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Report of the Ninth Annual Forest Pest Control Forum Government Conference Centre Ottawa, Ontario December 1-3, 1981

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ENVIRONMENT CANADA

Report of the

NINTH ANNUAL FOREST PEST CONTROL FORUM

GOVERNMENT CONFERENCE CENTRE

Ottawa, Ontario

DECEMBER 1-3, 1981

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

APRIL, 1982

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In Attendance (full- or part-time):

United States Forest Service

D.R. Kucera, Broomall, PA
R.L. Talerico, Broomall, PA

Maine Forest Service

H. Trial, Old Town
S. Oliveri, Augusta

Newfoundland Department of Forest Resources and Lands

N.E. Carter, St. John's

New Brunswick Department of Natural Resources

R. West, Fredericton

New Brunswick Department of the Environment

C. MacLaggan, Fredericton
K. Browne, Fredericton

Ontario Ministry of Natural Resources

J.R. Carrow, Maple
C.S. Kirby, Maple
S. Nicholson, Maple
H.H. DeVries, Kemptville

Manitoba Department of Natural Resources

K.R. Knowles, Winnipeg

British Columbia Ministry of Forests

P.M. Hall, Victoria

Forest Protection Limited

H.J. Irving, Fredericton
L.K. Hartling, Fredericton

J.D. Irving Limited

D.D. Oxley, St. John
J.F. Couturier, St. John

Eastern Spruce Budworm Council

G. Paquet, Quebec

Canadian Forestry Association

D.R. Redmond, Ottawa

Health and Welfare Canada

L. Ritter, Ottawa

National Research Council

M.F. Mitchell

Agriculture Canada

B.E. Hopper, Plant Quarantine Division, Ottawa
W.P. Campbell, Plant Quarantine Division, Ottawa
A.E. Straby, Plant Quarantine Division, Ottawa
A.C. Schmidt, Plant Quarantine Division, Ottawa
E.T.N. Caldwell, Pesticides Division, Ottawa
W. Stewart, Pesticides Division, Ottawa

Industry, Trade and Commerce

J.E. Serveau, Ottawa

Fisheries and Oceans Canada

P. Ryan, St. John's
C. Morry, Halifax

Environment Canada

Legal Services
P. Haskins, Ottawa

Environmental Protection Service
W.R. Ernst, Halifax
F. Perron, Montreal
J. Stewart, Ottawa

Canadian Wildlife Service
P.A. Pearce, Fredericton
D.J. Forsyth, Ottawa

Parks Canada
T. Wallace, Ottawa
V. Brownell, Cornwall

Canadian Forestry Service
J. Hudak, St. John's
D.G. Embree, Fredericton
E.G. Kettela, Fredericton
B.A. Pendrel, Fredericton
D.P. Ostaff, Fredericton
A. Lavallée, Ste. Foy
J.R. Blais, Ste. Foy
L. Jobin, Ste. Foy
W.A. Smirnoff, Ste. Foy
W.L. Sippell, Sault Ste. Marie
G.M. Howse, Sault Ste. Marie
J.H. Meating, Sault Ste. Marie

K.J. Griffiths, Sault Ste. Marie
G.W. Green, Sault Ste. Marie (Cochairman)
J.A. Armstrong, Sault Ste. Marie
P.D. Kingsbury, Sault Ste. Marie
T.J. Ennis, Sault Ste. Marie
B.L. Cadogan, Sault Ste. Marie
O.N. Morris, Sault Ste. Marie
W.H. Fogal, Chalk River
G. Murray, Chalk River
H.F. Cerezke, Edmonton
G.A. Van Sickle, Victoria
J.H. Cayford, Ottawa (Cochairman)
T.E. Sterner, Ottawa (Cochairman)
M.A. Hulme, Ottawa
C.H. Buckner, Ottawa
R.G. Taylor, Ottawa
D.A. Winston, Ottawa
A.G. Davidson, Ottawa (Secretary)

Agenda

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   Legal Services, DOE

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   3.2 The Gypsy Moth Picture in the United States
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Reports and comments by representatives of state and federal agencies

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8. Reports on Status and Control of Other Pests

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Prairie Provinces
Ontario
Quebec
Maritime Provinces
Newfoundland
United States

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9. Tree Improvement and Forest Pest Management - Dr. W.H. Fogal, Petawawa National Forestry Institute

   Opportunity for informal discussions of topics of interest, working group or committee meetings.

OPENING REMARKS TO THE 9th FOREST PEST CONTROL FORUM

December 1, 1981

J.H. Cayford

On behalf of the Canadian Forestry Service, it gives me great pleasure to welcome all delegates to the 9th Annual Forest Pest Control Forum. This Forum is held under the auspices of the Canadian Forestry Service and is designed to provide an opportunity for representatives of provincial and federal governments and private agencies to review and discuss Forest Pest Control operations in Canada and research related thereto. I think the Forum has been successful in the past in achieving this main purpose and it is the intention of the CFS to continue to convene the Forum as long as it meets your collective needs.

In his opening remarks to you last year, Mr. Reed, Assistant Deputy Minister, Canadian Forestry Service, indicated that one of his main priorities in leaving the private sector and coming into the organization was to promote sound forest management. The need for this is described in a recent discussion paper prepared by the CFS and entitled "A Forest Sector Strategy for Canada". The paper examines policy options for increasing the contribution of the forest sector to the social and economic fabric of Canada and forms a background document against which subsequent memoranda to Cabinet for support of specific programs will be made. A few excerpts from this document will help highlight the importance of forestry to Canadians and the Canadian economy.

- The forest sector accounts for approximately one million jobs, or one job in every ten.

- Forest products make up 14 percent of all manufactured goods in Canada with shares as high as 30% in New Brunswick and 50% in B.C.

- In 1980, forestry resulted in net earnings in foreign exchange of nearly 12 billion dollars which was significantly more than agriculture, fisheries, mining and coal and crude petroleum combined.

- No other industrial sector has the potential to contribute more to Canada's economic development than forestry in the next two decades.

- In view of this potential, the Canadian Council of Resource and Environmental Ministers at its 1980 meeting endorsed a harvest level target of 210 million M3 by the year 2000, some 40 percent above the anticipated harvest for 1981.

-BUT-

- Timber supply is a critical issue facing the forestry sector in Canada today; we are exceeding our annual allowable cut of softwoods in many areas of the country and approaching it at a very dangerous rate in most other areas.

- If the forest sector is to meet these new demands that will be made upon it in the years to come, it is abundantly clear that we must embark on a massive program of intensive forest management now to assure this future wood supply.

- This program of intensive forest management will include site preparation, use of genetically superior planting stock, prompt regeneration of cutover land including the extensive backlog of unacceptably stocked forest land, suppression of competing vegetation, thinning and fertilization. It will also include more comprehensive protection practices to protect this very valuable stock from inroads made upon it by destructive insects, diseases and fire.

- Forestry in Canada is obviously in a critical stage where "mining" must give way to systematic forest renewal and the role of the forest manager has changed from that of a "tree harvester" to a "forest farmer".

Forestry in Canada is faced with a major challenge for the future. Though it will be difficult to achieve the forest renewal and production goals that I alluded to earlier, there is no question in my mind that these goals can be met if forest managers are provided with the management tools required and allowed to use them in an intelligent and responsible manner. Chemical and/or biological pesticides including insecticides, fungicides and herbicides are examples of such essential tools and these must be made available to the forest manager in as wide an array as possible to assure that he has a range of viable options from which to choose to meet specific problems in the most practical, efficacious and environmentally conscious manner.

It is somewhat paradoxical that just as forestry is advancing from a "mining", exploitive stage in its development to a "farming" or intensive management era, the tools that it requires in the form of chemical and/or biological pesticides to achieve its production goals are much less available to it now than they were in the past, and the problems in obtaining registrations for forestry use appear to be much more formidable than for agricultural or commercial use.

In outlining the program of the Forest Pest Management Institute to you last year at this Forum, Dr. G.W. Green indicated that forest protection in Canada was in very dire straits, indeed. Some of the reasons he suggested that were responsible for this unfortunate state of affairs were:

- An extremely meagre arsenal of pest control products for forestry use.

- Lack of a public, and to a certain extent, political understanding of the importance of the contribution that the forest resource makes to the socio-economic well being of all Canadians and failure to understand that this resource must be managed intensively if it is to continue to serve Canadians optimally.

- Reluctance on the part of the pest control products industry to invest in the development and/or registration of materials for the forestry market which is small and cyclical relative to that of agriculture, but for which registration protocols are exceedingly rigorous, and within which, continuing use of registered materials appears more subject to emotional than objective decision-making on the part of politicians and, to a certain extent, regulatory authorities.

- Failure of all natural renewable resource and public health jurisdictions to sit down together and to consider forestry's plight and to reinstate some reasonable perspective into considerations of the controversies and myths currently surrounding the use of pest control products in forestry.

I agree completely with these observations, and find it incredible that, in a forest nation such as ours, we have only two widely used and truly proven chemical insecticides (aminocarb and fenitrothion) and one biological insecticide (B.t.) registered under the Restricted Forestry Use Category for use against our more important forest defoliators. It is even more incredible in my mind that for the whole of Canada, there are only two herbicides (2-4D and 2-4-5T) registered for site preparation and conifer release - and one of these (2-4-5T) is banned from use through provincial regulations in some provinces.

It is alarming also that there appears to be a dearth of new candidate materials (both insecticides and herbicides) in line for upcoming forestry use registration. Where forestry use herbicides are concerned, I understand that there are four potentially good candidates sitting in the wings (glyphosate, krenite, velpar and garlon) but their fate at the moment is uncertain because industry perhaps understandably, is reluctant to undertake the very expensive toxicological testing that apparently is required to clear them for forestry use. They are reluctant, perhaps, because they cannot understand, as I cannot, the need to provide such expensive toxicological testing for forestry use when the same material can be utilized adjacent to a proposed forestry use site to remove undesirable brush from a hydro or a road right of way.

I am concerned with the apparent lack of Canadian protocols for the registration of biological insecticides for forestry and for agricultural use, and for the delays in registration that this will surely impose on materials that the Canadian Forestry Service is entering into the registration stream in an attempt to reduce our dependence on chemical pesticides. I am concerned also with what appears to me to be an over regulation concerning the specific pests a material is registered for use against. It would appear to me that some generic as opposed to specific approach could be developed to give a forest manager more scope to meet individual problems that from time to time crop up.

From a forestry point of view, this is a completely unacceptable state of affairs and I know I am supported in this viewpoint by provincial forestry colleagues and by the forestry industry in the major wood-producing provinces. However, I am optimistic that the situation can and will be turned around to give forestry the due consideration it deserves relative to the extremely high value of the forest resource. To achieve this, it will be necessary for representatives of all agencies concerned with the development, registration and use of pest control products in forestry to meet at the conference table, to objectively consider the problems facing the forestry sector, and to arrive at an enlightened approach that will ease the path to registration and use without significant added hazard to other renewable natural resource sectors, to the environment in general, or to public health and safety.

To this end it is encouraging that the Canadian Council of Resource and Environment Ministers has recently established a task force consisting of federal and provincial officials to review the entire registration process of chemicals for Forest Management. The CFS has membership on this task force and will be participating actively in its work.

I wish you well in your deliberations; I hope you will keep some of the points I just made in the back of your minds during the course of this Forum; and collectively I hope we can deliver forestry from the dilemma it currently faces with respect to the registration and use of pesticides.

THE GYPSY MOTH REVIEW

This is by no means the first time the gypsy moth has been discussed at the Forest Pest Control Forum. It was included on the agenda at least over the past 3 years. Accordingly we are taking for granted that you as attendees are acquainted with the insect, its hosts, its habits and generally its past history and impact in North America since 1869.

