22	26	0	0	[illegible]
[illegible]	17	rS	518.3	timber	16-17	Novabac	25	4.[illegible]	33.0	4.1	0.7	12	2	83	37	14	23	62	9.2
Total Mainland			20 239.7																
Cape Breton																			
[illegible] Road	12	bS	35.0	cones	18	Novabac	NM[3]	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
[illegible] Road	13	wS	73.1	cones	16	Novabac	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
[illegible] Brook	14	bS	28.6	cones	18	Novabac	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
[illegible] Road [illegible]	15	wS	112.3	cones	15	Novabac	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
[illegible] Road	21	bF	237.6	spaced	13	Novabac	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Total Cape Breton			406.8																
Total Nova Scotia			20 776.5																

1. Cover type use Quebec System: bF = balsam fir, wS = white spruce, bS = black spruce, rS = red spruce species complex
2. Data from navigator's reports.
3. Data not determined for Cape Breton treatment areas.
4. [illegible]
5. [illegible] Percent Reduction in survival = (((Expected − Observed) ÷ (Expected))·100)
6. Method 1: Absolute percentage foliage saved = Expected − Observed
7. Method 2: Percentage of foliage saved = (((Expected − Observed) ÷ (Expected)·100)

A PRELIMINARY REPORT ON THE 1983 FOLIAGE PROTECTION PROGRAM AGAINST THE SPRUCE BUDWORM IN NEW BRUNSWICK[1]

In 1983, 1 495 000 hectares of susceptible forest were sprayed by Forest Protection Limited. An additional area of approximately 200 000 hectares were treated privately by Forest Patrol Limited on freehold land owned by J. D. Irving Limited.

The majority of forest was treated with the insecticide fenitrothion in oil or water formulation. Aminocarb was applied to 101 000 hectares and B.t. to 10 300 hectares by Forest Protection Limited. A summary of insecticides, dosages, application rates, formulation, aircraft type, and acreages are given in Table 1. The actual areas sprayed are shown on the map in Figure 1.

It should be brought to the reader's attention that the emulsifier Atlox 3409F was used in the 1983 spray program. The New Brunswick Department of Health had suspended its use in 1982 amid concerns of potential health risks. The Department of Health reinstated the use of Atlox 3409F in the 1983 program after reviewing the results of two recent scientific studies:

(1) The Task Force on Reye's Syndrome, chaired by Dr. Spitzer concluded that Atlox 3409F and other emulsifiers used to date were not implicated in any alleged increase in Reye Syndrome in New Brunswick and that forest spraying "has not, to date, augemented the chance of developing Reye's Syndrome among New Brunswick's children."

(2) Tests conducted by Dr. Rozee at Dalhousie University which raised the initial concern over the potential of various emulsifiers, solvents, and insecticides to cause viral enhancement could not be replicated in three independent laboratories. Drs. D.J.Ecobichon and L. Ritter who co-ordinated the independent laboratory tests concluded that "the utility and biological significance of this [viral enhancement] test remains suspect and has yet to be established and validated".

Spraying began on May 21st and was completed on June 19th. All designated areas were sprayed twice as planned with a few exceptions. The exceptions were areas where budworm populations were found to be low after one application. These areas received a single treatment.

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1. Report to the Forest Pest Control Forum held in Ottawa on Nov. 15 - 17, 1983.

Entomological surveys and assessment related to the 1983 foliage protection program against the spruce budworm were conducted by the Department of Natural Resources and the Canadian Forestry Service. Field and laboratory staff were supplied by DNR and supervisory responsibilities shared by DNR and CFS. A total of 38 persons were involved in the surveys during the period May to July. The staff was increased to 79 during the egg mass survey in August.

Outlined below is a brief description of the surveys that were conducted during the period May 1 to mid September.

(1) Spruce budworm instar development and shoot flaring of spruce and fir were monitored throughout the Province. This information was used to determine the appropriate timing of insecticide application and appropriate timing for conducting other biological surveys.

(2) Pre-spray budworm population counts were made in spray blocks and control plots. Interpretation of these counts provides a measure of expected defoliation if not sprayed. As well, blocks found to have low budworm counts can be deleted from the spray program.

(3) Budworm population counts were made in spray blocks following one application of insecticide. This information was used to determine whether a second application was needed.

(4) Spray blocks and control plots were assessed from the ground to measure budworm feeding damage. The defoliation estimates provide a measure of the efficacy of the protection program.

(5) An aerial defoliation survey was conducted throughout New Brunswick using 7 fixed wing aircraft. This survey provides a second assessment of the efficacy of the spray program and is a good method of evaluating the distribution and severity of budworm defoliation throughout the Province.

(6) An egg mass and hazard survey was conducted at 1316 locations throughout New Brunswick. This information is used to forecast the budworm infestation for 1984 and to select areas in need of protection.

In-depth analysis of the efficacy of the protection program is currently underway. A detailed report will be published by the Department of Natural Resources by December 31. Final assessment of the program will be based on results from all surveys conducted in 1983. The following comments on the spray assessment are only preliminary.[2]

2.3 million hectares of forest were mapped as defoliated during the 1983 aerial survey. This is a significant increase from 1982 when approximately 1.4 million hectares were defoliated (Table 2).

Although 2.3 million hectares of New Brunswick forest were defoliated, there was good foliage protection in the industrial spray blocks treated by Forest Protection Limited. There were only 372 000 hectares of defoliated forest within the industrial blocks,representing 26% of the sprayed area (Table 3). In other words there was no defoliation detected within 74% of the sprayed area. This level of protection is comparable to the 1982 program in which no defoliation was detected within 79% of the sprayed area.

The aerial survey does not have the resolution to measure defoliation, or lack of defoliation in small woodlots. Tables 4A and B summarize preliminary analysis of the efficacy of the woodlot program based on ground defoliation estimates. Foliage retention on red/black spruce was excellent with 76% of the woodlots retaining 70% or more of their current year's foliage (Table 4B). In contrast are the results of foliage protection on balsam fir and white spruce (Table 4A). Less than half of the current year's foliage was retained on fir and white spruce in 51% and 75% of the woodlots, respectively.

Based on 1983 egg mass counts there will be a reduction in area sustaining a moderate to high infestation in 1984. 48% of the locations sampled had low egg mass counts compared to only 26% and 34% in 1982 and 1981 respectively. The predicted decrease in the area of infestation is largely due to a decline in budworm populations throughout much of southern New Brunswick. Nevertheless there remains approximately 2/3's of the Province expected to sustain moderate to high populations in 1984.

A summary of egg mass counts and hazard for the Province is given in Tables 5 and 6.

Lester Hartling
Forest Management Branch
New Brunswick Department
of Natural Resources
November 9, 1983

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2. The data presented in this report were analysed and compiled by the Department of Natural Resources and the Canadian Forestry Service.

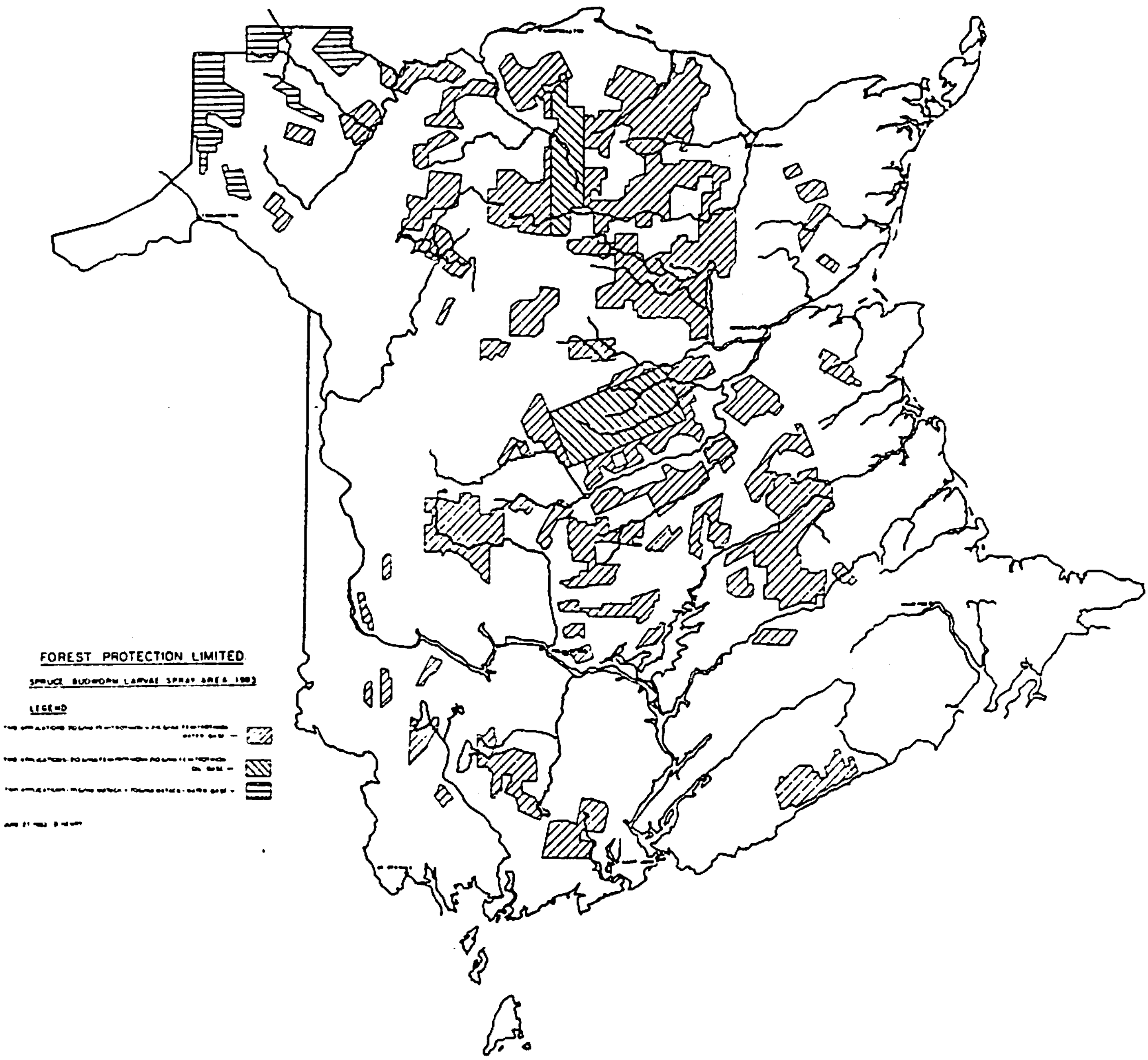
TABLE 1. Summary of New Brunswick's 1983 Foliage Protection Program Against Spruce Budworm (Areas Treated by Forest Protection Limited)

Area Sprayed in Hectares and Acres, by Insecticide, Dosage, Application Rate, Carrier and Aircraft Type

Industrial	Hectares Thousands	Acres Thousands	A/C Type
Two Applications			
(a) 210 g/ha Fenitrothion in 1.46 1/ha + 210 g/ha Fenitrothion in 1.46 1/ha - Dowanol, Atlox 3409F and Water	1155.0	2854.2	DC-6 TBM M-18
(b) 210 g/ha Fenitrothion in 1.46 1/ha + 210 g/ha Fenitrothion in 1.46 1/ha - Cyclosol 63 and 585 Oil	157.0	387.0	DC-6
(c) 70 g/ha Matacil 180F 1.46 1/ha + 70 g/ha Matacil 180F in 1.46 1/ha - Atlox 3409F and Water	101.0	249.0	TBM
	1413.0	3490.2	
Small Woodlots			
One Application			
(a) 210 g/ha Fenitrothion in 1.46 1/ha Dowanol, Atlox 3409F and Water	.7	1.8	Cessna 188
(b) 30 BIUs/ha Novabac 3 in 4.68 1/ha - water	10.3	25.5	M-18
Two Applications			
(a) 210 g/ha Fenitrothion in 1.46 1/ha + 210 g/ha Fenitrothion in 1.46 1/ha Dowanol, Atlox 3409F & Water	71.0	175.5	M-18 Cessna 188 Ag Cat
TOTAL	82.0	202.8	
GRAND TOTAL	1495.0	3693.0	

(from Forest Protection Limited 1983 Program Report)

FIGURE 1. Industrial Spray Blocks Treated by Forest Protection Limited in 1983.



In addition to the areas shown above some 202,800 acres of woodlots were treated in 1983 scattered in 375 different locations.

(from Forest Protection Limited 1983 Program Report)

Table 2: Estimated area of spruce Budworm caused defoliation in New Brunswick from 1975 to 1983 as determined from maps showing the results of aerial defoliation surveys.

	Defoliation Category ('000 ha)			
Year	Light	Moderate	Severe	Total
1975	820	861	2 706	4 387
1976	192	174	230	596
1977	123	134	347	604
1978	141	219	450	810
1979	105	235	1 085	1 425
1980	176	226	447	849
1981	135	382	839	1 356
1982	185	391	811	1 387
1983	301	355	1 673	2 329*

* An additional 94 000 hectares had detectable spruce defoliation with no visible defoliation to the balsam fir component. This defoliation may have been caused by other forest defoliators or in combination with budworm.

Table 3: Summary of Spruce Budworm defoliation in 1983 in New Brunswick.

	Defoliation Category			
	Light	Moderate	Severe	Total Defoliation
Total Area (ha) Defoliated in the Province	301 000	355 000	1 673 000	2 329 000
Area Defoliated (ha) within Spray Blocks (b)	91 000	83 000	198 000	372 000*
Percentage of Spray Area with Detectable Defoliation (b/a x 100)	6.4	5.9	14.0	26.3
Area Sprayed (Industrial) by Forest Protection Ltd. (a)	- 1 413 000 ha			

* An additional 50 000 hectares within the spray area had detectable spruce defoliation with no visible defoliation to the balsam fir component.

Table 4A: A summary of foliage protection on Balsam Fir and White Spruce in woodlots treated with Fenitrothion.

Percent Defoliation	Percent Foliage Retained	Percentage of Woodlots Falling in Each Defoliation Category	
		Balsam Fir	White Spruce
0-25	75-100	22.8	13.0
26-55	45-74	26.3	11.6
56-75	25-44	18.3	20.3
76-100	0-24	32.6	55.1
		100%	100%

Table 4B: A summary of foliage protection on red/black spruce in woodlots treated with Fenitrothion.

Percent Defoliation	Percent Foliage Retained	Percentage of Woodlots Falling in Each Defoliation Category
		Red/Black Spruce
Light ($\leq$30)	70-100	76.0
Moderate (31-69)	31-69	19.8
Severe ($\geq$70)	0-30	4.2
		100%

Tables 4A and B are based on an assessment in 178 woodlots. Balsam Fir defoliation was assessed in 175 woodlots, Red/Black Spruce in 167 woodlots, and White Spruce in 69 woodlots.

TABLE 5. A comparison of Egg Mass Counts in New Brunswick for 1981, 1982, and 1983.

EGG MASSES/10 m^2 of Foliage

	Low (0-99)	Moderate (100-239)	High (240-999)	Very High (1000+)	Total
			1981		
Number of Locations	591	441	660	48	1740
Percent of Total	34%	25%	38%	3%	100%
			1982		
Number of Locations	458	512	701	82	1753
Percent of Total	26%	29%	40%	5%	100%
			1983		
Number of Locations	636	257	399	24	1316
Percent of Total	48%	20%	30%	2%	100%

TABLE 6. A comparison of Hazard Indices in New Brunswick for 1981, 1982, and 1983*

	Hazard Rating				
	Low (0-7)	Moderate (8-10)	High (11-14)	Extreme (15+)	Total
			1981		
Number of Locations	1022	381	231	106	1740
Percent of Total	59%	22%	13%	6%	100%
			1982		
Number of Locations	1020	332	287	114	1753
Percent of Total	59%	19%	16%	6%	100%
			1983		
Number of Locations	790	261	201	64	1316
Percent of Total	60%	20%	15%	5%	100%

* The hazard index is an estimate of the probability of tree death or deterioration given budworm attack in the subsequent year. It is a composite measurement based on tree vigour, previous defoliation, current defoliation, and predicted defoliation (= egg mass counts) in the subsequent year.

NEW BRUNSWICK COMMITTEE FOR ENVIRONMENTAL MONITORING OF FOREST INSECT CONTROL OPERATIONS (EMOFICO)

Report to Forest Pest Control Forum, November 15-17, 1983

Copies of the draft 1980-1981 EMOFICO report are now available. This report summarizes the research and monitoring activities carried out in conjunction with operational and experimental spruce budworm spraying in New Brunswick. It is now translated, and is in the process of being printed. Final release is expected sometime early in 1984.

Summaries of the 1982 monitoring and research projects are contained in an interim report now available. Summaries of the 1983 projects are expected to be available by March 1984.

The next meeting of EMOFICO is planned for March, 1984. Those interested are invited to attend.

Requests for EMOFICO reports or other information should be directed to:

Cathy MacLaggan
Secretary of EMOFICO
Environment New Brunswick
Box 6000
Fredericton, New Brunswick
E3B 5H1

TEL: 506-453-2669

ATTACHMENT - a list of 1983 projects

ERRATUM: p. 2 in the 1980-1981 EMOFICO report - 'approximately 370 million ha are infected' should read 'approximately 37 million ha are infected'.

1983 ENVIRONMENTAL MONITORING OF FOREST INSECT CONTROL OPERATIONS

1. The environmental impact of Sumithion F on forest ecyosystems. FPMI.
2. The efficacy of various insecticides to control spruce budmoth. P. Kingsbury, FPMI.
3. A survey of fenitrothion residues in various substrates. S. Sundaram, FPMI.
4. A study of singing activity of birds in spruce budworm spray buffer zones. B. McLeod, FPMI.
5. Distribution of *Ceratophyllum sp.*, an aquatic vascular plant that accumulates both fenitrothion and aminocarb. D.C. Eidt, CFS.
6. Effects of forest spraying on soil litter decomposition rates. D. C. Eidt, CFS.
7. Investigation of the relationship of singing activity in birds and brain cholinesterase levels. D. Busby, CWS.
8. Fenitrothion residues and metabolites in aquatic systems. B. Ernst, EPS.
9. 1983 pesticide study: monitoring of off-target fallout during the spruce budworm spray program. T. Polluck, G. Brun, IWD.
10. Fenitrothion residues study. W. C. Ayer, ENB, EPS, CFS.
11. *Zeiraphera* sp. study. FPMI.

Response of songbirds to exposure to fenitrothion

Report to the Eleventh Annual Forest Pest Control Forum

Ottawa, Ontario

November 1983

by

D.G. Busby and P.A. Pearce

Canadian Wildlife Service

Fredericton, N.B.

Presented here are a summary of recent CWS research on the influence of exposure to fenitrothion on the breeding biology of the White-throated Sparrow, and a note on a local bird kill associated with the 1983 budworm suppression project in New Brunswick.

Initial investigations of the effects of aerial application of fenitrothion on the reproductive biology of White-throated Sparrows indicated an impairment of growth and development of nestlings - those from treated areas showed a reduced growth of about 10% compared to controls studied in the context of normal operational spraying. It was subsequently revealed that simulated spray overswathing caused heavy impact, lowering breeding success to 11% from a normal 58%. Surviving nestlings grew poorly, adult mortality was high and behavior of surviving adults was erratic. Follow-up experiments on artificial dosing of nestlings with sub-lethal amounts of fenitrothion showed that they fledged smaller than controls. The effect was directly related to the dose. It appeared that exposed nestlings did not respond to the feeding trips of adults.

The present study was designed to determine if exposure of adults alone would reduce the growth of nestlings. Upon establishment of territories adult males were color-banded. Nestlings were measured daily and behavior of adults was monitored from blinds. On day four of the nestling period, adult males were orally dosed with sub-lethal amounts of fenitrothion (10 mg/kg, as determined by previous range-finding) and released. Measurements of nestlings and observations of adults continued until the young fledged. Dosed birds were collected for brain ChE analysis at the time young fledged.

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The effect of dosing on adult behavior was evident almost immediately - they remained near the ground, became relatively inactive, flew only sporadically and feeding of nestlings became irregular. Females (undosed) increased the frequency of feeding trips but could not equal the combined feeding rate of control pairs. Nestlings showed a consistently slower growth rate of three to five % after dosing of adult males than did controls. Brain ChE activity of dosed males was 40% depressed compared to controls.

This study indicates that sub-lethal exposure of only one adult to fenitrothion can have measurable impact on the growth of nestlings. Exposure of both adults would almost certainly have had a greater effect; if both adults had responded similarly, the young would have been fed very little and would probably have died. The brain ChE activity of dosed birds compares very closely with that in birds sprayed in the previously-mentioned overswathing experiment. In that sudy, post-exposure adult behavior was very similar to that in the present one except that both adults were exposed, resulting in poor breeding success.

It is now evident that forest spraying with fenitrothion can affect birds in several ways: exposure of adults can result in poor parental care; direct toxic effects on nestlings can influence their ability to respond to the feeding efforts of adults; and other studies indicate that temporary knock-down of the food supply can have a measurable impact on growth of young birds. Under normal spray conditions the cumulative effect may be manifested as reduced growth of nestlings, the long-term

.../3

significance of which is unknown. In cases of accidental overswathing or other circumstances resulting in double-dosing the effects can be much greater. Brain ChE depression of 40% can cause some mortality and induce behavior abnormalities in adults sufficient to impair breeding success.

Laboratory studies elsewhere have shown that brain ChE depression of 20% is sufficient for diagnosing exposure of birds to ChE inhibitors and that 50% depression can be used to diagnose cause of death. In earlier studies we found that normal operational spraying induced 20% brain ChE depression and was associated with a 10% reduction in the growth of free-living White-throated Sparrow nestlings. That impact, although significant, appears not to impair short-term reproductive success of the species. In the previously-mentioned overswathing experiment, and in the present study, 40% ChE depression resulted in severe disruption of reproduction in the same species. We conclude, then, that as ChE depression increases beyond the 20% level, breeding success is increasingly jeopardized. We regard the 20% depression level as the limit of tolerance of White-throated Sparrows to ChE inhibiting insecticides. Although diagnostic data are lacking, it is likely that other songbird species are subject to similar constraints.

The effects of spraying on songbirds were not, to our knowledge, monitored during the 1983 forest protection operation in New Brunswick but one instance of a deleterious, local impact was reported. A wildlife biologist involved in an unrelated study at Whitney Brook noted "numerous"

.../4

birds unable to fly and exhibiting symptoms strongly suggestive of exposure to a ChE inhibitor. That was in an area adjacent to a zone sprayed one or two days before. Among birds taken by hand were a White-throated Sparrow, an Ovenbird, and Bay-breasted and Yellow-rumped Warblers, all males. Measurement of brain ChE activity in the latter two revealed a depression of 83% and 45%, respectively, from normal levels in about ten control birds of each of those species. Although the results of whole-body insecticide residue analysis are not yet available, the circumstances and the results of enzyme testing strongly indicate that the birds were indeed spray casualties.

Although no other reports of suspected bird intoxication were brought to our attention, it seems reasonable to believe this was not an isolated incident. Sporadic mortality of songbirds has marked the history of operational fenitrothion spraying in New Brunswick. Such impacts are believed to be the result of overspraying and have indeed been induced experimentally. For them to become known, certain conditions have to be met: the poisoning of birds must be manifest (presence of incapacitated, moribund or dead individuals), a competent observer must be present at the right time and place to note the phenomenon, and the observer must report the incident to an appropriate authority. The chances for all conditions to be met are slim. If very local and in wilderness areas, such impacts probably would go unnoticed. Adoption of no-spray setback zones near human habitations may have increased the likelihood that acutely toxic effects on songbirds go unobserved.

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In summary, sporadic loss of songbirds seems inevitable when fenitrothion is sprayed at currently recommended operational dosages. Our research has shown that where overspraying occurs, some mortality can be expected. It has also revealed the probability of much more universal sub-lethal effects on exposed individuals of one representative species. Clearly, use of an insecticide less impactive on songbirds than fenitrothion would be preferable.

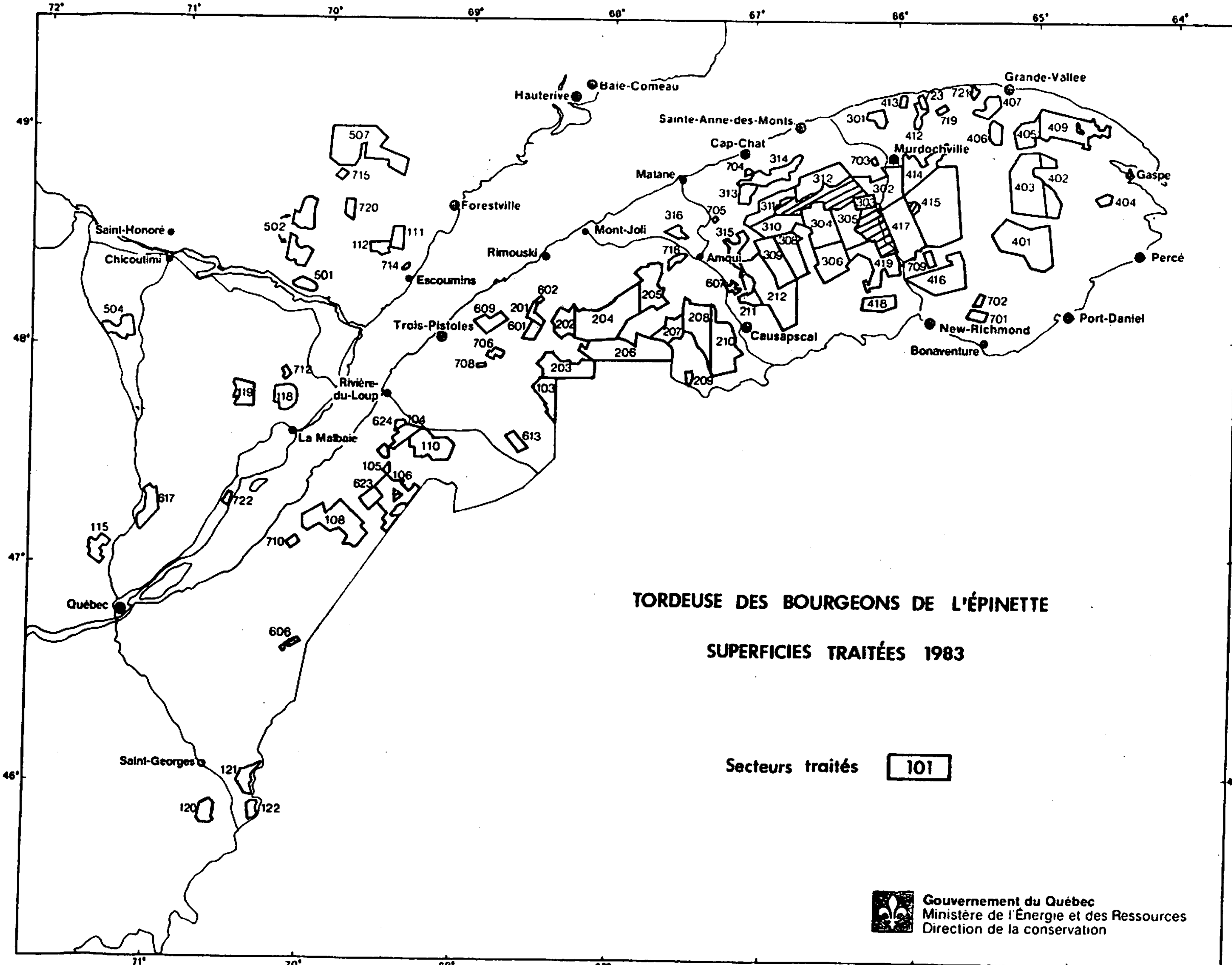

TORDEUSE DES BOURGEONS DE L'ÉPINETTE
SUPERFICIES TRAITÉES 1983
Secteurs traités
101
Gouvernement du Québec
Ministère de l'Énergie et des Ressources
Direction de la conservation
Baie-Comeau
Hauterive
Grande-Vallee
Sainte-Anne-des-Monts
Cap-Chat
Murdochville
Matane
Gaspe
Forestville
Saint-Honoré
Chicoutimi
Mont-Joli
Rimouski
Amqui
Percé
Escoumins
Trois-Pistoles
Causapscal
New-Richmond
Port-Daniel
Bonaventure
Rivière-du-Loup
La Malbaie
Québec
Saint-Georges
72°
71°
70°
69°
68°
67°
66°
65°
64°
49°
48°
47°
46°

TABLEAU 3 Préparations devant être utilisées dans le cadre du programme opérationnel de lutte contre la tordeuse au Québec en 1983

TRAITEMENTS CHIMIQUES AUX QUADRIMOTEURS

Produit	Dose	Volume	Préparations (V/V)			
			Insecticide	Cyclo-Sol 63	Diluant 585	Colorant
Fénitrothion (96%)	210g/ha	1,403 litre/ha	11.3%	35%	53.6%	.1%
Aminocarb (180g/ℓ)	52g/ha	1,403 litre/ha	20.8%	-	79.1%	.1%
	87,5g/ha	2,34 litres/ha	20.8%	-	79.1%	.1%

TRAITEMENTS BIOLOGIQUES AUX QUADRIMOTEURS

Produit	Dose	Volume	Insecticide	Sorbitol	Eau	Chevron
Dipel 88	20BIU/ha	5,85 litres/ha	40.5%	-	59.5%	1/1600
Novabac°3	20BIU/ha	4,68 litres/ha	50%	20	30%	1/1600
	30BIU/ha	6,6 litres/ha	50%	20	30%	1/1600

TRAITEMENTS CHIMIQUES AUX MONOMOTEURS

Produit	Dose	Volume	Insecticide	Diluant 585	Colorant
Aminocarb (180g/ℓ)	87,5g/ha	2,34 litres/ha	20.8%	79.1%	.1%

TABLEAU: Pourcentage en territoire traité selon le développement de l'insecte (IDI) et le développement de la pousse (IDP)

A. Développement de l'insecte (IDI)

Classe IDI	Traitement hâtif		Traitement conventionnel	
	1ère app.	2e app.	1ère app.	2e app.
1.1 - 1.5	12	-	-	-
1.6 - 2.0	88	-	-	-
2.1 - 2.5		-	2	-
2.6 - 3.0	-	26	23	-
3.1 - 3.5	-	52	19	20
3.6 - 4.0	-	11	14	3
4.1 - 4.5	-	-	4	6
4.6 - 5.0	-	-	18	2
5.1 - 5.5	-	1	4	19
5.6 - 6.0	-	10	14	47
6.1 - 6.5	-	-	2	3

B. Développement de la pousse (IDP)

Classe IDP	Traitement hâtif		Traitement conventionnel	
	1ère app.	2e app.	1ère app.	2e app.
1.0 - 1.3	100	-	-	-
3.4 - 3.7	-	21	7	-
3.8 - 4.1	-	14	6	-
4.2 - 4.5	-	24	18	3
4.6 - 4.9	-	41	69	97

Results per region of the 1983 Spruce Budworm spraying program concucted in Quebec.

Region	N.Plot	Larval population PRE	POST	M(%)	Defoliation Treated	Check	Protection
Beauce	14	15.5	1.1	93	17	73	56
Apalache	3	26.7	3.2	88	88	69	0
RDLoup.	48	24.7	1.8	92.7	45	85	40
Riki	54	14.9	1.9	82.3	36	67	31
Bonaventure	61	8.2	1.8	78.0	28	61	33
Gaspé	27	12.0	1.9	84.2	43	68	25
Matane	38	5.6	2.7	51.8	41	60	19
Laurentides	4	12.7	5.5	65.4	62	63	1
Charlevoix	14	35.4	5.6	84.2	79	89	10
Escoumins	31	7.4	2.1	71.6	45	65	20

Efficacité des traitements chimiques et biologique réalisés contre la tordeuse des bourgeons de l'épinette en 1983.

Traitement	Nb PE	Pop. pré trait. Lar/Br. de 45 cm	Pop. post L/Br	Mort %	Défoliation obs	Défoliation prév.	Protect.
Trait. Hâtif	38	11.3	2,3	80	26	59	33
Trait. Biologiques.	18	17.0	3,5	79	53	83	30
2 Appl. Chimiques	223	14.2	1.7	88	29	70	41
1 Appl. Chimique quadrimoteurs	72	11.4	4.0	65	53	68	15
1 App. Chimique Monomoteurs	52	8,7	2,4	72	42	64	22

Tableau 4 Superficie (hectares) traitée en 1983 présentée en fonction du degré de défoliation

BLOCS (base d'arrosage)	Degré de défoliation				
	NUL	LEGERE	MODERE	SEVERE	TOTAL
100 Rivière-du-Loup	3 281	60 312	65 471	43 094	172 968
200 Mont-Joli	1 718	97 188	154 533	41 719	295 158
300 Matane	468	91 878	106 721	59 217	258 284
400 Bonaventure	1 562	125 624	189 379	68 126	384 691
500 St-Honoré	1 094	15 781	11 563	41 250	69 688
600 Bt	469	4 374	25 315	15 469	45 627
700 Mono-moteur	---	7 032	13 750	6 407	27 189
	8 592 (1%)	402 189 (32%)	566 732 (45%)	276 092 (22%)	1 253 605 (100%)
	78% (NUL + LEGERE + MODERE)				

AVIS DE RECHERCHE

Vous connaissez un indice nous permettant de retracer l'un de vos camarades de classe, vous aideriez tout le monde en nous le communiquant au 1150, ouest boul. St-Cyrille, Québec, P.Q. G1S 1V7.