As for the introduction, two specific points stand out by way of necessary background for this brief review of the gypsy moth problem in Canada. I am anxious that these points are made at the outset because much of what you will hear over the next two hours will relate directly or indirectly to them. I apologize in advance to the speakers if I may steal some of their thunder, but in my mind at least, these few points seem so important to the overall picture that a little repetition would simply tend to emphasize. So, I hope the speakers won't change what they were going to say.

My first point relates to the gypsy moth situation to the south of us. According to the information provided me by Mike McManus of the U.S. Forest Service, Northeastern Forest Experiment Station, Hamden, Connecticut, gypsy moth populations in the northeastern U.S. increased to enormous proportions in 1981. As shown on this USDA graph, the total area defoliated since 1960 has climbed progressively through a pattern of oscillations, first with low amplitude then moderate amplitude until 1980 when a major change took place and the total area defoliated reached over 5 million acres. The unexpected happened when this total, i.e., the accumulated area showing gypsy moth feeding, reached 12.2 million acres in 1981. Collectively then over nine northeastern States from Maine in the north, New Jersey in the south and westward through New York State often butting up onto the Canadian border accumulative defoliation extended over about 19,000 square miles. This figure I understand is still somewhat tentative and should only be used as an approximation of the extent of damage. I expect we will hear something more of this and of what can be expected in 1982 from Dan Kacera one of our guests.

My second point relates to the Canadian Plant Quarantine Advisory Board. As many of you may know this Board was formed in December 1980 through a letter of agreement between Environment Canada and Agriculture Canada to advise the Director General, Research and Technical Services, Canadian Forestry Service, and the Director, Plant Products and Quarantine Division (Directorate) of Agriculture Canada on more effective and more efficient handling of forestry-related quarantine problems. This Board recognized largely at the insistance of Agriculture Canada that the gypsy moth situation in Canada has rapidly reached the point where Agriculture Canada despite their commendable efforts using pheromone traps and the valuable contribution of their cooperators simply cannot keep up with the detection of newly established populations on the Canadian side. There is also no question that the increased numbers of gypsy moth in the U.S. has created a proportionately higher probability of separate gypsy moth introductions into Canada on recreational vehicles and in others ways.

Assuming realistically that there is a delay of from 1 to 5 years or more between the time an introduction takes place and detection is made, we must project that following 1981 the gypsy moth problem will be more widely distributed in Canada than detection surveys now indicate. This is no reflection on the detection programs underway, it is being realistic as to the current situation we are here to discuss. The future prospects are not at all bright. Again the Plant Quarantine Advisory Board has pointed out the need for stepped-up action to reduce the probable future impact of gypsy moth in Canada in four ways, namely through:

(i) the procurement of more complete surveys on the occurrence and spread of the gypsy moth: - Agriculture Canada (Plant Quarantine) and Environment Canada (Canadian Forestry Service).

(ii) continued follow-up containment action against newly detected populations: - Agriculture Canada.

(iii) research on the control of gypsy moth with emphasis on biological methods: - Environment Canada.

(iv) the implementation of management action in areas of more or less continuous gypsy moth establishment by provincial forestry departments according to their own provincial policies and with entomological advice and assistance from the Canadian Forestry Service.

Concerning point (iv), there now exist extensive areas in Ontario, Quebec and perhaps other provinces where the gypsy moth occurs on a more or less continuous basis. On all forest insect and disease problems which arise from time to time the Canadian Forestry Service traditionally has worked side by side with provincial forest managers in providing the entomological information so vital in decision making, in helping to develop control strategies, and in evaluating the results of management action taken. Evaluation is done again with provincial assistance. I see no reason for discontinuing this policy.
Initial discussion of these needs with the scientific and forest management communities in Canada it was agreed would be initiated at the Forest Pest Control Forum.

I have a few comments of my own. The following principle must be applied namely that little can be done or should be done about management action against a forest insect without sufficient entomological information being available to be able to evaluate in advance the probable success of the venture. At least that makes sense to me biologically, economically and environmentally. For example "containment action" with the possible exception of urban areas requires a firm and virtually complete picture of where the gypsy moth is established.

The situation with respect to research in Canada and for Canada is a difficult topic in view of the breadth of entomological research in the USA and in view of the accelerated research program carried out south of the border between 1972 and 1978. Not all the U.S. research outputs apply to Canada, however, and more background research is required particularly emphasizing biological control.

To comply with the theme of a forum, i.e., "an assembly for the discussion of public matters", it is essential that as Chairman I leave 15-20 minutes open for comments and questions following presentations on this important problem. With your indulgence I am going to press straight through, not allowing questions until the last, (ADM and DG excepted) I am going to be strict as to timing so that you will all have opportunity to make comments or ask questions which I suggest you jot down for yourself as they come to mind when listening to the various speakers whom we have arranged for you this morning.

WLS

The Gypsy Moth Situation in the Northeast

by

D.R. Kucera

USDA Forest Service, Broomall, Pa.

In 1981 the Gypsy Moth defoliated an unprecedented 13 million acres in 11 Northeastern States, 8 million acres more than in 1980. A similar situation will probably occur in 1982, with light to moderate defoliation occurring in Virginia, West Virginia, and Michigan.

This is the area where susceptible hardwood forests were defoliated 30 percent or more in 1981. Nassau County and the New York City counties had defoliation, but were not surveyed.

In 1981 an unusual combination of early egg hatch, extremely large numbers of caterpillars, and favorable weather conditions for their development, resulted in severe defoliation in several states. Tree species not normally fed upon by the Gypsy Moth were completely stripped of their foliage. Most hardwoods refoliated by mid-summer, but were seriously weakened. Pines and hemlocks died after one defoliation.

Gypsy Moth caterpillars were a major nuisance throughout the Northeastern States in 1981. They found their way into homes, swimming pools, and picnic lunches. Some people suffered a skin rash from exposure to the caterpillar hairs and in some cases to moth scales. Campground owners lost business during the period of heavy caterpillar activity, May 14 - June 15. Many homeowners became upset and resorted to ineffective or environmentally undesirable measures.

In the U.S. the federal role is covered by the USDA Forest Service and Animal and Plant Health Inspection Service, and State and Local Governments in coping with the Gypsy Moth problem.

The USDA Forest Service Authority to protect trees and forests from Insects and Diseases is contained in section 5 of the Cooperative Forestry Assistance Act of 1978 (P.L. 95-313). The administration of this Act is delegated to the Chief of the Forest Service. Under the Act, the Forest Service can take direct action on national forests. On other Federal Lands, we work in cooperation with the managing agencies providing whatever assistance is needed. On State and Private Lands Suppression of Forest Pests is carried out in cooperation with the State Forester, or the state official responsible for Forest Pest Management.

The USDA Forest Service provides technical and financial assistance upon request by the States. Technical assistance includes workshops in Management of Control Projects and help in development of work and safety plans. USDA Forest Service Financial Assistance may be up to a maximum of 50 percent of the cost of control projects, depending upon the availability of funds and the size ownership of properties involved.

As required under the National Environmental Policy Act (NEPA), the Forest Service conducts an environmental analysis before considering requests for financial assistance for Gypsy Moth Control. A site specific environmental analysis document is prepared jointly with States requesting assistance.

Each year's analysis is guided by a programmatic environmental impact statement prepared in FY 1981. Based on this programmatic document, the USDA Forest Service and the Animal and Plant Health Inspection Service selected an integrated Pest Management approach to guide cooperative Gypsy Moth management activities. Only those projects that are biologically sound, economically effective, environmentally acceptable, and for which a Federal Role or interest has been established, are eligible for Federal financial assistance.

The objectives of cooperative Gypsy Moth suppression projects are to protect forest resources on high value, high use areas from excessive tree defoliation, tree mortality, and to reduce larval population and insect nuisance. Treatment does not eliminate the Gypsy Moth, and some defoliation occurs even in treated areas. These projects have no effect on the outbreak as a whole since less than 10 percent of the area affected by the Gypsy Moth has been treated in recent years.

State Foresters or other officials responsible for Forest Pest Management have the lead role in Gypsy Moth Control. The State Agency decides on the extent of control, requests Federal technical and financial assistance; determines if local governments intend to participate; sets specific criteria for selection of high value, high use areas for protection; selects the insecticides to use from among those registered for Gypsy Moth Control; plans and supervise the insecticide applications; notifies the public during insecticide applications; and receives and administers use of Federal funds to cover project expenses.

Local governments also play a major role in Gypsy Moth Control. Towns or counties must request inclusion in a cooperative State/USDA Forest Service suppression project. Since local governments decide whether or not cooperative Gypsy Moth suppression is carried out in their jurisdiction, individual citizens and property owners must make their wishes regarding Gypsy Moth Control known to their local governments.

In most States, local governments provide the largest share of non-Federal funds for control. Local governments also may assist the State Forester in selecting high use, high value areas for protection, mark areas to be treated, notify citizens about the time and date of treatment, locate those who do not want their properties treated, or carry out other support activities.

Some States, local governments, or individuals may decide to carry out Gypsy Moth Control on their own. In these cases, the USDA Forest Service is not involved financially, but may provide technical assistance to the State.

The USDA Forest Service is not the only agency of the Department of Agriculture working on the Gypsy Moth problem. The Animal and Plant Health Inspection Service (APHIS) is responsible for the regulatory program while ARS is involved with research activities.

PREPARATIONS FOR 1982

We expect defoliation to be at a high level in most areas of the Northwest U.S. next year, although some areas may experience less defoliation than last year.

Preparations are well underway for 1982. We have asked each of the affected States to indicate if Federal technical or financial assistance will be needed. We have met with each State Forester to explain the assistance available and how to apply for it. We have participated with each State Forester in at least one public meeting to explain proposed plans for 1982 and to determine public issues and concerns not previously considered in the NEPA process. We are planning workshops in management of Gypsy Moth suppression projects at the request of several State Foresters.

Nine of the 11 States heavily defoliated in 1981 have tentatively requested Federal financial assistance for 1982. Delaware has not yet decided to request assistance. Most State Foresters now know which communities wish to be included in the 1982 suppression projects. State Foresters are now making surveys in those areas where local governments have requested control to determine whether the areas meet the State Forester's criteria for treatment. These criteria consider the number of Gypsy Moth egg masses, land uses, and values involved.

While preparations are well underway for 1982, all issues are not resolved. The USDA Forest Service and State Foresters are faced with a number of significant issues. Major issues facing us as we prepare for 1982 are:

1) Limited State and local funds in some States.
2) A shortage of experienced staffs to manage suppression projects in some States.
3) A possible shortage of well-qualified and equipped insecticide applicators.
4) Policies in some States that prevent or limit use of chemical insecticides.
5) A tendency by some States to rely too heavily on the biological agent B.T. despite its higher cost and its lack of control in extremely heavy Gypsy Moth populations.

6) Concern about use of chemical insecticides by some organizations and individuals.
7) Concern about aerial application of insecticides.
8) A need for strong State agency supervision of cooperative suppression projects to insure that project objectives are met and adverse environmental impacts are minimized.
9) Ineffectiveness of homeowner self-help measures and a need to provide more information to homeowners so they can make better decisions.

The Gypsy Moth in Canada - 1981

A.E. Straby

Background

The Gypsy Moth was first found in Canada as early as 1924 at Lacolle, Quebec, (North of Lake Champlain). In 1936 it appeared near St. Stephen, New Brunswick. Both of these infestations were successfully treated. An annual survey program commenced in 1954 when expansion of the generally infested area in U.S.A. threatened Southern Quebec. From 1959-1965, isolated infestations were found in Quebec each year and were controlled. This involved treating up to 2,000 acres each year. However, during 1966-1967, the infested area increased rapidly to cover 35,000 acres and for the first time Canadians were forced to accept the fact of a generally infested area. In 1969-1979, the infestation moved into Ontario on two fronts: Westward from Quebec and Northward from Islands on the St. Lawrence River Near Kingston. In the period 1975-1980, the Northward movement was slowed down by the treatment of critical areas of infestation, nevertheless almost all of Eastern Ontario East of a line from Ottawa to Belleville is now generally infested.

Detection

In order to detect and act upon new distant urban pockets of infestation, the number of pheromone traps in use has increased annually; VIZ. 3,500 in 1979, 7,000 in 1980, 10,000 in 1981 and probably 12,000 for 1982. The second major use of traps is to establish the limits of the generally infested area in Ontario and Quebec.

Defoliation

The first report of severe (75%) defoliation in Canada occurred in Southern Quebec in 1978 involving about 20,000 acres. Since then some defoliation has occured annually but rarely exceeds that acreage. In 1981, populations in many areas of Quebec collapsed due to a 15% egg hatch and heavy viral infection of surviving larvae. Only minor defoliation has occurred in Ontario but this year a newly detected area of infestation of about 3,000 acres at Kaladar on the Western edge of the infested area of Ontario was partially defoliated.

Significant Developments - 1981

- 1 egg mass at Yarmouth, Nova Scotia; a first record for that Province.
- Several egg masses in the Grand Manan Island - St. Stephen Area of New Brunswick (near the Maine Border).
- Small urban infestations in Ontario at London and Niagara Falls.
- 25 urban acres in the Oakville Area West of Toronto were treated this year with only partial success.
- 1100 acres along the St. Lawrence River near Kingston were treated by air with Sevin 4 Oil with good control.
- The 1979 Vancouver treatment area remains free of Gypsy Moth.

Gypsy Moth in Ontario, 1981

by

G.M. Howse and J.H. Meating
Canadian Forestry Service
Great Lakes Forest Research Centre
Sault Ste. Marie, Ontario

Situation in 1981 Based on Defoliation

This introduced defoliator has been present in eastern Ontario for a number of years (since 1969) when it was found on Wolfe Island near Kingston. However, infestations have been generally light. In 1981, some 23 pockets of gypsy moth defoliation or infestation were detected by the Forest Insect and Disease Survey in the Eastern Region of Ontario (Figure 1). This year, ground and aerial surveys detected and mapped pockets of infestation ranging from light to heavy in a continuous band north of the St. Lawrence River from the Quebec border to Prince Edward County in the Cornwall, Brockville and Napanee districts (Figure 1). The most severe damage was found in the Kaladar area of Tweed District where 3 pockets totalling approximately 14.5 km^2 of mixed hardwoods and white pine were almost completely defoliated. An additional 3 km^2 in the same area was lightly defoliated. Heavy infestations were also reported in the city of Ottawa.

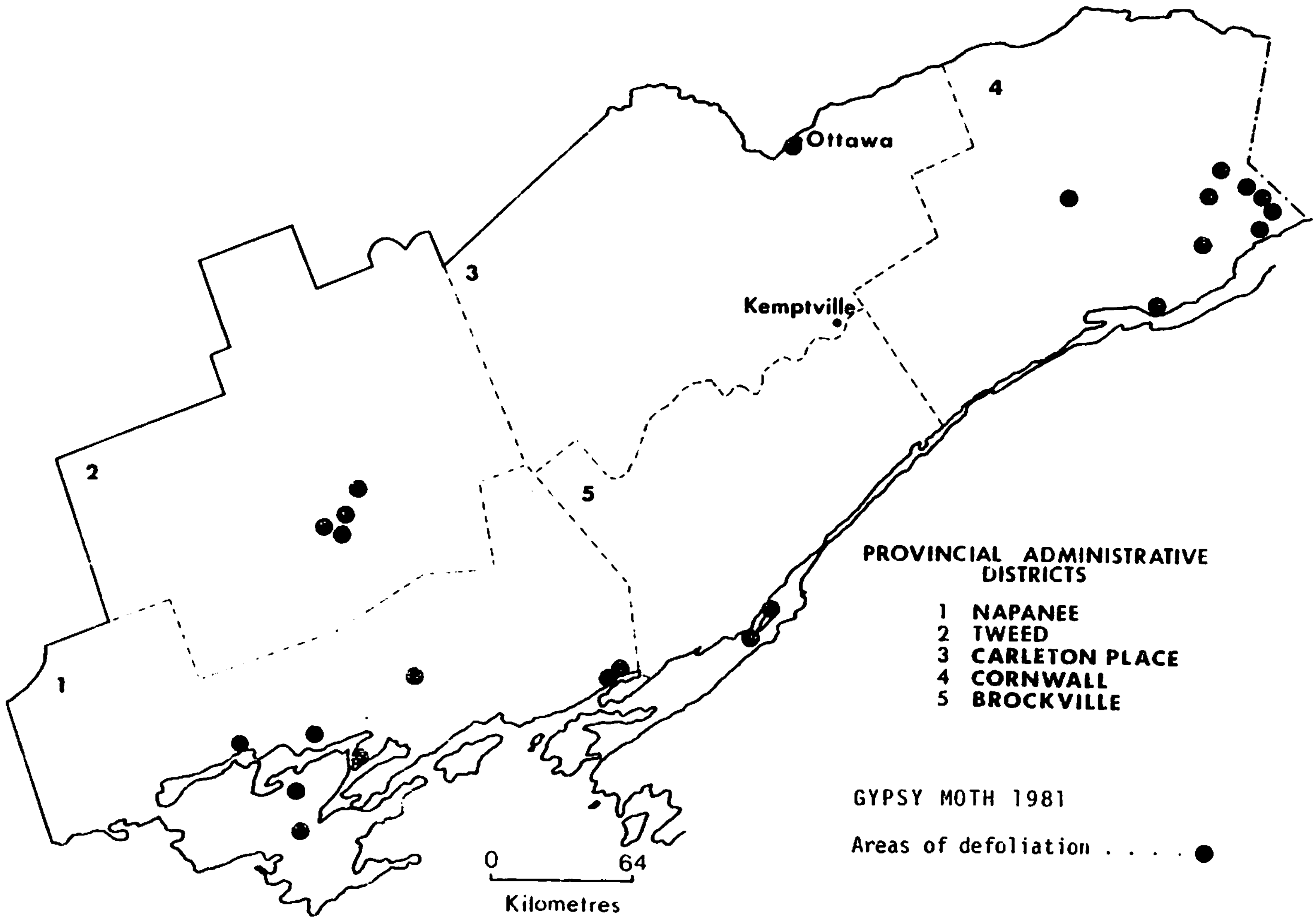
Surveys

In response to this increase in gypsy moth activity, a working committee composed of provincial representatives from the Ministry of Natural Resources and federal representatives from Agriculture Canada and the Canadian Forestry Service was established to develop management strategies to deal with this problem. At a recent meeting of this working committee (14 October, 1981) in Kingston, it was decided to concentrate initially on the 4 areas of defoliation in the Kaladar area of Tweed District. The FIDS Unit of the CFS accepted responsibility for delineation of the infestations and assessment of treatment effectiveness if a control program is conducted in 1982. Surveys based on egg-masses to delineate infestation boundaries and to estimate egg-mass densities within the infestation were completed recently by CFS-OMNR crews. Results show high numbers of egg-masses in two of the infestations, i.e. 30,000 egg-masses/ha, low numbers in another infestation and no egg-masses could be found in the fourth infestation.

Moth Trapping

Starting in 1979, the FIDS Unit at GLFRC, in cooperation with Agriculture Canada, has deployed gypsy moth pheromone traps in 36 provincial parks and campgrounds throughout the Northern, Northeastern and North Central regions of the province. In 1980, two gypsy moths were caught in a single trap at Rabbit Blanket Lake Campground in Lake Superior Provincial Park. In 1981, a total of 12 traps were set out in this area but no moths were caught. Elsewhere this year, however, single moths were caught at Windy Lake Provincial Park, northwest of Sudbury and at Obatanga Provincial Park, northwest of Wawa.

EASTERN REGION



GYPSY MOTH IN ONTARIO:
PROVINCIAL CONCERNS AND ANTICIPATED ACTION 1982

by

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Ontario Ministry of Natural Resources
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THE GYPSY MOTH IN ONTARIO:

PROVINCIAL CONCERNS AND ANTICIPATED ACTION 1982

This segment of the gypsy moth discussion is simply a condensed W5 statement of the main Ontario concerns, going from general to specific, and the intervention that the Ministry of Natural Resources is likely to invoke in 1982.

W.1 WHAT is the major concern?

In Ontario, the forest insect which has caused the greatest losses, and against which the major control programs of the past 40 years have been directed, is the spruce budworm. In spite of this, destructive infestations have prevailed in recent years throughout vast areas of the coniferous forest. Similarly, despite massive control programs undertaken periodically over the last half-century in the northeastern United States, the gypsy moth has persistently increased its distribution, and in 1981 caused severe defoliation over an unprecedented area of infestation, including Ontario. This, despite the fact the female moth does not have benefit of flight.

A major concern of the Ministry of Natural Resources, therefore, is whether the gypsy moth is destined to become the budworm of Ontario's hardwood forests. Indeed, might it even become the premier depredator of Ontario's forests since its wide range of hosts includes not only deciduous trees but several other species favoured for food by older larvae, for example, jack pine, black spruce and white spruce.

W.2 WHERE is the gypsy moth likely to spread?

Early optimism that climatic conditions might restrict the distribution of gypsy moth in Ontario is not encouraged by work done at the Great Lakes Forest Research Centre. Studies (by Sullivan and Wallace) of 'The Potential Northern Dispersal of the Gypsy Moth' led to the conclusion ".... in the presence of abundant snow cover the insect may spread as far north as suitable food plants exist. This would favour extension of the range of the gypsy moth throughout the Great Lakes — St. Lawrence Forest Region and much of the Boreal Forest Region of Ontario and Quebec south of James Bay".

W.3 WHEN will intervention become necessary?

The magnitude of the potential for spatial establishment understandably spawns concurrent concern of its temporal occurrence. The natural spread of the gypsy moth by wind-borne young larvae is relatively slow, allowing the forest manager some time to plan control strategies. However, the accelerated dispersal to new and distant areas by transport of egg masses, particularly on fuel wood and recreational vehicles, is of immediate concern. Inspections and quarantines are too difficult to adequately enforce to be effective control measures.

Companion to concerns of place and time of establishment, is concern of intensity of infestation, which, of course, is one of the main factors that will determine the extent of economic and aesthetic damage. In this respect, gypsy moth populations were undetected in the Tweed District in 1980, but burgeoned to a level sufficient to severely defoliate several hundred hectares in 1981. Continued at this rate, the potential for economic damage in this area of eastern Ontario is substantial and ominous.

W.4 WHO will be involved in the gypsy moth problem?

Basically, anyone responsible for the planting, maintenance, management, harvesting or replacement of gypsy moth susceptible trees will be concerned and involved in their protection. Although the gypsy moth has often been referred to as a 'people problem', the present discussion will exclude consideration of urban infestations which currently exist along the southern boundary of the province from London to Quebec. Control actions here have, to date, been conducted by Agriculture Canada and in future they will become a municipal or private responsibility. Also excluded are the hybrid poplar plantations of the MNR Eastern Region, as protection will be an integral component of their intensive management. Instead, attention is directed almost entirely to the Tweed Administrative District where 'forest' defoliation became evident in 1981.