PERSONNES RECHERCHÉES (promotion 1964-65)

Jean Eudes, Beaulieu,

Jean Guy Brouillette,

Denis Cantin,

Pierre Charest,

Pierre Claveau,

André Cloutier,

Serge Doyon,

Claude Dubé,

Jacques Gagnon,

Yves Grenier

Paul Lachance,

Jacques Lambert,

Claude Lamontagne,

Louis Lebel,

Bruno Maranda,

Claude Michaud,

Michel Morissette,

René Nadeau,

Jean Pierre Paradis,

François Rochette,

André Savary,

Marc Simard,

Jean Eudes, St-Laurent,

Michael St-Martin,

Bertrand Thivierge,

Jean Trépanier,

André Vinette,

Tableau 5 Description des traitements expérimentaux réalisés contre la tordeuse des bourgeons de l'épinette en 1983

TYPE DE TRAITEMENT			1ère APPLICATION				2ième APPLICATION			
	BLOCS	SUPERFICIES (ha)	PRODUIT	DOSE par hectare	VOLUME l/ha	SYNCHRONISATION	PRODUIT	DOSE g/ha	VOLUME l/ha	SYNCHRONISAT
CHIMIQUE HATIF	104	10 469	Fénitrothion	210 g	1,403	40-50 % L2	Matacil flow.	52	1,403	L3 - L4
	108 A	13 594	Fénitrothion	210 g	1,403	40-50 % L2	Matacil	52	1,403	L3 - L4
	108 B	8 906	Fénitrothion	210 g	1,403	40-50 % L2	Matacil	52	1,403	L3 - L4
CHIMIQUE CONVENTIONNEL	106	8 281	Fénitrothion	210 g	1,403	L3 - L4	Matacil	52	1,403	5 jrs/après à 1ère applicat
	110	10 625	Fénitrothion	210 g	1,403	L3 - L4	Matacil flow.	52	1,403	5 jrs/après à 1ère applicat
BIOLOGIQUE	609	6 719	Dipel 88	20 UI	5,85	L4	---			
	623	4 688	Futura II	20 UI	2,5	L4	---			
	624	4 219	Novabac 3	20 UI	6,6	L4	---			

Tableau 6 Préparations utilisées dans le cadre du programme expérimental réalisé en 1983

PRODUIT	DOSE UI/ha	VOLUME l/ha	PREPARATIONS			
			INSECTICIDE (%)	EAU (%)	SORBITOL (%)	CHEVRON
Futura II	20	2,5	60	40	---	1/1 600
Novabac 3	30	6,6	54	28	18	1/1 600
Dipel 88	20	5,85	40,5	59,5	---	1/1 600

PRODUIT	DOSE g/ha	VOLUME l/ha	PREPARATIONS			
			INSECTICIDE (%)	CYCLO-SOL 63 (%)	DILUANT 585 (%)	COLORANT (%)
Fénitrothion 96%	210	1,403	11,3	35	53,6	0,1
Aminocarb 180 g/l Matacil	52	1,403	20,8	--	79,1	0,1

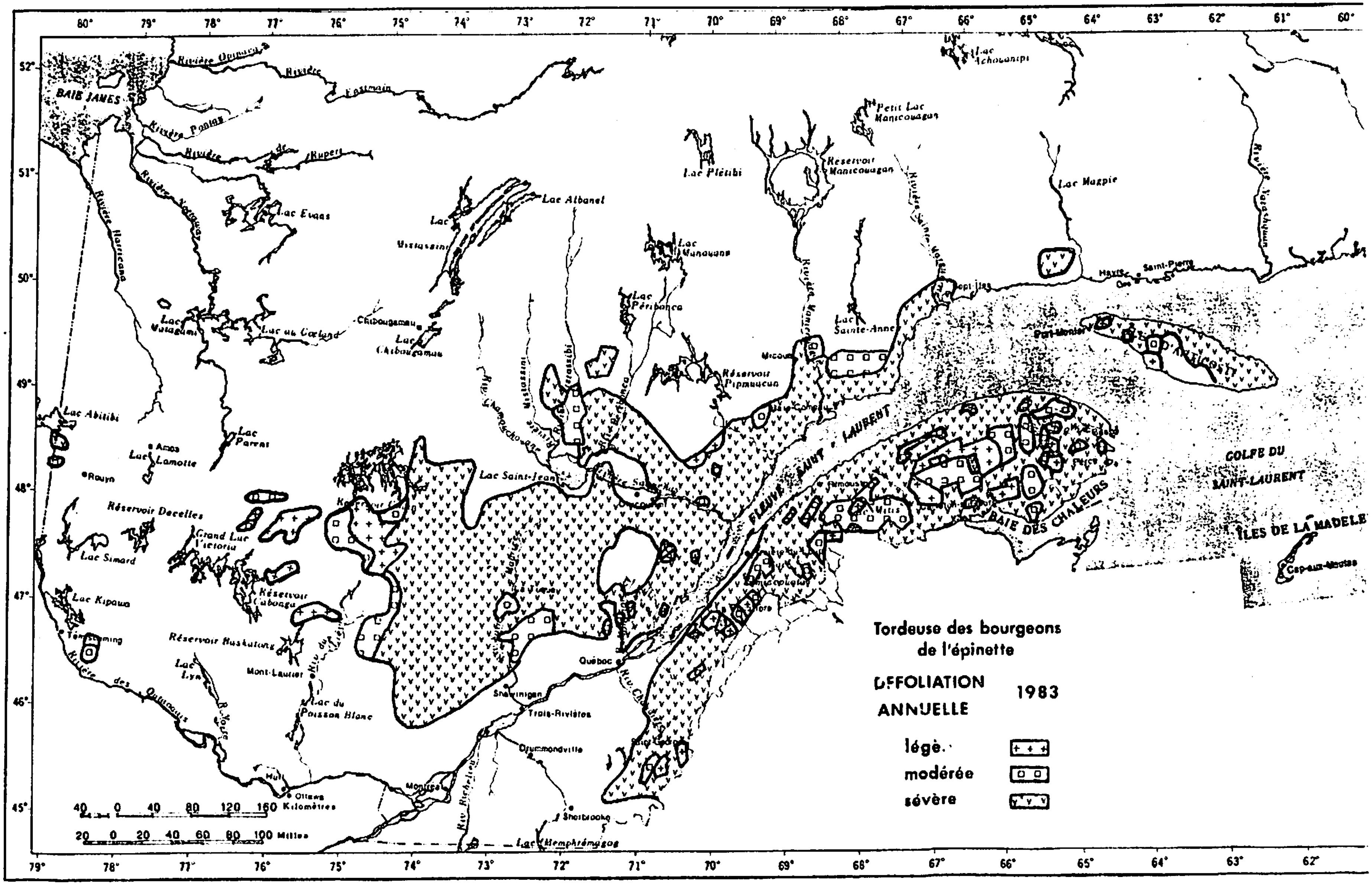
Tableau 7 Population larvaire, mortalité larvaire et protection accordée par le traitement dans chacun des blocs expérimentaux 1983

BLOC	SUPERFICIE (ha)	Nb. PE	POPULATION PRE-TRAITEMENT L/Bourg.	POPULATION PRE-TRAITEMENT L/Br 45	POPULATION POST-TRAIT. L/Br 45 cm	MORT (%) TOTALE	MORT ABBOTT[1]	DEFOLIATION FETTES	PROTEC. DE FEUILLAGE[3]	DEFOLIATION INVENTAIRE AERIEN LEGER	DEFOLIATION INVENTAIRE AERIEN MODERE	DEFOLIATION INVENTAIRE AERIEN SEVER
104 Tr. Chi.ha.	10 469	40	,274 ± ,048	25,4*	2,6[2] ± 0,9	89,8	57,5	42%	56%	8%	87%	5%
Tem.		40		25,4 ± 4,2	6,1 ± 0,7	76,0		93%				
108 (A) Tr. Ch.ha.	13 594	30	,330 ± ,069	30,6*	10,2 ± 2,4	66,7	---	85%	13%	40%	34%	26%
Tém.		30		30,6 ± 5,2	6,2 ± 0,9	79,7		98%				
108 (B) Tr. Ch.ha.	8 906	20	,261 ± ,076	24,8*	0,4 ± 0,2	98,4	93,4	8%	91%	79%	21%	0%
Tém.		20		24,8 ± 7,1	6,0 ± 1,0	75,8		91%				
106 Tr. Ch. c.	8 281	80	,430 ± ,055	31,2 ± 4,4	0,5 ± 0,3	98,4	94,5	27%	71%	62%	32%	6%
Tém.		80	,425 ± ,054	31,7 ± 4,5	9,2 ± 0,9	71,0		93%				
110 Tr. Ch. c.	10 625	80	,422 ± ,051	31,4 ± 3,9	3,1 ± 0,4	89,2	60,3	72%	23%	12%	81%	7%
Tém.		80	,423 ± ,049	31,6 ± 3,9	8,6 ± 0,9	72,8		93%				
609 Tr. Biol.	6 719	80	,27 ± ,028	34,0 ± 3,9	2,7 ± 0,5	92,1	77,4	55%	41%	5%	46%	49%
Tém.		80		33,7 ± 3,6	11,8 ± 1,4	65,0		93%				
623 Tr. Biol.	4 688	80	,31 ± ,033	50,6 ± 5,5	3,0 ± 0,5	94,1	78,9	50%	49%	3%	83%	13%
Tém.		80		48,0 ± 5,2	13,4 ± 1,4	72,1		97%				
624 Tr. Biol.	4 219	80	,34 ± ,044	36,4 ± 4,8	2,4 ± 0,4	93,4	78,0	41%	56%	0	59%	41%
Tém.		80		36,0 ± 4,2	10,8 ± 1,2	70,0		91%				

1 Abbott: Survie Témoin - Survie Traité / Survie Témoin
2 Intervalle de confiance de la moyenne à un niveau de probabilité de 90%
* Populations larvairres estimées à partir des échantillons non traités comparables au niveau du nombre de larves et de bourgeons par branche de 45 cm
3 Protection: Défoliation Témoin - Défoliation Observée / Défoliation Témoin X 100

Province de Québec

RÉGIONS ADMINISTRATIVES	nul	léger	modéré	sévère	TOTAL
~~North Bay~~ 1	—	578411	825952	2760779	4065172
~~Pembroke~~ 2	—	3594	108750	1574535	1686879
~~Ottawa~~ 3	—	76095	88125	1779533	1943753
~~Montréal~~ 4	—	138907	224812	1974844	2338563
~~Sherbrooke~~ 5	—	2188	13125	99219	114532
~~Presqu'Isle~~ 6	—	16095	43125	564844	624064
~~Campbellton~~ 7	—	204689	89377	6563	300629
~~Gaspé~~ 8	—	24374	68281	28437	121092
~~Anticosti~~ 9	—	101877	335001	1580314	2017192
~~Havre/St-Pierre~~	—	—	—	—	—
	—	—	—	—	—
	—	946260	1796548	10469068	13211876


Tordeuse des bourgeons
de l'épinette
DÉFOLIATION ANNUELLE
1983
légè.
modérée
sévère
BAIE JAMES
Lac Abitibi
Amos
Rouyn
Réservoir Decelles
Grand Lac Victoria
Lac Simard
Lac Kipawa
Réservoir Cabonga
Réservoir Baskatong
Mont-Laurier
Lac du Poisson Blanc
Hull
Ottawa
Montréal
Trois-Rivières
Shawinigan
Drummondville
Sherbrooke
Québec
Lac Saint-Jean
Lac Mistassini
Lac Albanel
Chibougamau
Lac Chibougamau
Lac Evans
Lac Matagami
Lac au Goéland
Lac Plétibi
Réservoir Manicouagan
Petit Lac Manicouagan
Lac Magpie
Lac Manouane
Lac Péribonca
Réservoir Pipmuacan
Lac Sainte-Anne
Sept-Îles
Havre-Saint-Pierre
ANTICOSTI
FLEUVE SAINT-LAURENT
GOLFE DU SAINT-LAURENT
BAIE DES CHALEURS
ÎLES DE LA MADELEINE
Rimouski
Lac Memphrémagog
Rivière Eastmain
Rivière de Rupert
Rivière Harricana
Rivière des Outaouais
0 40 80 120 160 Kilomètres
20 0 20 40 60 80 100 Milles

R.A.	mortalité 1 - 25 %	26 - 50 %	51 - 75 %	76 - 100 %	total	TOTAL
1	1145006	202966	42968	2969		1393909
2	1186564	501094	171877	3125		1862660
3	796564	286877	74532			1157973
4	424376	191564	118708	26875		761723
5	69063	22656	625			92344
6	211251	19844	938			232033
7	492657	267970	119126	2873909		3753662
8	173909	240940	370002	888439		1673290
9	643750	179375	50001	54063		927189
	5203140	1913286	948777	3849380		11764773

231109

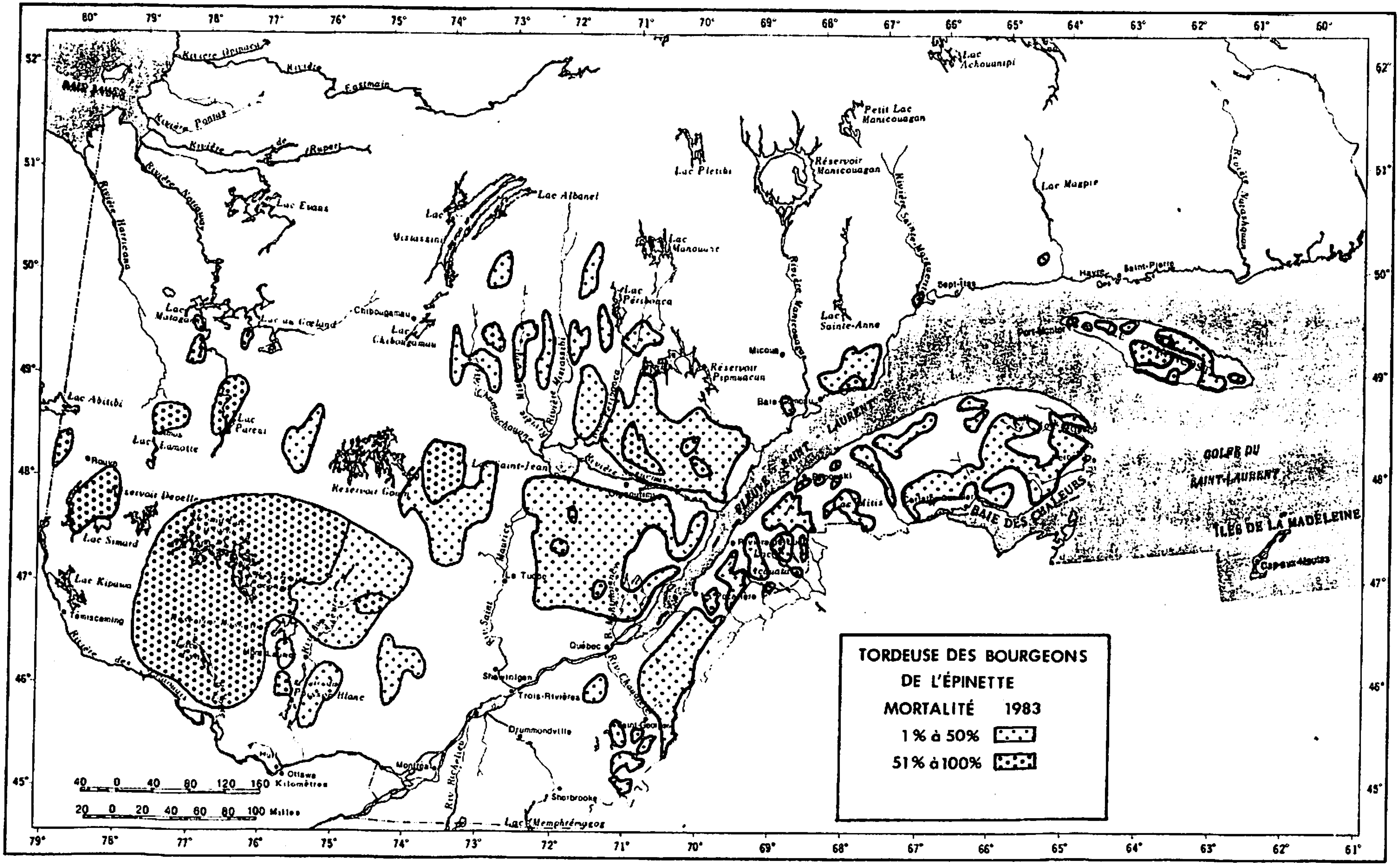
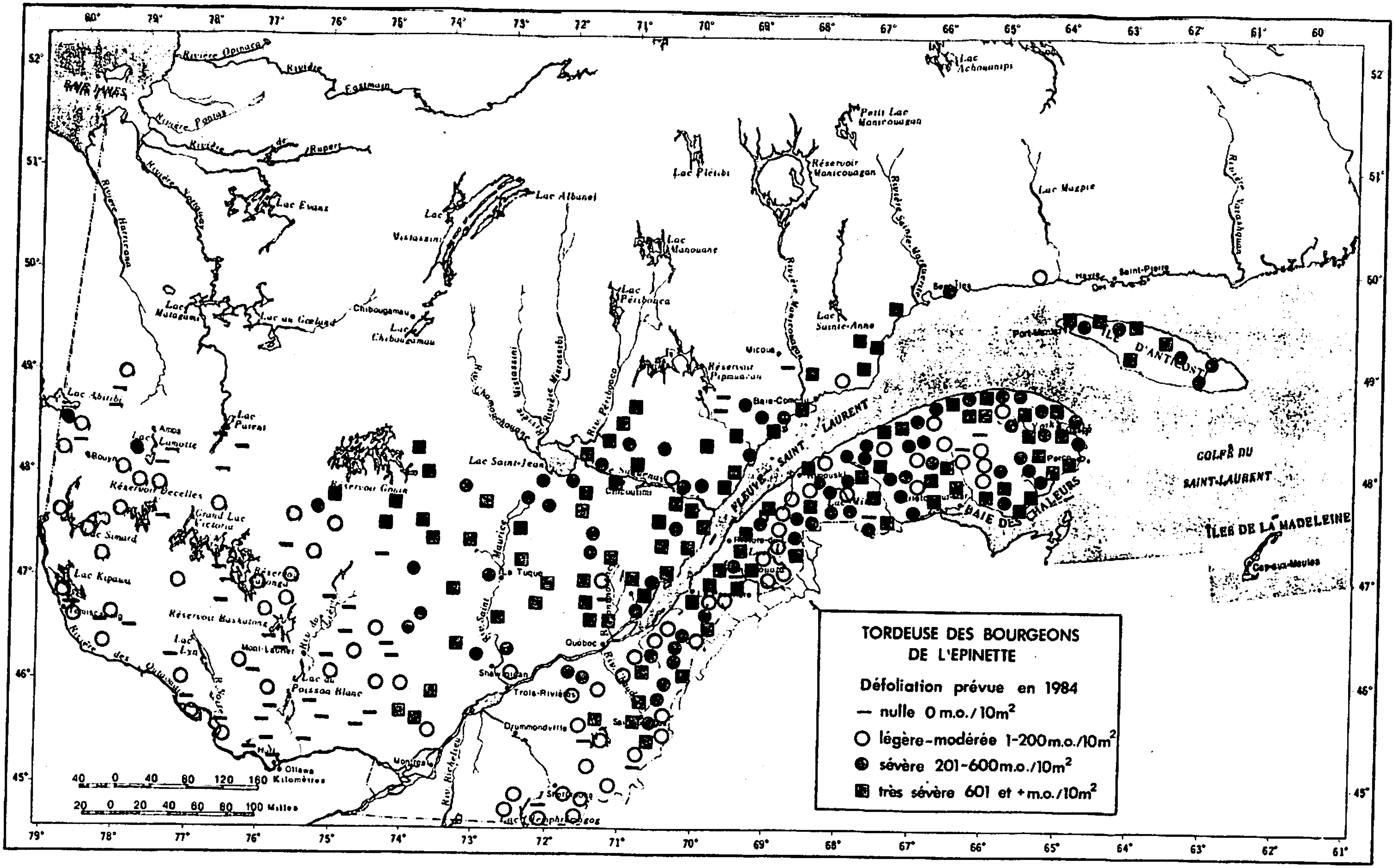

TORDEUSE DES BOURGEONS
DE L'ÉPINETTE
MORTALITÉ 1983
1 % à 50%
51% à 100%
Lac Albanel
Lac Mistassini
Réservoir Manicouagan
Petit Lac Manicouagan
Lac Magpie
Lac Pletipi
Lac Manouane
Lac Péribonca
Réservoir Pipmuacan
Lac Sainte-Anne
Sept-Îles
Chibougamau
Lac Chibougamau
Lac Evans
Lac Abitibi
Lac Kipawa
Témiscaming
Lac Saint-Jean
Réservoir Gouin
La Tuque
Québec
Shawinigan
Trois-Rivières
Drummondville
Sherbrooke
Montréal
Hull
Ottawa
Lac Memphrémagog
FLEUVE SAINT-LAURENT
BAIE DES CHALEURS
GOLFE DU SAINT-LAURENT
ÎLES DE LA MADELEINE
Lac Mitis
Baie-Comeau
Rivière Eastmain
Rivière de Rupert
Rivière Harricana
Rivière des Outaouais
Riv. Richelieu
Riv. Chaudière
Kilomètres
Milles

Tableau 8 Nombre de masses d'oeufs de la tordeuse des bourgeons de l'épinette dans l'ensemble du territoire à l'étude (1,6 millions d'hectares)

AOUT 1983			1982		
BLOC NO.	PE	M.O./10 m^2 (1)	PE	M.O./10 m^2 (2)	RATIO (1) (2)
100	105	694	66	903	0,77
200	76	606	61	1 225	0,56
300	65	589	64	1 016	0,64
400	73	525	72	1 066	0,49
500	22	715	17	679	1,05
600	42	711	30	1 254	0,57
700	55	631	31	719	0,88
*Témoins	525	701			
TOTAL PE	963		341		
MOYENNE NO/10 m^2		630		1 041	0,61

* Témoins: places échantillons situées à l'intérieur du territoire d'étude et non traitées en 1983


TORDEUSE DES BOURGEONS
DE L'EPINETTE
Défoliation prévue en 1984
— nulle 0 m.o./10m²
○ légère-modérée 1-200m.o./10m²
● sévère 201-600m.o./10m²
■ très sévère 601 et +m.o./10m²
GOLFE DU
SAINT-LAURENT
ILES DE LA MADELEINE
BAIE DES CHALEURS
FLEUVE SAINT LAURENT
ILE D'ANTICOSTI
Lac Saint-Jean
Lac Mistassini
Lac Albanel
Réservoir Manicouagan
Lac Abitibi
Baie-Comeau
Québec
Trois-Rivières
Drummondville
Montréal
Chicoutimi
La Tuque
40 0 40 80 120 160 Kilomètres
20 0 20 40 60 80 100 Milles

SPRUCE BUDWORM IN ONTARIO

BY

G.M. HOWSE

GREAT LAKES FOREST RESEARCH CENTRE

INTRODUCTION

Nine outbreaks of spruce budworm have occurred in Ontario since the early 1700's. One outbreak was recorded in the 18th century, three in the 19th century and five (so far) in the 20th century. The pattern of outbreak occurrence and character has apparently changed in the last 60 years. Outbreaks prior to 1920 were fewer in occurrence, of shorter duration and more or less local in nature. Since 1920, outbreaks have occurred more frequently, lasted longer and have become quite widespread. This change has occurred coincident with mans increasing utilization and management of the forests of Ontario.

CURRENT OUTBREAK

The most recent outbreak of spruce budworm in Ontario began in 1967 when three separate infestations became evident. Each has followed a different pattern over the years (Table 1).

The outbreak in southern Ontario has gone through periods of increase and decline and is at present on the decline. The infestation in northeastern Ontario seems to have reached a peak (in 1980) and is on the decline. In northwestern Ontario infestations have followed a different pattern, possibly as a result of the influence of suppression spraying conducted from 1968 to 1976. Subsequent to 1976, however, we have witnessed a slow but steady buildup in this part of the province.

SPRAYING

Spraying operations have been conducted by the Ontario Ministry of Natural Resources every year since 1968 (Table 1). The total area treated during the past 16 years amounts to some 345,000 ha or an annual average of about 21,560 ha. The area treated each year varies considerably as can be seen in Table 1. From 1968 to 1976, most of the spraying was conducted for the purpose of population suppression in northwestern Ontario. Elsewhere in the province, starting in 1970, small operations were conducted each year for the purpose of protecting high value stands and in 1979 spraying for the protection of commercial forests was started. High value stands include provincial parks, regeneration, nurseries, seed production areas and wildlife habitats. Bacillus thuringiensis (B.t.) is now the main operational insecticide although chemical insecticides such as Matacil and Orthene are used in some situations.

IMPACT

In 1983, budworm-associated tree mortality was present within an area of approximately 12.1 million ha. A large proportion of the area affected is in northeastern Ontario (Table 2). Most of the impact to date has occurred to balsam fir with white spruce and black spruce affected to a lesser degree. Budworm-associated tree mortality and growth loss from 1970 to the present for the three major host species totals some 85-100 million m^3. During the period 1977-81, approximately 66.7 million m^3 of wood fibre have been lost because of budworm; balsam fir - 50.6 million m^3; white spruce - 8.5 million m^3 and black spruce - 7.6 million m^3. In 1982, approximately 12.7 million m^3 of balsam fir, 2.0 million m^3 of white spruce and 1.9 million m^3 of black spruce were killed. Although balsam fir is generally not an important economic component of the forests in Ontario, loss of this species can be a serious problem in some management units with localized concentrations of balsam. Another impact on industry could be a reduction of annual allowable cuts to compensate for budworm mortality. Salvage logging is being conducted in a number of situations to utilize as much of the loss as possible. Concentrations of dead fir and spruce may represent a serious fire hazard.

CURRENT SITUATION

The outbreak reached a peak in 1980 and, at least overall, declined for two years although there were regional differences. However, in 1983, the gross area infested by budworm increased to a total of slightly more than 9 million ha compared to 8.023 million ha in 1982. In southern Ontario, the outbreak declined from .423 million ha in 1982 to .408 million ha in 1983. In northeastern Ontario, infestations further declined to 6.45 million ha in 1983 compared to 6.67 million ha in 1982. The largest change this year occurred in northwestern Ontario where the infestation more than doubled in size to 2.18 million ha.

Tree mortality surveys in 1983 mapped 12.1 million ha of budworm caused tree mortality compared to 11.6 million ha mapped in 1982. Egg-mass surveys indicate a further decline in southern Ontario compared to increases in northwestern and northeastern Ontario in 1984.

THE FUTURE

The long term future course of spruce budworm in Ontario cannot be predicted with absolute certainty. However, since 1920 there has been only 8 years when Ontario was free of significant infestation or that during the past 46 years (1937-1983) significant infestations did not occur in only three of those years (1964, 1965 and 1966). Thus, history indicates that budworm infestations will occur virtually constantly somewhere in Ontario. Although the outbreaks in southern and northeastern Ontario are declining, the northwestern infestations are expanding. A devastating pattern of impact will likely occur in the northwest similar to what has occurred in the northeast.

Table 1. Gross area of moderate-to-severe defoliation mapped each year for the three regional outbreaks in Ontario and total area treated in Ontario for spruce budworm each year since 1968.

	Gross area of moderate-to-severe defoliation in hectares				Area treated (ha)
	Southern	Northeastern	Northwestern	Total	Total
1967	60 704	3 035	16 188	79 927	0
1968	121 408	202 347	0	323 755	111 291
1969	310 805	667 746	1 619	980 170	10 522
1970	647 511	2 104 411	52 610	2 804 532	9 389
1971	1 821 125	3 480 372	52 610	5 354 107	32 942
1972	2 347 228	5 422 906	28 329	7 798 463	19 628
1973	2 428 167	5 058 681	4 047	7 490 895	38 062
1974	2 225 820	7 486 847	4 735	9 717 402	19 500
1975	2 428 167	11 007 689	18 211	13 454 067	13 500
1976	647 511	14 042 898	61 514	14 751 923	39 468
1977	407 932	13 468 231	211 979	14 088 142	3 855
1978	24 282	14 789 543	342 663	15 156 488	200
1979	1 001 534	16 939 972	487 873	18 429 379	20 250
1980	1 007 000	17 119 000	724 000	18 850 000	9 948
1981	601 000	16 958 000	658 000	18 217 000	9 801
1982	423 057	6 669 069	931 361	8 023 487	3 429
1983	407 494	6 450 910	2 181 458	9 039 862	3 162

Table 2. Gross area of budworm-associated tree mortality mapped each year for the three regional outbreaks in Ontario.

	Gross area of budworm-associated tree mortality in hectares			
	Southern	Northeastern	Northwestern	Total
1970				
1971				
1972	*a*	80 939		80 939
1973	*a*	202 347		202 347
1974	*a*	667 746		667 746
1975	121 408	1 214 083		1 335 491
1976	647 511	2 630 514		3 278 025
1977	1 315 257	4 168 353	405	5 484 015
1978	1 347 025	4 734 925	8 095	6 090 045
1979	1 384 055	6 110 886	20 235	7 515 176
1980	1 493 000	6 839 000	24 000	8 356 000
1981	1 550 000	9 572 000	88 000	11 210 000
1982	1 550 000	9 934 000	150 000	11 634 000
1983	1 573 000	10 355 000	191 000	12 119 000

[a] Mortality present but area not determined.

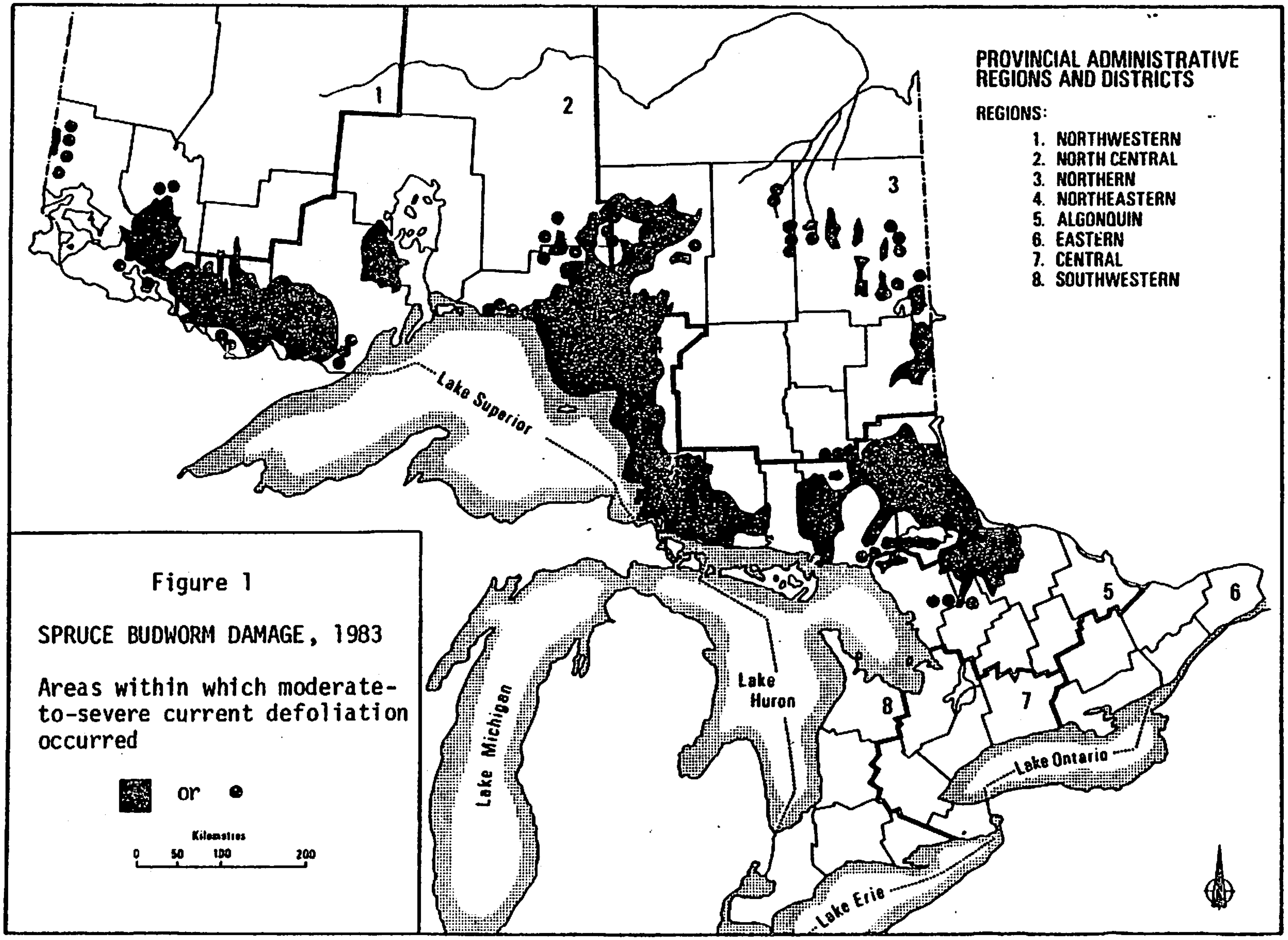


Figure 1

SPRUCE BUDWORM DAMAGE, 1983

Areas within which moderate-to-severe current defoliation occurred

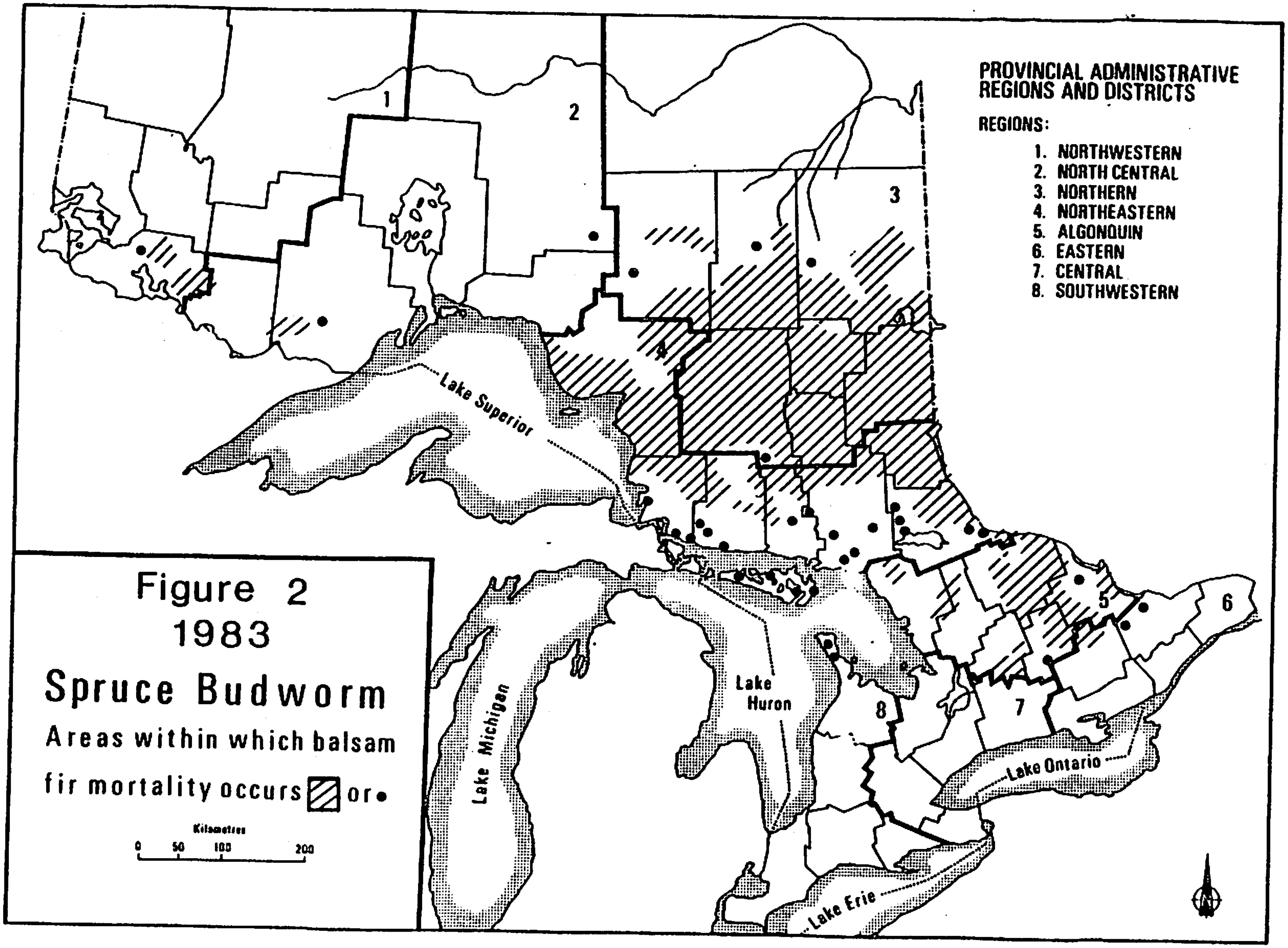


Figure 2
1983
Spruce Budworm
Areas within which balsam fir mortality occurs ▨ or ●

SPRUCE BUDWORM IN ONTARIO, 1983[1]

- Outbreak Status 1983
- Forecasts 1984
- Results of Spraying Operations, 1983
- Plans for 1984

by

J.H. Meating[2], G.M. Howse[2] and B.H. McGauley[3]

[1] Report prepared for the Annual Forest Pest Control Forum, Ottawa, November 15-17, 1983.