W.5 WHY is Tweed District concerned about gypsy moth?

The total area highly susceptible to gypsy moth infestation is 200,000 hectares, comprising two main forest types; poplar-oak-pine and maple-oak-birch. The values which are potentially at risk have been documented by Alec Denys, Management Forester.

Recreational Values

Recreational use, probably the largest and most important use at risk, may be divided into five categories:

1. Cottaging
   - 4,400 private dwellings
     300 user days/annum/cottage (1.3 million user days)
   - expenditures of $850/year/cottage ($3.74 million/year)

2. Tourism
   - 800 commercial cottages and cabins
     200 hotel rooms
     2,000 commercial campsites
     5% of labour force
   - associated expenditures of $7 million/year

3. Provincial parks
   - 2 in area of potential gypsy moth infestation (Sharbot Lake, Bon Echo: largest in Ontario south of Algonquin)
     200,000 swimming opportunities
     170,000 camping opportunities
     32,000 picnicking opportunities
   - $200,000 gate receipts annually
     $530,000 corollary expenditures generated

4. Hunting
   - 3 major deer yards in susceptible area
   - small game and waterfowl affected to a lesser extent
   - 7,000 deer hunters
   - $70,000 in license sales
   - $900,000 expenditures attributed to hunters

5. Fishing
   - some loss due to aesthetics
     loss of shade would increase water temperature and adversely affect trout streams

Commercial Fur Production

Commercial fur production is also 'big business'.

- beaver: Tweed is No. 1 producer in Ontario
  $600,000 sales annually
  much of beaver habitat is on fragile sites in protection forest area
- muskrat is second in importance
- fisher: $40,000 sales annually
  depends on mature forest habitat
- 700 licensed trappers
- 25,000 man days employment
- total fur sales $1.2 million annually

Commercial Timber

- timber production capability is low to moderate as depth of soil is a limiting factor. Site class 3 and 4.
- 11 sawmills, but none depends entirely on timber from area (1/3 of supply)
- main concern is for high value forests (young pine and poplar plantations)
- 6,000 acres with establishment costs of $100 to $300 per acre, white pine, red pine

Protection Forest

- mainly bedrock to very shallow soils
- area logged over at turn of century; subject to erosion and severe wildfires until 1930
- has been regenerating naturally; young oak, poplar and pine stands now up to 50 years old
- loss of this cover would result in high cost of regeneration and loss of watershed protection for main rivers flowing into Lake Ontario
- difficult to place a dollar value on this aspect

Management Options

There are basically two options open to management:

- do nothing: let nature take its course
- intervene: initiate action to reduce impact

Non-intervention

The impact of the 'do-nothing' option, based on the assumption of 3 years severe defoliation over 75% of the susceptible area resulting in 80% tree mortality and 50% loss in the use of the resource, would be a potential economic loss of $7 million annually (not including municipal tax base losses, bankruptcies, reduced cottage resale values, loss of jobs, etc.).

Interventions

The interventions possible are basically:

- pesticide applications
- non-pesticide treatments

Of these, only one appears to have promise for immediate use in the Tweed District: the application of pesticides. Even this option is restricted.

The objectives of intervention by aerial application of insecticides as outlined in MNR's Policy/Procedure TM. 13-05 are:

1. Outbreak control
2. Containment
3. Protection

Anticipated Action 1982

Since Ontario is just at the threshold of having to deal with the gypsy moth in a 'forest' environment the following action is anticipated:

Option - outbreak control.

Objective - to attempt to suppress the gypsy moth population while it is still at a pre-epidemic level in a localized area, or epicentre.

Requisite - delimit the proposed spray area by fall egg-mass surveys and spring larval sampling.

Method - aerial spraying.

Material - carbaryl (Sevin 4-oil). Carrier Diluent 585.

Rate - 1 lb. a.i./U.S. gal./acre (1.1 kg. a.i./9.4 ℓ/hectare) single application

OR (preferably)

1/2 lb. a.i./U.S. gal./acre (0.56 kg. a.i./9.4 ℓ/hectare) double application 10 days apart

Timing - When hatching is 90% complete and larvae in 2nd-3rd instar.

THE STATUS OF GYPSY MOTH, *Lymantria dispar* (L.), IN ST. LAWRENCE ISLANDS NATIONAL PARK

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ABSTRACT

Gypsy moth, *Lymantria dispar* (L.), was first discovered in St. Lawrence Islands National Park in September, 1981. Results of a preliminary survey are presented. Parks Canada's policy on manipulation of insect populations in national parks is discussed briefly.

* * * * *

The presence of gypsy moth, *Lymantria dispar* (L.), in southeastern Ontario has been known since 1969 (Sippell *et al.* 1970). Populations found on Wolfe Island, Howe Island and the adjacent Ontario mainland near Kingston and in Glengarry and Prescott counties have been closely monitored and studied by several agencies. In late August, 1981, Parks Canada staff at St. Lawrence Islands National Park were approached by the private owner of Prince Regent Island regarding a serious tree defoliation occurrence on his property. Gypsy moth was confirmed as the responsible agent by Agriculture Canada personnel. Subsequent investigations of St. Lawrence Islands National Park determined the presence of egg masses on eight of the twenty major islands. All of the infested properties are located adjacent to Wolfe Island (Figure 1) and Howe Island and the mainland near Gananoque, Ontario (Figure 2). Egg mass

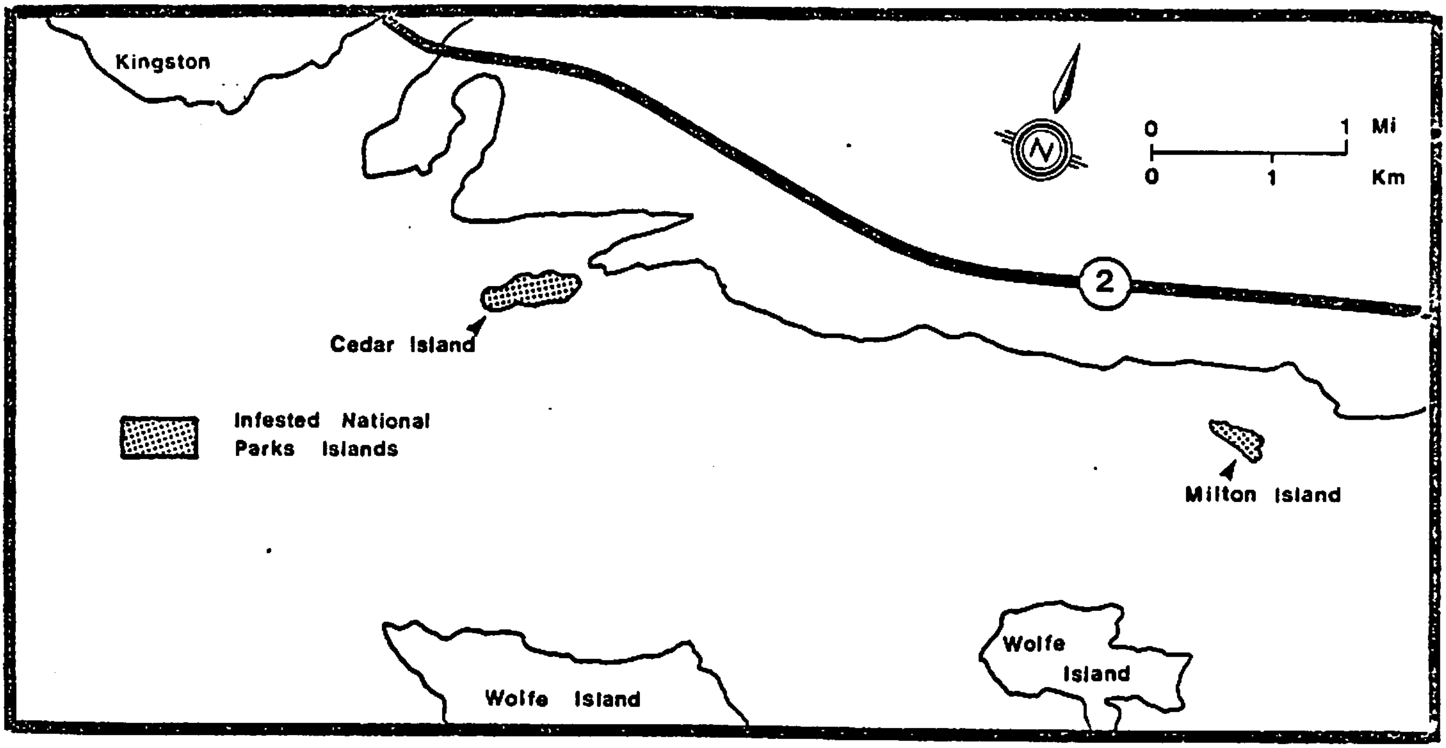

Figure 1 - Distribution of gypsy moth egg masses in St. Lawrence Islands National Park - Bateau Channel Outlier Islands Group

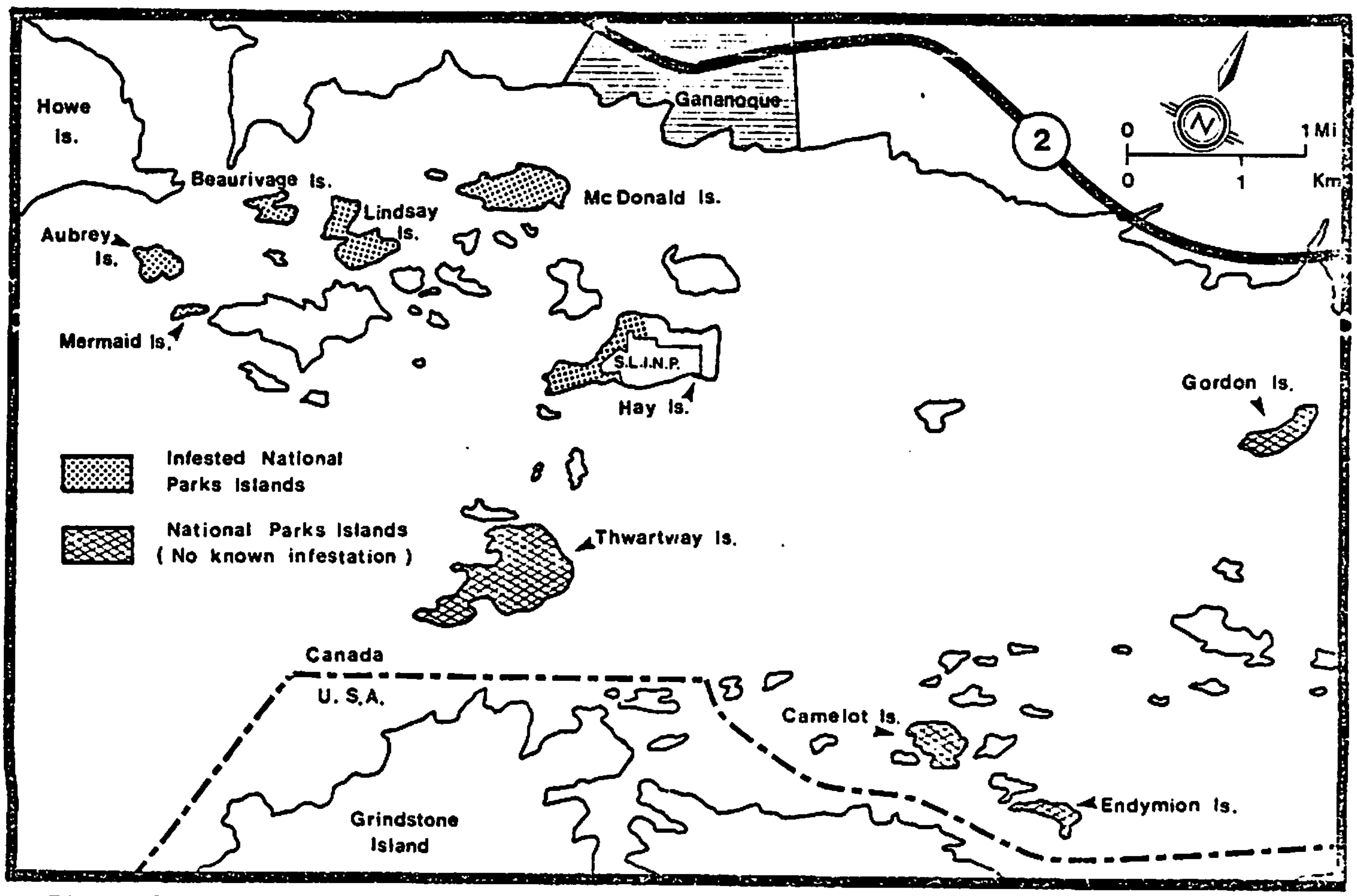

Figure 2 - Distribution of gypsy moth egg masses in St. Lawrence Islands National Park - Admiralty - Lake Fleet Islands Group

densities are presently quite low with estimated concentrations of less than 300 egg masses per acre. A search of Gordon Island revealed an adult female moth but no egg masses. Monitoring of St. Lawrence Islands National Park for gypsy moth infestation will be continued.

It is Parks Canada's policy that the manipulation of naturally occurring processes, such as insects, may take place in National Parks only after monitoring has shown that:

"i) there may be serious adverse effects on neighbouring lands; or

ii) public health or safety is threatened; or

iii) major park facilities are threatened; or

iv) natural processes have been altered by man and manipulation is required to restore the natural balance; or

v) a major natural control is absent from the park; or

vi) the continued existence of a plant or animal species, which is rare or endangered or which is critical to representation of the natural region, is threatened by a natural cause such as insects or disease; or

vii) the population of an animal species or stage of plant succession which has been prescribed in the objectives for a park, cannot be maintained by natural forces." (Parks Canada, 1979, p.41).

Pesticide management guidelines have been developed on the appropriate and safe management of pesticides in National Parks, National Historic Parks and Sites and Heritage Canals (Parks Canada, 1981). The use of pesticides is considered only when Parks Canada is satisfied that:

"a) Manual, mechanical or biological control measures have been assessed and found not to be cost effective; and

b) Insect infestations or plant diseases occurring on Parks Canada lands are a threat to adjacent lands and lack of control measures will seriously prejudice Provincial control programs; or, the target organism is not naturally occurring; or the insect infestation or plant disease threatens the survival of a species recognized by Parks Canada as threatened or endangered, or the target organism occurs in an area of intensive development." (Parks Canada, 1981, p.3).

Applications for the use of pesticides are reviewed and assessed subject to the following criteria:

"i) there is an acceptable and demonstrable need for the use of a pesticide;

ii) the pesticide is registered for use in Canada for the purpose proposed;

iii) there is no satisfactory alternative pesticide for this application;

iv) evidence demonstrates that the proposed product is effective in the control of the target organism specified;

v) the proposed product is target specific, non-persistent, sedentary and the active ingredients are simple compounds rather than complex mixtures;

vi) the proposed application rates and techniques are considered appropriate." (Parks Canada, 1981, p.4).

In conclusion, Parks Canada will continue to monitor for the presence of gypsy moth on Parks Canada properties and liaise with other agencies for information exchange purposes. Based on the results of the field work and information received from other agencies involved, a decision on future actions will be made.

REFERENCES CITED

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PARKS CANADA. 1981. Management Guideline - The Management of Pesticides by Parks Canada. Natural Resources Conservation Division, Parks Canada, Environment Canada, Ottawa.

SIPPELL, W. L., A. H. ROSE AND H. L. GROSS. 1970. Ontario region. p.52-71 in Annu. Rep. For. Insect Dis. Surv., 1969. Can. For. Serv., Ottawa.

Item 3.7: Control Research With Emphasis on Biological Methods

The gypsy moth was accidentally introduced into the New England states some 110 years ago and it quickly became a serious pest there. Around the turn of the century a massive program of introduction of gypsy moth insect parasites and predators from Europe and Japan was undertaken by American scientists, to try to duplicate the indigenous natural control regime of the gypsy moth in the U.S. In this program, 44 species of parasites and 9 of insect predators were released and 13 parasites and 1 predator established. In the course of this research a total of 26 native insect parasites and 17 native insect predators were found to be attacking the gypsy moth in the northeastern United States. However, of these 60 odd species only 2 native species and 8 exotic species of parasites and 1 exotic predator were common and appeared regularly in outbreaks. There is no definitive study on the influence these parasites and predators are now having on the gypsy moth in the United States, but some authors have indicated that in the New England states, where gypsy moth and the parasites and predators have been together for the longest period, these common species may be reducing peak gypsy moth numbers during outbreaks and prolonging the period between outbreaks. At Great Lakes Forest Research Centre we are interested initially in these 13 common species. Two of these species attack the egg of the gypsy moth and we started with these, largely because of their accessibility.

The first of these is *Ooencyrtus kuwanai*, a Japanese species established in the U.S. in 1909. We found in preliminary laboratory studies that both because of its high supercooling or freezing point and because of its inability to survive prolonged periods at 0°C, this species probably could not survive in Canada. To test this, we introduced 25,000 adults in August 1976 on Wolfe Island, near Kingston, Ontario. We recovered 28 adults there in eggs collected in 1978, one adult in 1980 and none this year. If this was all the evidence we had it would appear that our predictions were correct. However, we recovered some 50 adults of *O. kuwanai* in Glengarry County in 1980, some 200 km from our release site. Evidently it had reached there by natural means and had survived our winters at least temporarily. We did not recover any specimens of this species there in 1981.

A second egg parasite, *Anastatus disparis*, that was also successfully established in the U.S. was also studied at GLFRC. From our laboratory work it appeared that this species could survive anywhere in Canada where the gypsy moth could survive. An introduction was made in Quebec by members of the Laurentian Forest Research Centre in 1979, and it appears to have been successful. We released *A. disparis* in 1980 near Kingston, but it is too early to say anything about its success there. We are hopeful it is established.

We have also assessed the parasites that attack the later stages of the gypsy moth, by sampling plots near Kingston and near Cornwall, Ontario. In 1974 and 1975 we obtained 3 of the common exotic parasites and one of the common native parasites. In a repetition of sampling in 1979 and 1980 we recovered 2 more exotic species and 1 more native species. So, to date, we have recovered 5 of the 8 common exotic parasites established in the U.S. earlier and are working on introducing another 2 species. Perhaps I can add that our colleagues in Quebec have recovered the same species we have and have also recovered the eighth species which we have not found yet. Thus, all the common exotic parasites established in the U.S. are now accounted for in Canada, without a great deal of effort on our part.

K. J. Griffiths
Great Lakes Forest Research Centre

MARITIMES FOREST RESEARCH CENTRE

TECHNICAL NOTE NO. 43

GYPSY MOTH IN THE MARITIMES

Egg-masses and pupal remnants of the gypsy moth (*Lymantria dispar*) have been found in the Maritimes in 1981 for the first time in 45 years. Although the numbers were low, the discovery raises concern that this voracious feeder of hardwoods and to a lesser degree of conifers could become a permanent addition to our list of forest pests.

In New Brunswick, all egg-masses were found in Charlotte County: 6 near Milltown, across from a mill at Woodland, Maine; 1 near Pennfield; 1 near Beaver Harbour and 1 on Grand Manan Island (Fig. 1). In Nova Scotia, an egg-mass was found in the town of Yarmouth on November 24 (not indicated on map). Egg-mass searching was conducted as a joint operation of the Forest Insect and Disease Survey of the Maritimes Forest Research Centre and the Plant Quarantine Division of Agriculture Canada. The search was widespread but the effort was concentrated in areas of high adult male catches.

An adult male pheromone trapping program, again a joint effort of the two organizations, has been conducted annually since 1971, when gypsy moth was becoming a problem in neighboring Maine. Males have been trapped each year and generally in increasing numbers. The results of the 1981 program, when 1023 traps were placed in the Maritimes Region, are summarized in Figure 2.

The source of both egg-masses and male adults is the subject of speculation but since no defoliation by the gypsy moth has been observed in the Maritimes this is taken as an indication that a local population, if it exists, is presently at a very low level.

-B.A. Pendrel, L.P. Magasi

Forest Insect and Disease Survey

November 27, 1981

- NURSERIES ☐
- PLANTATIONS ☐
- SILVICULTURE ☐
- UTILIZATION ☐
- ECONOMICS ☐
- TREE IMPROVEMENT ☐
- INSECTS AND DISEASES ■

CANADIAN FORESTRY SERVICE

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Box 667, TRURO, N.S. B2N 5E5 Tel 902-895-1621

ENVIRONMENT CANADA

MARITIMES

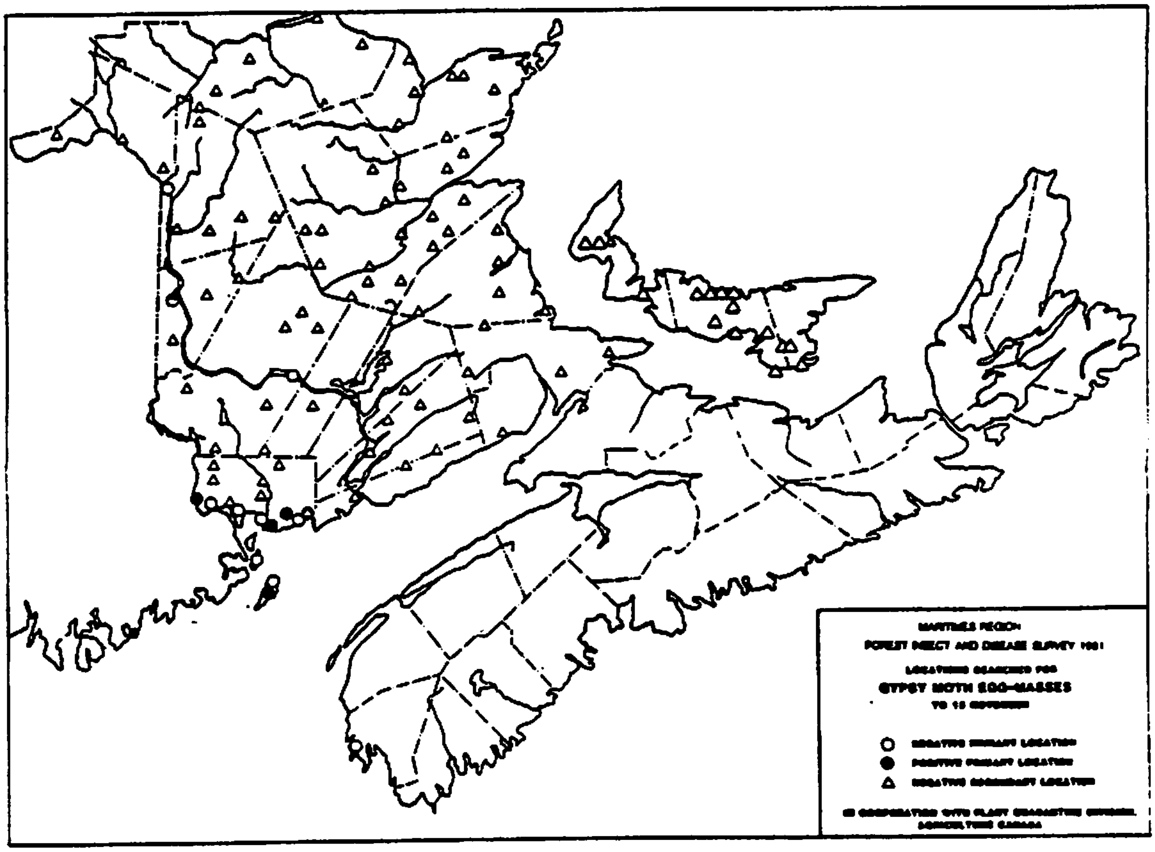


Figure 1.