[2] Environment Canada, Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario.

[3] Ontario Ministry of Natural Resources, Pest Control Section, Maple, Ontario.

OUTBREAK STATUS 1983

In 1983, the overall area sustaining moderate-to-severe budworm defoliation increased by over a million ha to 9 032 862 ha (Fig. 1), reversing a downward trend which began in 1981 (Table 1). Budworm-associated tree mortality also increased in 1983 and now encompasses an area of approximately 12 119 710 ha (Fig. 2) an increase of some 485 982 ha (Table 2).

The figures presented above in this report represent gross areas within which stands of the major host species (balsam fir, *Abies balsamea,* [L.] Mill., white spruce, *Picea glauca* [Moen.] Voss., and black spruce, *Picea mariana* [Mill.] BSP) showed evidence of moderate-to-severe defoliation or mortality during the course of aerial surveys. These are performed in early to mid-July when the characteristic discoloration of budworm damaged foliage is at its peak, using flying time provided by the Ontario Ministry of Natural Resources. Ground checks are carried out before and after to substantiate aerial findings.

The spruce budworm outbreak in Ontario occurs in three major geographical areas: northwestern Ontario (mainly the Northwestern and North Central regions), northeastern Ontario (Northeastern and Northern regions) and southern Ontario (primarily the Algonquin Region).

Weather conditions during April, May and early June remained cool and wet following an unusually mild winter. As a result, budworm development, particularly in the more northern areas was somewhat retarded until about mid-June when the weather changed dramatically. From the second week in June through the remainder of June and July, temperatures were higher than normal and budworm development was very rapid. As a result, the completion of larval feeding and pupation was normal or earlier than normal in most areas.

The bulk of the increase in defoliation in 1983 occurred in northwestern Ontario where the infestation more than doubled in size to 2 181 000 ha. The two large infestations which straddled the Atikokan, Fort Frances and the Atikokan-Thunder Bay District boundaries, merged and enlarged to form a single infestation stretching from the Adrian and Marks townships area of Thunder Bay District to the Rowan-Kakagi lakes area of Kenora District, totalling some 1 722 000 ha. A number of smaller pockets of moderate-to-severe defoliation occurred around the main body of infestation, affecting a total area of 55 456 ha in the Kenora, Fort Frances, Ignace, Atikokan and Thunder Bay districts. The infestation in the Poshkokagan Lake-Black Sturgeon Lake area of Thunder Bay and Nipigon districts expanded to the east and north to encompass 251 000 ha, an increase in area of about 126 500 ha. A small isolated pocket of about 200 ha persisted in islands in Moar Lake in the Red Lake District.

The outbreak in northeastern Ontario consists of two main sections, eastern and western along with a number of sizeable pockets in the northern part of the area. The western section stretches from the western Espanola District through the Blind River, Sault Ste. Marie and Hearst districts to the eastern Terrace Bay and southeastern Geraldton districts affecting a total area of 3 987 305 ha. Within this section substantial increases in the area of moderate-to-severe defoliation were recorded in the Sault Ste. Marie, Hearst and Wawa districts and somewhat smaller increases were noted around the western periphery of the infestation in the Terrace Bay and Geraldton districts.

These increases were more than offset by declines which occurred in the eastern section of the outbreak. This section extends from the eastern Espanola District through the Sudbury, Temagami and North Bay districts to the Quebec border totalling approximately 1 759 259 ha of moderate-to-severe defoliation. Substantial declines occurred in the Sudbury, North Bay and Espanola districts while moderate increases occurred in Tamagami and Kirkland Lake districts. In addition, a number of other medium to large patches of moderate-to-severe defoliation totalling 616 176 ha were recorded in the Kapuskasing, Cochrane, Kirkland Lake, Gogama, Sudbury and North Day districts. The Timmins and Chapleau districts remained virtually free of infestation but low populations were present in a number of areas. Overall the area of moderate-to-severe defoliation in northeastern Ontario declined by approximately 218 000 ha.

Despite a small decrease (15 000 ha) in the total area of moderate-to-severe defoliation in southern Ontario, sizeable areas remained infested in the Algonquin Park, Parry Sound and Minden districts. Small pockets of infestation which occurred in the southern Minden, Owen Sound and southern Bracebridge districts in 1982 subsided this year. The total area of moderate-to-severe defoliation in southern Ontario was 407 494 ha.

As stated above, budworm-associated tree mortality increased in all three geographical areas of the province and now stands at 12 119 710 ha, a total increase of 485 710 ha or 4.2%. The largest increase (420 982 ha) occurred in northeastern Ontario where 10 354 982 ha of tree mortality now occurs. In northwestern Ontario, budworm-associated mortality increased by 41 417 ha to 191 417 ha. The smallest increase, 23 311 ha, occurred in southern Ontario where the total now stands at 1 573 311 ha.

Estimates of the impact of spruce budworm, in the form of depletion of primary growing stock of the three host species (white spruce, black spruce and balsam fir) are summarized in Table 3. As predicted in the 1982 report, amount of growth loss and tree mortality for balsam fir and to a lesser extent white spruce, have diminished in northeastern and southern Ontario where continued decreases in the budworm populations have meant reduced stress on host stands. In contrast, growth loss and tree mortality increased in Northwestern Ontario where infestations have been building steadily for several years. Not included in Table 3 is some 14 000 000 m^3 of accumulated growth which brings the total accumulated loss to date to about 104 000 000 m^3.

FORECASTS 1984

Egg surveys and defoliation estimates were carried out at locations across Ontario in August and September. The results of these show an overall increase in egg densities of 61% (Table 4). In northwestern Ontario, densities increased by 75% overall, with increases occurring in all districts. Consequently, infestations are expected to intensify, and the area of moderate-to-severe defoliation increase substantially in 1984 in this part of the outbreak. In northeastern Ontario, results were much less uniform, with egg densities increasing in six districts and decreasing in eight districts. However, overall, an increase of 32% was recorded. It is expected that areas of moderate-to-severe defoliation will increase in the western portions of the outbreak (Wawa and Hearst districts) and in the northeastern part of the outbreak (Temagami and Kirkland Lake districts). Populations, and consequently defoliation, will probably decrease in the Sault Ste. Marie, Blind River, Espanola and Sudbury districts and persist at about the same levels in North Bay District. Increased populations, based on a 35% increase in egg densities, are expected in the Chapleau District, which has been free of moderate-to-severe defoliation for the past two years. In southern Ontario, overall egg densities declined by 17% and this should be reflected in a continued decline in the total area of moderate-to-severe defoliation. However, numerous areas of moderate-to-severe defoliation will probably persist in the Parry Sound and Algonquin Park districts in the Algonquin Region.

RESULTS OF SPRAYING OPERATIONS

In 1983, aerial spraying operations were conducted against the spruce budworm over an area of 3 502 ha in Hearst District. Some 2 600 ha of commercial forest and another 902 ha of high value forest (provincial parks, plantations and a moose yard) were treated with both chemical and biological insecticides. Included in the total of 3 502 ha treated in 1983 were 7 experimental plots totalling 340 ha that were treated with several *B.t.* (*Bacillus thuringiensis*) formulations. Each plot received 30 BIU's per hectare although the application rates varied. The *B.t.* formulations tested were Dipel 88, Dipel 6L, Dipel 8L and Bactospeine. The *B.t.* formulations used operationally on some 2 763 ha were Dipel 88 and Novabac 3. As in 1982, most of this year's program (89%) involved the use of various formulations of *B.t.* The remaining 11% (399 ha) of the area was treated with the chemical insecticide Matacil. A summary of the 1983 budworm spraying program is provided in Table 5.

Under normal conditions, spruce budworm emergence usually occurs during the second week of May in Hearst District. However, in 1983 cool, damp spring weather delayed this process by two or more weeks and in several areas emergence did not occur until the first week of June. Warmer-than-normal temperatures in June and July tended to compensate for the cool May temperatures and budworm larval development progressed rapidly. On June 13, when spraying began, larval development was approaching the peak of the third instar and by June 20, when spraying was complete, most budworm were in the fourth and fifth instars. Spruce budworm development is summarized in Table 6.

The results of the 1983 aerial spraying program are presented in tables 7 to 12. Basic data, such as pre- and post-spray population densities, larval mortality (due to treatment) and foliage protection, are presented in each table.

In 1982, three blocks of commercial forest in McEwing Township, totalling 1 842 ha, were aerially treated with *B.t.* to reduce budworm populations. Each block is scheduled to be harvested by 1986 and, as outlined in the provincial spraying policy (Policy No. TM 13-04), is eligible for treatment in any of 3-year's within the 5-year period. Based on the results of egg-mass surveys conducted in 1982, which indicated moderate-to-severe defoliation would likely occur in 1983, it was decided to continue the protection spraying program in these blocks again this year. An additional 758 ha, scheduled to be harvested by 1987, was also included. Dipel 88 (20 BIU/5.9 l/ha) was applied to two commercial blocks (1 390 ha) between June 15 and 18 when budworm larvae were predominantly in the third and fourth instars. Novabac 3 (20 BIU/5.9 l/ha) was used in a third block during the same period. Results of these treatments are presented in Table 7. Unexpectedly low pre-spray larval densities were encountered in the sample plots. Nevertheless, assessment of the two treatments revealed that both were equally effective in further reducing budworm populations and limiting defoliation.

Novabac 3 and Dipel 88 (both applied at 20 BIU/5.9 l/ha) were also used to protect foliage in two provincial parks: Nagagamisis Provincial Park in McEwing Township and Fushimi Provincial Park northwest of the Town of Hearst. Spraying operations against budworm were conducted in Nagagamisis Provincial Park in 1981 and 1982, and in Fushimi Provincial Park in 1982. Results of the 1983 treatments, as summarized in Table 8, show that each formulation was very effective in reducing larval populations and protecting foliage on balsam fir. Dipel 88 proved to be less effective on white spruce in Nagagamisis Provincial Park and no assessment was conducted on white spruce in Fushimi Provincial Park due to a lack of spruce in this area.

A comparison of tables 7 and 8 reveals that both Dipel 88 and Novabac 3, applied at a dosage and rate of 20 BIU/5.9 l/ha, appear to be equally effective in reducing budworm populations and protecting foliage. It is also evident that each was more effective on balsam fir than on white spruce.

In the summer of 1982, OMNR began an experimental program of multi-year applications of *B.t.* in white spruce to establish whether or not foliage protection on mature white spruce can be achieved using operational applications of only *B.t.* during the 5-year time frame outlined in the provincial spray policy. A stand of mature white spruce was selected in Frost Township, Hearst District and treated with Thuricide 32B in 1982. The same area was treated again on June 20, 1983 with Bactospeine (30 BIU/4.7 l/ha). Based on the results presented in Table 9, and considering the relatively high pre-spray larval densities, this *B.t.* formulation seems to have been very effective in reducing budworm populations and limiting defoliation.

In 1981, another project was started for the purpose of determining the impact of continued spruce budworm defoliation on growth in valuable white spruce plantations. In order to determine the extent of growth loss in the infested plantations, it was necessary to limit budworm impact, as much as possible, in one of the neighbouring plantations. A study site was located in an area of white spruce plantations in Rogers Township, Hearst District and each summer, since 1981, an area of approximately 200 ha (Rogers #43A) has been sprayed with Matacil 1.8D. Results of this year's treatment are summarized in Table 10 along with results of an identical Matacil treatment in Chelsea Township. The Chelsea Hill moose yard was first treated in 1982 to preserve balsam fir foliage while studies of the effects of experimental harvesting techniques upon moose behaviour could be assessed. While excellent results were achieved in the Rogers Township plantation, population reduction and foliage protection were less than satisfactory in the Chelsea Hill moose yard. These poor results may, in some way, be linked to technical problems reported during this operation.

Experimental trials, involving several formulations of the biological insecticide Dipel, were carried out in a number of white spruce plantations in Rogers Township. The dosage of each treatment was kept constant at 30 BIU and only the rates of application were varied. Each formulation of Dipel 88, Dipel 6L and Dipel 8L was applied at two rates: neat (or directly from the barrel) and in a 50:50 dilution with water. Spraying occurred between June 16-18 when most budworm larvae were in the third and fourth instars. The results, as summarized in tables 11 and 12, indicate a greater effectiveness on balsam fir in terms of population reduction, however, defoliation of both tree species was relatively heavy in most cases. It should be noted, that pre-spray populations varied considerably among treatments and were generally quite high. Past experience has shown *B.t.* to be most effective when pre-spray larval densities are less than 25 or 30 per 46 cm branch tip. Unfortunately, only two of the experimental treatments were conducted in areas with pre-spray populations within this range - Dipel 88 at 3.5 ./ha and Dipel 6L at 2.3 l/ha. Excellent results were achieved on balsam fir in the area treated with Dipel 88 but as noted earlier, results on white spruce continued to be disappointing.

In 1981 and 1982, ground spraying operations were carried out in the Barbara Lake Seed Production Area (SPA) in Terrace Bay District. Using a mistblower, this same SPA was treated again on June 23, 1983 with Orthene Tree and Ornamental Spray 75% AE. A check of larval development on June 20 revealed that most budworm were in the fifth and sixth instars and that considerable defoliation had already occurred. Therefore, despite substantial larval mortality, foliage protection was minimal (Table 13).

In 1982, FIDS staff also conducted surveys to assess ground and aerial releases of the budworm egg parasite *Trichogramma minutum* that were conducted in Rogers Township, Hearst District. Experimental releases of this parasite were first attempted in 1982 in Rogers Township by OMNR in cooperation with the CFS, the University of Guelph and University of Toronto. While results were somewhat disappointing in 1982, parasitism levels of 22 to 64% were observed this year.

PLANS FOR 1984

At this time, plans have not been finalized for the 1984 aerial spraying program. Results of the 1983 egg-mass survey indicate high budworm populations are likely to recur in Hearst District in 1984. As well, very high populations are expected in the northwestern districts of Thunder Bay, Atikokan and Fort Frances. Consequently, aerial spraying operations totalling 3 000 to 4 000 ha are likely to be continued in Hearst District and a new program involving some 6 000 ha may be initiated in Thunder Bay District in 1984.

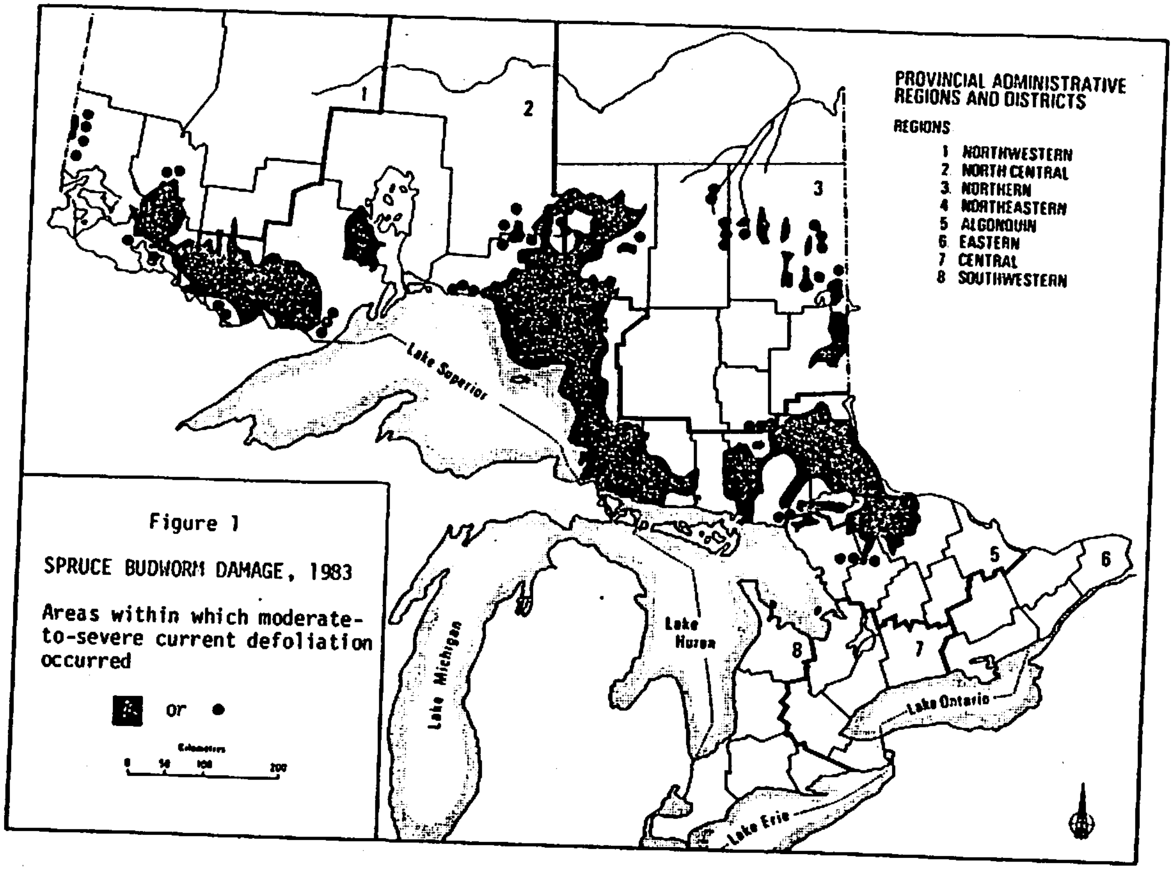


Figure 1

SPRUCE BUDWORM DAMAGE, 1983

Areas within which moderate-to-severe current defoliation occurred

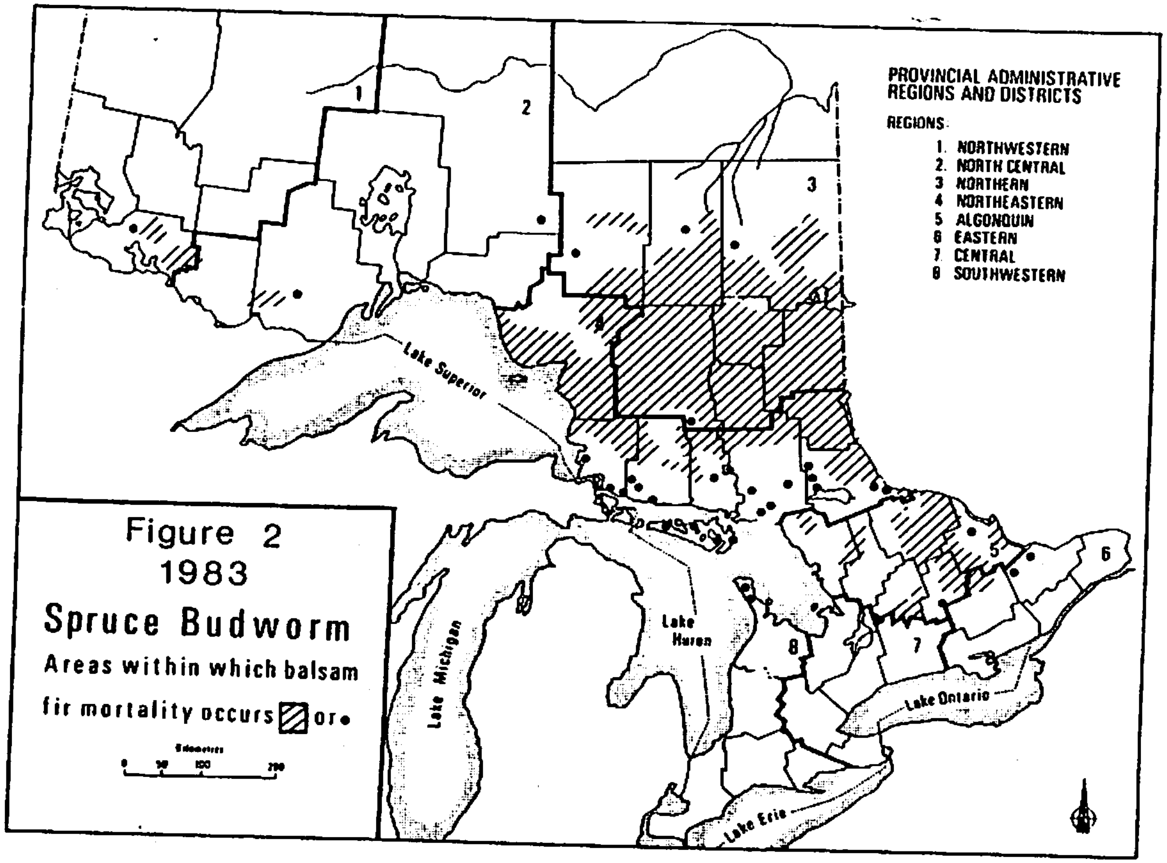


Figure 2
1983
Spruce Budworm
Areas within which balsam fir mortality occurs ▨ or ●

Table 1. Comparison of spruce budworm defoliation in Ontario 1981 to 1983

Outbreak region	Gross area of moderate-to-severe defoliation (000 000 ha)			
	1981	1982	1983	Change in 1983
Northwestern	0.658	0.931	2.181	+1.250
Northeastern	16.958	6.669	6.451	-0.218
Southern	0.601	0.423	0.408	-0.015
TOTAL:	18.217	8.023	9.040	+1.017

Table 2. Comparison of the area of budworm-associated tree mortality in Ontario in 1982 and 1983

Outbreak region	Gross area of budworm-associated tree mortality (000 000 ha)		
	1982	1983	Change
Northwestern	0.150	0.191	+0.041
Northeastern	9.934	10.355	+0.421
Southern	1.550	1.573	+0.023
TOTAL:	11.634	12.119	+0.485

Table 3. Depletion of primary growing stock by spruce budworm in Ontario (000 000 m^3)

	Growth loss (CAI) in 1983	Tree mortality in 1983	Volume loss in 1983	Cumulative mortality to 1983
Balsam fir	1.288	7.966	9.254	69.062
White spruce	.185	1.743	1.928	11.556
Black spruce	.340	1.727	2.067	9.553
TOTAL:	1.813	11.435	13.249	90.171

Table 4. Comparison of average egg-mass density for four regions in Ontario in 1982 and 1983.

Outbreak region	No. of locations	Average no. egg masses per 9.3 m^2		
		1982	1983	% Change
Southern	76	55	46	-17
Northeastern	182	211	279	+32
North Central	65	423	749	+77
Northwestern	128	489	860	+75
OVERALL:	451	294	472	+61

Table 5. Summary of aerial spraying against spruce budworm in Hearst District, Ontario in 1983.

Location	Hectares	Date sprayed	Treatment	Status*	Number of applications
Rogers Twp					
Plantation 37A	30	June 16	Dipel 88 30 BIU/3.5 ℓ/ha	E	1
" 37B	40	" 17	Dipel 6L 30 BIU/2.3 ℓ/ha	E	1
" 49A	60	" 17	Dipel 6L 30 BIU/4.7 ℓ/ha	E	1
" 26A	50	" 17	Dipel 8L 30 BIU/1.75 ℓ/ha	E	1
" 49C	60	" 17	Dipel 8L 30 BIU/3.5 ℓ/ha	E	1
" 43B	40	" 18	Dipel 88 30 BIU/7.0 ℓ/ha	E	1
" 43A/26B	214	" 18	Matacil 1.8 F 90 g/3.0 ℓ/ha	0	1
Chelsea Twp. Moose Yard	185	" 13	Matacil 1.8F 90 g/3.0 ℓ/ha	0	1
McEwing Twp					
Block A	190	" 17, 18	Dipel 88 20 BIU/5.9 ℓ/ha	0	1
" B	1210	" 18, 19	Novabac 3 20 BIU/5.9 ℓ/ha	0	1
" C	1200	" 15, 16, 17	Dipel 88 20 BIU/5.9 ℓ/ha	0	1
Frost Twp. Experimental Block	60	" 20	Bactospeine 30 BIU/4.7 ℓ/ha	E	1
Nagagamisis Prov. Park	123	" 17	Dipel 88 20 BIU/5.9 ℓ/ha	0	1
Fushimi Prov. Park	40	" 20	Novabac 3 20 BIU/5.9 ℓ/ha	0	1
TOTAL	3502				

*Status

E = Experimental

0 = Operational

Table 6. Spruce budworm larval development in Hearst District, 1983

Area	Date	Tree species	Larval Development (%) II	III	IV	V	VI	Pupae
Chelsea Twp Sprayed June 13	June 8	bF	74	16				
		wS	100					
	June 10	bF	5	95				
		wS	49	51				
	June 12	bF	10	90				
		wS	14	86				
Nagagamisis Prov. Pk.	June 8	bF	75	25				
		wS	91	9				
	June 10	bF	72	28				
		wS	41	59				
	June 13	wS	14	40	46			
Rogers Twp Sprayed June 16-20	June 8	bF	66	33				
		wS	85	15				
	June 10	bF	18	82				
		wS	15	85				
	June 14	bF		48	52			
		wS	2	12	79	7		
	June 16	bF	2		78	20		
		wS	2	33	60	5		

Table 7. Population reduction, pupal survival and foliage protection attributable to single applications of Dipel 88 and Novabac 3 (20 BIU/ 5.9 L/ha) on commercial forests in McEwing Twp, Hearst District, 1983.

	Host	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation %
<u>Dipel 88</u>					
Block A & C	wS	4.6	0.3	50	7
Checks	wS	5.0	0.7		16
<u>Novabac 3</u>					
Block B	wS	7.3	0.4	60	7
Checks	wS	8.0	1.0		28

Table 8. Population reduction, pupal survival and foliage protection attributable to single applications of Dipel 88 and Novabac 3 (20 BIU/ 5.9 L/ha) in two provincial parks in Hearst District, 1983.

	Host	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation %
<u>Dipel 88</u>					
Nagagamisis Prov. Pk.	bF	5.2	0.3	80	5
Checks	bF	6.0	1.8		24
Nagagamisis Prov. Pk.	wS	5.6	0.3	57	10
Checks	wS	6.0	0.8		21
<u>Novabac 3</u>					
Fushimi Prov. Pk.	bF	4.2	0.1	92	3
Checks	bF	5.0	1.5		20

Table 9. Population reduction, pupal survival and foliage protection attributable to a single application of Bactospeine (30 BIU/ 4.7 L/ha) on a white spruce experimental plot, Hearst District, 1983.

	Host	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation %
Frost Twp					
Experimental Block	wS	38.5	1.5	77	25
Checks	wS	35.9	6.2		99

Table 10. Population reduction, pupal survival and foliage protection attributable to single applications of Matacil 1.8F (90 g/ 3.0 L/ha) on two areas of Hearst District, 1983.

	Host	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation %
Chelsea Hill Moose Yard	bF	15.4	3.3	33	53
Checks	bF	20.2	6.5		69
Chelsea Hill Moose Yard	wS	20.2	1.5	0	48
Checks	wS	34.0	2.6		43
Rogers Twp #43A	bF	28.5	0.2	98	24
Checks	bF	25.2	9.7		99
Rogers Twp #43A	wS	31.4	0.2	97	11
Checks	wS	48.4	9.0		90

Table 11. Population reduction, pupal survival and foliage protection on balsam fir attributable to single applications of Dipel 88, Dipel 6L and Dipel 8L (30 BIU) in Rogers Township, Hearst District in 1983.

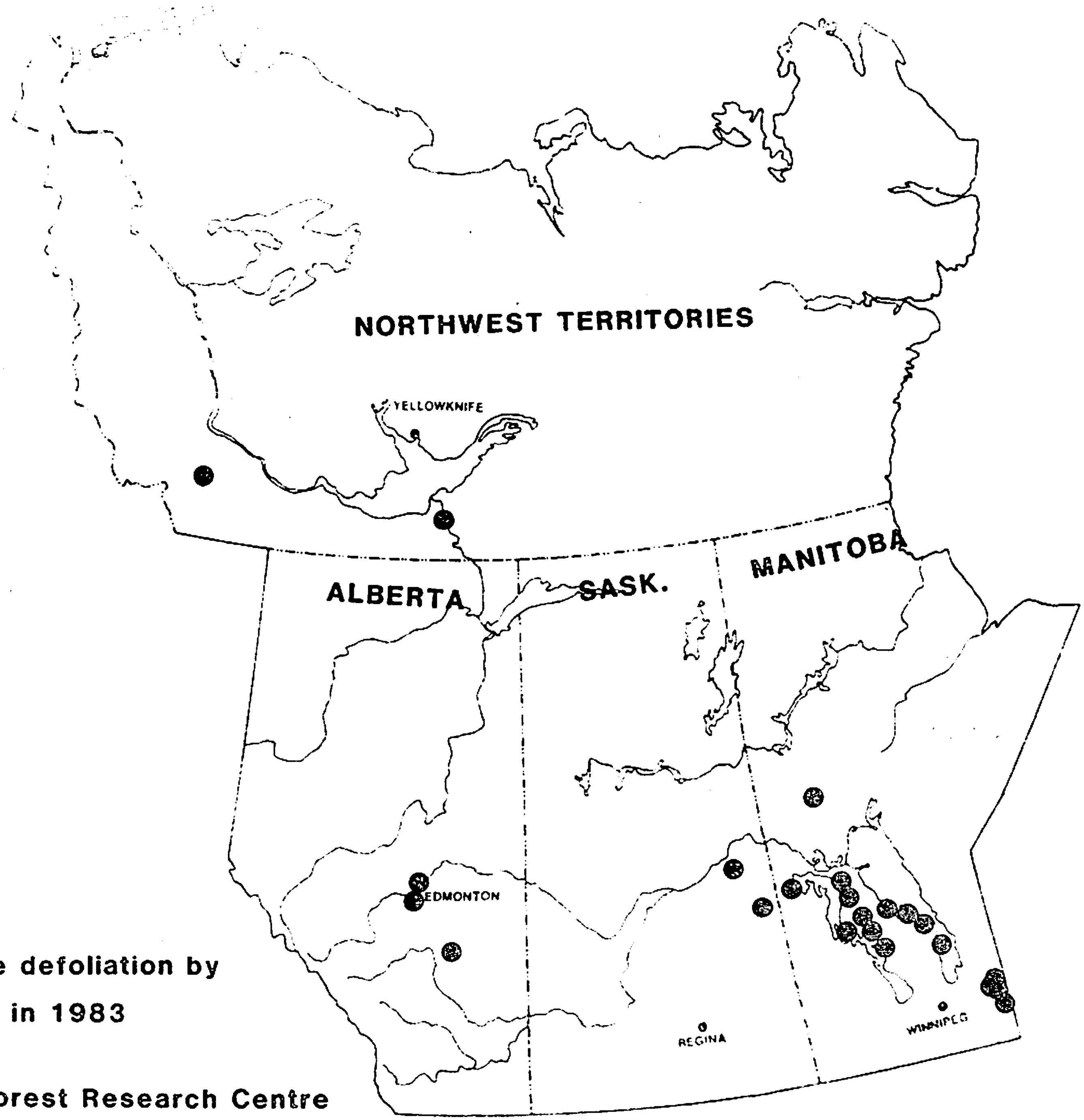
Treatment	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation (%)
Dipel 88 - 3.5 ℓ/ha	24.8	0.8	92	21
Checks	25.2	9.7		99
Dipel 88 - 7.0 ℓ/ha	49.1	0.8	89	65
Checks	46.7	7.2		98
Dipel 6L - 2.3 ℓ/ha	27.7	3.4	68	61
Checks	25.2	9.7		99
Dipel 6L - 4.7 ℓ/ha	56.2	4.3	51	86
Checks	46.7	7.2		98
Dipel 8L - 1.75 ℓ/ha	47.2	3.2	56	78
Checks	46.7	7.2		98
Dipel 8L - 3.5 ℓ/ha	34.9	4.4	58	59
Checks	30.3	9.1		99

Table 12. Population reduction, pupal survival and foliage protection on white spruce attributable to single applications of Dipel 88, Dipel 6L and Dipel 8L (30 BIU) in Rogers Township, Hearst District in 1983.

Treatment	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation (%)
Dipel 88 - 3.5 ℓ/ha	36.5	6.4	12	56
Checks	48.4	9.0		90
Dipel 88 - 7.0 ℓ/ha	56.9	4.8	34	71
Checks	59.5	7.7		93
Dipel 6L - 2.3 ℓ/ha	23.9	4.5	6	60
Checks	48.4	9.0		90
Dipel 6L - 4.7 ℓ/ha	71.2	4.5	43	76
Checks	74.2	8.3		94
Dipel 8L - 1.75 ℓ/ha	47.3	5.9	39	83
Checks	51.3	10.4		92
Dipel 8L - 3.5 ℓ/ha	36.0	5.6	23	56
Checks	51.3	10.4		92

Table 13. Population reduction, pupal survival and foliage protection attributable to a single treatment of Orthene 97SP applied by mistblower to a white spruce seed production area (SPA) in Terrace Bay District, 1983

	Pre-spray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	Population reduction due to treatment (%)	1983 defoliation %
Barbara Lake SPA	38.1	3.6	68	49
Checks	35.5	10.6		58



Moderate-severe defoliation by spruce budworm in 1983

FIDS,Northern Forest Research Centre

A SUMMARY REVIEW

The 1983 Maine Spruce Budworm Spray Program, Spruce Budworm Population Conditions in 1983, and a Forecast for 1984.

Maine Forest Service
DEPARTMENT OF CONSERVATION

TABLE OF CONTENTS

LIST OF TABLES & FIGURES

Spray Project Operations

The Maine Forest Service treated 846,382 acres (342,665 hectares) of spruce budworm infested forest land in 1983 with biological and chemical insecticides. Table 1 indicates the various insecticides used and the acreage treated with each. Total cost of the 1983 Spruce Budworm Management Program was $5.862 million (U.S.) or $6.93 per acre sprayed ($17.12/hectare), a significant reduction in cost from the 1982 program. Cost savings were accomplished primarily through the elimination of rotary wing aircraft and a switch to Matacil 180F[R] as the principal chemical insecticide. A breakdown of program costs by major component is shown in Table 2.

Spray operations began on May 25 (A.M.) and were completed on June 23 (A.M.) Budworm development and spray operations were hampered during the first 10 days of the project by cool, damp weather. The weather then became very warm and dry and continued so through the remainder of the operational period.

Project Headquarters was again centered at Presque Isle and seven air bases of operation were utilized in northern and eastern Maine. Figure 1 shows the 1983 spray area. Tables 3 and 4 contain information on acres treated by airport and gallons by aircraft type, respectively.

Funding for the 1983 Maine program was generated from an excise tax assessed on participating landowners. In addition, the State's General Fund contributed $108,596 to support budworm research and survey activities, and the USDA Forest Service contributed $98,000 to support the Small Landowner Assistance Program.

TABLE 1. *Insecticides Used and Acres Treated, 1983 Maine Spruce Budworm Program.*

	Acres (Hectares)	Percent of Total
Matacil 180F (aminocarb)	632,953 (256,256)	75%
Sevin-4-Oil (carbaryl)	89,498 (36,234)	11%
Orthene Forest Spray (acephate)	4,627 (1,873)	1%
Dipel 6L (Bt)	25,814 (10,451)	3%
Dipel 4L (Bt)	2,954 (1,196)	--
Thuricide 32LV (Bt)	80,205 (32,472)	9%
Thuricide 24 B (Bt)	8,479 (3,433)	1%
Bactospeine (Bt)	1,852 (750)	--
TOTAL	846,382 (342,665)	100%

TABLE 2. 1983 Maine Spruce Budworm Management Program Cost Summary

ITEM		COST ($1,000 U.S.)
Spray Aircraft		$1,446
Monitor/Admin. Aircraft		181
Survey Aircraft		33
Insecticide		1,600
Fuel Oil #1		158
Mixing/Loading		428
Personal Services		1,156
Food/Lodging		99
Research		157
Health Monitoring		52
Equipment		56
Operating Expenses		497
	TOTAL	$5,863

Acres treated = 846,382

Cost per acre = $6.93 (U.S.)

Cost per Hectare = $17.12 (U.S.)

FIGURE 1. 1983 Project Spray Area

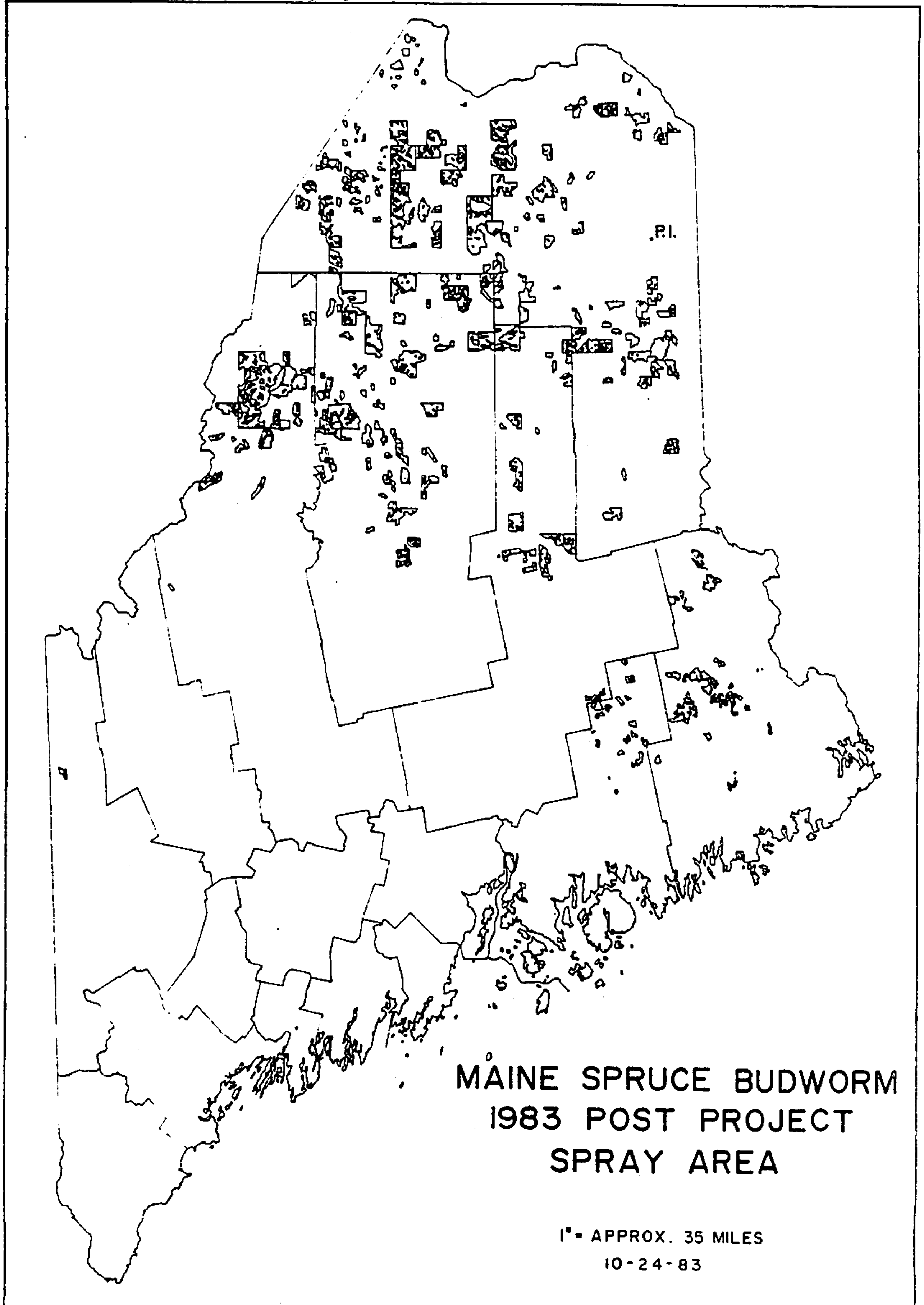


TABLE 3. Acres Treated by Airport, 1983 Maine Spruce Budworm Spray Program.

AIRPORT	ACRES (HECTARES) TREATED		PERCENTAGE OF TOTAL
Presque Isle	501,240	(202,931)	59%
Millinocket	103,556	(41,926)	12%
Red Pine	76,844	(31,111)	9%
Frenchville	53,792	(21,778)	6%
Princeton	49,415	(20,006)	6%
Jackman	48,870	(17,761)	5%
Old Town	17,665	(7,152)	2%
	846,382	(342,665)	99%*

*Does not total 100% due to rounding of individual figures

TABLE 4. *Gallons Sprayed by Aircraft Type, 1983 Maine Spruce Budworm Program.*

AIRCRAFT & SPRAY SYSTEM	GALLONS	PERCENTAGE OF TOTAL
C-54, boom & nozzle	111,149	40%
M-18, micronair	37,047	13%
Thrush, micronair	47,174	17%
Thrush, boom & nozzle	49,140	18%
Airtractor, micronair	16,880	6%
Airtractor, boom & nozzle	16,251	6%
TOTAL	277,941	100%

Long-Term Environmental Monitoring Project

The Maine Forest Service initiated the first year of a Long-Term Environmental Monitoring project in 1983. A private contactor was chosen to initiate the project by collecting data on terrestrial and aquatic vertebrate and invertebrate populations, plant communities, abiotic factors, and ecosystem functions on twenty-two fixed sample plots though-out Maine's spruce fir forest. The project is scheduled to last 5 years and should provide insights into the long term effects of spraying and budworm defoliation on terrestrial and aquatic ecosystems.

Private Spray Programs

In addition to the Maine Forest Service Program, six private spruce budworm spray programs treated a total of 165,000 acres in Maine in 1983. International Paper Company sprayed 104,000 acres in northern Maine with aminocarb, mexacarbate and *Bt*. J.D. Irving Company sprayed 20,000 acres in northern Maine with aminocarb. The Passamoquoddy Indians treated 30,000 acres, and Baskahegan Company 8,000 acres respectively with *Bt* in Washington County. The Town of Garfield treated 1,000 acres with aminocarb and Blanchette treated 2,000 acres with *Bt*.

PRELIMINARY RESULTS

MAINE SPRUCE BUDWRORM SUPPRESSION PROJECT, 1983

PREPARED BY

HENRY TRIAL, JR., DIRECTOR OF SURVEY & ASSESSMENT

AUGUST, 1983

INTRODUCTION

In 1983, the Maine Forest Service conducted an aerial spray program against the spruce budworm beginning on May 25th and ending on June 23rd. The project covered 848,624 acres and involved the use of eight insecticides applied at ten rates. Timing of each rate was based on the insecticide used, the population, and the major target host (spruce or fir). Orthene was applied in a single application, but all other chemicals were applied as a split application. All Bt was applied as a single 12 B.I.U. application. The major portion of the acreage (635,331 acres) was sprayed with Matacil 180 F in a split application. The remaining project area was sprayed with Sevin-4-Oil (89,441 acres), Orthene (4,624 acres) or with one of five Bt products (119,228 acres). Bt products used were Dipel 4L, Dipel 6L, Thuricide 32LV, Thuricide 24B, and Bactospiene.

Most of the blocks treated in 1983 had been protected for two or three years prior to 1983 and were in fair prespray condition. Exceptions to this generalization occurred in new blocks added in Hancock, Washington Counties and in a few scattered blocks in northern Maine. These blocks were in critical condition prior to the 1983 operation. Surveys predicted extreme populations in all of northwestern Maine. Populations were as predicted and higher than any seen since 1978.

DEVELOPMENT, SPRAY TIMING, AND WEATHER

Larval instar development and the expansion of host tree buds were closely monitored in order to properly time the release of spray blocks. Data were collected every three days from fifteen permanent development locations throughout the State. Each sample provided a larval index and a bud index. When the index of a permanent point in the vicinity of treatment blocks approached the desired release timing, spot developments were initiated within the blocks for final timing. The desired timing for each treatment variation is shown in Table 5.

A large number of spot developments were taken in 1983 to properly time applications. Spot developments were especially important for timing the first applications in spruce stands. Timing in these areas required direct observations of the position of insects and the swelling of shoots.

TABLE 5. TREATMENT VARIATIONS EVALUATED IN THE 1983 MAINE SPRUCE BUDWORM CONTROL PROJECT INCLUDING PLANNED TREATMENT TIMING

INSECTICIDE	RATE ACTIVE INGREDIENT (OZS.)	FINAL SPRAY VOLUME OZS.	AIRCRAFT	NUMBER OF APPLICATIONS	TIMING*
MATACIL	1.0	20	C-54 THRUSH M-18	2	1,2,3
SEVIN-4-OIL	6.0	24	C-54 THRUSH	2	1,2
ORTHENE	8.0	64	THRUSH	1	4
DIPEL 6L	12 B.I.U.	64 32	THRUSH M-18	1	4
DIPEL 4L	12 B.I.U.	48	THRUSH	1	4
THURICIDE 32LV	12 B.I.U.	64 48	THRUSH M-18	1	4
THURICIDE 24B	12 B.I.U.	96	M-18	1	4
BACTOSPIENE	12 B.I.U.	64	THRUSH	1	4

*TIMING:

1. 1st application before larvae enter spruce buds; 2nd application 5th or early 6th instar.
2. 1st application 50 to 70% 4th instar; 2nd application 5 to 7 days later.
3. Both applications before larvae enter spruce buds.
4. Peak 4th instar.

The larval development season in 1983 was unusual containing two radically different and long lasting weather patterns. During the early instars in May and early June the weather was cool and wet. Rain fell nearly every day. In early June the weather changed to a very hot, dry pattern, which lasted through the remainder of the project. Temperatures were in the 80's for most of this period.

Larval development during the early wet weather was extremely slow. Larvae emerged at or slightly before normal, but quickly became retarded in their development. Larvae were very inactive during the cool, wet weather and fed very little. By the 4th instar, larval development was 10 to 14 days slower than normal.

Larval development was very fast during the hot, dry weather. After about two weeks of hot, dry weather development had quickened to a pace only slightly slower than normal.

Shoot development was also drastically affected by the unusual weather. The cool, wet weather seemed to be favorable for fir shoot development. By the late 3rd instar, fir shoots were well elongated with individual needle tips showing (Index 4). The shoot development index was advanced relative to the larval index.

Shoot development data is not kept for spruce, but observations suggest that spruce was not advanced as was fir. Red spruce buds broke at the normal time or later than normal in some areas.

Wet weather in May and early June delayed first applications in some areas, but most treatments were delayed for five days or less. Very slow development during this period caused these delays to be insignificant in terms of defoliation. The second application of several blocks was also delayed by weather, however, these delays were caused by high temperatures, haze, and wind. Delays were generally less than seven days, but even four to five days under very hot, dry conditions resulted in measurable losses of foliage. Most notable losses were seen on fir in the northwest.

APPLICATION VARIATIONS AND TIMING

Several application variations were used in 1983 (Table 5). Most of the project area was treated with split applications of Matacil or Sevin-4-Oil. Most splits were timed such that the first application occurred before larvae entered the spruce buds and the second application was planned for peak 5th instar or red spruce bud break, whichever occurred first. This timing was used in red spruce areas and where red spruce made up an important portion of the stand. In areas stocked predominantly with fir, the first application was applied when 50 to 70 percent of the larvae were 4th instar (Index 3.4 to 3.7) and the second application was applied five to seven days later. Both variations were expected to provide good fir protection, but the later second application was expected to provide better spruce protection. In 1983, 1st application release came at about the same time for both timing variations because larvae were slow to enter the spruce buds. Usually the two timing regimes differ by two to five days. Often larvae move from the needle to around spruce buds in the 3rd instar, but in 1983 the wet weather delayed the move until most larvae were in the 4th instar. One small block was sprayed twice with Matacil before the larvae entered the spruce buds. This timing was used with Sevin-4-Oil in a similar test in 1982 with good results in terms of spruce protection.

All Orthene and Bt products were applied as a single application. Orthene was sprayed at the 8 oz. per acre A.I. rate and all Bt at 12 B.I.U.. Spray regimes used for the various Bt products varied considerably. Dipel 6L, Thuricide 32LV and Bactospiene were all applied at the 64 oz. rate. In addition, Dipel 4L, Dipel 6L, and Thuricide 32LV were applied undiluted at 48, 32 and 48 oz. respectively. Thuricide 24B was applied at 96 ozs. per acre rate.

Orthene and all Bt products were timed for peak 4th instar. A well expanded fir shoot target was also necessary for block release (Index 3.5 to 4.0)

PRE-SPRAY POPULATION LEVELS

Population levels in all spray areas were evaluated prior to spraying (Figure 2). These evaluations allow for deletion of low population areas and finalization of block release timing based on spring populations.

Extreme populations were found in northwestern and northcentral Maine (26 to 70 larvae per 18 inch branch tip) (Figure 2). High and very high levels were found in the northeast, the Rangeley area, and in portions of the southeast. Other areas were found to be moderate with the exceptions of low counts in blocks treated for the last few years in the west and some blocks in the Millinocket area.

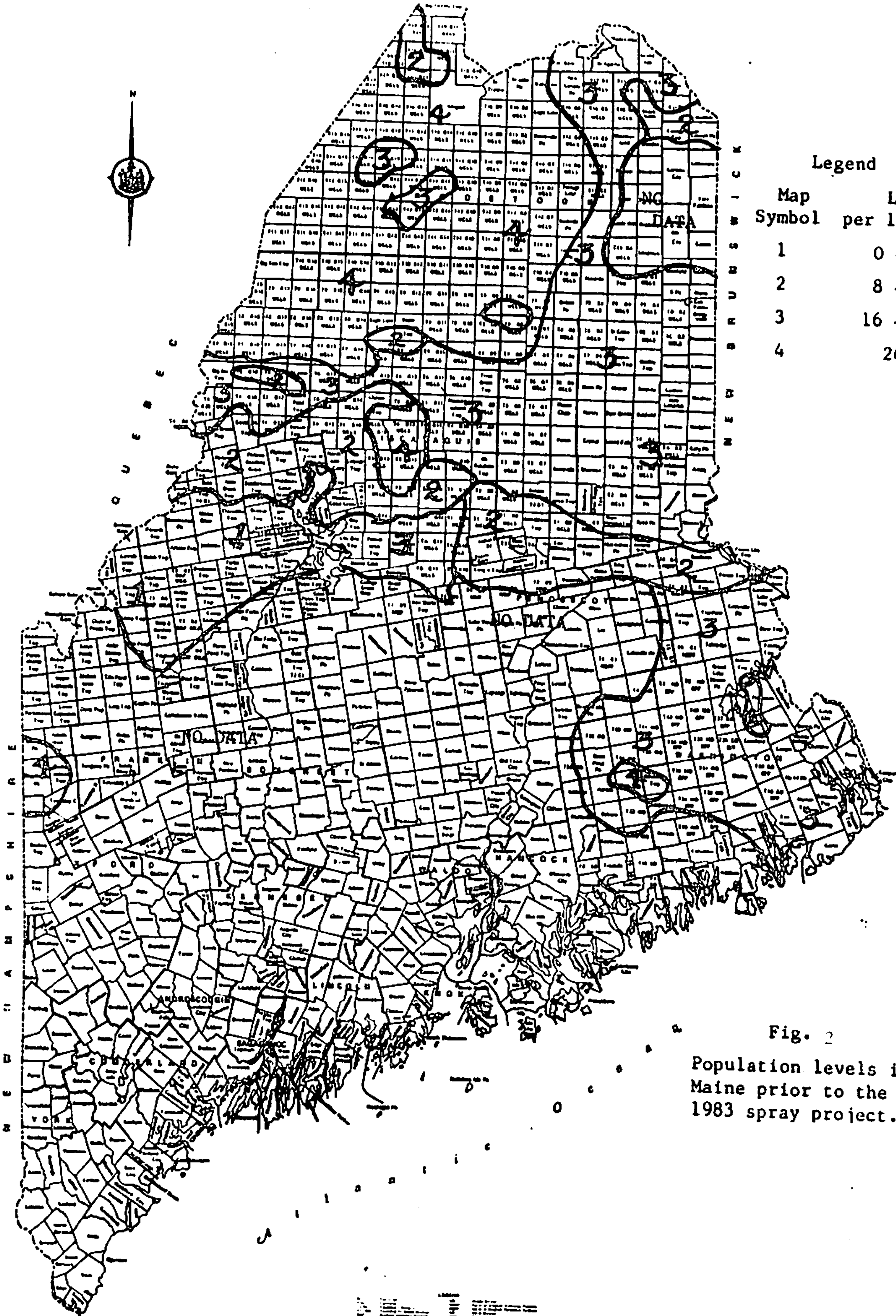
In many areas, large variations were noted between fir and spruce counts. Extreme counts on spruce and low or moderate counts on fir were found in many areas. In most cases spruce had high counts. In some spruce survey lines, individual inter-tree counts varied as much as 200 larvae per tip.

As a direct result of the 1983 prespray survey six blocks containing about 16,501 acres in western and central Maine were dropped from the project. These blocks were all found to have low populations.

PRESPRAY HOST CONDITIONS

Host tree condition was fair or good (terms referring to the stands ability to recover if sprayed) in blocks which had been sprayed two or three times since 1978. Most of these protected blocks were in northwestern or northeastern Maine. Some blocks in the northwest were sprayed for the first or second time in several years and these blocks were in poor condition.

Many blocks in Washington, Hancock, and Penobscot Counties have not been protected aggressively in the past five years and host trees in these areas were in poor or critical condition. Many blocks in these areas had some



Legend

Map Symbol	Larvae per 18" branch
1	0 - 7
2	8 - 15
3	16 - 25
4	26+

Fig. 2

Population levels in Maine prior to the 1983 spray project.

volume of dead fir and were designated for spruce protection. Tree condition in Washington County and southern Aroostook Counties blocks that were treated in 1981 and 1982 were generally improved by spraying and were in fair condition.

Stands in the southwestern treatment area were generally in good condition. Low populations throughout the southwest in 1981 and 1982 resulted in good foliage crops on trees still able to produce buds. These improved conditions aided in the decision to drop several of these blocks from the 1983 program.

The amount of dead wood in unprotected areas and buffers in the spring of 1983 was impressively high. Large volumes of dead wood can now be found anywhere in the infested area where protection has been withheld. The volume of dead spruce in the north and southeast is increasing dramatically.

SPRAY RESULTS

Spray results will be reported for each treatment variation employed in the 1983 operation. Many of the treatment variations used were evaluated in several areas and each area is listed separately. Tables 6 and 7 list spray results for chemical insecticides and Bt respectively. Results are presented as the number of survivors per 18 inch tip, unadjusted mortality, defoliation in sprayed areas, and foliage saved (defoliation in the unsprayed check minus defoliation in the blocks) for fir, spruce, and in some areas, hemlock.

Methods for efficacy determination of the 1983 project are shown in Sampling and Analysis Design For Experimental Insecticide Monitoring (Maine Forest Service Technical Report No. 12, Kemp, et. al., 1979) and the Maine Forest Service Spruce Budworm Survey and Assessment Manual (MFS Technical Report in preparation).

Data presented is preliminary and results may change somewhat in the final report due to additional analysis.

The 1983 spray project had variable results, with much of the treatment area showing more damage than had been seen in the 1979 through 1982 seasons. Despite this general observation of poorer results, most blocks showed acceptable foliage protection and population reduction compared to relevant untreated checks.

Unadjusted population reduction ranged from 82 to 99 percent with chemical insecticides and from 73 to 98 percent with Bt. The highest and most consistent reductions were in Sevin blocks. Generally, unadjusted mortality was extremely variable with Matacil and Bt products and the majority of lines evaluated showed higher survival than in years 1979 to 1982. Higher survival occurred in scattered blocks throughout the project area and on both fir and spruce. Areas of consistent high or low suvival were not seen as was the case in 1982. The variability in survival seems to be related to inconsistent spray results and unusual weather conditions.

Natural mortality in untreated areas was also extremely variable, probably due to weather. Mortality in checks ranged from 98 to 40 percent. Mortality was generally higher on spruce than on fir, but variability was seen with both

TABLE 6. RESULTS OF CHEMICAL INSECTICIDE TREATMENT
VARIATIONS BY AREA FOR THE 1983 MAINE SPRUCE BUDWORM CONTROL PROJECT

Treatment	Area	Host	No. Sur. Per 18" Tip	% Red. Unadj.	% Def.	% Fol. Saved
MATACIL Split Application 1.0 oz. + 1.0 oz. A.I. in 20 oz.						
Early/Late Small Aircraft	A48, A50 T15R14	F	3.45	81.8	78.0	19.6
		S	1.05	93.7	66.6	22.2
	B48, B49 T28 MD	F	2.93	82.7	58.8	23.9
		S	4.07	83.6	31.1	31.0
		H	3.65	85.9	25.8	36.7
	B10, Stockholm	F	0.13	99.7	64.8	30.6
		S	0.40	98.8	44.3	41.4
	C63, T10R16	F	0.50	98.8	70.7	26.9
		S	0.47	98.6	49.9	39.7
	M57, M59, M84 Princeton Area	F	1.78	89.4	33.8	22.5
		S	0.67	97.0	53.4	31.8
		H	1.48	91.1	25.4	25.0
Early/Late Large Aircraft	A30, T16R12	F	4.33	85.2	94.1	3.5
		S	2.33	90.3	78.5	10.3
	F 1, T8R13	F	0.40	97.7	14.6	63.9
		S	0.70	95.1	47.4	39.0
	G 1, G12 ,T10R7	F	0.67	97.6	19.7	46.2
		S	0.70	97.3	47.6	32.9
	B18, T14R7	F	1.13	96.5	67.9	27.5
		S	0.67	97.9	35.9	49.8
	D10, T12R9	F	1.27	97.3	89.3	8.3
		S	0.87	97.8	68.7	20.1
	D25, T10R12	F	0.27	97.4	17.6	72.4
		S	0.07	99.5	45.0	43.8
	E46, E10, Russell Pd. Area	F	4.49	75.5	69.4	28.2
		S	1.85	92.1	40.5	48.3
Early/Early	M70, Alligator Lk.	F	2.93	85.7	20.0	26.9
		S	0.80	97.6	28.4	25.1
		H	3.56	77.9	28.7	28.4

TABLE 6 (CONTINUED). RESULTS OF CHEMICAL INSECTICIDE TREATMENT VARIATIONS BY AREA FOR THE 1983 MAINE SPRUCE BUDWORM CONTROL PROJECT

Treatment	Area	Host	No. Sur. Per 18" Tip	% Red. Unadj.	% Def.	% Fol. Saved
SEVIN-4-OIL 6.0 oz. + 6.0 oz A.I. in 24 oz. Early/Late	F18, F21; T8R8	F	0.48	98.1	28.7	43.0
		S	0.18	99.3	39.1	36.1
	A59 T15R10	F	0.40	98.9	84.5	13.1
		S	0.67	99.0	20.4	68.4
	E 8, T6R18	F	1.33	95.6	58.5	39.1
		S	0.13	99.3	26.1	62.7
Orthene 8 oz. in 64 ozs. Peak 4th	Not Available at this time					

TABLE 7. RESULTS OF BT INSECTICIDE TREATMENT
VARIATIONS BY AREA FOR THE 1983 MAINE SPRUCE BUDWORM CONTROL PROJECT

Treatment	Area	Host	No. Sur. Per 18" Tip	% Red. Unadj.	% Def.	% Fol. Saved
DIPEL 6L 12 B.I.U. in 64 ozs.	G 46, Smyrna	F	2.20	73.0	47.1	25.7
		S	2.05	85.5	58.7	13.5
	M82, M111; T26ED	F	2.12	93.6	44.6	43.6
		S	0.80	97.4	26.0	45.3
		H	2.27	89.3	34.1	33.8
	M72, M73; T34MD SMALL TREES	F	0.80	81.3	12.3	18.1
		S	0.73	90.4	13.8	16.6
	M121	F	3.67	78.7	26.1	33.4
		S	3.47	79.7	20.0	41.6
		H	0.33	97.8	6.3	26.4
DIPEL 4L 12 B.I.U. in 48 oz. Undiluted	M 5; Danforth	F	0.83	94.5	15.1	36.1
		S	0.55	96.4	16.4	16.4
DIPEL 6L 12 B.I.U. in 32 oz. Undiluted	M 10; Topsfield	F	0.95	87.5	28.4	22.8
		S	0.52	86.6	20.9	11.9
THURICIDE 32LV 12 B.I.U. IN 64 Ozs.	G 26; T9R3	F	0.75	91.3	52.2	20.6
		S	0.35	97.4	34.1	38.1
	B 5; T17R5	F	2.80	88.6	45.6	27.0
		S	1.53	93.7	59.1	13.1
THURICIDE 32LV 12 B.I.U. IN 48 oz. Undiluted	B 13; Stockholm	F	2.10	85.4	56.9	34.3
		S	0.43	96.9	24.3	47.9
THURICIDE 24B 12 B.I.U. in 96 ozs.	J12; Medway	F	1.40	91.2	33.4	45.6
		S	1.27	91.8	13.1	38.0
BACTOSPIENE 12 B.I.U. in 64 ozs.	G 27; T8R3	F	1.01	86.7	45.6	27.2
		S	1.63	81.9	42.8	29.4

species. Variability occurred within areas and even within assessment lines.

Untreated survival is used to calculate mortality adjusted by the Abbott's formula. However, the variability of survival in checks meant that the Abbott's formula correction was meaningless and thus not used.

Defoliation was generally heavier in 1983 than has been seen in the last few seasons, but treated areas have much less defoliation than untreated checks. Distinguishing treated and untreated areas during the aerial survey was extremely easy.

In the years 1979 to 1982 defoliation in sprayed areas was 30 to 50 percent of the expected defoliation (based on unsprayed checks). Figures in 1983 showed less foliage saved than past years. Defoliation was 40 to 70 percent of the expected. Foliage saved figures in the northwest were very low in some blocks due to high larvae counts. If larval feeding on one year old foliage (back feeding) had been considered (added to the defoliation level in check areas), foliage saved would be much higher. Little back feeding was observed in spray areas.

Mean defoliation to fir in sprayed areas ranged 94 to 17 percent with the highest defoliation occurring in the northwest. Fir defoliation in most blocks was an acceptable 40 to 60 percent compared to near 100 percent defoliation in many untreated areas.

Fir defoliatioon was low in the more moderate population areas and in areas receiving good spray coverage. Fir defoliation in some of the large aircraft areas was high due to very high larval counts and delays in the second application due to bad weather.

Fir in spray blocks generally appeared to have less defoliation when observed during the aerial survey than when observed from the ground. This variation was due to lower defoliation on tree tops than on lower and middle crowns as confirmed by occular estimates taken for each crown segment. Less upper crown defoliation was probably due to much better spray deposit on tree tops. The advanced flush and rapid growth of fir foliage probably resulted in much of the spray being intercepted by upper crown foliage, thus not reaching the lower and middle crowns.

Mean defoliation to spruce range from 78 to 12 percent again, with the highest levels in the northwest. Most blocks were 40 to 60 percent defoliated in 1983 compared to 25 to 50 percent levels in past seasons. Spruce defoliation in untreated checks was much higher than normal with most areas 60 to 90 percent defoliated.

In general, spruce defoliation in both treated and untreated areas was far heavier than normal in 1983. Differences between 1983 and past years may include; heavier than normal larval population, unusual larvae/spruce synchrony, or less effective spray results on spruce.

In many treated blocks a portion of the spruce had moderate or even heavy defoliation, but the remainder of the spruce and the fir in the block would have only light defoliation. This "spotty" defoliation on spruce was not due to spray misses, but rather to extreme variability of population and timing of bud flush between spruce trees.

Hemlock defoliation was lower than in past years, in most cases 20 to 30 percent. This is probably due to lower counts in the southeast where most hemlock is found.

The best and most consistent foliage protection was seen in areas sprayed with Sevin. With the exception of high fir defoliation on block A59, all Sevin areas showed a high percentage of foliage saved. Good Sevin results were probably due to the long residual of the material and good deposit under marginal weather conditions.

Results with Matacil varied from very good to unacceptable. Nearly all blocks with unacceptable results had application problems with one or both applications, or in a few cases, were treated late due to weather delays or unusual development. Most Matacil blocks were acceptable or good relative to untreated areas. Some unacceptable blocks would be acceptable if back feeding on one year old foliage was considered. In some northwest blocks less than 20 percent of the 1983 foliage was saved, but in untreated areas nearby 100 percent of the 1982 foliage and 50 to 80 percent of the 1983 foliage was lost due to back feeding.

Large aircraft Matacil blocks seem to have inconsistent results probably due to unusual weather which adversely effected deposit with larger planes.

Bt was generally sprayed in areas of high to moderate population pressure and was not used under extreme conditions such as in the northwest. Most Bt treatments were good or acceptable in terms of foliage saved. Undiluted treatments with Dipel and Thuricide were as good or better than higher volume diluted applications. Nearly all Bt treatments were as effective on spruce as they were on fir. This was not true in many Matacil blocks where spruce was more heavily defoliated than fir.

Five Bt blocks in the Princeton area, treated with Dipel 6L at 64 oz., were sprayed during the long rainy period when larvae were very inactive. Post treatment checks of these blocks gave no indication of adequate treatment. All five blocks were retreated with Thuricide 32LV at 48 oz. in an attempt to achieve adequate results. Results on two of these blocks show adequate results despite the loss of significant foliage prior to the second treatment.

MAINE SPRUCE BUDWORM SURVEYS FOR 1983

AND

FORECAST FOR 1984

Following the 1983 spruce budworm feeding season, surveys were conducted to evaluate 1983 conditions and to make predictions for 1984. Surveys included an aerial defoliation survey, a population predictions survey, a ground tree condition evaluation, and an aerial tree condition survey. Data gathered in these surveys were used to establish a hazard rating for 1984 and to prepare treatment recommendations for the landowners.

AERIAL DEFOLIATION SURVEY

An aerial survey conducted in July showed extreme 1983 defoliation in unsprayed portions of Northwestern and Southeastern Maine. About a third of the sprayed portion of these areas showed light defoliation and most other spray blocks had moderate defoliation. Spray blocks in all other areas had predominately light and some moderate defoliation. Unsprayed areas in the northeast, and far southwest portions of the outbreak area showed moderate to extreme defoliation. Most of the central portion of the outbreak area had only light defoliation. In summary , the area of moderate to extreme defoliation increased slightly from 3.8 million acres in 1982 to 4.0 million in 1983. Defoliation intensity within the moderate to extreme area also increased significantly.

POPULATION PREDICTION SURVEY

The Maine 1983 population prediction survey was conducted from August through Mid-October.

In August, an egg mass survey was conducted in the northwest, southeast, and far southwest. Approximately 500 sample points were visited and samples were taken from fir and spruce. Beginning in Mid-September, the remainder of the outbreak area was evaluated with the overwintering larval method (L-II). About 500 L-II points were taken. The L-II method is used in areas where variable, low or moderate population levels were expected. Egg mass is only used in areas where uniform high population levels are expected. L-II has been a much more accurate population predictor in Maine in recent years.

Results of the 1983 population survey show large decreases in much of the infested area. Nearly all of Northern Maine had high or extreme populations in 1983, but 1983 predictive surveys show much of the area to be moderate or low. Mean predicted population levels for the north were less than half the 1982 level, but several areas of high and extreme population remain in the northwest.

Population levels were found to be very low in much of the southwest and central portions of the infestation. An area of high and extreme population was again found in the Rangeley area. In the southeast, predicted population showed a decrease from uniform high and extreme to a variable moderate and high level. Smaller low and extreme areas were also found in the southeast.

HAZARD FORECAST

A hazard rating was determined for each egg mass and L-II sample point. The system employed has been used for several years and is designed for fir. The rating includes predicted populations (from egg mass and L-II sampling), current defoliation, past defoliation (2 previous years), tree vigor, and presence of dead tops. Hazard is classed as low, moderate, high, or extreme. Points are plotted on maps and used in combination with aerial damage data to produce a final hazard map for landowners.

The portion of the budworm area in high or extreme hazard is somewhat smaller than the 1982 area (4.5 million acres in 1982 compared to 4.2 million acres in 1983). Hazard intensity has decreased in several areas due mainly to lower predicted populations. The north remains primarily in high hazard with spots of extreme. Large areas in the northeast have improved to moderate. Several years of low population and low defoliation have resulted in a lowering of hazard in the southwest and central areas. Most of this area is now in low or moderate hazard. Sprayed areas in the southeast have reduced hazard due to lower defoliation. Much of this area has been lowered from extreme to high or moderate hazard.

HOST MORTALITY

The 1983 mortality survey has not been completed, but an increase in host mortality is expected. Increases in size and mortality intensity are expected in untreated portions of the northwest and southeast. Most mortality areas mapped in the past contain 80% or more dead fir and spruce mortality is increasing.

Some areas now have more than 25% spruce mortality.

TREATMENT FORECAST FOR 1984

A treatment area of from .5 to 1 million acres is expected. Most treated land will be in the northwest and southeast. The operation will be conducted with chemical and biological insecticides.

ENVIRONMENTAL MONITORING IN MAINE, 1983

By Kristina Weeks Oliveri
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There were two environmental monitoring projects funded by the Maine Forest Service in 1983. One was the last year of a four year study on the effects of carbaryl on pond macroinvertebrates. The other was the first year of a five year study of the long-term effects of insecticide spraying and budworm defoliation on the spruce-fir forest ecosystem.

Pond Macroinvertebrate Study Conducted by K. Elizabeth Gibbs, Ph.D. University of Maine, Orono, Maine.

Ponds in the Jackman, Maine area were sampled for the fourth year to determine whether populations of pond macroinvertebrates had recovered from carbaryl sprayed in 1980. One group of organisms, the amphipods, had been apparently eliminated from the two treated ponds and the number of Odonata (dragonflies) in one of the treated ponds was depressed. Sampling in 1982 indicated a return of amphipods to one of the treated ponds. Initial analysis of two months of 1983 samples shows the recolonization of one of the treated ponds by amphipods continues. The other treated pond shows no signs of a similar recolonization. Data on the Odonata has not yet been analyzed.

Long-Term Environmental Monitoring Study (LTEM) Conducted by Eco-Analysts, Inc., Georgetown, Maine and the Maine Forest Service.