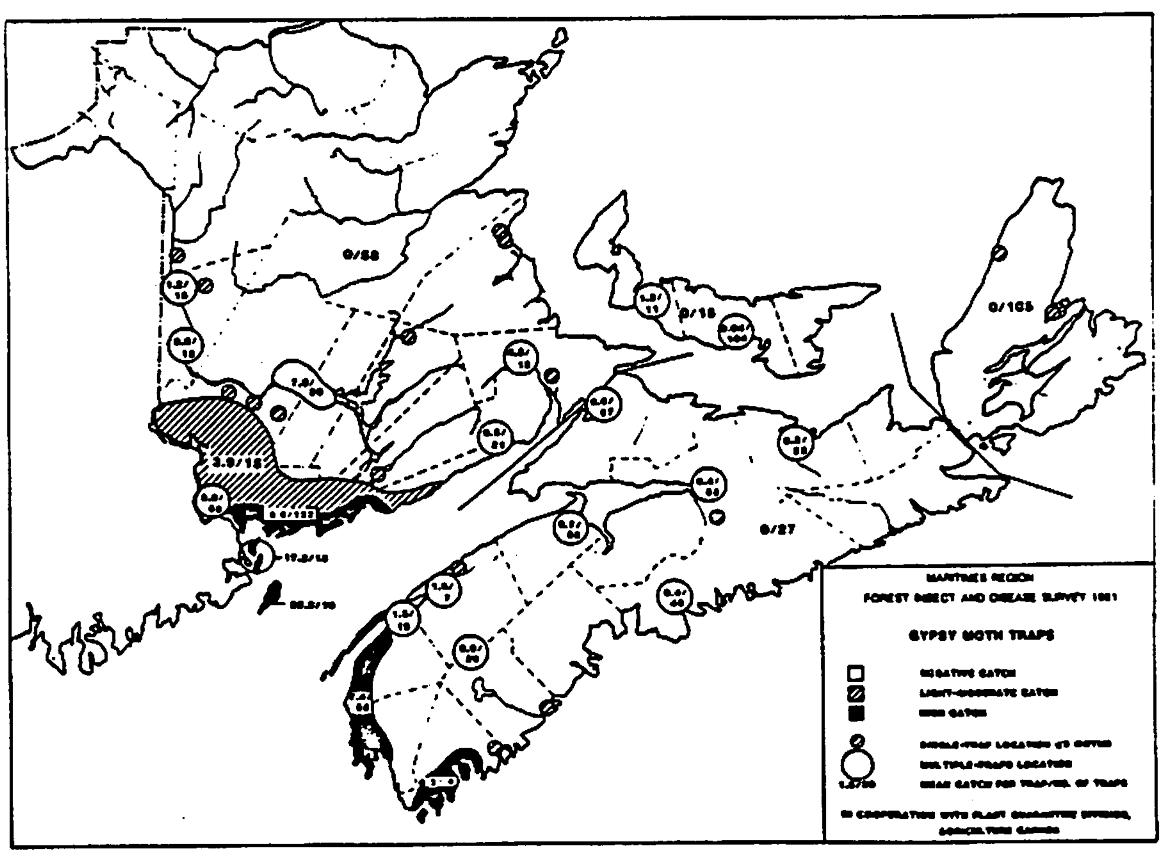


Figure 2.

Gypsy moth situation in Quebec in 1981

by

L. Jobin

Egg masses of the gypsy moth were first observed in Quebec in 1924 and isolated infestations have been reported in that province since 1955. Aerial and ground surveys of defoliation by the gypsy moth in July 1981 indicated that some 22,600 ha were defoliated of which 16,900 ha suffered moderate to severe defoliation. Some 30 outbreak areas were located and they varied in size from less than an ha to 3,400 ha. In many cases up to 50% of the total defoliation was the result of feeding by the Forest Tent caterpillar. The area where defoliation occurred is located from the Saint-François River to the Ontario border and from the Saint-Lawrence River to the Quebec-USA border. The infested area covers 13,200 km^2; an increase of only 150 km^2 from 1980. Tree species defoliated were mostly aspens and grey birch. The average number of adults captured in 200 phero-traps located at the fring of the infested area was 5.3 per trap a reduction from 1980 when an average of 9.1 males moth per trap were captured. A natural collapse of gypsy moth populations occurred this year following a high egg mortality because of insufficient snow cover and very low temperatures of last January. Also, the combined action of a NPV virus and a bacterial disease killed an average of 70% of the larval populations in outbreak areas.

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

REPORT FROM
EASTERN SPRUCE BUDWORM COUNCIL (*)

The Eastern Spruce Budworm Council is a joint body made up of representatives from the various jurisdictions in eastern North America with a view to have a collective look at the spruce budworm problem and to stimulate dialogue at the senior policy level on such a common problem in forest management. Its membership presently includes the Provinces of Quebec, New Brunswick, Nova Scotia and Newfoundland as full members and the Province of Ontario, the Canadian Forestry Service and the State of Maine as associate members.

Two Council meetings were held in 1981, the one on April 8 and 9 in Montreal and the other on November 9 and 10 in St. John's. The council has also been active in 1981 through its three working committees on (a) spray technology, (b) environmental monitoring and (c) the standardization of survey and assessment techniques. A fourth committee

(*) Presented at the Ninth Annual Forest Pest Control Forum, held in Ottawa on December 1-2, 1981 on human health issues has been formed in 1981 with a view to deal with the controversy on the question of the human health effects of the aerial spraying programs.

Again this year, the committee for the standardization of survey and assessment techniques has been working at the preparation of four maps collating available information for eastern Canada and Maine on (a) the areas of moderate to severe defoliation in 1981, (b) the areas of softwood mortality in 1981, (c) the prospects of attack in 1982 on the basis of the egg-mass counts and (d) the areas sprayed in 1981. These maps will be shown and commented by Mr. E.G. Kettela, representing the Canadian Forestry Service on this committee.