The LTEM study was launched in 1983 with the first sampling activities being conducted according to the techniques manual designed for the study in 1982. The need for modifications became apparent during this first year of field work.

Bird censusing started in June and ended in mid-July. Ten hectare plots had been established at 22 sites. These were set up in a 50 x 50 meter grid system. Tape recording of bird songs revealed dialects apparently unique to the study areas.

The aquatic invertebrate sampling did not proceed as smoothly as the bird censusing. Many of the streams selected as study sites had conditions which prevented sampling in the manner outlined in the techniques manual. Some of the outstanding problems included: no resident trout populations, streams which were outfalls of dams and hence not typical forest stream environments, streams which dried up as the summer progressed, streams too large for effective sampling, and streams with excessive sedimentation that hindered sampling.

More suitable aquatic sites are being selected for the remaining four years of the study.

Five streams were electrofished in the spring of 1983 and four in the fall. Data is being analyzed for brook trout production and utilization of aquatic invertebrates.

Artificial substrates were placed in the streams to determine types and relative numbers of aquatic invertebrates. Rocks in mesh bags and leaf packs were used as substrates. Some substrates set in the streams in the spring were subjected to flood conditions and did not provide representative samples. Others were not adequately colonized because they were not truly representative of stream bed conditions. For 1984, rock bags will be set in place in the fall of 1983 to allow time for conditioning.

Leaf packs, using sugar maple (*Acer saccharum*) leaves, were set in streams to monitor leaf processing invertebrates. Sedimentation in some streams also caused problems with this portion of the study. Streams subject to excessive sedimentation will not be used in 1984. American beech

(Fagus grandifolia) leaves will be used for spring leaf packs to more closely align the study with natural forest conditions.

Weather observations and aquatic parameters (i.e. stream pH, temperature, turbidity and current were also recorded.)

Tree and lesser vegetation data were collected by Maine Forest Service personnel. Tree data included such measurements as DBH of all live trees over 4.6", species, merchantability and crown position in the selected plots. Dead and dying trees were also noted, as well as the extent of budworm damage. Additional information on the site, such as drainage, was included.

All of the parameters measured will be analyzed and an attempt will be made to model the interactions between various environmental components, as they are influenced by either insecticide application or spruce budworm caused defoliation.

SPRUCE BUDWORM CONDITIONS IN THE UNITED STATES 1983

EASTERN SPRUCE BUDWORM
Choristoneura fumiferana (Clemens)

LAKE STATES

There was a slight increase in the extent of defoliation in Minnesota, Michigan, and Wisconsin this year. After only two years of light to moderate defoliation on 250,000 acres (101,000 ha) following an extensive outbreak, defoliation increased to 305,461 acres (123,712 ha). Defoliation occurred on about 25 percent of the spruce-fir type in the Lake States. Populations of budworm are increasing throughout the region, but much of the defoliation was not evident from aerial surveys.

Nearly 1.2 million cubic meters (500,000 cds) of spruce-fir were killed on National Forest lands between 1977 and 1982. Additional dead timber was salvaged where accessibility, harvest regulations, and markets permitted. The harvest of dead and dying timber has reduced losses significantly where markets exist. About half the spruce-fir volume in attacked stands remains alive. This residual volume is now being defoliated by spruce budworm.

Four major methods for assessing spruce-fir mortality on the Nicolet National Forest, Wisconsin are being evaluated, to determine the one that is most cost effective. Results of the evaluation will be available early in 1984. We do know that even with the serious outbreak of the 1970's and 1980's nearly half the spruce-fir remains alive.

Between 1977 and 1982, the budworm killed about 50,965 cords of spruce and fir on 186,876 acres (75,280 ha). This equates to 2.7 cords/acre or 20 percent of the available balsam fir volume, according to a State of Minnesota survey. White spruce losses were negligible, while black spruce loss was not detected. Suppression of budworm populations on 5,800 acres (2,349 ha) is proposed on the Superior National Forest in Minnesota for 1984.

The extent and intensity of defoliation is expected to increase throughout the Lake States in 1984.

NEW ENGLAND STATES

MAINE

Since the Maine Forest Service will present their budworm status for 1983, it will not be repeated here, but I will discuss the Maine Indian Lands. This year the Passamaquoddy Tribe treated approximately 40,000 acres (16,200 ha). The major objective, to protect 35 million cu ft of spruce, fir, and hemlock stands, was met. Defoliation in treated stands was negligible. For 1984, the

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Comments by Peter W. Orr, Staff Director, Forest Pest Management, Northeastern Area, State and Private Forestry, Broomall, PA at the Eleventh Annual Forest Pest Control Forum, Ottawa, Ontario, Canada on November 15, 1983.

Passamaquoddy Tribe proposes to treat 30,000 acres (12,150 ha) and the Penobscot Tribe proposes to treat 10,000 acres (4,050 ha). Current defoliation on the Penobscot Tribe's holdings is 14,589 acres (5,909 ha) while that on Passamaquoddy tribal lands is 21,509 acres (8,711 ha).

VERMONT

In 1983, defoliation occurred on 178,086 acres (72,125 ha), an increase of over 28,000 acres from 1982 and 78,000 acres from 1981. Defoliation increased for the last 8 years. Tree mortality is occurring on 114,386 acres (46,326 ha) with 20,000 acres (8,100 ha) being in the over 25 percent dead category. The Vermont Department of Parks and Recreation staff is encouraging industries such as power and light companies to use dead and dying material for fuel.

Vermont conducted a suppression project on over 1,411 acres (571 ha) to prevent defoliation and protect timber stands. Various formulations of the biological B.t. were used. In general, foliage protection was satisfactory and over 1.5 million cu ft of spruce-fir volume were protected. An additional 310 acres (126 ha) were also treated as part of a Demonstration Project begun in 1983. The Demonstration Project is a cooperative effort between the Vermont Department of Forests and Parks, USDA Forest Service, University of Vermont, and CANUSA. The project, which includes 9 Towns in northeastern Vermont, is designed to demonstrate to landowners the latest techniques in protection, silviculture, and utilization and marketing. Thinnings to favor wildlife such as deer and also the snowshoe hare have been initiated.

NEW HAMPSHIRE

Spruce budworm populations are currently at a low level. However, dead and dying trees on 23,430 acres (9,489 ha) have been harvested by large industrial landowners in the past 5 years. Mortality is presently occurring on 30,805 acres (12,476 ha) and 25 percent of the trees are dead on about half of the area. Defoliation in 1983 covers 5,765 acres (2,335 ha) and no significant change is anticipated for 1984. This is the fourth year of a decline in the area defoliated.

WESTERN SPRUCE BUDWORM
Choristoneura occidentalis Freeman

NORTHERN REGION

The western spruce budworm outbreak areas in Region 1 increased during 1983. Buildups, in 1982 and again in 1983, follow a 4-year decline (1978-1981). Visible budworm defoliation in 1983 was recorded on 2,616,228 acres (1,058,755 ha), up 358,213 acres (144,967 ha) from 1982. Defoliated acres increased on 8 of 10 National Forest areas in Region 1. The largest increase occurred on the Gallatin National Forest, where defoliation increased from 331,537 acres (134,171 ha) in 1982 to 633,354 acres (256,315 ha) in 1983. Defoliation occurred on about 1,400 acres (567 ha) on the Nezperce National Forest, representing the first defoliation recorded there since 1978. Small declines occurred on the Bitterroot and Lolo National Forests. No budworm suppression was conducted in Region 1 in 1983.

Defoliation in Montana is expected to remain static in 1984, while in northern Idaho, a moderate increase is likely. No plans for a suppression project are anticipated at this time.

ROCKY MOUNTAIN

Defoliation increased from 2,001,510 acres (810,000 ha) in 1982 to 2,718,100 acres (1,100,000 ha) in 1983. Most of the increase is on the Colorado Front Range and on the San Juan National Forests.

In 1983, defoliation was generally moderate throughout the infested area. Almost all the Douglas-fir type has been defoliated in recent years. The latest increase is due to western spruce budworm populations expanding into mixed conifer forests. Defoliation within the currently infested area is expected to remain at similar levels in 1984. Approximately 15 percent of the infested area has some mortality, especially in the northern part of the Front Range in Colorado.

SOUTHWESTERN REGION

The western spruce budworm is at outbreak levels throughout most of the mixed conifer host type in the Southwest. The current outbreak has been underway since 1975. Visible defoliation of current year's growth remained relatively unchanged, decreasing from 348,411 acres (141,000 ha) in 1982 to 346,755 acres (140,330 ha) in 1983. The most extensive defoliation occurred in New Mexico on the Carson, Santa Fe, and Lincoln National Forests and the Mescalero Apache Indian Reservation. Less extensive defoliation was also observed on the Cibola and Gila National Forests, New Mexico, and the Kaibab National Forest and Grand Canyon National Park, Arizona, as well as on several other Federal and nonindustrial ownerships scattered throughout the Region. Although some mortality has occurred as a result of several years of consecutive defoliation, specific data on these losses is not available at the present time. Defoliation within areas currently infested is expected to continue at similar levels in 1984.

For the past two years, a western spruce budworm suppression project was conducted on the western half of the Carson National Forest. The total area treated was about 37,142 acres (15,031 ha), of which 35,187 acres were treated with carbaryl and 1,955 acres were treated with *B.t.* Unadjusted larval mortality in areas sprayed averaged 85.7 percent for carbaryl and 74.5 percent for *B.t.*

INTERMOUNTAIN

Visible defoliation increased in Utah, Wyoming, and southern Idaho. Defoliated acres increased from 2,503,123 acres (1,013,000 ha) in 1982 to 2,784,817 acres (1,127,000 ha) in 1983. In southern Idaho, the western spruce budworm defoliated 2,386,986 acres (966,000 ha) of Douglas-fir, subalpine, and grand fir. In Utah and Wyoming, 410,186 acres (166,000 ha) of Douglas-fir, subalpine, and white fir were visibly defoliated.

Defoliation increased on the Salmon, Challis, and Dixie National Forests. The greatest expansion occurred on the Boise, Payette, Bridger-Teton and Manti-LaSal National Forests. Most of the defoliation in the Region was classified as moderate to heavy.

PACIFIC SOUTHWEST REGION

Choristoneura carnana californica Powell, a new species, defoliated Douglas-fir in Trinity and Shasta Counties in California. The infestation expanded from 38,795 acres (15,700 ha) in 1982 to 88,956 acres (36,000 ha) in 1983.

PACIFIC NORTHWEST REGION

Oregon State Department of Forestry, Bureau of Land Management and the USDA Forest Service personnel are preparing an environmental analysis of the western spruce budworm problem in eastern Oregon's Blue Mountains. The team expects to complete the analysis and develop management alternatives by early February 1984. Most of the infestation is on National Forest land on the Wallowa-Whitman, Umatilla, Malheur, and Ochoco National Forests. Lesser amounts are on State and BLM lands.

The current infestation in the Blue Mountains began in 1980 when significant observable damage was recorded in 1981 on 300,000 acres (121,500 ha). The infestation rapidly expanded to more than 1.6 million acres (648,000 ha) by late 1982. This year it has risen to 2.6 million acres (1,048,377 ha). Of this total, 126,610 acres was defoliated by the Modoc budworm. Every National Forest in eastern Oregon currently has a spruce budworm outbreak. In Oregon, the western spruce budworm outbreak is expected to increase.

Major control projects were completed in 1982 and 1983. These projects were successful in collectively treating an area of over 700,000 acres (283,500 ha) of defoliation and associated host type. They will also reduce estimated volume losses by 350 million board feet over one rotation of the treated stands.

ALASKA REGION

In Alaska, ground surveys indicated a substantial increase in *Choristoneura orae* Freeman populations on white spruce in the Copper Center area. At least 1,236 acres (500 ha) of defoliation is occurring along the Edgerton Highway. Pheromone trapping studies have detected moderate numbers of budworm on both Sitka and white spruce from Anchorage to the Kenai Peninsula and in the Haines and Juneau areas of southeast Alaska.

Budworm life history and pheromone studies continued throughout 1983 in cooperation with the Institute of Northern Forestry (PNW) at Fairbanks and the Canadian Forestry Service. These studies support the opinion that, in south-central Alaska, *C. orae* is the species in question. However, future studies are needed to delineate the range of this new species in southeast and interior Alaska.

Table 1.--Summary of 1983 Spruce Budworm Defoliation, Tree Mortality, Suppression, and Forecast of 1984 Infestation

EASTERN UNITED STATES

State	Visible Defoliation	Tree Mortality	Area Sprayed	Defoliation Forecast for 1984
	Acres (X 1000)			
ME	5,500	275	849	Decrease
Indian Lands	36	-- 1/	40	Decrease
MI	146	--	0	Increase
MN	127	--	0	Increase
NH	6	31	0	Decrease
VT	178	114	2	Increase
WI	21	--	0	Increase
TOTALS	6,014	420	891	--

WESTERN UNITED STATES

State	Visible Defoliation	Tree Mortality	Area Sprayed	Defoliation Forecast for 1984
R-1	2,616	1,127	0	Static
R-2	2,718	408	0	Static
R-3	347	--	37	Decrease
R-4	2,785	--	0	Static
R-5	89	--	0	Increase
R-6	2,586	2,643	525	Increase
R-10	1	--	0	Increase
TOTALS	11,142	4,178	562	--
UNITED STATES	17,156	4,598	1,453	--

1/ Tree mortality evident but data not available.

GYPSY MOTH STATUS

Cooperative State/Federal gypsy moth suppression projects were conducted in Delaware, Massachusetts, Maryland, New Jersey, Pennsylvania, Rhode Island, and West Virginia in 1983. A total of 591,461 acres (239,361 ha) were treated with chemical or biological insecticides. About 70 percent of the treatments involved application of the biological insecticide *Bacillus thuringiensis* (*B.t.*). Most *B.t.* applications involved one application at 12 BIU's per acre (29.65 BIU/ ha). Average cost per acre of all applications was $15.75 ($38.92/ ha) ranging from $9.26 to $24.70 per acre ($22.88 to $61.04/ha). These costs include insecticide, application, overhead, and administrative costs.

In 1983, gypsy moth defoliation occurred on 2,383,368 acres (964,531 ha) throughout the northeastern United States, down from 8,171,191 acres (3,306,836 ha) in 1982. Although the trend of defoliation has declined since the record high of 12,873,000 acres (5,209,632 ha) in 1981, we expect the amount of defoliation to again increase to higher levels in 1984.

While the amount of defoliation is down in most States, increases were recorded in the peripheral States of Delaware and Maryland and the established infestation in central Michigan. In addition, populations are increasing in northern Virginia and northeastern West Virginia.

Vigorous populations still remain in central Pennsylvania, west central New York, Delaware, Maryland, and West Virginia.

Plans are underway for cooperative State/Federal suppression projects on about 554,350 acres (224,342 ha) of high value forests and forested recreational or residential areas in the spring of 1984. Most of these areas will be treated with the biological insecticide *B.t.*

Table 2.--Proposed 1984 Gypsy Moth Suppression Acreage by State.

State/Agency	Suppression Acres	Suppression Hectares	Insecticides
Delaware - Forestry	10,000	4,046.9	B.t., Dimilin
Maryland - Agriculture	120,000	48,563.3	B.t, Dimilin, Sevin
Michigan - Agriculture	1,850	748.7	B.t., Dimilin, Sevin
New Jersey - Forestry	15,000	6,070.4	Dimilin
New Jersey - Agriculture	80,000	32,375.6	B.t., Sevin, Dylox
Pennsylvania - Forestry	250,000	101,173.6	B.t., Dimilin
Rhode Island - Forestry	35,000	14,164.3	B.t., Sevin
West Virginia - Agriculture	50,000	20,234.7	B.t., Dimilin
	561,850	227,377.5	

Table 3.—1983 Gypsy Moth Defoliation by State 1/

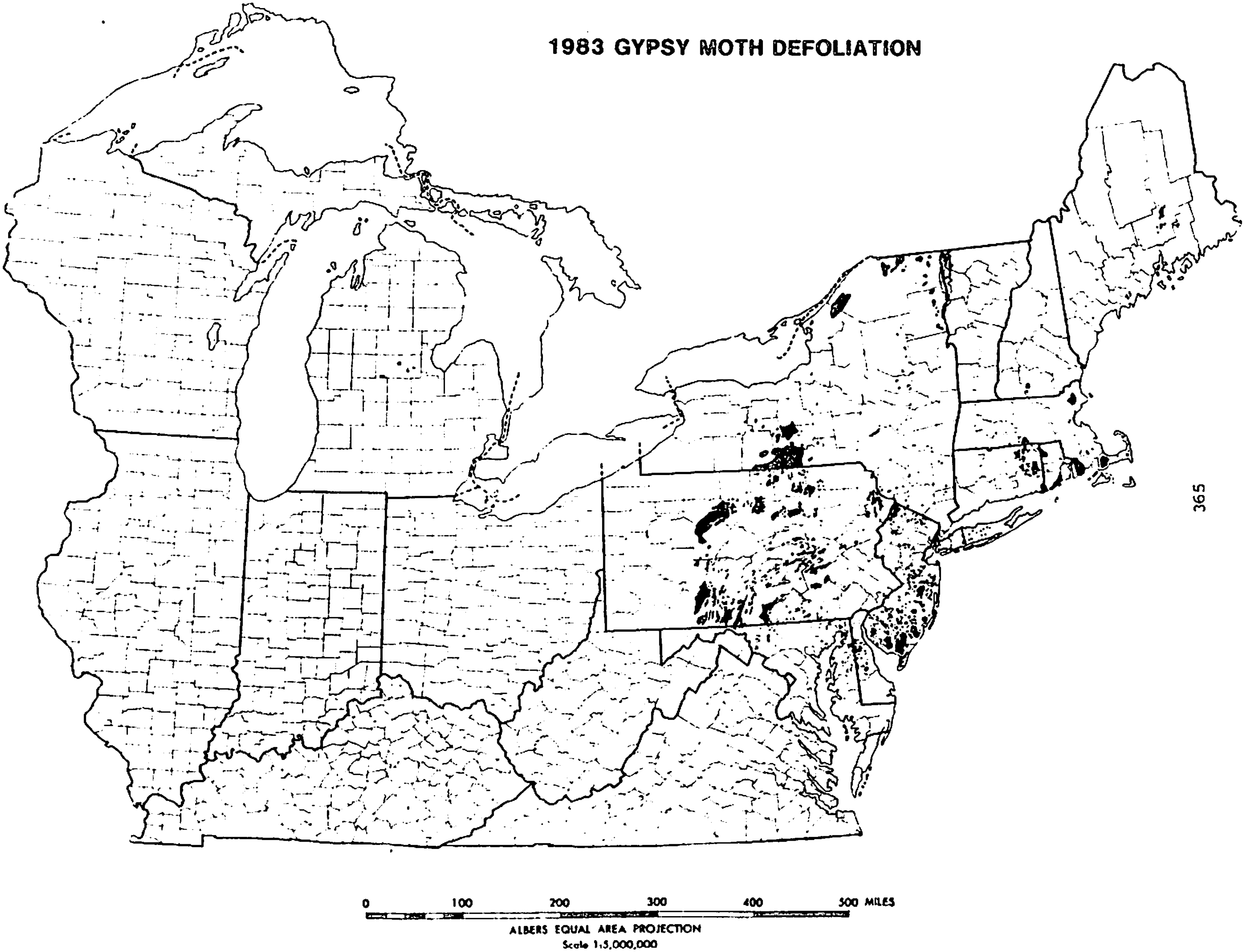
State	Defoliation Intensity 2/		
	Moderate	Heavy	Total Defoliation 3/
Connecticut	100,798	52,441	153,239
Delaware	1,855	1,137	2,992
Maine	4,574	11,711	16,285
Maryland	11,562	4,308	15,870
Massachusetts	84,045	64,088	148,133
Michigan	85	372	457
New Hampshire	560	0	560
New Jersey	156,930	183,355	340,285
New York	183,554	107,289	290,843
Pennsylvania	1,003,770	357,054	1,360,824
Rhode Island	38,590	15,290	53,880
Total	1,586,323	797,045	2,383,368

1/ Based upon State-conducted aerial detection surveys.

2/ Moderate defoliation = 31-60 percent.
Heavy defoliation = 61-100 percent.

3/ USDA Forest Service did not ask States to report light defoliation (< 30 percent). Some States, however, report light defoliation for their own purposes.

1983 GYPSY MOTH DEFOLIATION



RED PINE SCALE STATUS

The red pine scale, *Matsuccoccus reinosae*, is reported from Connecticut, adjoining southern counties in New York, northern New Jersey, and a single find in a Philadelphia arboretum in 1982. The acreage of the infested area is not large because of the limited distribution of red pine which is mostly in small plantations. The area and intensity of damage did not change dramatically in 1983.

Attempts to control the scale have not been successful, and thus, once a red pine plantation is infested, it is expected to die over a period of years. The red pine scale, formerly thought to be limited in its northward movement by cold temperatures, now appears to be moving north and west. The northward spread of the insect may be due to the limited number of red pine seedlings shipped north, and the small number of red pine plantations in the present range of the scale.

RED PINE ADELGID STATUS

The red pine adelgid, *Pineus boerneri*, was discovered in Connecticut in 1979. In a 1980 survey conducted by Dr. McClure, Connecticut Agricultural Experiment Station, the pest was found in southern Connecticut, most of Rhode Island, and along the Connecticut-Massachusetts border. Surveys have been made up to the Canadian border, but no other infestations have been found. The infested acreage is not known, since red pine is found in scattered small plantations.

Damage on red pine is similar to that caused by red pine scale, and frequently is erroneously identified as being caused by the scale. Damage progresses from twig and branch mortality to the eventual death of the tree. The early impression is that the adelgid may prove to be a more aggressive pest than the scale.

The red pine adelgid was probably introduced in Connecticut more than 25 years ago. The rather limited current distribution suggests that natural spread and establishment is slow. However, greenhouse experiments and field observations show that spread on nursery stock is possible, and that cold temperature may not limit its spread throughout the range of red pine in the United States. No extension of the range of red pine adelgid occurred in 1983.

SCLERODERRIS CANKER STATUS

Scleroderris canker is caused by two strains of the fungus *Gremmeniella abietina* in the United States. The North American strain is present in the Lake States, parts of New York, and New England. The European strain is known to occur throughout northern New York and Vermont, with small isolated infections in New Hampshire and Maine.

Currently, problems with the less virulent North American strain of the fungus in the Lake States has been greatly reduced through the use of effective fungicides in nurseries. Only in a few areas of eastern and central parts of Michigan's Upper Peninsula where the fungus is well established, are problems encountered in regenerating red pine.

The more virulent European strain is potentially more serious because it can kill susceptible pines of all sizes. The known infested area in New York nearly doubled between 1973 and 1980, and increased proportionately in Vermont due to natural spread. Since 1980, the infested area has not increased and infections in New Hampshire and Maine were apparently eradicated.

Natural spread of the disease to the west and south in New York and Vermont, if it occurs, is likely to be slow. Therefore, spread of the European strain to other areas, such as the Lake States, will probably occur through the shipment of nursery stock or Christmas trees. If infection does appear in new areas, prompt detection and eradication holds the most promise for controlling the problem.

The Federal quarantine against the European strain was removed in 1983. New York and Vermont have maintained their State imposed quarantines.

EUROPEAN LARCH CANKER STATUS

In 1983, the European larch canker was detected in tamarack stands in 5 Towns in southern Washington County, Maine, bringing the number of Towns infected to 17. Infections found in 1981-82 are as follows:

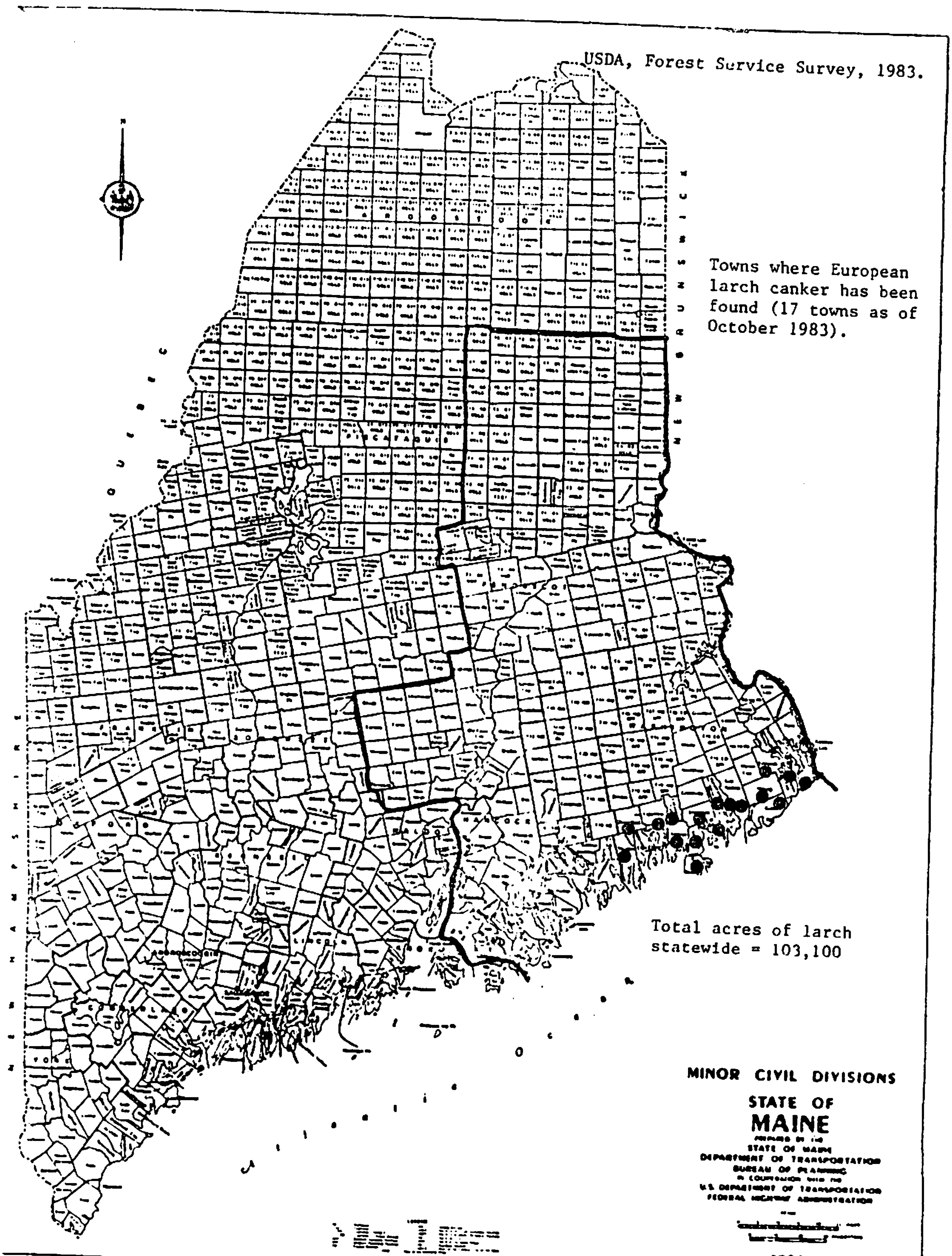
Steuben	Jonesport	Machias
Harrington	Beals Island	Whiting
Columbia Falls	Whitneyville	Cutler
Jonesboro	Rogue Bluffs	Lubec

Infections found in 1983 are as follows:

Addison	Trescott	Mount Desert
Edmunds	Cherryfield	

The net volume of tamarack growing stock on commercial forest land in New York, New England, and Pennsylvania totals over 174 million cubic feet. There is a total of 445 million cubic feet of tamarack on commercial forest land in the Lake States.

The State of Maine and the USDA Animal and Plant Health Inspection Service (APHIS) are currently reviewing the data before imposing a quarantine.


USDA, Forest Service Survey, 1983.
Towns where European larch canker has been found (17 towns as of October 1983).
Total acres of larch statewide = 103,100
MINOR CIVIL DIVISIONS
STATE OF
MAINE
1980

PACIFIC REGION - 1983

STATUS OF IMPORTANT PESTS AND EXPERIMENTAL CONTROL PROJECTS

Prepared for the Eleventh Annual Pest Control Forum

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SUMMARY OF IMPORTANT PESTS

The following have been selected as the pests most likely to be of interest to participants of the Forum. For more details of these and other pest conditions, the reader is referred to the PFRC annual publication, Forest Pest Conditions in British Columbia and Yukon.

Mountain Pine Beetle

The mountain pine beetle continued to spread and intensify in 1983 in mature lodgepole pine forests from the International border north to Prince Rupert. The area of recent pine mortality mapped during aerial surveys was about 445 500 ha, an increase from 290 500 ha in 1982. Increases resulted mainly from the expansion of outbreaks in parts of the Cariboo and Kamloops regions, but were affected in part by increased levels of data input. Current attack in cruised stands ranged from 7% to 40%. This compares with 6% to 33% in 1982 and indicates continuing infestations in 1984.

The major downturn in the demand for forest products affected some salvage operations and rescheduled harvesting programs.

A non-renewable forest licence was recently offered to harvest 500 000 m^3 of beetle infested lodgepole pine timber per year for 10 years from lands within the Williams Lake Timber Sale Area.

A localized outbreak in a provincial park was successfully abated in a cooperative program involving parks, CFS and B. C. Ministry of Forests. The program has reduced the impact from more than 3568 trees attacked in 1981 to 252 in 1982 and 36 in 1983, a high level of control. A population buildup in lodgepole pine stands within 16 km of the park constitutes a threat of reinfestation.

The mountain pine beetle Inter/Agency Committee, which includes C.F.S., British Columbia, Alberta, national and provincial parks representatives, met in October for the purpose of liaison and discussion and proposal of control action. Progress continues to be encouraging in the National Parks and Alberta but current economic restraints have affected efforts in British Columbia.

The Executive Summary and Action Plan of the Canada-

USA memorandum of understanding on cooperation in forestry related programs includes a supplement on mountain pine beetle. The action plan includes the exchange of information and techniques, wood utilization research, a survey to evaluate 8 hazard rating systems in 300 stands in B. C. and 100 in Alberta, and the establishment of a demonstration area of thinning regimes.

Spruce Beetle

Mortality of mature spruce killed by spruce beetle in 1983 declined from more than 99 000 ha in 1982 to about 64 000 ha, mainly in the Prince George and Cariboo regions. The decline was due mainly to the logging of infested stands. Outbreaks remained static in the Prince Rupert Region, and in small localized infestations in the Kamloops and Nelson regions. Favorable climatic and host conditions in early 1983 saw an increased proportion of the population accelerate their development. Cruises of infested stands indicate mainly declining populations in many areas but increases in parts of the Prince Rupert Region. As estimated 65% of the stems contained progeny of mainly two year cycle to emerge in 1985 with one year cycle in about 35%, mainly in the Prince Rupert Region.

Douglas-fir Tussock Moth.

The most serious defoliator outbreak in British Columbia in recent years continues to be the Douglas-fir tussock moth which severely defoliated about 28 000 ha of mature and immature stands; more than double the 1982 area and more than 25 times greater than 1981, the first year of the outbreak. Defoliated stands extended from near the International border to the southern part of the Cariboo Region. Many contained dead or dying trees in and around 2- and 3-year-old outbreaks in the Kamloops and Cariboo regions with localized pockets in the Nelson and Vancouver regions.

Egg mass surveys around infested stands indicate a collapse of much of the population due to natural control factors. A nuclear polyhedrosis virus affected more than 50% of the mid-instar larvae in more than 40 sample areas and Diptera parasites affected up to 58% of the late instar larvae in 8 sample areas. Pheromone trap catches were variable and small numbers of egg masses persist in some localized areas to very lightly defoliate some stands in 1984. Small numbers of mature Douglas-fir in a few areas were attacked and killed by Douglas-fir beetle after being weakened by successive years of severe defoliation.

Spruce Budworms.

The western budworm defoliated 73 550 ha of Douglas-fir forests in the Kamloops, Cariboo and Nelson regions in 1983. This represents a more than fourfold increase over 1982. Moderate and severe defoliation with some tree mortality apparent, totalled 18 725 ha with lighter feeding over 54 800 ha. Defoliation was not observed in the Fraser River drainage in the Vancouver Region for the second consecutive year, after more than a decade of infestation. The number of egg masses in and adjacent to currently defoliated stands averaged 124 (range 44-275). This indicates populations should continue in 1984 with light to severe feeding in most of the 1983 infested stands.

Light to moderate defoliation by one and two-year-cycle budworms, *Choristoneura* spp. of the current growth of alpine fir-white spruce extended over 165 200 ha mainly in the Prince Rupert and Prince George regions. Localized areas of light to moderate current defoliation occurred in the Nelson and Cariboo regions. A one-year cycle is suspected to be active in much of 153 000 ha defoliation in the Prince Rupert Region. Light to moderate defoliated is forecast for the major outbreak areas in 1984 however the increasing incidence of a naturally occurring larval and pupal pathogen, *Beauvaria bassiana*, may affect 1984 population levels.

Larch Defoliators.

Larch sawfly severely affected 10 300 ha in 72 areas in the Nelson Region, down from 12 000 in 1982. Three years after populations collapsed, a Larch budmoth severely defoliated about 6 600 ha in more than 30 high elevation western larch stands in the Nelson and Kamloops regions. After two years of decline in the Nelson Region, Larch casebearer expanded significantly in the East Kootenay area of the region. Parasites of larch casebearer reared in Ontario from European sources were released in three infested western larch stands in the Nelson Region. Since 1969 periodic parasite releases, as part of a biological control program, have contributed to a major decline of casebearer populations in larch stands in the West Kootenay area of the Nelson Region.

Black Army Cutworm.

Between 10% and 80% of newly planted lodgepole pine and spruce seedlings were killed or severely defoliated by black army cutworm in about 12 previously burned sites in widely scattered areas of the Prince Rupert and Prince George regions. Early spring population assessments and planting schedule revisions helped reduce losses.

EXPERIMENTAL CONTROL PROJECTS

Douglas-fir tussock moth.

Four 10 ha plots were treated from the air with NPV at Veary Lake in 1982 to test the effectiveness of reduced virus dosages against the Douglas-fir tussock moth (DFTM). (Population reduction caused by the spray was about 60% in the plot receiving the lowest dosage and between 90% and 93% in the other three plots. The incidence of naturally occurring NPV in the untreated control plots was low).

In 1983 the four treated plots and the 5 buffer zones between and adjoining them and the four check plots were sampled twice to determine the population density of DFTM larvae and the incidence of NPV in the larvae.

In the first samples, composed of 2nd and 3rd instars, larval populations were very low in the sprayed as well as in the buffer zones, and the incidence of larvae infected with NPV ranged from 7.3% to 43.5% in these areas. Population of larvae in the four check plots were high and the incidence of NPV low.

In the second samples, composed of 4th and 5th instars, populations in the treated plots and buffer zones were even lower while the incidence of NPV increased, ranging from 39.2% to 80.8%. DFTM populations in three of the four check plots virtually collapsed and NPV infection in the three plots ranged from 74.4% to 81.7%.

The NP virus apparently spread from the treated plots into the buffer zones in 1982 reducing DFTM density and providing inoculum which further reduced DFTM population in the early instars in 1983. DFTM populations were also reduced later in three of the four check plots by a naturally occurring epizootic.