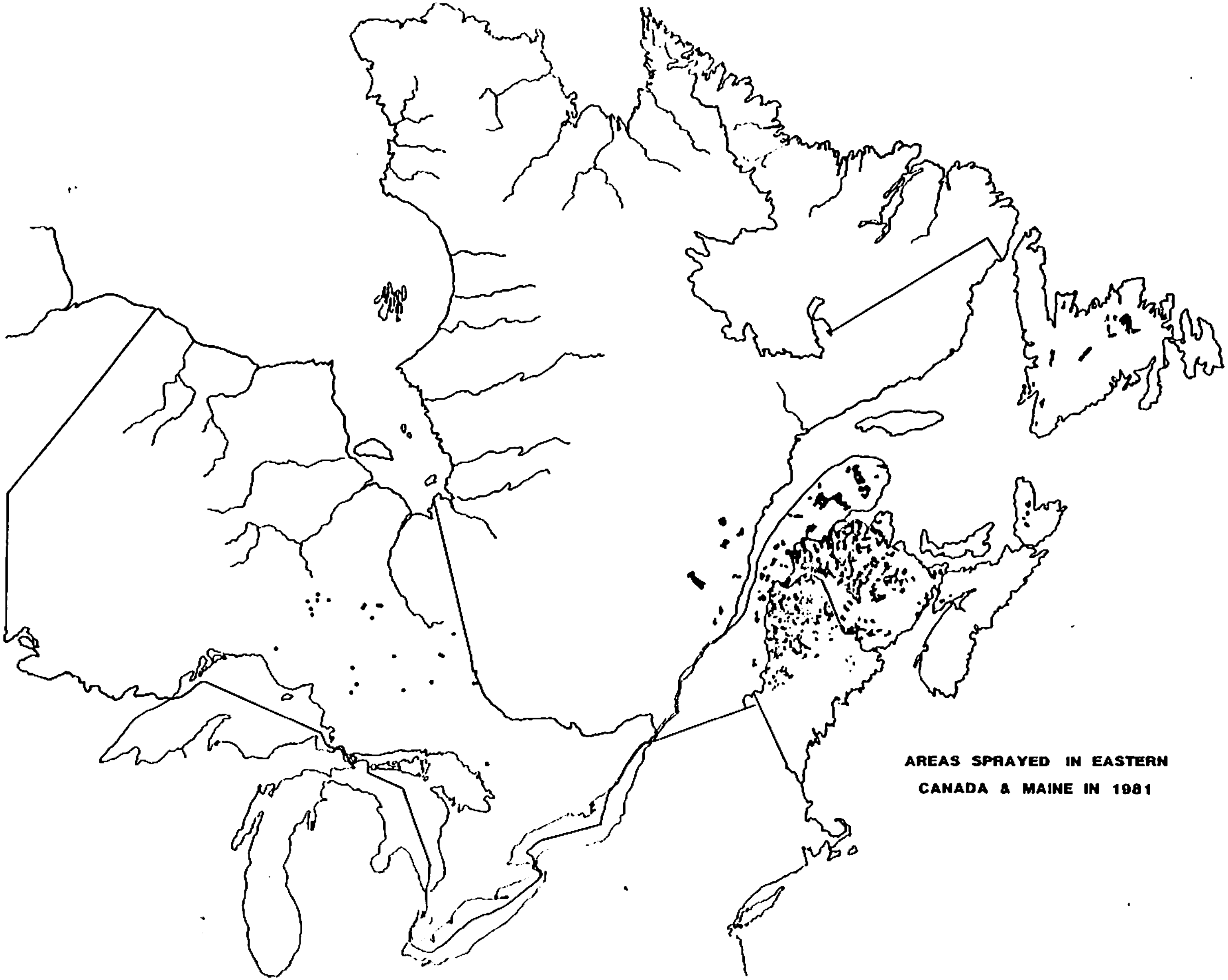
Gerard Paquet

Executive Secretary
Eastern Spruce Budworm Council

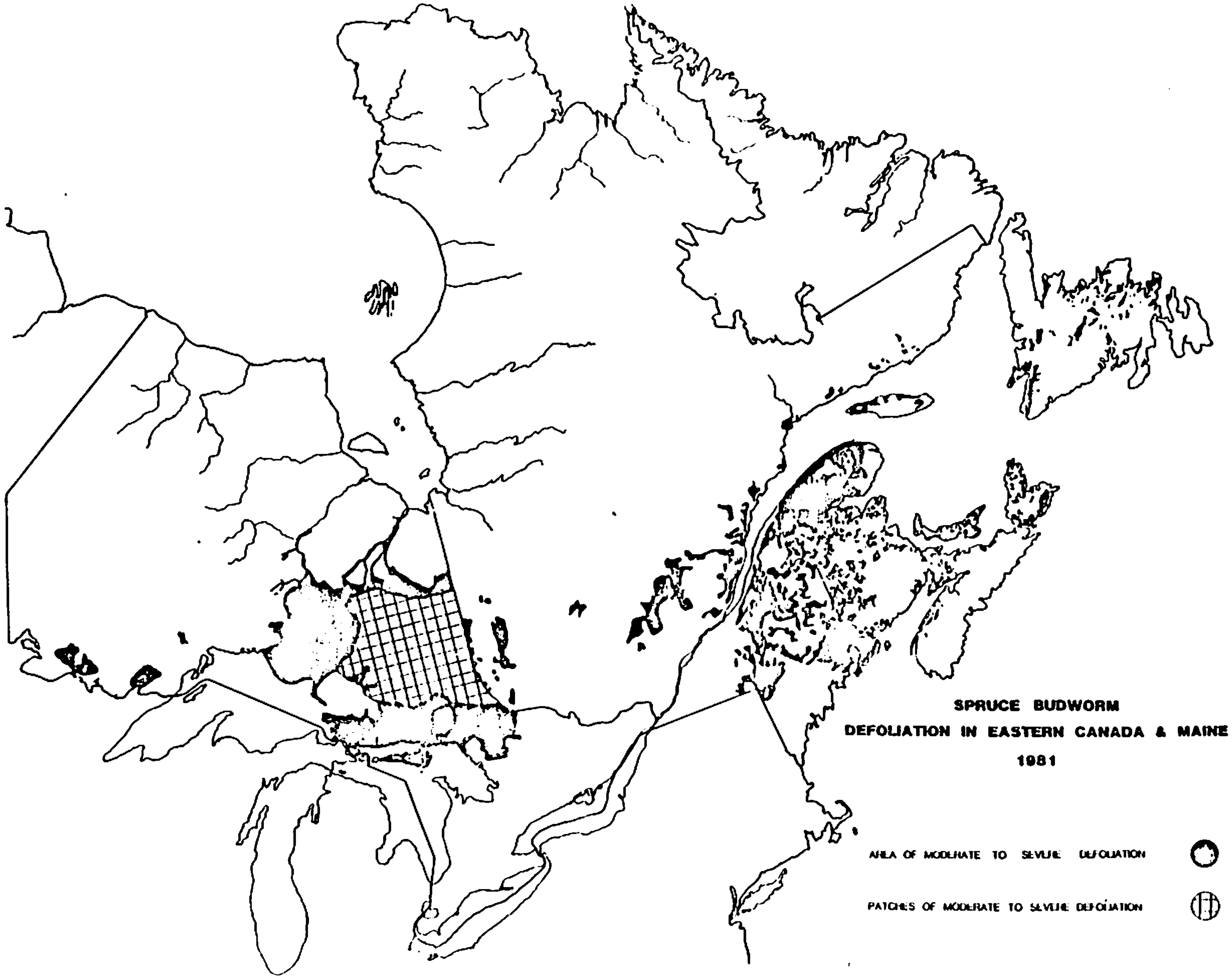
November 18, 1981

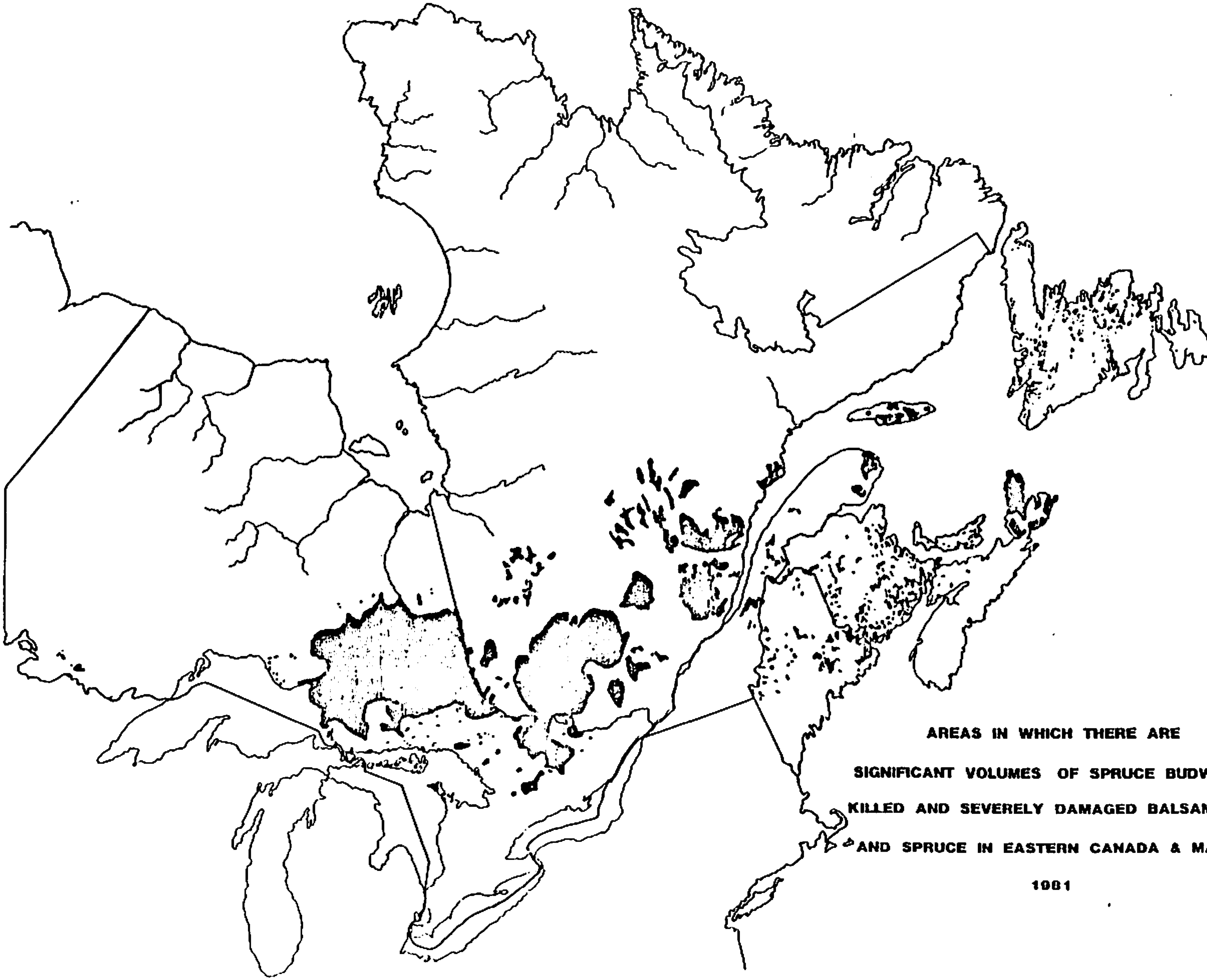
Synopsis for 1981 of Extent of Spraying, Defoliation, Tree Mortality and Forecasted Infestation Area for 1982.

Province or State	Area Sprayed	Moderate to Severe Defoliation (hectaresx1000)	Area of Dead and Dying Trees	Forecasted for 1982	82/81
Maine	481	1 640	200	24 600	-
Ontario	10	18 217	11 210	22 500 $(\frac{10.2}{12.5})$	-
Quebec	705	6 303	10 164	20 000	+
New Brunswick	1 900	1 237	300	4 000	+
P.E.I.	0	133	25	100	Same
Nova Scotia	31	567	500	200	-
Newfoundland	240	380	421	154	-
TOTAL	3 367	28 477	22 820	71 554	

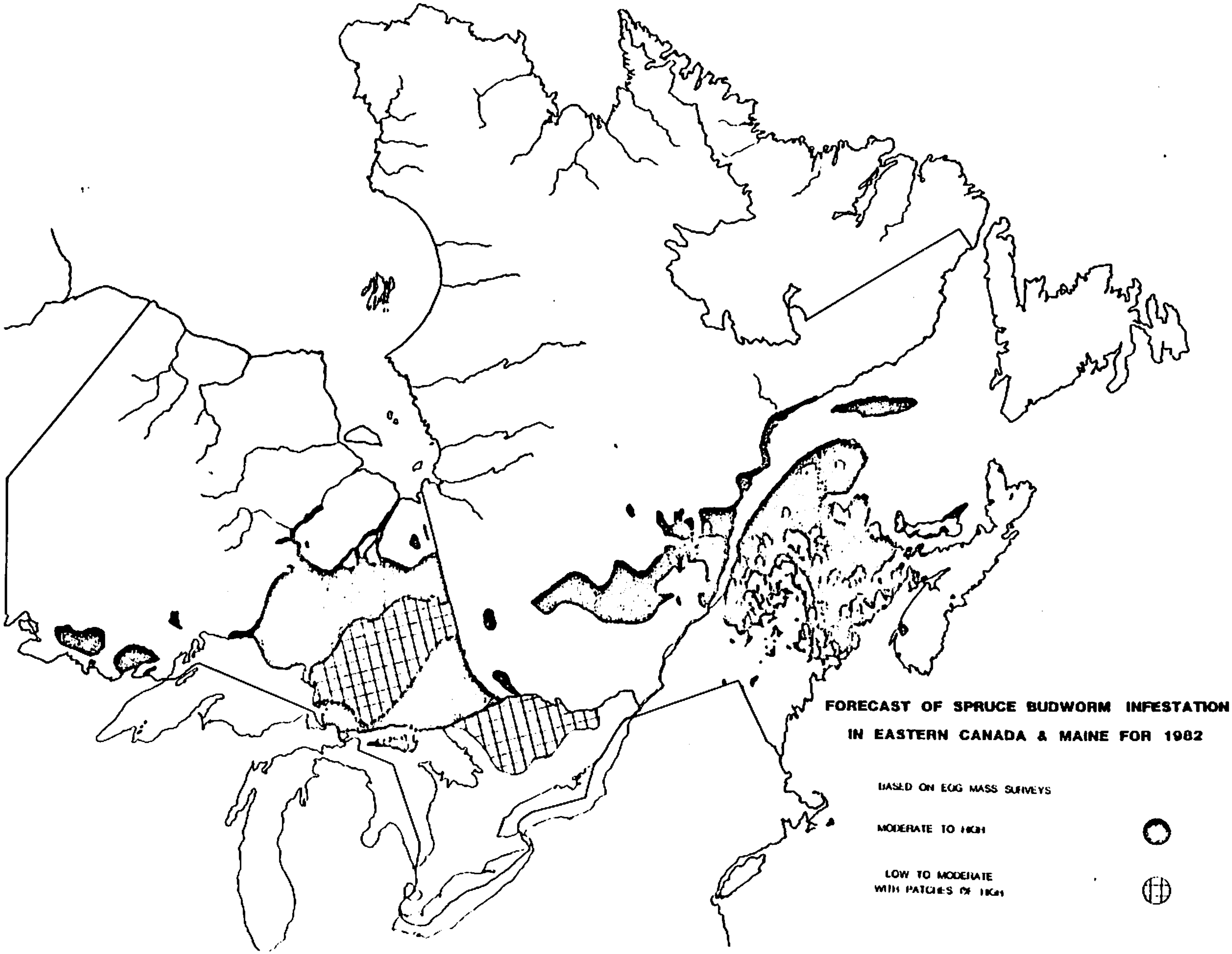


AREAS SPRAYED IN EASTERN CANADA & MAINE IN 1981


SPRUCE BUDWORM
DEFOLIATION IN EASTERN CANADA & MAINE
1981
AREA OF MODERATE TO SEVERE DEFOLIATION
PATCHES OF MODERATE TO SEVERE DEFOLIATION



AREAS IN WHICH THERE ARE SIGNIFICANT VOLUMES OF SPRUCE BUDWORM KILLED AND SEVERELY DAMAGED BALSAM FIR AND SPRUCE IN EASTERN CANADA & MAINE 1981


FORECAST OF SPRUCE BUDWORM INFESTATION
IN EASTERN CANADA & MAINE FOR 1982
BASED ON EGG MASS SURVEYS
MODERATE TO HIGH
LOW TO MODERATE
WITH PATCHES OF HIGH

THE SPRUCE BUDWORM IN NEWFOUNDLAND IN 1981

Report prepared for the Ninth Annual
Forest Pest Control Forum, Ottawa
1-3 December 1981

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L.J. Clarke
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Canadian Forestry Service
St. John's, Newfoundland
30 November 1981

THE SPRUCE BUDWORM IN NEWFOUNDLAND IN 1981

Larval Development and Defoliation

The total area of moderate and severe defoliation by the spruce budworm in Newfoundland in 1981 was forecast to be about 800 000 ha. This forecast was based on intensive egg mass and overwintering larval surveys in the fall of 1980. Winter survival was normal and the number of young larvae feeding in spring was as expected. In general, budworm phenology was ahead of last year by about two weeks and shoot growth was more advanced than larval development when feeding began. A three-day period of below freezing temperatures occurred in mid June, and a period of very heavy rain on June 20 and 21 disrupted larval feeding. However, larval numbers continued at outbreak levels for about a week. Field observations of larvae and examinations of fir and spruce branches indicated that larvae did not feed at that time though weather was suitable for feeding.