For additional details of the 1983 sampling see joint report tabled by FPMI.

The results of the experiments with NPV tested against populations of DFTM over the past two years indicate that outbreak development and subsequent defoliation, at least in localized areas, may be prevented or delayed by the application of the virus at the beginning phase of the outbreak. The virus application at reduced dosages makes it economically more acceptable and provides forest managers with an alternative control measure to the use of chemical insecticides in their management decision.

Western spruce budworm.

One 172 ha plot was treated with NPV, another 172 ha plot with GV in 1982 to test the effectiveness of these viruses as control agents against the western spruce budworm. The two treated plots and three untreated plots were sampled in 1983 to monitor the effect of the virus (for full details of the 1983 results see joint report tabled by FPMI). The impact of virus carry-over in 1983 was considered to be disappointing: 33.7% in the NPV and 14.7% in the GV treated plot. This is a considerable reduction in percent infection from 1982 (the year of application) when the corresponding population reduction in the two plots was 51.8%, and 34.6%, respectively. Percent successful adult emergence in the two treated plots ranged from 6.1% to 23.8% in 1982 compared to 42.4% to 49.6% in 1983. In the check plots the corresponding adult emergence was 52.7% in 1982 and it ranged from 60.5% to 73.4% in 1983.

The NPV- and GV-treated plots and the three check areas will be re-sampled in 1984 to determine the incidence of infection two years after virus application.

Winter moth.

In 1983 the winter moth outbreak continued on Garry oak, other shade trees and fruit trees in the Greater Victoria area in B. C. No additional specimens of *Agrypon flaveolatum* or *Cyzenis albicans* were released after 1982 (See Pacific Region Report to 1982 Forum).

Monitoring the establishment of these two introduced parasites continued by collecting mature larvae in May before they dropped from trees to pupate in the duff and by placing parasite emergence boxes in the field the following spring. Both *A. flaveolatum* and *C. albicans* overwinter in the host pupae in the duff and emerge in the spring.

Both species of parasites were recovered again in 1983, and in increasing numbers, both in laboratory rearing from host pupae (collected as larvae in late May 1982), and from emergence boxes in the field.

Large numbers of *A. flaveolatum* were observed in 1983 around host trees of the winter moth at a number of release sites.

It appears that both *A. flaveolatum* and *C. albicans* are well established at the release sites and their numbers are increasing.

Over 2500 winter moth pupae are in rearing at present. This rearing should provide a good estimate of percent parasitism.

Monitoring the introduced parasites will continue in 1984.

Mountain Pine Beetle.

Knowledge of bark beetle dispersal is minimal and much comes indirectly from observation of spread and infestations and host selection behavior. Evidence that long distance dispersal occurs is present but difficult to interpret. Knowledge of dispersal characteristics is necessary to evaluate the efficacy of control procedures and to provide the forest manager with an additional important means to develop management strategy.

With the wet season the results from the continuing dispersal study were poor but enough information has been obtained during the past two seasons for an appraisal of short range dispersal inside a stand. In an earlier study up to 30% of the marked, released beetles were recaptured at trap trees baited with attractants. Some beetles were trapped more than 1 km from the release site within 6 hours of release. Beetles were trapped up to 9 days after release but the majority was caught within 2 days. Wind had a strong influence on the dispersal pattern as disproportionately larger numbers of beetles were trapped downwind than upwind from the release site. In a preliminary test using a balloon, 19 beetles were trapped in a clearing at levels up to treetop height. A technique has been perfected for marking emerging beetles by dusting trunks of infected trees with fluorescent powder. The powder is picked up by the emerging beetles and makes an excellent marker for dispersal studies.

Pine oil has been shown highly effective in preventing attacks by mountain pine beetle on treated lodgepole pine, and trees within 10 m, through two flight periods. However, a preliminary test using pine oil soaked particle boards placed singly on the ground at the center of 20 metre grids as a means of protecting a stand near an active infestation was ineffective.

ELEVENTH ANNUAL FOREST PEST CONTROL FORUM:

Review of Pest Control Operations

by the

British Columbia Ministry of Forests

Although many programs were reduced or uncertain as a result of the Provincial restraint program, several important activities were undertaken in forest pest management in B.C. during 1983. These are summarized in the discussion sections which follow.

A. Entomology

Forest insects continued to cause significant damage to the forest resource in 1983. Most significant of the pests currently active in B.C. were the Douglas-fir tussock moth, mountain pine beetle, spruce Beetle, Douglas-fir beetle, black army cutworm and white pine weevil (on spruce).

Douglas-fir tussock moth defoliated over approximately 23 450 ha in 1983. Defoliation was concentrated in the Kamloops Forest Region primarily in the Douglas-fir/ponderosa pine transition forests. The Ministry of Forests conducted small scale ground application trials of carbaryl and Bt. No large aerial control operations were conducted by the Ministry.

A grant-in-aid program was established to aid private landowners wishing to treat their lands for tussock moth control. This program provided 50% of the costs of treatment. 2 675 ha were aerially treated under this program, 2 375 ha with acephate and 300 ha with carbaryl. As well, a large number of trees were treated by ground application.

Preliminary surveys indicate a general decrease in moth populations in known infested areas. Plans for 1984 will be prepared when final survey results are available. Long term plots have been established in mature and immature stands defoliated for from 1 to 3 years to determine levels of mortality in relation to stand age and intensity of defoliation.

Mountain pine beetle continues to be the most damaging insect pest in 5 of the 6 forest regions in the province. Direct control activities, such as single tree disposal, have been largely curtailed due to governmentrestraint programs. Cutting priorities are being used to remove infested stands. Aggregation pheromones were also deployed in 1983. Proposed cut blocks were baited with pheromones so that the beetle population would be prevented from emigrating out of the block and into unknown areas. Approximately 1100 baits were deployed in various regions. Effectiveness of the technique will be assessed this fall.

Thinning mature pine stands has been suggested as a method of "beetle proofing". The remaining stems and success of this treatment has been reported from the U.S.A. The Ministry of Forests in co-operation with the Canadian Forestry Service, is proposing to establish a demonstration site using several thinning regimes in infested areas. The site will be monitored over several years.

Priority harvesting and trap tree programs have been used against Douglas-fir and spruce beetle in B.C. More than 30,000 trap trees were felled in the spring of 1983 to attract and remove spruce beetle populations from infested areas throughout the province. Further trap tree programs and harvesting of currently infested stands on a priority basis will be continued to reduce the spread of the insect. Trials using pheromone to limit dispersal out of proposed cutblocks have also been carried out with promising results.

The most important plantation insect pest is currently the white pine weevil infesting Sitka and Engelmann spruce on the coast and in the interior of the province. Approximately 5 700 ha have been surveyed for weevil incidence and clipping trials have been conducted on about 2 300 ha. Weevil incidence in plantations that have been clipped for 3 to 5 years is estimated as less than 1% versus about 40% in unclipped plantations. Costs of clipping operations are approximately $22 per ha.

The B.C. Ministry of Forests is participating with other agencies in both the US/Canada Mountain Pine Beetle Agreement and the InterAgency Committee for Mountain Pine Beetle. The former group includes the B.C. Ministry of Forests, Alberta Forest Service, Canadian Forestry Service and the U.S. Forest Service. This group will be consolidating existing information on the mountain pine beetle and developing new, practical management procedures.

The InterAgency Committee is made up of members from the B.C. Ministry of Forests, Alberta Forest Service, Canadian Forestry Service, Parks Canada and B.C. Provincial Parks Branch. This committee co-ordinates beetle control efforts in areas of mutual concern, especially in the Alberta, British Columbia border area. (P.M. Hall)

B. Pathology

Preliminary results of a statistically based survey of coastal Douglas-fir forests in the Vancouver Region indicated significant percentages of various forest types and forest age classes were infected by root disease fungi - Phellinus weirii was the major pathogen, and others include Armillaria mellea, Phaeolus schweinitzii, Verticicladiella wageneri and Fomes annosus. Root disease is apparently a major factor in growth of young forests, and substantial volume increases could be realized if effective root disease controls could be developed and implemented. A project is underway to estimate the effect of root diseases on timber supplies.

Following beetle salvage cutting of mixed lodgepole pine, Douglas-fir forests in the southeastern interior B.C., considerable root disease was evident of Douglas-fir left as seed trees or reserve blocks. Trials of removing stumps and planting more resistant tree species were initiated.

Demonstration areas to show effects of dwarf mistletoes and root diseases and their control at harvesting or thinning have been planned and/or established.

A workshop was held in cooperation with the Canadian Forestry Service and B.C. Institute of Technology to discuss forest management of coastal hemlock mistletoe. Several recommendations were made by government and industry participants. A proceeding is being prepared.

Concern was expressed by several forest companies over the use of borax to treat large, second-growth stumps of hemlock, spruce and true firs in coastal B.C. Dr. D. Morrison, CFS, discussed his research progress and recommendations at a workshop held in Victoria. Borax, although ineffective at times, is recommended. Zinc sulphate when registered will give much better control. Efforts to register zinc sulphate have been underway for several months.

In eastern Cariboo Region, Rhizina root disease of young planted bare root stock, but not container stock, was common in several cutblocks which were burned in 1982. Further planting trials are planned.

Western gall rust infection of nursery seedlings is also a concern in the same region. From 5 to 15% of young outplanted trees had basal stem galls. These infected trees will probably remain stunted or die within a few years.

Under the Federally and Provincially funded EBAP and NEED programs, several disease surveys and projects were completed. Pruning young western white pine for control of blister rust was done at several locations. Monitoring of these trials is planned. (J.A. Muir)

DWARF MISTLETOE MANAGEMENT

BY

K. KNOWLES
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IMPLEMENTATION OF DWARF MISTLETOE MANAGEMENT

The development and implementation of a tangible cost-effective dwarf mistletoe management program is complex. A number of critical factors must be examined prior to adopting a management strategy for a given area or for that matter any given site:

1. The extent and severity of the infection.
2. The distribution pattern of the disease.
3. The age of the infected host trees.
4. The potential of the site.
5. The volume losses incurred.
6. The proximity to mills and/or market.
7. The long range plans for the area, i.e., future demand for the wood.
8. The accessibility of the area.
9. The economic value of the area or sites considered for treatment.

Considering the intricacies of the situation, a multi-disciplinary approach is needed. Pathologists, biologists, foresters, computer specialists and economists must all be involved if sound management is to be achieved. Input from Regional Forestry staff, Forest Management, Forest Pest Management, Forest Inventory, and Economics and Program Review will be required.

Detailed accurate mapping of infections is necessary as an initial step to intensive dwarf mistletoe management. Disease incidence within specific stands should be recorded in the Forest Inventory. Mapping of infections will require the use of the aerial event-recorder, aerial photography, ground surveys and perhaps remote sensing as techniques become more refined. The mapping phase of the program should be complimented with the development of a dwarf mistletoe loss simulator model based on the rate of disease spread and the resulting host mortality. Information derived from aerial and/or ground surveys would be applied to the model. Output data would provide a means for assessing the future impact of the disease and for selecting the appropriate management options based on valid economic criteria.

A general outline of the sequence of events for dwarf mistletoe management could

2.....

be as follows:

1. Development of a dwarf mistletoe loss simulator model should begin in the early stages of the program. Although three models will eventually be necessary, i.e., jack pine, black spruce and white spruce, A. americanum on jack pine will be done initially.
2. Based on the broad general knowledge of dwarf mistletoe's range and the critical factors outlined above, F.M.U.'s would be selected for disease management.
3. Detailed survey and mapping would be done within the selected management units in order to locate specific control sites. This information could be put into the Forest Inventory system for storage to later be applied to the loss simulator model, once it is available.
4. With the assistance of the loss simulator model the appropriate management strategies will be chosen for a given site.
5. The actual on site treatment would be carried out.

The staff inputs for each of the above mentioned phases would be:

1. The model development is to be done by Forest Pest Management using contract personnel well versed in dwarf mistletoe loss simulator modelling.*
2. Selecting F.M.U.'s for disease management would require consultation and planning between Forest Management, Regional Foresters, Forest Inventory, Forest Pest Management and Economics and Program Review.
3. Survey and mapping and incorporation into the Inventory system would be done by technical staff from both Forest Pest Management and the Regions, plus the necessary input from Forest Inventory.
4. Regional Forestry staff in cooperation with Forest Pest Management would arrive at site specific management decisions with the use of the model and upon examination of the various critical factors.
5. The on site treatment would be carried out by private operators and labour crews under the supervision of Regional Forestry staff or Regional Services. Technical staff (Regional and Pest Management) would lay out treatment areas and ensure treatments are carried out according to the correct technical specifications.

* Aside from labour and work supervisors two additional staff would be required for program implementation.

1. One staff for the computer modelling.
2. One technical staff to assist regional staff in surveys, mapping, laying out treatment areas and site inspections.

April 20, 1983

DWARF MISTLETOE MANAGEMENT STRATEGIES

Dwarf mistletoe infection can occur at varying intensities in stands of all ages. Consequently, the management of this disease is quite intricate and requires a variety of well thought out management strategies. The appropriate strategy for a given situation is dependent upon the intensity and distribution of the infection, the age and size of the infected stand and the geographic location of the infection. Commercial harvesting, complemented by some "cleanup" techniques, should always be considered first as a means to controlling dwarf mistletoe. Where circumstances render a commercial operation impossible, a number of other management strategies must be employed to bring the land back into production. The various situations under which dwarf mistletoe infection occurs are discussed along with the appropriate strategies for each given situation.

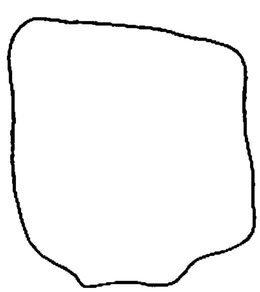
I Merchantable Sites

There are a number of infected stands which, due to a low intensity of disease produce a merchantable product, albeit, below the site potential. When logging such stands, one of the major objectives should be to produce subsequent generations of trees which are either disease free or infected below the tolerable limit (economic threshold). Harvesting activities and a number of post-logging treatments should be carried out in such a mananer so as to facilitate this objective:

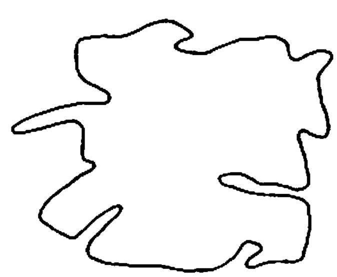
1. Where possible cutblock boundaries should be laid out so as to avoid leaving "edge infections" along the periphery of the cutover. By doing so, a major source of infection for the succeeding new stand will be removed.
2. The design of the cutblock should be such that the ratio of perimeter to area is kept to a minimum.

Example

(a)



(b)



Although the size of cutover in (a) and (b) are similar, the ratio of perimeter

2....

to area is much less in (a). This design reduces the amount of stand boundary exposed to adjacent infections, and consequently, re-invasion into the new stand will be lessened.

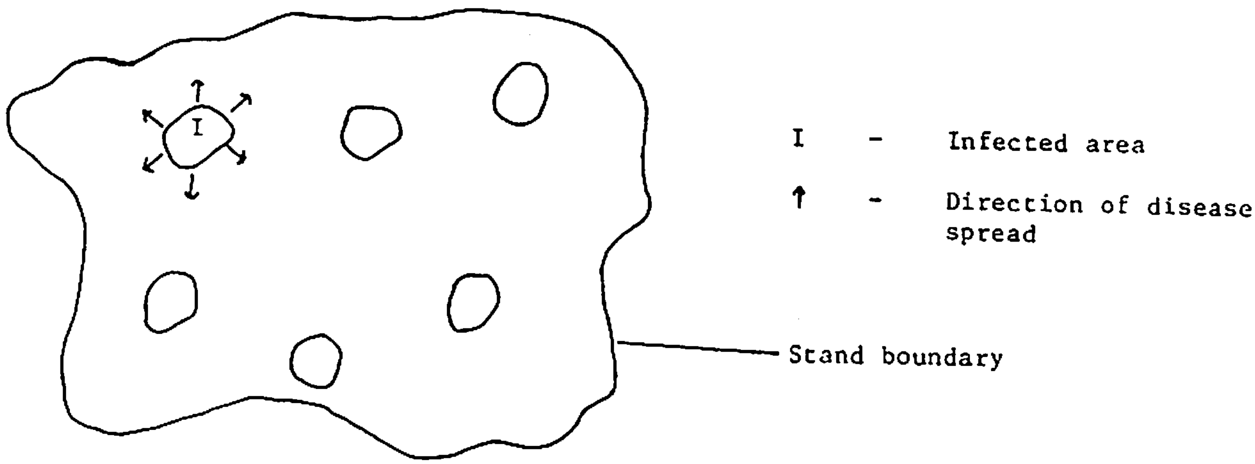
3. The size of the cutblock will also influence re-invasion of the site. The larger the clearcut, the lower will be the perimeter to area ratio.
4. In addition to the removal of the merchantable material from the site, the operator should also fell all unmerchantable stems (within reason).
5. Following the harvest a site inspection should be made for any living infected stems. There are usually three possible sources of infection remaining:
   a) Advanced regeneration - young stems in the understorey
   b) Unmerchantable residuals - intermediate and suppressed stems not taken in the harvest
   c) Adjacent stands - infected trees along the cutblock periphery which were unavoidably missed during the harvest
6. The different infection sources can be eliminated or reduced through various post-logging treatments:
   a) Prescribed burning is the most effective means of removing the infected advance regeneration. If burning is not feasible for either technical or environmental reasons other alternatives can be employed. Hand eradication, herbiciding, scarification, and crushing with a Marden drum chopper are all feasible under certain conditions.
   b) Unmerchantable residuals can best be eliminated by hypo-hatcheting, power saw or prescribed burn.
   c) Where possible, infections along the cutblock periphery should be removed by power saw, brush saw or hypo-hatchet. If it is not feasible to remove these adjacent infections, a 30 meter buffer can be planted to an alternate resistant species.
7. Five years following the re-establishment of the site, the area should be checked for infection. The appropriate measures, either pruning or removal, should be carried out if any infection is detected.

The cost-effectiveness of each post-logging treatment is generally dependent on the size of the cutblock and the distribution and density of the residual stems.

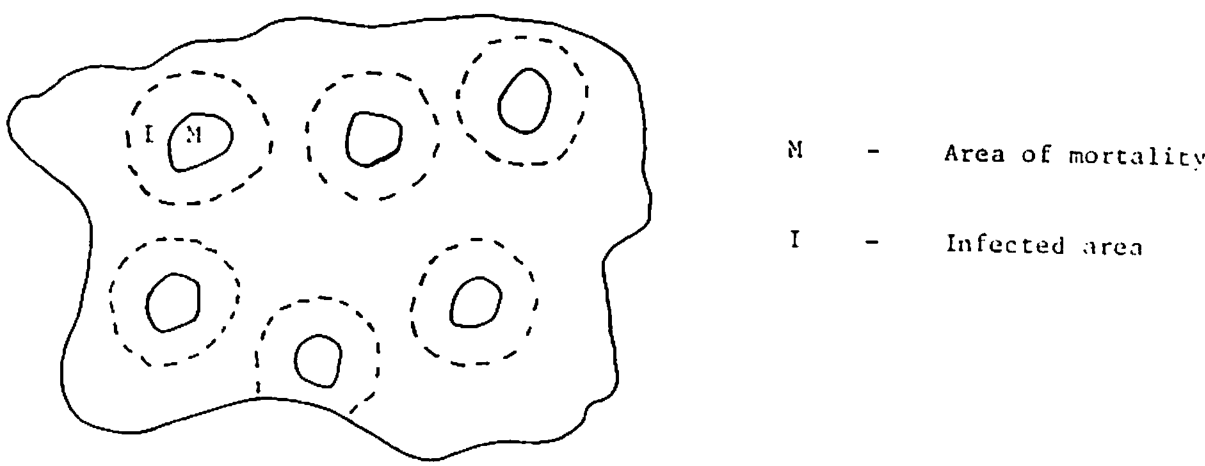
3. . . .

11 Mature Unmerchantable Sites

In any area of severe dwarf mistletoe infection, there will be numerous stands which are mature, but unmerchantable due to mortality, deformity and stunted growth. Stands heavily infected at an early age often die out in an uneven pattern. This pattern develops as scattered pockets of severe infection die out gradually. Mortality begins at the centre of an infection and progresses outward from there. Concurrently, the disease continues to spread in a similar outward pattern. Infected areas become larger and finally coalesce. The mortality results in the formation of openings within the stand. Regeneration occurs within these openings. The regeneration is then readily infected by the adjacent older diseased trees. The process continues indefinetely, resulting in an unevenaged heavily infected stand, incapable of producing a merchantable volume.

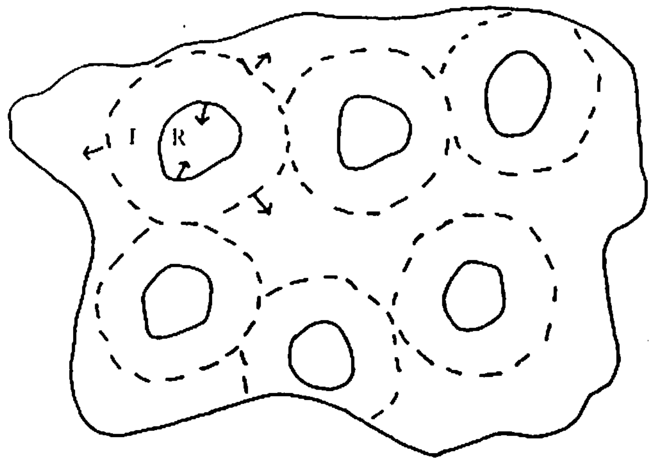


The disease spreads outward from the infection centre in all directions



Diseased areas die out gradually in an outward direction, leaving openings surrounded by infection.

4....



Stand openings regenerate only to become infected from the surrounding diseased trees. Infection continues in an outward direction as well. The size of the infected areas increase and finally coalesce.

Stands of this nature become unmerchantable for an infinite number of years unless this cycle is broken naturally by fire or by disease management. The approach to managing unmerchantable mature stands should be as follows:

1. Any possible form of utilization should be encouraged, such as posts and rails, firewood, wood chips, etc.
2. Once utilization has been achieved techniques similar to the post-logging treatments of infected merchantable stands can be applied.

III Immature Stands - Cutting Class II & III

The management approach to diseased immature stands depends largely upon three criteria. The age of the stand, the degree of infection and the distribution of disease are all factors to be considered. The following management options are available:

1. If the degree of infection and the stand age is such that overall stand volume will not be greatly reduced by maturity, then treatment is not justified. Generally, the lower the level of infection and the closer to maturity the stand is, the less need there is for treatment. The stand should be left to rotation age and harvested, carrying out the necessary post-logging sanitation treatments.
2. Where the level of infection is sufficient to reduce stand volume to a level substantially below site potential, treatment is warranted. Infection should be removed to prevent increased spread throughout the stand. It is often possible to remove a large percentage of the infection,

allowing the site to produce a merchantable product by maturity. Sanitation can be achieved through the thinning and pruning of diseased trees. Material removed from the stand during this treatment should be utilized wherever feasible.

3. Where severe infection is widespread and no merchantable product will be derived by maturity, complete host removal and reforestation of the site is necessary. The rationale is that heavy infection of this nature "ties up" the site for the rotation age (approximately 60 to 80 years) with little or no merchantable volume produced. Removal at an early age will result in a loss of perhaps 15 to 30 years rather than 60 to 80 years. If an unevenaged, heavily infected stand with no merchantable value such as described in section II becomes established on the site then the land is taken out of productivity for an infinite number of years rather than just for the rotation age.

The management decisions involved in the treatment of immature stands are complex as a number of factors must be considered. A dwarf mistletoe loss simulator model similar to those developed in certain areas of the United States, is a necessary tool in this decision making process. Taking into consideration stand volume, age, tree mortality and rate of dwarf mistletoe spread, the model determines the cost effectiveness of control and the most economically feasible time to harvest. Such a model has to be specific to the species of dwarf mistletoe, the host tree species and the geographic region. It would be part and parcel of the growth-yield models much needed for each of our commercial species.

IV Immature Stands - Regeneration and Cutting Class I

Fire is the most effective natural enemy of dwarf mistletoe. In heavily infected areas "broomed" trees plus dead and dying branches and trees provide an excellent source of fuel. Under these circumstances fire can destroy vast areas of infection. Unfortunately, fires do not always burn "clean". Residual pockets of diseased trees remain providing a large source of innoculum to infect the regeneration which follows. Two approaches can be taken in order to protect the young growth:

1. Immediately after a fire, prior to the establishment of regeneration, residuals can be removed by aerial ignition device.

2. Where the new stand is already established, residuals should be removed by power saw and/or brush saw or hypo-hatchet. By the time of treatment there is likely to be some degree of infection in new growth immediately surrounding the residuals. This can be effectively controlled by removing the regeneration within a 25 metre radius of the residual infection.

This phase of dwarf mistletoe management is one of the most important and cost-effective. It is a preventative approach which will protect healthy young stands and allow the site to produce a merchantable volume for generations.

We will never eradicate dwarf mistletoe, but through carefully planned management, we can reduce volume losses to a tolerable level. Management of this disease should become an integral part of forest management within those management units where losses are significant.

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STATUS OF OTHER IMPORTANT FOREST PESTS
IN ONTARIO, 1983

- Jack pine budworm
- Swaine jack pine sawfly
- Gypsy moth

by

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Great Lakes Forest Research Centre

Sault Ste. Marie

Prepared for the

Annual Forest Pest Control Forum

Ottawa, Ontario

November 15-17, 1983

JACK PINE BUDWORM

The last jack pine budworm outbreak in Ontario occurred between 1966 and 1973 when heavy infestations damaged jack pine stands in northwestern and central Ontario. In 1982, population increases became evident in the Georgian Bay area where several pockets of moderate and severe defoliation totalling 1 020 ha were mapped in the Owen Sound, Huronia and Parry Sound districts. Populations of this insect increased to outbreak proportions in 1983. A total area of 67 142 ha of jack pine were moderately-to-severely defoliated in the Algonquin (30 200 ha), Northeastern (29 970 ha) and North Central (6 970 ha) regions (Figures 1 and 2). Egg-mass counts indicate that infestations will persist and probably expand somewhat in 1984.

SWAINE JACK PINE SAWFLY

The Swaine jack pine sawfly infestation in northeastern Ontario reached a peak in 1981 when 5 699 ha of jack pine suffered moderate-to-severe defoliation in the Banks-Makobe lakes area of Temagami District. Populations began to decline somewhat in 1982 when a total area of 4 650 ha was affected.

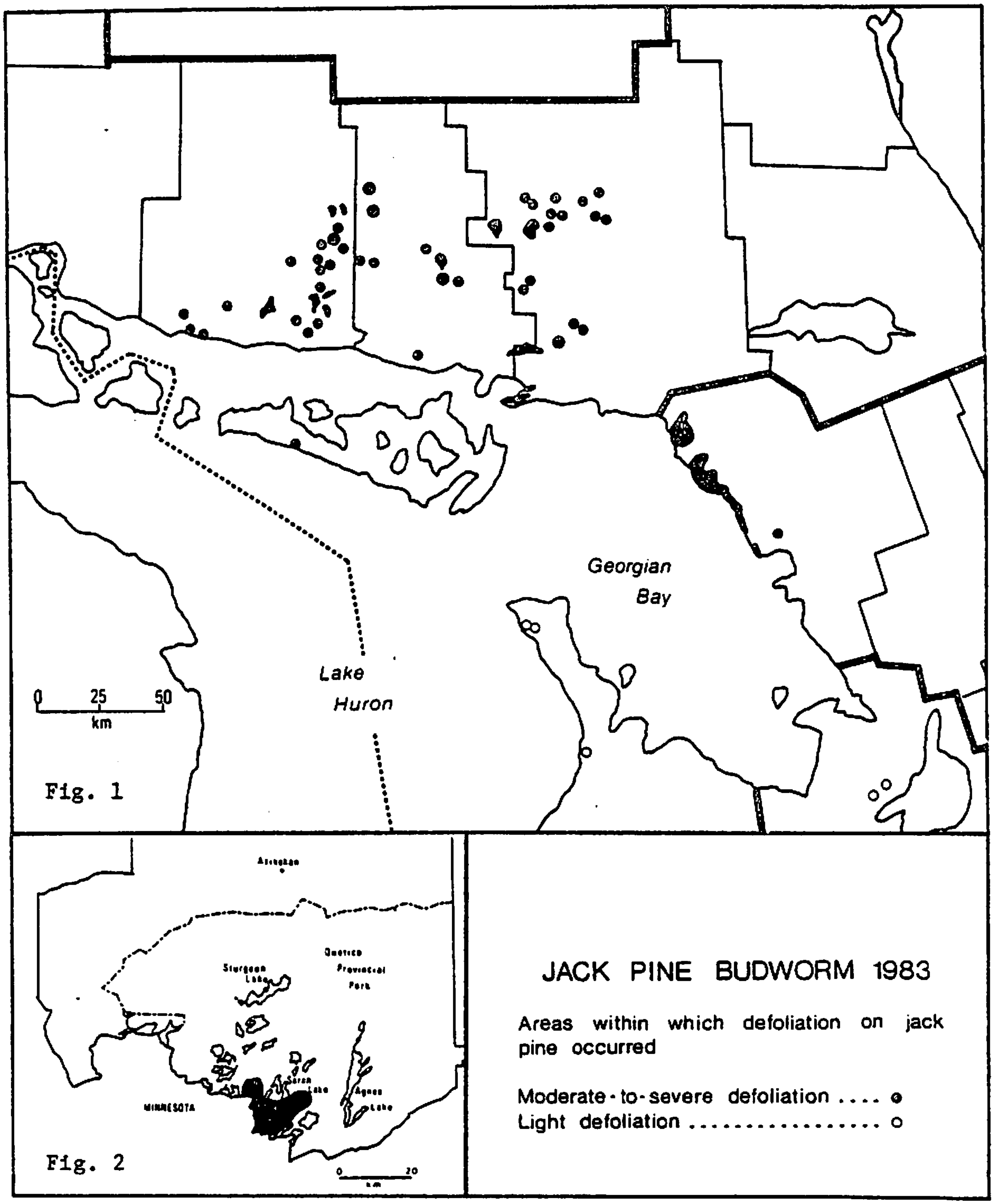
In 1983, populations continued to decline with only two small pockets of medium defoliation totalling 518 ha persisting in Banks Township, north of Banks Lake along the Makobe River and in Willet Township, on the southwest side of Alexander Lake. Small numbers of colonies were present in the remainder of the areas infested in 1982 but in all cases defoliation was negligible in 1983.

GYPSY MOTH

Populations of this pest increased markedly in the Napanee and Tweed districts of the Eastern Region for the third consecutive year. The total area of moderate-to-severe defoliation in these districts increased from approximately 4 800 ha in 1982 to about 40 954 ha in 1983. (Fig. 3)

The Forest Insect and Disease Survey Unit and the Parks Branch of the Ontario Ministry of Natural Resources carried out a larval trapping and an adult pheromone trapping program at most provincial parks in southern Ontario. Gypsy moth larvae were trapped at seven provincial parks, all in the Eastern Region, which is considered to be generally infested. Gypsy moth adults were trapped in 27 of the 71 parks where pheomone traps were deployed. As expected, the largest numbers were caught in parks in the Eastern Region, however, adults were also captured in Bancroft, Lindsay, Huronia, Cambridge, Simcoe, Bracebridge, Chatham, Owen Sound, Parry Sound and Algonquin Park districts. Pheromone trapping in 35 northern Ontario (east of Lake Nipigon) provincial parks produced only a single moth in Samuel D. Champlain Provincial Park, North Bay District.

Control operations may be carried out in 1984 to suppress high populations in several provincial parks in the Eastern Region. Egg-mass counts conducted in these parks in Tweed, Napanee and Carleton Place districts confirm that high populations will likely occur next year depending on overwintering survival.


Georgian Bay
Lake Huron
0 25 50
km
Fig. 1
Fig. 2
0 20
JACK PINE BUDWORM 1983
Areas within which defoliation on jack pine occurred
Moderate-to-severe defoliation ....
Light defoliation ....

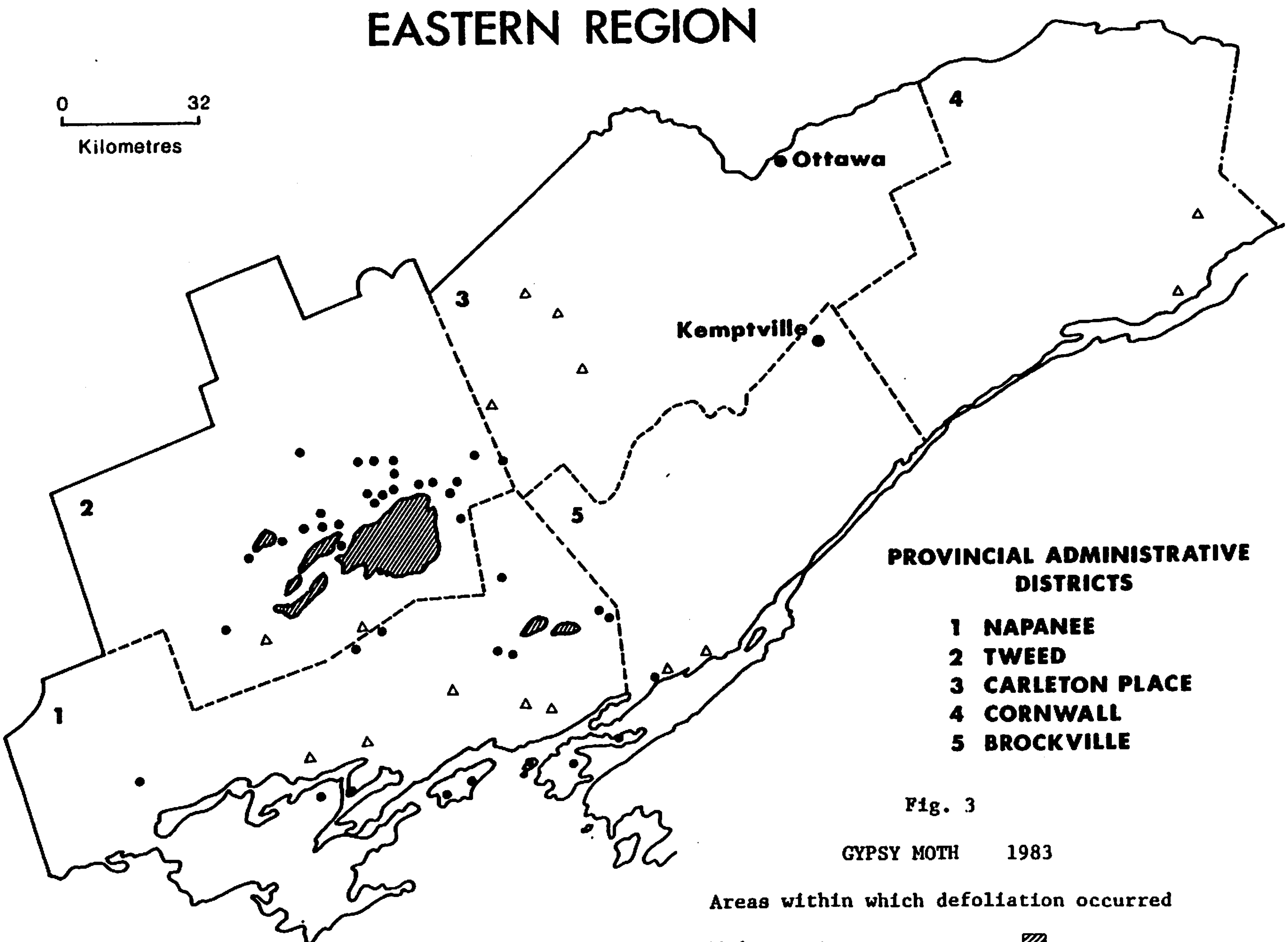


Fig. 3

GYPSY MOTH 1983

Areas within which defoliation occurred

Moderate-to-severe . . . ▨ or ●

Light . . . . △

OAK LEAF SHREDDER AERIAL SPRAYING OPERATIONS

IN ONTARIO, 1983[1]

by

J.H. Meating[2], G.M. Howse[2] and B.H. McGauley[3]

INTRODUCTION

Between 1973 and 1980 some 3 000 ha of oak forest in southern Ontario were aerially treated with chemical insecticides to reduce populations of the oak leaf shredder, *Croesia semipurpurana* (Kft.). This insect has a wide geographic distribution in eastern North America and in recent years has been a persistent pest in red oak stands in Ontario. Defoliation by this insect is probably a major predisposing factor in oak decline, dieback and mortality and serious damage has occurred in many areas in Ontario with a history of oak leaf shredder infestations. It has been estimated that some 600 000 cubic metres of oak have died as a direct result of insect defoliation or the decline condition since 1977.

Spraying operations conducted in 1977, 1978, 1979 and 1980 were effective in reducing oak leaf shredder populations. Surveys conducted by the Forest Insect and Disease Survey Unit (FIDS) of the Canadian Forestry Service (CFS) between 1980-82 showed that oak leaf shredder populations remained low in most areas. The only exception to this trend was in Dufferin County Forest and adjacent areas in Simcoe County Forest in Mulmur and Tosorontio townships, Huronia District. Here, egg counts indicated a steady population buildup. Moderate-to-severe defoliation occurred throughout Dufferin County Forest in 1982 and forecasts for 1983 indicated heavy defoliation would likely occur. OMNR staff consider the oak in this area of Huronia District an important timber and wildlife species that is worthy of protection.

1983 AERIAL SPRAY OPERATIONS

On May 24 and 25, 1983, OMNR aerially treated 579 ha of oak-maple forest in Dufferin County Forest and adjacent areas in Simcoe County Forest, Huronia District to reduce oak leaf shredder populations. Two Piper Pawnee's equipped with Micronairs were used to

[1] Report prepared for the Annual Forest Pest Control Forum Ottawa November 15-17, 1983.

[2] Environment Canada, CFS, GLFRC, Sault Ste. Marie.

[3] Ministry of Natural Resources, Pest Control Section, Maple.

apply single applications of both chemical and biological insecticides (Table 1). Orthene 97 SP (Chevron Chemicals Limited) was applied at two dosages - .84 Kg/9.4 l/ha and .56 Kg/9.4 l/ha - to approximately 195 ha. The lower dosage of Orthene was applied in response to a request from the Canadian Wildlife Service. The other chemical insecticide, Sevin-4-Oil (Union Carbide Corp.), was applied to 320 ha at 1.1 Kg/9.4 l/ha. Dipel 88 (40 BIU/4.7 l/ha), a biological insecticide, (*Bacillus thuringiensis*), was used to treat the remaining 63 ha. This is the first time that *B.t.* has been used against the oak leaf shredder in Ontario.

Oak leaf shredder larval development and host development as well as spray efficacy were assessed by staff of the Forest Insect and Disease Survey Unit (FIDS) of the Canadian Forestry Service (Table 2). Spraying began the evening of 24 May and was completed the following morning. At this point, the larvae were predominantly in the first and second instar and the red oak buds had flushed with leaves about 4 cm in length.

A total of 33 plots were established to assess the effectiveness of this spraying operation. Pre-spray sampling began on May 22 and was finished on May 23. Post-spray sampling was conducted between May 30 and June 2. In each case, two 45 cm branch tips were sampled from each of 5 trees (minimum) in each plot and the number of larvae and leaves counted on each.

RESULTS

Results of the spraying operation are summarized in Table 3. Dipel 88, Sevin and Orthene (.56 Kg/9.4 l/ha) were applied under ideal conditions on the evening of 24 May. The higher dosage of Orthene was applied the following morning. Just as spraying was completed, a light rain began to fall and continued for the rest of the day. As well, temperatures decreased considerably and it remained cool for 2 or 3 days following the spray. Spray deposit was assessed for each treatment using Kromekote cards and the results are summarized in Table 4. It appears that, with the exception of the area treated with the reduced dosage of Orthene, spray deposit was not especially good in most plots. However, despite this, and despite the heavy rain, both Sevin and Orthene (at both dosages) were very effective in reducing oak leaf shredder populations and thereby limiting defoliation. Larval populations were substantially reduced in the areas treated with Dipel and this resulted in some foliage protection. It is very likely that the cool, wet weather following the spray reduced the effectiveness of this treatment.

PLANS FOR 1984

Results of an egg survey conducted in the spray and check areas in August are presented in Table 5. Forecasts, based on this survey, indicate a much reduced oak leaf shredder population in the Dufferin and Simcoe County Forests in 1984. The same situation seems to exist throughout the rest of Ontario and it is unlikely that any control programs will be conducted in 1984.

Table 1. Summary of aerial spraying in the Dufferin and Simcoe county forests, Huronia District conducted in May, 1983.

Treatment	Dosage	Area (ha)	Date sprayed
Sevin-4-Oil	1.1 Kg/9.4 l/ha	320	May 24
Dipel 88	40 BIU/4.7 l/ha	64	"
Orthene 97 S.P.	.56 Kg/9.4 l/ha	63	"
Orthene 97 S.P.	.84 Kg/9.4 l/ha	132	May 25
	Total	579	

Table 2. Summary of oak leaf shredder larval development and red oak shoot development in Dufferin County Forest, Huronia District, 1983.

Date	Plot	Larval Instar (%)			Shoot length (cm)
		I	II	III	
May 12	95		Observed bud mining		Buds swollen
May 17	10	84	16		0.7
May 22	10	70	20	10	
	99	92	8		
May 23	10	72	24	4	3.7
	99	79	19	2	4.6
May 24	99	66	32	2	4.2

Table 3. Population reduction and foliage protection attributable to aerial spraying operations in Dufferin and Simcoe county forests, Huronia District, 1983.

Treatment	Prespray larvae per 45 cm tip	Postspray larvae per 45 cm tip	Population reduction due to treatment	% Defoliation
Sevin-4-Oil	43.1	0.4	99	11
Checks	43.1	31.0		31
Orthene (.56Kg)	76.2	1.3	97	16
Checks	45.8	29.5		30
Orthene (.84Kg)	54.1	0.8	98	13
Checks	45.8	29.5		30
Dipel 88	43.9	16.1	49	21
Checks	43.1	31.0		31

Table 4. Oak leaf shredder, 1983. Summary of spray deposit in the treated plots.

Treatment	Plot	Droplets per cm^2
SEVIN		
	3	1.6
	3A	5.3
	4	1.5
	5	4.8
	5A	3.5
	99	2.5
	99A	1.8
	99B	1.2
	$\bar{X}$	2.8
ORTHENE (.56 Kg)		
	8	0.9
	14	25.8
	14A	18.2
	14B	7.6
	$\bar{X}$	13.1
ORTHENE (.84 Kg)		
	12A	7.6
	12B	2.6
	96	4.0
	$\bar{X}$	4.6
DIPEL		
	1A	3.7
	1B	2.0
	1C	3.3
	1E	0.4
	95	0
	C2	0
	$\bar{X}$	1.6

Table 5. 1982 and 1983 oak leaf shredder egg counts and forecasts for 1984 in Dufferin and Simcoe county forests, Huronia District.

Treatment	Plot	Mean no. eggs per 38 cm tip		Defoliation forecast 1984*
		1982	1983	
Sevin	3	24.5	0	N-L
	4	11.8	0.4	L
	5	21.6	0.3	L
	5A		0	N-L
	6A	15.9	0	N-L
	99		0	N-L
	99A		0.1	L
Orthene (.56Kg)	8	20.2	0	N-L
	14	40.5	0.2	L
	14B		0.2	L
Orthene (.84Kg)	12A		0.2	L
	12B		0.4	L
	96		0	N-L
Dipel	1A		0	N-L
	1E		0.2	L
	95	29.4	1.0	L
	C2	21.8	0.5	L
Checks - Dufferin	1	35.6	2.4	L
	3	32.2	6.1	L
	9		1.1	L
	10	21.9	2.1	L
Uxbridge	1	3.2	1.9	L
	2	19.9	3.2	L
	3		3.0	L
Awenda	17	16.5	15.9	M

*N = Nil
L = Light
M = Moderate
S = Severe

GYPSY MOTH IN QUEBEC, 1983

Report to the Canadian Forest Insect Pest Control Forum

Ottawa, November 15-17, 1983

Denis Lachance

Laurentian Forest Research Centre

Canadian Forestry Service

Department of the Environment

Sainte-Foy, Québec

G1V 4C7

Situation in 1983

Overall, gypsy moth populations were low in the province of Québec in 1983. No severe defoliations were recorded. Moth catches recorded in the 215 pheromones traps set by FIDS-LFRC increased slightly over those of 1982. The distribution of the insect extented lightly eastward. Egg masses were found at about 10 km east of the known area of infestation. The insect is thus now present in natural stands at about 50 km west of Québec City. Seventy-seven pheromone traps were set somewhat along the St.Lawrence River shore in three municipalities in suburb Québec, by a private enterprise on contract with them. Relatively high moth catches were recorded in three locations and egg mass surveys are being done. At least 30 egg masses have so far been found (and killed) in one of these areas.

Treatment in 1983

No chemical treatment was undertaken in 1983, in the province of Québec. Tests on biological control by the use of egg parasites were continued however. *Ooencyrtus kuwanai* released in 1982, could not overwinter local climatic conditions. This experiment is terminated. Another egg parasite *Anastatus disparis* obtained from Romania is being tested. About 10 000 specimens were released in southern Québec. This parasite is known to have 1½ generation per year and can affect only up to 20% egg masses.

Projections for 1984

Based on egg mass surveys of 58 naturally infected stands in southern Québec, we expect a notable increase in population levels for 1984. Local spray treatments with *Bacillus thuringiensis* and Gypcheck are contemplated in Québec City area if isolated foyers are detected in spring 1984.

A SUMMARY OF THE 1983 GYPSY MOTH SUPPRESSION PROGRAM IN SOUTHWESTERN NEW BRUNSWICK

(1) Background

The gypsy moth is an exotic insect introduced into North America during the 1860's. It feeds on a large variety of plant hosts and is recognized as an important pest of agriculture, forestry, and urban environments. The larvae consume the leaves of numerous hardwood tree species and will feed on softwoods under epidemic conditions. Gypsy moth is among the most serious forest pests in northeastern United States.

Entomological surveys in 1981 detected several egg masses and pupal cases of gypsy moth at a few locations in southern New Brunswick. This was the first evidence of the insect's presence in the Province in 45 years. It began apparent from surveys conducted in 1982 that a population was building up within a red oak stand at Mohannes, west of St. Stephen.

Entomologists cannot accurately predict whether forest and climatic conditions are suitable for the insect's spread and establishment throughout New Brunswick. However, events of 1981 and 1982 were sufficient cause for concern among the Province's entomological community. Provincial and Federal forestry officials met in December, 1982 to review the situation. A concensus was reached to initiate a suppression program at Mohannes in 1983.

The stated objectives were to (1) apply B.t. insecticide to severely reduce the gypsy moth population and prevent its spread beyond the infested site, and (2) remove the oak stand which was favourable to the build up of the insect population.

The suppression program was co-ordinated by the Department of Natural Resources (DNR). Georgia-Pacific Limited conducted the clearcutting operation. Agriculture Canada (CDA) advised DNR on the timing of the insecticide applications and the Canadian Forestry Service (CFS) provided technical advise and assistance in conducting the entomological surveys. All three government agencies contributed to the assessment of the program. Details of the suppresion program are summarized below. Appended to the report is a map showing the location of the operation.

(2) Monitoring of Gypsy Moth Development and Leaf Expansion (DNR, CFS, & CDA)

Proper timing is essential to the successful application of any insecticide. The leaves must be expanded enough to provide a substrate on which the B.t. can be deposited. The eggs must be hatched and the larvae migrated to the crown and commenced feeding. Therefore, precise monitoring of egg hatch, larval development, and leaf expansion before and during the spray applications were an integral part of this suppression program.

Communications were initiated with the United States Forest Service to determine when egg hatch first occurred in Maine. This information enabled entomologists in New Brunswick to predict when hatching would occur at the spray block.

Beginning May 9, egg hatch and larval development were monitored daily within the designated spray area by observing 24 egg masses placed in cages or left on tree trunks surrounded with tanglefoot. Leaf expansion within the forest canopy and the understory were also closely monitored.

(3) The Suppression Program

(3.1) The Clearcutting Operation (Georgia-Pacific Ltd.)

Approximately 18 hectares (45 acres) of red oak were clearcut and chipped on the site. The chips were immediately taken to a nearby mill for processing. Much of the residual branches left after the clear-cut were burnt on site. The entire operation was conducted in winter so that the trees could be cut and disposed of before the insects hatched.

(3.2) The Application of B.t. Insecticide (DNR)

The clear-cut and surrounding hardwood forest were treated with three applications of the B.t. insecticide Dipel 88. In all, 182 hectares (450 acres) were sprayed at a total dosage of 100 BIU/ha using a Piper Pawnee aircraft equipped with a micronair delivery system. Polyco 2142 sticker was added to the formulation to ensure that the B.t. adhered well to the foliage.

Details on application rates, formulation rates, and time of spray treatments are summarized in the following table:

Application Number	Application Rate	Total Formulation Rate	Number of Loads per Application	Date of Application
1	30 BIU/ha	9.4 l/ha (1 U.S. gal/ acre)	4	1st load- May 22p.m. 2nd load- May 23 a.m. 3rd & 4th loads - May 26 a.m.
2	30 BIU/ha	9.4 l/ha (1 U.S. gal/ acre)	4	May 29 a.m.
3	40 BIU/ha	11.7 l/ha (1 ¼ U.S. gal/ acre)	5	June 3 a.m.

(3.3) Release of Egg Parasites (CFS)

Approximately 5,800 chalcid wasps, Anastatus disparis were released at Mohannes on August 24, 1983. This non-stinging insect is a natural parasite of gypsy moth eggs.

This parasite release project was conducted by the Canadian Forestry Service and was not part of the original suppression program. However, it was supported in principle by the Department of Natural Resources and Agriculture Canada.

(4) Assessment of the Efficacy of the Suppression Program (DNR, CFS, CDA)

(4.1) Larval and Pupal Surveys

Mature gypsy moth larvae feed in the forest canopy at night and migrate down the tree trunk during the day. Placing burlap traps around the trunks provides a location for the larvae to congregate and is used as a standard tool in monitoring gypsy moth populations. At Mohannes, 50 burlap traps were placed inside and adjacent to the sprayed area and monitored from late June to August. A total of 2 larvae and 5 pupae were found in two burlap traps.

In addition to the monitoring of burlap traps, random searches were conducted inside and adjacent to the spray block during the period June 27 - August 23. A total of 23 man hours were expended. Random searches failed to locate any larvae or pupae within the sprayed area.

(4.2) Monitoring B.t. Activity

Cadavers of forest tent caterpillar were collected inside and outside the sprayed area. Owing to the scarcity of gypsy moth larvae after three applications of insecticide, micro-organisms from tent caterpillar larvae were cultured to provide a measure of the viability of the B.t. product and to assess the deposition pattern of the insecticide.

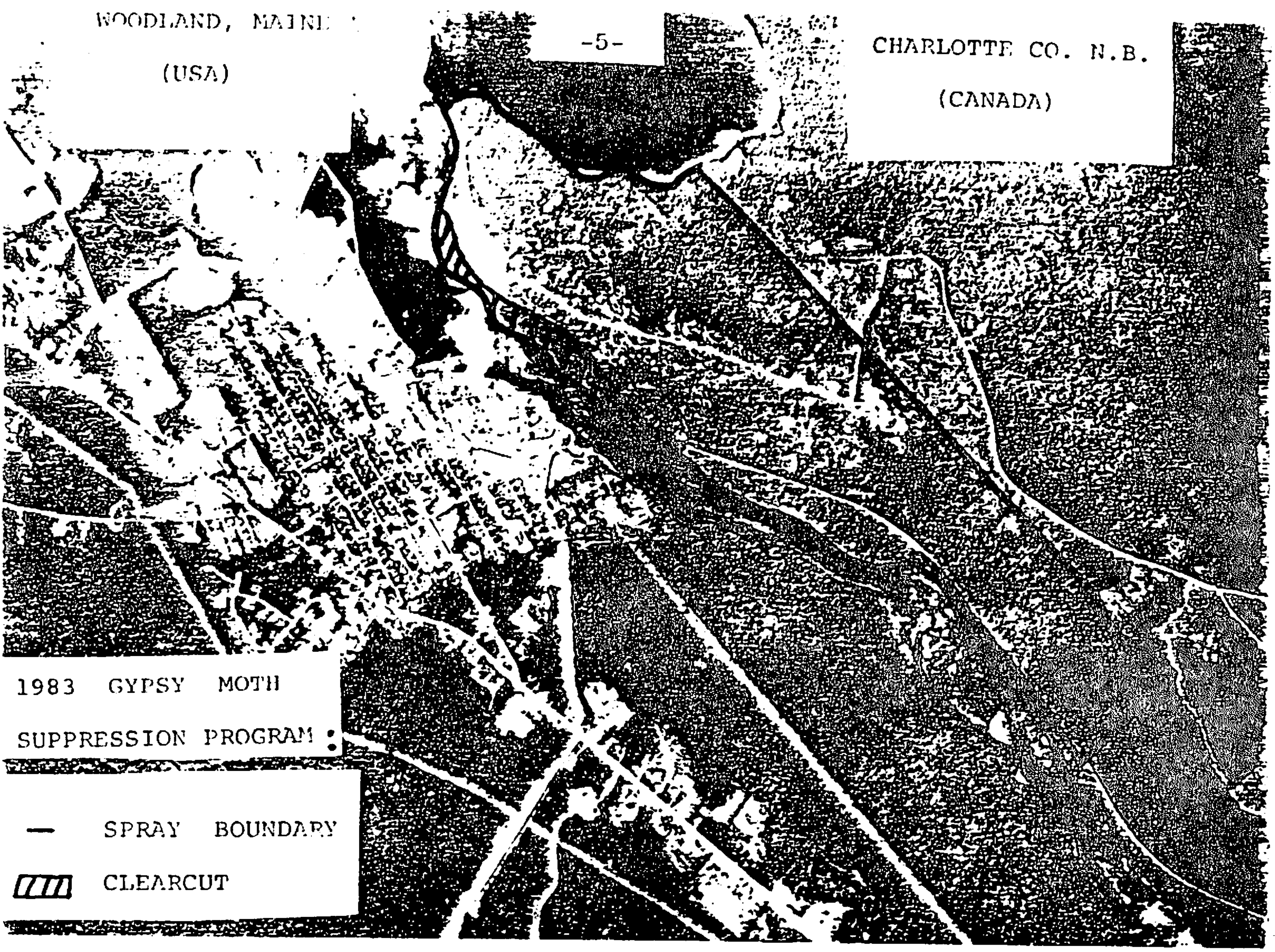
(4.3) Egg Mass Survey

The gypsy moth program was not designed like that of other pest control programs in which foliage protection is the stated objective. Rather, the gypsy moth program incorporated such drastic measures as clear-cutting and spraying of very high dosages of insecticide in order to suppress the population and prevent its spread from the infested area. The egg mass survey is therefore the best method of assessing the suppression program because it is an evaluation of the number of gypsy moth offspring which survived the clear-cut and spray operations.

A total of 77.5 staff hours were spent searching the spray block and the adjacent area for newly layed egg masses. 22 old egg masses were found within the sprayed area and an additional 23 old egg masses were found near a boundary of the spray block. However, no new egg masses were found inside or outside the sprayed area.

Upon evaluating the results of all the entomological surveys, it can be concluded that the 1983 suppression program achieved its objective.

Lester Hartling
Forest Management Branch
N.B.Dept.of Natural Resources
October31, 1983


WOODLAND, MAINE
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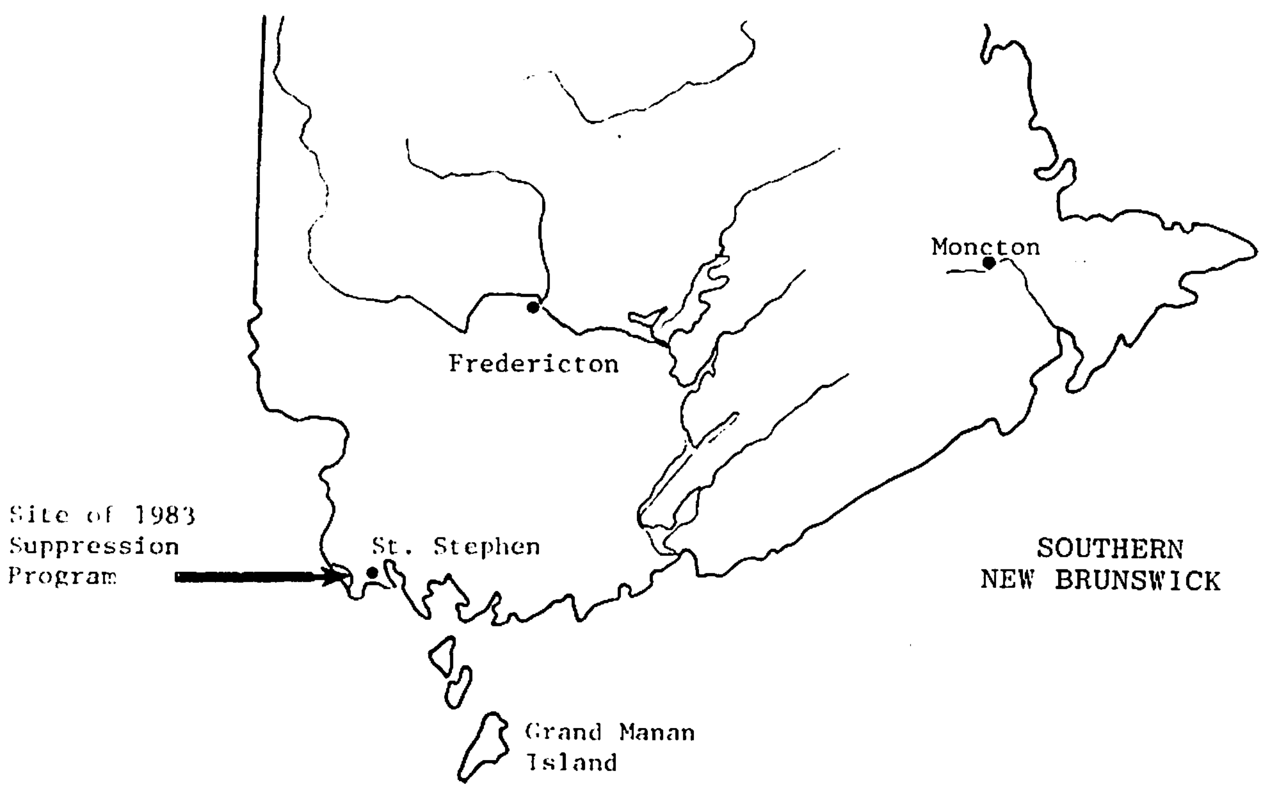
CHARLOTTE CO. N.B.
(CANADA)
1983 GYPSY MOTH
SUPPRESSION PROGRAM:
SPRAY BOUNDARY
CLEARCUT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Site of 1983
Suppression
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St. Stephen
SOUTHERN
NEW BRUNSWICK
Grand Manan
Island

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MARITIMES FOREST RESEARCH CENTRE

TECHNICAL NOTE NO. 95

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PLANTATIONS

SILVICULTURE

UTILIZATION

ECONOMICS

TREE IMPROVEMENT

INSECTS AND DISEASES

MAJOR FOREST PESTS IN NOVA SCOTIA IN 1983

Many pests interfere each year with the production of wood in the forest or with the aesthetic appearance of trees. One of these, the SPRUCE BUDWORM has again been forest enemy No. 1 in Nova Scotia in 1983. A separate Technical Note deals with the 'budworm story'. Other pests of economic importance are briefly mentioned here. These and others will be discussed in detail in the annual report of the Forest Insect and Disease Survey.

GYPSY MOTH has been the most important hardwood defoliator in the northeastern part of North America during the last several decades. It has annually defoliated trees over millions of hectares in the United States. The insect was first found in Nova Scotia in 1981 when several egg masses were discovered in Yarmouth. In the fall of 1982 egg masses, each with a potential of several hundred larvae for the following year, were found in five areas from Yarmouth to Paradise in the Annapolis Valley. In 1983 larvae were seen at two of these locations, at Paradise and at Grosses Coques, Digby County. In addition, the insect was discovered in Halifax in early July, was found at Parrsboro, Cumberland County and we have an unconfirmed report from Boylston, Guysborough County. All gypsy moth found are destroyed as a matter of control policy. Additional control procedures in 1983 included ground spraying with *Bacillus thurengiensis* and a 'trap out' of adult males in Yarmouth and chemical treatment in Halifax. The results of the Province-wide multi-agency pheromone trapping program are not yet available and egg mass surveys are only getting under way. Therefore, it is too early to indicate what may be in store in 1984 for Nova Scotia.

SPRUCE BEETLE infestations causing white spruce mortality are

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common in much of the Province but the outbreak is most spectacular - and devastating on Cape Breton Island. More than 20% of mature white spruce had been killed during the current outbreak by the end of last year. In 1983 the main outbreak shifted westward and beetles killed as much as 50% of the surviving mature trees in some areas in the Margaree and the Mabou River valleys in Inverness County and around Baddeck and North Bridge in Victoria County. There are now no substantial areas of mature white spruce on Cape Breton Island without significant tree mortality. If the outbreak persists and trees continue to die, the spruce beetle, an insect of mature and overmature white spruce, will cease to be a major pest due to lack of suitable host material.

FOREST TENT CATERPILLAR, after a few years of rapid population increase, caused defoliation of hardwoods, mostly trembling aspen, over about 35 000 ha in 1983, up from the 4 500 ha affected in 1982. Most of the severe defoliation occurred in Annapolis and northern Hants counties, although the insect was also present in many other areas in the western half of the Province. Predictions for 1984 will be based on late fall sampling.

SIROCOCCUS SHOOT BLIGHT has been causing damage in red pine plantations in much of the Province for well over a decade but its importance is only beginning to be recognized by the forestry community. Twig and branch mortality, crown dieback, tree deformation and death are common in many plantations of different ages. A preliminary survey just under way already located plantations where all trees are infected. In one more than 75% of the branches are red and either dead or dying. Dead trees were found at several locations and as much as 30% mortality was recorded at one of these. There are of course many disease free plantations in the Province and many others harbor only low level infections at present. However, considering the heavy inoculum-load present and a practical control method lacking, ways will have to be found to prevent or manage the disease in the protection of plantations.

DUTCH ELM DISEASE did not spread much in 1983 and the extension occurred only around the peripheries of infected areas. The disease was found in new areas for the first time at Annapolis Royal, Annapolis County; Canning, Kings County; and in Dartmouth, Halifax County. The number of infected trees has shown a significant increase in 1983 in some areas of Hants County where the disease has been present at low levels for a number of years. This is the usual patterm of spread in areas without proper sanitation programs. It is expected that after this initial "jump" in incidence most elm trees will die within a few years there.

Other pests of note include EASTERN LARCH BEETLE, BALSAM GALL MIDGE, BALSAM TWIG APHID, EUROPEAN LARCH CANKER, OAK LEAF SHREDDER, OAK LEAFROLLER, WINTER MOTH, BRUCE SPANWORM, ORANGEHUMPED MAPLEWORM and EUROPEAN PINE SHOOT MOTH.

-L.P. Magasi
Forest Insect and Disease Survey

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MARITIMES FOREST RESEARCH CENTRE
TECHNICAL NOTE NO. 96

SPRUCE BUDWORM INFESTATIONS IN NOVA SCOTIA IN 1983 AND A FORECAST FOR 1984

Spruce budworm egg-mass surveys in August 1982 detected a major increase in infestations. It was predicted that substantially more defoliation by the spruce budworm could be expected in 1983 in Digby, Annapolis, Kings, Cumberland, Colchester, Pictou, and Antigonish counties and in Inverness and Victoria counties on Cape Breton Island (Figure 1). Surveys for overwintering larvae in most of these areas confirmed that the infestation was high.

Conditions in the Spring of 1983:

The spring of 1983 initially had a long, cold, wet period that enhanced tree growth and, in general, retarded spruce budworm development. However, in June the weather turned in the budworm's favor, and large areas of fir and spruce were defoliated. Survival of the budworm to the adult stage, however, was generally low and this, in part, affected the forecast for 1984.

Defoliation (Browning of Foliage):

An aerial survey for spruce budworm defoliation was conducted by the Canadian Forestry Service. The results are shown in Table 1 and Figure 2. A map showing defoliation in 1982 is included for comparison (Figure 3).

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PLANTATIONS

SILVICULTURE

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In 1983, 63 000 ha of light, 52 000 ha of moderate and 242 000 ha of severe defoliation were mapped compared with 36 900 of light, 125 200 of moderate and 49 700 of severe in 1982. It is evident from Table 1 that there was a significant increase in the extent and severity of defoliation throughout the Annapolis Valley and from Cumberland County east to Cape Breton Island, which is in keeping with the forecast made in 1982. Of entomological interest was the resurgence of spruce budworm activity on Cape Breton Island. Many of the areas in which defoliation occurred had in excess of 75% tree mortality and the noted defoliation was on the residual surviving trees -mostly on white spruce, but sometimes on black spruce. Ground checks confirmed that this was current spruce budworm defoliation.

Egg Masses

The results of egg-mass surveys conducted by Nova Scotia Lands and Forests and the Canadian Forestry Service in 1983 are shown in Table 2 and Figure 4. It is evident that there has been a dramatic downturn in numbers of spruce budworm egg masses in 1983 in all areas, excepting Kings County, where infestations are similar to a year ago.

On Cape Breton Island Of the 95 locations sampled only 23 had a detectable increase in egg masses and of these 23, only one point located north of Baddeck had a moderate egg-mass count, all others were low.

On the Mainland In Antigonish, Pictou, and Guysborough counties egg-mass counts had declined substantially but there is still a moderate to high infestation on Cape George and in a few locations west of Trenton.

In Cumberland and Colchester counties infestations declined sharply over those in 1982. In Colchester County only three locations had high infestations. In Cumberland County, although the infestation has declined, there are still substantial areas of moderate to high infestations: a) in the Amherst-Tidnish area, b) in the general area bounded by Joggins, Oxford, Springhill, and Sand River, and c) in an area near Apple River.

In Digby and Annapolis counties, infestations have declined and only patches of moderate infestation were detected on the North Mountain and at one location on the South Mountain.

In Kings County, the average egg-mass count in 1983 is only slightly less than in 1982. Consequently for 1984 there is a probability of moderate to severe defoliation in the northwest section of Kings County.

Elsewhere in Nova Scotia, spruce budworm egg-mass infestations are very low and pose no threat to fir and spruce in 1984.

More on Balsam Fir Mortality on Cape Breton Island

In 1983, the Forest Insect and Disease Survey measured balsam fir mortality and tree condition at a series of semipermanent sample plots on Cape Breton Island. The results (Table 3) show that 76.9% of the fir on the Highlands and 90.8% on the Lowlands are dead and that another 3.3% on the Highlands and 1.9% on the Lowlands are near death.

Of the surviving balsam fir some will succumb to tree diseases and other beasts that feed on weakened trees thus adding to the total mortality figure.

It is of note that on the Highlands where most of the forest was mature balsam fir a few years ago and since has either been salvage cut or fallen down, or is still standing dead, the next crop of balsam fir is vigorously growing and establishing itself - for the next generation of wood cutters - and another budworm infestation. Who will get it the next time ???

E.G. Kettela
Technical and Information Services

October 1983

Table 1. Summary of areas of spruce budworm defoliation in Nova Scotia, 1982 and 1983

Sector of province	Defoliation categories (hectares 000)			
	Year	Light	Moderate	Severe
Cumberland County	1982	13.6	92.0	48.9
Colchester County	1983	6.4	18.9	158.6
Northumberland Coast	1982	11.0	28.7	0.8
	1983	21.8	16.5	38.2
Annapolis Valley	1982	0	4.1	0
Hants County	1983	34.7	14.4	29.9
Cape Breton Island	1982	12.3	0.4	0
	1983	0.5	2.2	15.5
Total	1982	36.9	125.2	49.7
	1983	63.4	52.0	242.2

Total area of moderate to severe defoliation
1982 — 174 900 ha (441,883 acres)
1983 — 294 200 ha (726,674 acres)

Table 2. Spruce budworm egg-mass infestation counts per 10m² in Nova Scotia by county from 1974 to 1983.

	Year									
County	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Richmond	125	203	430	649	364	403	423	51	2	4
Cape Breton	-	496	1608	524	437	349	378	17	7	2
Inverness	468	552	1319	758	389	316	308	50	151	13
Victoria	370	676	1832	771	435	647	258	27	50	14
Cumberland	293	263	191	71	218	307	235	197	622	203
Colchester	24	20	104	23	165	52	10	22	52	34
Pictou	-	23	29	125	140	214	116	13	103	68
Antigonish	204	135	196	182	252	65	136	79	228	92
Guysborough	0	0	6	78	-	8	0	8	19	4
Kings	14	12	12	25	73	183	245	86	245	228
Annapolis	19	16	18	27	121	165	224	72	331	29
Hants	36	11	6	6	0	19	61	12	5	11
Digby	12	6	11	20	-	3	86	36	42	9
Halifax	0	37	0	5	-	0	30	24	21	8
Lunenburg	0	6	0	6	9	16	10	15	20	6
Shelburne	0	3	0	12	-	8	28	4	2	2
Queens	0	3	4	4	0	0	-	6	11	1
Yarmouth	0	0	16	20	-	28	29	4	4	6

Table 3. Summary of the condition of balsam fir on Cape Breton Island 1982-1983, in selected plots

	As percentage of total fir stems			
	Highlands		Lowlands	
Condition	1982	1983	1982	1983
Standing dead trees	66.8	65.8	88.3	85.0
Fallen dead trees	4.8	11.1	1.3	5.8
Total mortality	71.6	76.9	89.6	90.8
Mortality increase 1982-1983		5.3		1.2
Absence of foliage (Defoliation)				
Less than 50%	1.5	4.9	1.3	3.2
50 - 75%	21.5	14.8	8.4	4.5
75 - 90%	4.7	3.3	0.6	1.9
More than 90%	0.6	0	0	0
	A further breakdown of the above data			
Total mortality	71.6	76.9	89.6	90.8
Trees >75% defoliation	5.3	3.3	0.6	1.9
% total dead & dying	76.9	80.2	90.2	92.7
% trees with less than 75% foliage missing*	23.0	19.7	9.7	7.7

*Fate of trees in this grouping will be variable, some will continue to die, others will survive the budworm outbreak. It is expected that Armillaria root rot or bark beetles etc. will kill many of these trees.

This information obtained from Forest Insect and Disease Survey plots on Cape Breton Island.

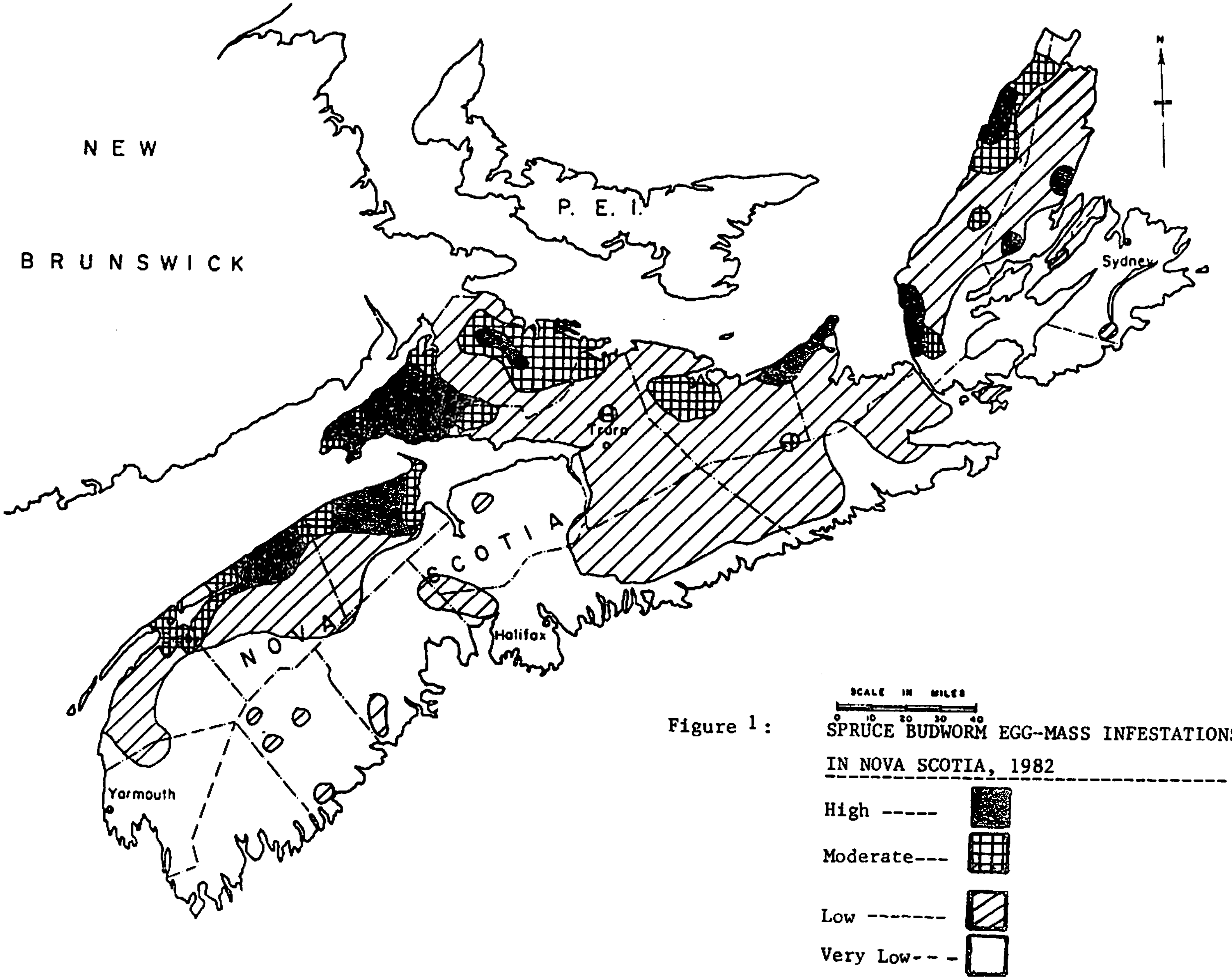

Figure 1: SPRUCE BUDWORM EGG-MASS INFESTATIONS IN NOVA SCOTIA, 1982

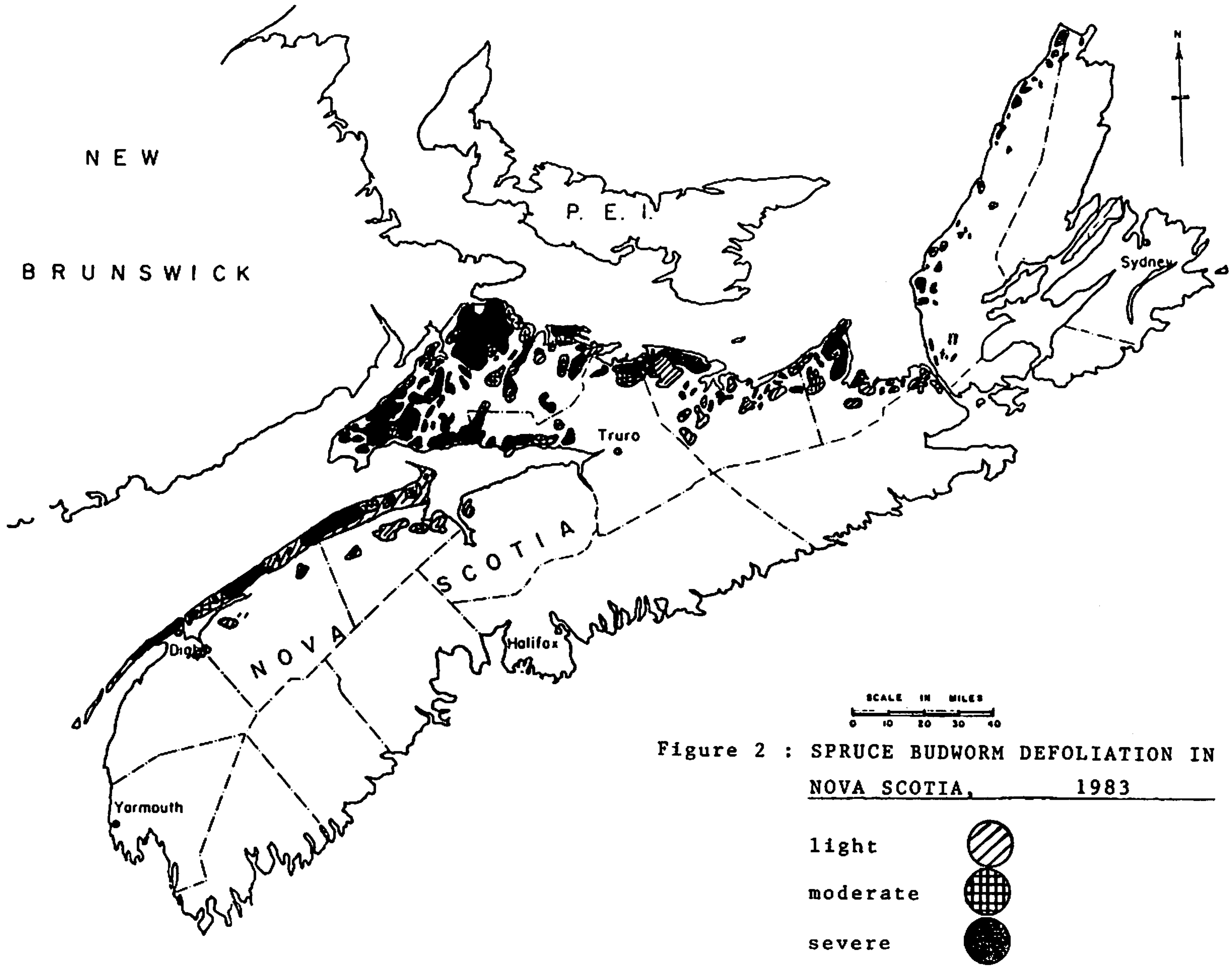

Figure 2 : SPRUCE BUDWORM DEFOLIATION IN NOVA SCOTIA, 1983

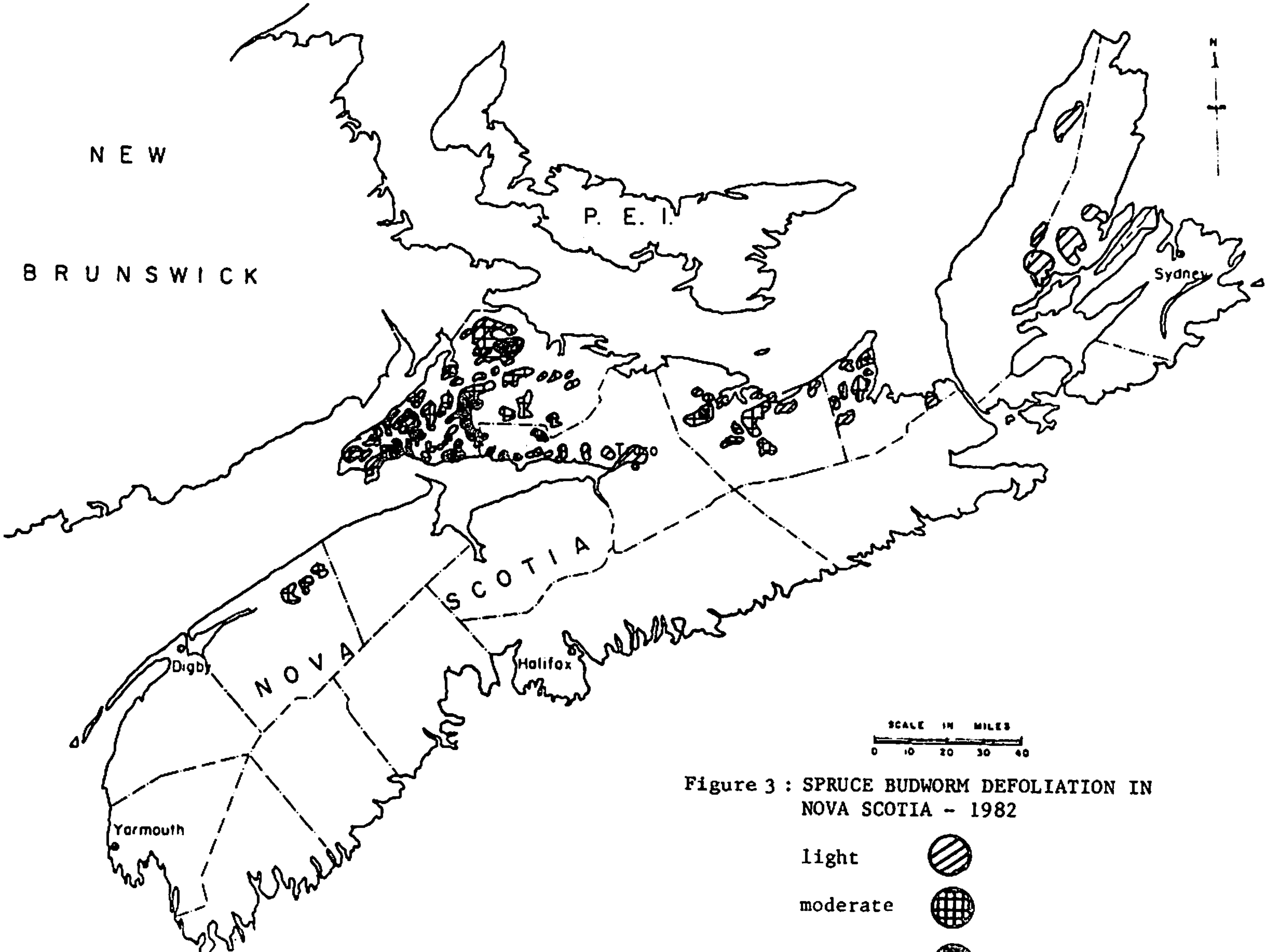

Figure 3 : SPRUCE BUDWORM DEFOLIATION IN NOVA SCOTIA - 1982

light

moderate

severe

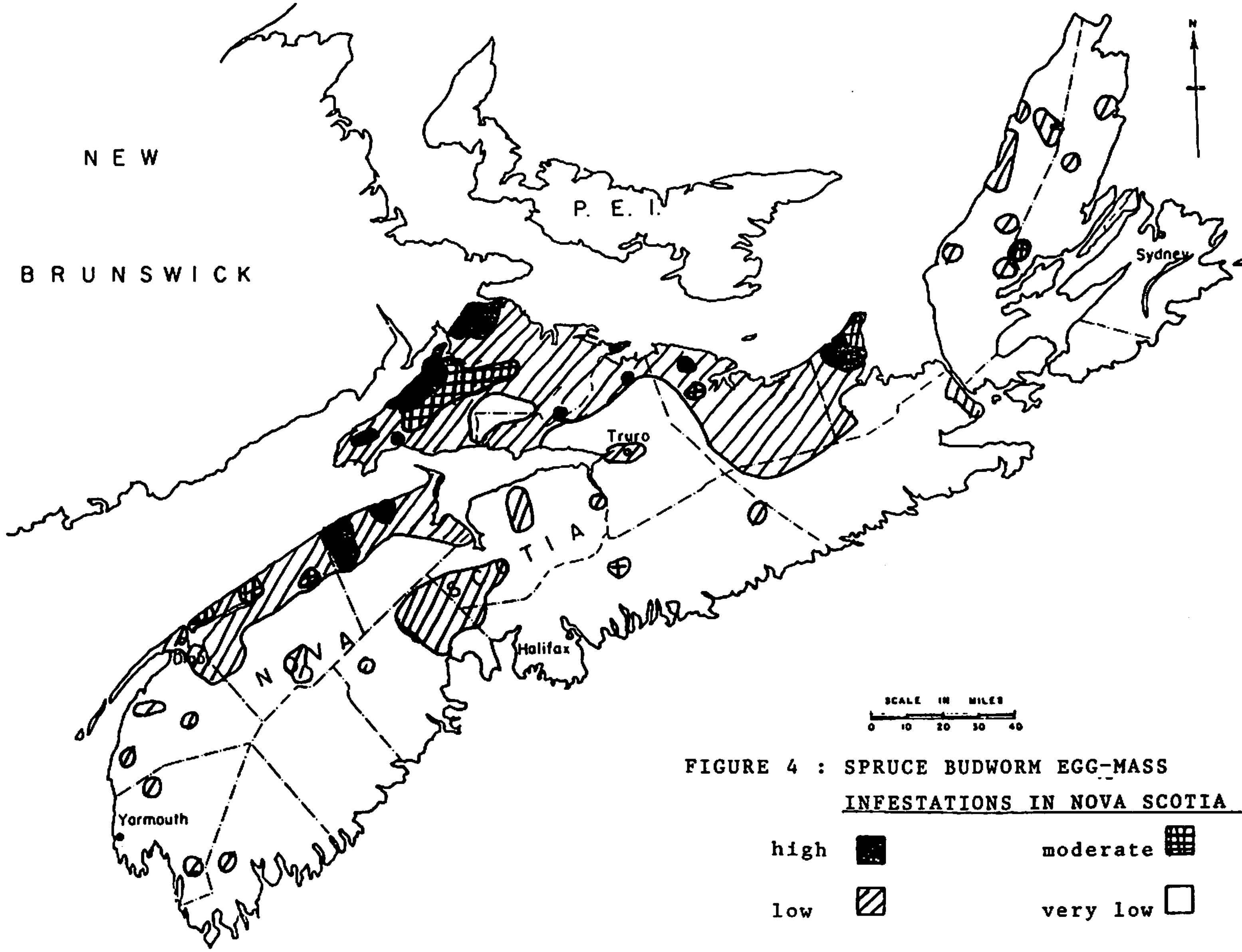

FIGURE 4 : SPRUCE BUDWORM EGG-MASS INFESTATIONS IN NOVA SCOTIA 1983.

high | moderate
low | very low

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MARITIMES FOREST RESEARCH CENTRE TECHNICAL NOTE NO. 97

MAJOR FOREST PESTS IN NEW BRUNSWICK IN 1983

Many pests interfere each year with the production of wood in the forest or with the aesthetic appearance of trees. One of these, the SPRUCE BUDWORM has again been by far the most important insect in New Brunswick. The 'budworm story' is the topic of other reports. The SPRUCE BUD MOTH, until recently an unimportant forest insect, has gained notoriety when it became a major damaging agent in white spruce plantations. Its 'story' and of efforts to control it are dealt with elsewhere. Other forest pests of economic importance are briefly mentioned here. These and others will be discussed in detail in the annual report of the Forest Insect and Disease Survey.

GYPSY MOTH has been the most important hardwood defoliator in the northeastern part of the United States during the last several decades. The insect annually defoliated trees over millions of hectares. Gypsy moth was a temporary resident in the late 1930's in parts of Charlotte County. It was not found again until 1981 in spite of concentrated searches since 1971. In the fall of 1981, egg masses, each with a potential of producing several hundred larvae, were found at Mohannes, Pennfield, Beaver Harbour, and on Grand Manan Island. In 1982 a small infestation existed at Mohannes and various stages of the insect were found at St. George, St. John and on Campobello Island.

In 1983, a concerted multi-agency effort to define distribution, found gypsy moth in the Mohannes area, at St. Stephen, St. Andrews, Oak Bay, St. George, Beaver Harbour and Oak Hill. Very few insects were found in most places except at Mohannes and in St. Andrews where several dozen larvae or pupae were destroyed. However, finding even a single insect is significant

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PLANTATIONS

SILVICULTURE

UTILIZATION

ECONOMICS

TREE IMPROVEMENT

INSECTS AND DISEASES

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when dealing with a new, potentially explosive and important pest since the find often indicates the presence of a population in an area. Fall surveys, for egg masses, based on 'finds' and on the results of a province-wide summer pheromone trapping program are not yet complete.

Control is based on a policy of destroying all life stages of the insect, even though it is recognized that finding all gypsy moth is beyond the manpower availability of any of the agencies involved in surveys. In addition to the 'search and destroy' method a special control program in the Mohannes area included a *B.t.* spray program, co-sponsored by the N.B. Dept. Natural Resources and Agriculture Canada, and the release of an egg parasite by the Canadian Forestry Service. Details of these will be reported later.

JACK PINE BUDWORM feeds on male flowers and on new foliage of jack pine and occasionally on Scots, red and white pine trees. The insect affects mostly the upper portion of the crown which can result in deformed trees because of top kill and subsequent multiple leadering. Repeated heavy defoliation may cause tree mortality. Although the insect at high populations is considered important in natural stands, its economic impact is likely to be even greater in younger plantations. Jack pine budworm populations have been increasing for the last three years, especially in the eastern half of the Province. In 1983, foliage browning, the result of feeding, was readily visible from the air within an area of about 200 000 ha in the east-central part of New Brunswick wherever jack pine occurred. Damage intensity was variable within the affected area but at selected locations 61% of the shoots lost more than half of their needles and only 20% of the shoots were unaffected by defoliation. Larvae were observed at a few other locations in the Province, especially in the Tracadie area.

FOREST TENT CATERPILLAR is our most visible hardwood defoliator. The insect prefers trembling aspen, oak, apple, birch and cherry for food, but at high populations foliage of sugar maple, alder, ash, elm and ground foliage is also readily consumed and defoliation of conifers, especially larch and white spruce, also occurs in extreme situations. The outbreak currently raging in New Brunswick is the most extensive ever recorded in the Province. It started in 1978 in the Woodstock area where a few patches of trembling aspen were defoliated. The outbreak increased steadily in size and reached its peak in 1982 when 1.4 million hectares of severe defoliation were recorded and covered much of the southern half of the Province. A change in areas of severe defoliation relieved pressure on hardwood forests in the northern part of the St. John River Valley. In 1983, the crescent shaped area of severe defoliation shifted further south and covered some 1.2 million hectares, only slightly less than last year. In the outbreak areas many trees did not respond to heavy feeding and failed to produce new foliage. Whether this was due to trees having been weakened by repeated defoliation or to this year's weather-related, prolonged feeding period is uncertain, however the result was extended areas of trembling aspen with bare twigs and branches and generally 'thin' foliage. A forest tent caterpillar related event was the appearance of great numbers of a parasitic fly (*Sarcophaga aldrichi*) attacking the insect and causing annoyance in inhabited areas.

OTHER FOREST PESTS of limited or localized importance in 1983 included: FALL CANKERWORM, BRUCE SPANWORM, LEAF ROLLERS, LEAF MINERS, DUTCH ELM DISEASE, SPRUCE BEETLE, SIROCOCCUS SHOOT BLIGHT, BALSAM GALL MIDGE and BALSAM TWIG APHID.

-L.P. Magasi
Forest Insect and Disease Survey

November 1, 1983

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PEST NOTE

European Larch Canker

The European larch canker, caused by the fungus Lachnellula (Dasyscypha) willkommii, was found on native larch in New Brunswick and Nova Scotia in 1980 and in Washington County, eastern Maine, in 1981. Relatively little is known of the disease on this continent but in parts of Europe it eliminated European larch as a plantation species. This disease should be considered potentially damaging in North America until and unless research proves otherwise. Foresters, tree breeders, pathologists, survey and plant quarantine organizations, and others should learn to recognize the disease in order to prevent spread and establishment in unaffected areas. The increased emphasis on both forest renewal, in general, and larch improvement programs, in particular, demand attention to forest protection by prevention.

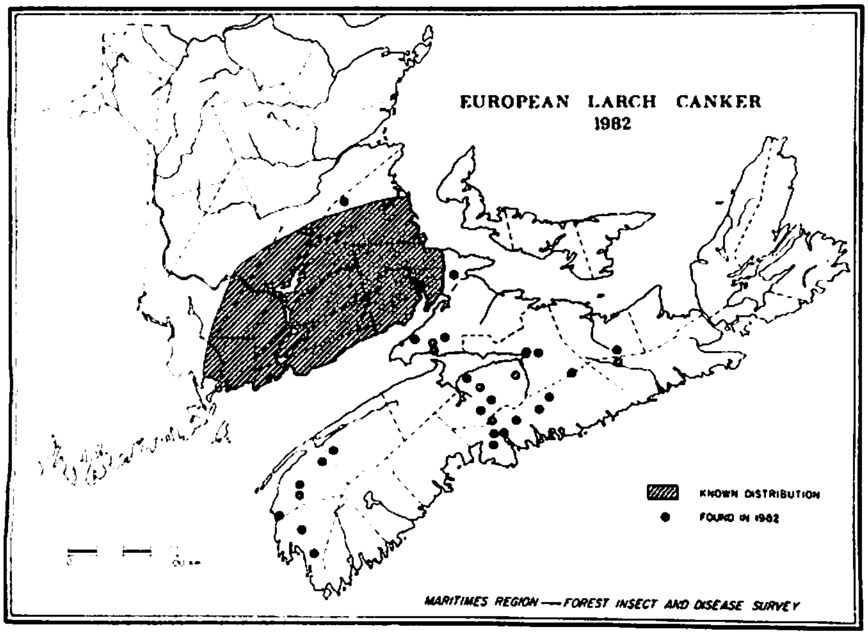
Infection by the fungus results in canker formation. Young cankers appear as swellings on twigs and branches or as depressions on larger stems, and are accompanied by exuding resin. This gives the cankers a shiny appearance, often with a bluish hue. White, hairy, cup-shaped fruiting bodies with yellowish interiors are usually found in or around the canker, during most of the year. The fungus kills the cambium within the affected area but as growth around it continues, a ridge rings the canker. Needles above the canker on affected branches and small stems either shrivel up and die in the spring or discolor early in the fall. One or more cankers may be present on a single branch or a section of stem. The cankers are perennial and enlarge from year to year. When girdled, the tree or the branch dies. Larch (tamarack) trees up to 25 cm in diameter are known to be affected and trees up to 10 cm diameter have died from the disease. The approximate age of cankers can be determined in cross section from the the number of deformed annual rings.

It is not known whether the disease can be transmitted on infected cuttings or on seedlings without visible symptoms, but branches as small as 1 cm, and trees as small as 2 cm in diameter at ground level are known to be affected or killed. Therefore, care should be taken to avoid the possibility of artificial spread of the disease from affected areas.

This communication is not intended to provide either a detailed account on the life history of the fungus or to cause undue concern. It was prepared to aid in recognition of the disease and to create an awareness of the possibilities of damage.

Prepared by

L.P. Magasi
Forest Insect and Disease Survey
Canadian Forestry Service
1983

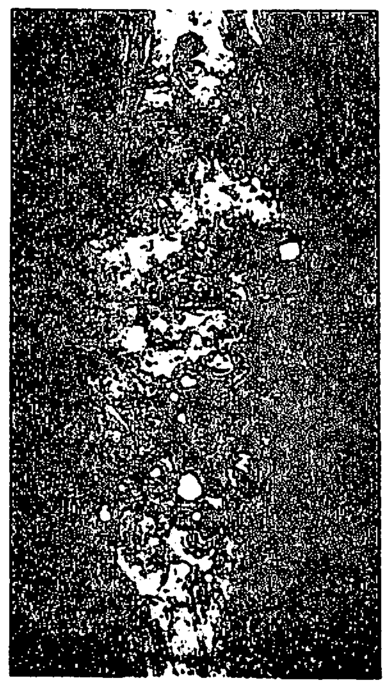


Canadian distribution - 1982

Discoloration above young canker

Fruiting bodies of the fungus

Cross section of young stem with canker



Resin covered perennial canker with fruiting bodies

Maritimes Forest Research Centre,
Department of the Environment,
P.O. Box 4000,
Fredericton, New Brunswick,
E3B 5P7

Canada

Government of Canada Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

CFS/J. Armstrong/7-2269/TC

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE

YOUR FILE/VOTRE RÉFÉRENCE

DATE January 11, 1984

DISTRIBUTION

FROM DE Scientific Advisor, Pesticides

SUBJECT OBJET B.t. sub-committee
Pest Control Forum

At the past Forest Pest Control Forum we met as a subcommittee to discuss the status of the registration of FUTURA. I was charged with the responsibility of preparing a letter for the signature of the ADM - Forestry, Mr. R. Herring - to BIOCHEM and Abbott and Sandoz about the interest in the high concentrate formulations. The agreement was that I would circulate immediately copies of the letter. Unfortunately I was not able to do this; the letters required an internal review and approval before they were acceptable. I have finally received copies of the letters which I append for your information. Please accept my apologies for the delay.

J. Armstrong

J. Armstrong

DISTRIBUTION : C.H. Buckner, CFS/HQ
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W. Stewart, Agr. Canada

Environment Canada | Environnement Canada
Canadian Forestry Service | Service canadien des forêts

R. Herring

A/ADM/CFS COPY
RETURN TO ORIGINATOR
HOLD COPY

Ottawa, Ontario
K1A 1G5

Biochem Products
C.R. Gleason, General Manager
Post Office Box 264
Montchanin, Delaware 19710
U.S.A.

Dear Mr. Gleason:

I am taking this opportunity of writing to you to express the concerns of the Canadian Forestry Service and forest managers over recent developments affecting the registration of Futura. As you are no doubt aware there is in Canada an acknowledgement of the need to manage our forest resources. This management involves the use of insecticides to control serious pests such as the spruce budworm. At present the most widely used materials are chemical insecticides; however, we realize that our dependance on these products must be reduced. To overcome public concerns and to reduce adverse environmental effects the biorational insecticide Bacillus thuringiensis offers a solution to our problems. The recent research program jointly carried out by Dr. Smirnoff and your company has resulted in the development of Futura. This high concentrate preparation which can be applied at low volumes has aroused great interest and papers presented at the recent Forest Pest Control Forum all report its success. The interest aroused among the provincial operators has resulted in requests as to its availability and status of registration since we are now looking to the 1984 spray season.

In conversation with representatives of Ag. Canada we understand that the registration of Futura is held up pending resolution of a compliance problem with respect to another of your products.

My purpose in writing to you is to urge you to meet the compliance requirements as laid down by Ag. Canada in order that the registration of Futura can be finalized. We realize that for a pesticide to be acceptable to the provincial operators there is a need for quality control and with a product such as B.t. that is still not widely used in Canada any suggestions or indications that cast doubts on the product will result in a lack of confidence and resistance against its use. We feel that B.t. is too important a product to suffer this fate.

Yours sincerely,

R. Herring
A/Assistant Deputy Minister

Environment Canada / Environnement Canada

Canadian Forestry Service / Service canadien des forêts

R. Herring

A/ADM/CFS COPY
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HOLD COPY

Ottawa, Ontario
K1A 1G5

DEC 8 1983

Abbott Laboratories
CAPD D-928
North Chicago, IL. 60064
U.S.A.

Attention: J. Curry

Dear Mr. Curry:

At the recent Forest Pest Control Forum I listened to reports pertaining to the developing and testing of new pesticides. One of the products tested was a high concentrate formulation of Bacillus thuringiensis that could be applied at volume rates approaching those used with chemical insecticides. Since one of the problems with B.t. acceptance has been the higher volume applications, which affected the cost of the spray program these reports suggest to me that B.t. is now on threshold of being generally accepted for operational use. At present there is only the one high concentrate, low volume application material that is at this stage. I am writing you to ask if your company is interested in developments along this line since it is obvious that there will be a much larger market for this product.

Yours sincerely,

R. Herring
A/Assistant Deputy Minister

Canada

Environment Canada / Environnement Canada

Canadian Forestry Service / Service canadien des forêts

R. Herring

A/ADM/CFS COPY

RETURN TO ORIGINATOR

HOLD COPY

Ottawa, Ontario
K1A 1G5

Sandoz Canada
P.O. Box 385
Dorval, P.Q.
H9R 4P5

Attention: Mrs. J. Echenberg

Dear Mrs. Echenberg:

At the recent Forest Pest Control Forum I listened to reports pertaining to the developing and testing of new pesticides. One of the products tested was a high concentrate formulation of Bacillus thuringiensis that could be applied at volume rates approaching those used with chemical insecticides. Since one of the problems with B.t. acceptance has been the higher volume applications, which affected the cost of the spray program these reports suggest to me that B.t. is now on threshold of being generally accepted for operational use. At present there is only the one high concentrate, low volume application material that is at this stage. I am writing you to ask if your company is interested in developments along this line since it is obvious that there will be a much larger market for this product.

Yours sincerely,

R. Herring
A/Assistant Deputy Minister

Canada

Vegetation Management Workshop

Report to the Annual Forest Pest Control Forum, Ottawa

Phillip Reynolds

Forest Pest Management Institute

Canadian Forestry Service

Sault Ste. Marie, Ontario

P6A 5M7

November 1983

The 1983 Forum gave birth to the first Vegetation Management Workshop to be held at an Annual Forest Pest Control Forum. With the advent of a new Herbicides R&D Program at CFS's Forest Pest Management Institute (FPMI), it was felt that a workshop should be held at the Forum on the topic of forest weed management. Hopefully, the Workshop will be replaced by a regular session on forest vegetation management at future Forums.

Approximately one-third of those present at the Forum attended the Workshop. Of those attending, approximately one-third were associated with federal registration of herbicides or with Provincial environmental regulatory agencies. The Workshop provided an opportunity to discuss 1) current herbicide research at FPMI and 2) to outline proposed herbicide research for 1984. Those associated with the registration process were asked to comment on the research and outline concerns which they felt should be addressed in future research. A number of conerns were expressed.

Many indicated that potential environmental impacts resulting from herbicide use should be compared and placed in perspective with the same environmental impacts resulting from (1) other types of forest practices or (2) other methods of vegetation management. Many felt there is a need to compare costs associated with various methods of vegetation management practices, including manual clearing of brush. Others stated a need to obtain and publish data which focuses on long-term (5, 10, 15, 20 and 25 years) growth response of forest plantations which have been treated with herbicides early after planting versus those which were manually needed or those which received no weeding at all.

Concerns were expressed by some that the federal registration process discriminates against the use of herbicides in the forest and that the process for registration of the same herbicides for use in agriculture is less stringent. Proponents of this view argue that trees are crops, and should be treated as an agricultural commodity. Human exposure to herbicides used in the forest is far less than exposure to similar herbicide use in agriculture. In nearly all instances, forest lands are remote, and infrequently visited by humans. Herbicides are applied much more infrequently to forest lands. A number of herbicides currently registered for agricultural use in Canada could not be registered in accordance with current standards. Since these registrations are unlikely to be cancelled, forestry registrations for the same herbicides will proceed in accordance with newer more stringent standards than those which were in existence at the time the herbicides were initially registered for agricultural use. However, extensions of existing agricultural registrations will have to conform to the same standards as those applied for forestry.

Others expressed concerns that forestry registrations are being delayed due to unresolved disputes within Health and Welfare Canada (H&W). At present, H&W has asked the manufacturers of Garlon and Velpar to submit a two generation-two litters per generation rat reproductive study. The manufacturers have submitted studies, used to register their products in the United States, which consist of three generations - one litter per generation. Resolution within H&W of the need for a new reproductive study is expected soon. Acceptance of the current study could result in temporary forestry registrations for badly needed herbicides. Foresters stress that they are not toxicology experts and do not wish to pass judgement on H&W criteria, but they do urge H&W to reach a quick resolution of acceptable registration protocols. Manufacturers are faced with repeating time-consuming and expensive reproductive studies if new protocols are required.

Existing reproductive data was completed several years ago in fulfillment of requirements for registration in several other countries. Forestry herbicide users hope that H&W will show some flexibility in developing new protocols. As a possible compromise, older herbicides (e.g., Velpar and Garlon) previously registered in other countries could be registered for forestry use in Canada based on existing reproductive data. A new reproductive protocol could then be applied to herbicide compounds which are as yet unregistered in Canada or elsewhere in the world.

Criticism was leveled at the Provinces and Canadian forest industries for not adequately or properly asserting their need for herbicides to successfully regenerate Canadian forests. Foresters have shown little commitment to use forestry herbicides in Canada as evidenced by historical use patterns. This lack of commitment is self-defeating when one attempts to convince others of the need for these products. Provinces and forest industries need to organize and lobby more vigorously. Although the views of farmers concerning the need for agricultural herbicides are well known, similar views of foresters are not. Expeditious registration of forestry herbicides, will not occur until the need for forestry herbicides is understood and recognized at the highest political levels. To accomplish this goal forest industries and Provincial Forest Ministeries will have to educate their staff, the public and politicians concerning the need to use herbicides and the importance of forestry to the Canadian economy. If continued commitment of herbicide manufacturers to register forestry herbicides is to be expected, foresters must resolve to demonstrate their faith in the need for herbicides by actively assisting in registration research and by committing themselves to use new herbicides as soon as they are registered for forestry use. Regeneration of Canada's forest resource has reached a point of critical mass. If herbicides are not used *NOW* (1) adequate new forests cannot be assured in time to offset Canada's current rate of harvesting, (2) the importance of forestry in the Canadian economy will rapidly decline and (3) numerous persons who currently depend upon forestry for a livelihood will soon be unemployed. Attempts to reduce the rate of harvest will result in more rapid unemployment of those currently working in forestry. If Canada's economy is not to suffer, environmentalists, politicians and the public must be made aware that the consequences of not using forestry herbicides are likely more consequential, ominous and imminent than presumed or unproven environmental and human health concerns.