Sampling for surveys and research purposes revealed a sudden drop of about 80% in larval numbers after June 28 but this rapid decrease levelled off after July 6. A few budworm had pupated by June 28 or reached the 6th instar, but most larvae were in the 4th and 5th instars. Few, if any, dead larvae or pupae remained on the branches and therefore larvae could not be collected to determine cause of death.

In 1981 the spruce budworm caused moderate and severe defoliation of about 380 000 ha, extending in a broken pattern from the Codroy Valley in the southwestern part of the Island to the Avalon Peninsula in eastern

Newfoundland (Fig. 1). It is noteworthy that three localized, new infestations occurred in western Newfoundland and one on the Burin Peninsula. In Labrador two small pockets of infestation recurred near Lake Melville.

Natural Control Factors

Weather parameters during the spring and summer of 1981 were compared to a 30-year average. Temperatures were about 60% to 70% higher than the average for the months of February, March and May, but near normal for the summer months. Precipitation was more variable across the Island than temperature. Generally, precipitation was below normal by 60% in February, above normal by 40% to 50% in June, and near normal for the other months.

Weather data were also summarized for 1980 because climate may also affect the progeny of the population. Temperatures in 1980 were near normal for February and somewhat below normal in June, July and August, but precipitation was decidedly above average by 70% to 140% for June, July, and August, and at some locations in May as well.

Budworm larval populations were repeatedly sampled in 1981 for general survey and specific research purposes and reared in the laboratory. The results of all rearings were similar. About 35% to 45% emerged as adults, 8% were parasitized, 8% were diseased, 30% to 40% died of unknown causes, and about 10% were lost during the rearing. The dead larvae were examined for disease organisms but none were found. Generally, larval collections made in late June had the highest percent of death by unknown causes and late pupal collections the lowest. Percent disease from all known factors was about 3% during the larval stages and 5% during the pupal stage. The fungal diseases of the budworm caused about 1% mortality in 1981, but the incidence of microsporidia increased from previous years and was the most common in 1981. Microsporidia are normally only debilitating and alone do not cause larval mortality.

Not one natural control factor can be singled out as a dominant reason for the general collapse of the budworm population in Newfoundland in 1981. However, the delayed effect of the 1980 wet and cool summer on the 1981 generation, the frost and a period of very heavy rainfall in mid and late June in 1981, and the associated lack of feeding by the larvae may have contributed to the large proportion of larval mortality that could not be attributed to the usual biotic control factors such as predators, parasites and known diseases.

Damage Assessment

Damage assessment surveys were conducted in young and merchantable stands where tree mortality was evident to determine the area and volume in various damage categories (Table 1, Fig. 2). Data for stands salvaged or destroyed by fire were tabulated separately. Generally, the area of merchantable stands with dead trees did not expand from the 427 500 ha listed in 1980, but the proportion of tree mortality increased in these areas and reached 67%, 29%, and 10% in the A, B and C damage categories respectively (Table 1). The total volume of dead trees was estimated at 18 454 000 m^3, an increase of 1 348 000 m^3 from 1980. The area of severely damaged stands (category D) was about 118 000 ha, a decrease from 427 000 ha in 1980. No volumes were computed for these stands. The area of submerchantable stands containing trees killed by the budworm increased from 62 900 ha in 1980 to 77 300 ha in 1981. This apparent increase is due largely to the use of age in 1981 instead of diameter to separate merchantable and submerchantable stands.

Forecast for 1982

Egg mass surveys were conducted in over 800 sample points across the Island and in 10 points in Labrador. Based on this survey, the area of moderate and severe defoliation is forecast to decrease significantly in 1982. There are only six small areas totalling about 21 000 ha where moderate and severe defoliation is expected. These areas are in the Codroy Valley; near Crabbes River; and near Gallants in western Newfoundland; near Hunts Pond south of Gander Lake; near Triton Brook; and near Twillick Brook, Bay d'Espoir in central Newfoundland (Fig. 3).

Light to moderate populations are forecast for several isolated areas distributed from Codroy Valley to Grand Lake, on the western half of the Baie Verte Peninsula, along the Noel Paul River, near Twin Lakes, and Bay d'Espoir, and on the ~~Avalon~~ Bonavista Peninsula for a total of about 134 000 ha. It should be noted that among these areas are new infestations which recurred in 1981 near Codroy Pond, along the Highlands River and South Brook Valley in western Newfoundland. Based on tree condition and expected defoliation, moderate and high hazard are forecast to occur on about 70 000 ha in 1982 on the Island. No defoliation is forecast for 1982 in Labrador.

--J. Hudak, A.G. Raske, K.P. Lim, L.J. Clarke
Nfld. Forest Research Centre, Canadian Forestry Service
St. John's, Newfoundland 30 November 1981

Table 1. Area and volume of productive merchantable stands where tree mortality caused b spruce budworm was evident in 1981.

	Damage Category[1]			
	A (Dead)	B (Moribund)	C (Very Severe)	Total
		Existing Stands[2]		
Total area ha	196 511	109 317	38 188	344 01
Dead vol. m^3	12 305 358	3 297 866	410 702	16 014 0[illegible]
Dying vol. m^3	996 797	1 305 559	535 707	2 838 0[illegible]
Total vol. m^3	17 660 872	10 740 102	3 514 923	31 915 8[illegible]
		Salvaged, Burned and Recovered Stands		
Total area ha	31 716	30 047	21 701	83 46
Dead vol. m^3	1 683 201	634 250	121 971	2 439 42
Dying vol. m^3	248 616	198 265	83 696	548 18
Total vol. m^3	3 349 873	2 777 943	2 042 605	8 170 42
		Existing, Salvaged, Burnt and Recovered Stands		
Total area ha	228 227	139 364	59 889	427 48
Dead vol. m^3	13 988 559	3 932 116	532 673	18 453 44
Dying vol. m^3	1 245 413	1 503 824	619 403	3 386 25
Total vol. m^3	21 010 745	13 518 045	5 557 528	40 086 31
% Dead of total vol.	67	29	10	46
% Dying of total vol.	6	11	11	8
% Dead and dying of total vol.	73	40	21	54

[1]A (dead): 50% or more of total volume of stand dead.

B (moribund): 20% to 49% of total volume of stand dead or more than 49% of total volume dying. Dying = More than 75% total defoliation.

C (very severe): 5% to 19% of total volume dead or 5% to 49% of total volume dying.

[2]Data contain some budworm-killed stands listed on inventory maps as "Not Sufficiently Restocked".

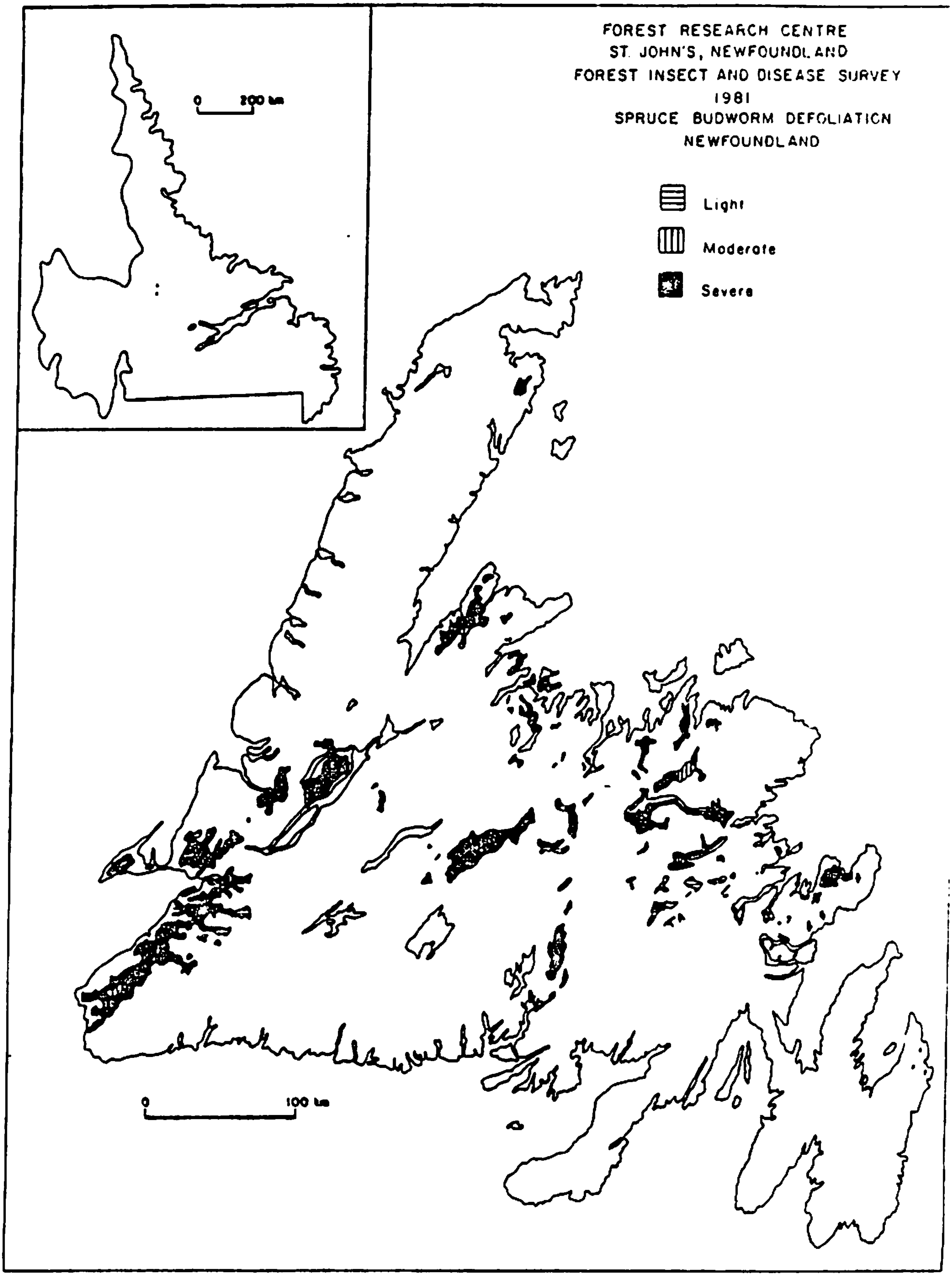

Figure 1. Areas of light, moderate and severe defoliation by the spruce budworm in Newfoundland in 1981.

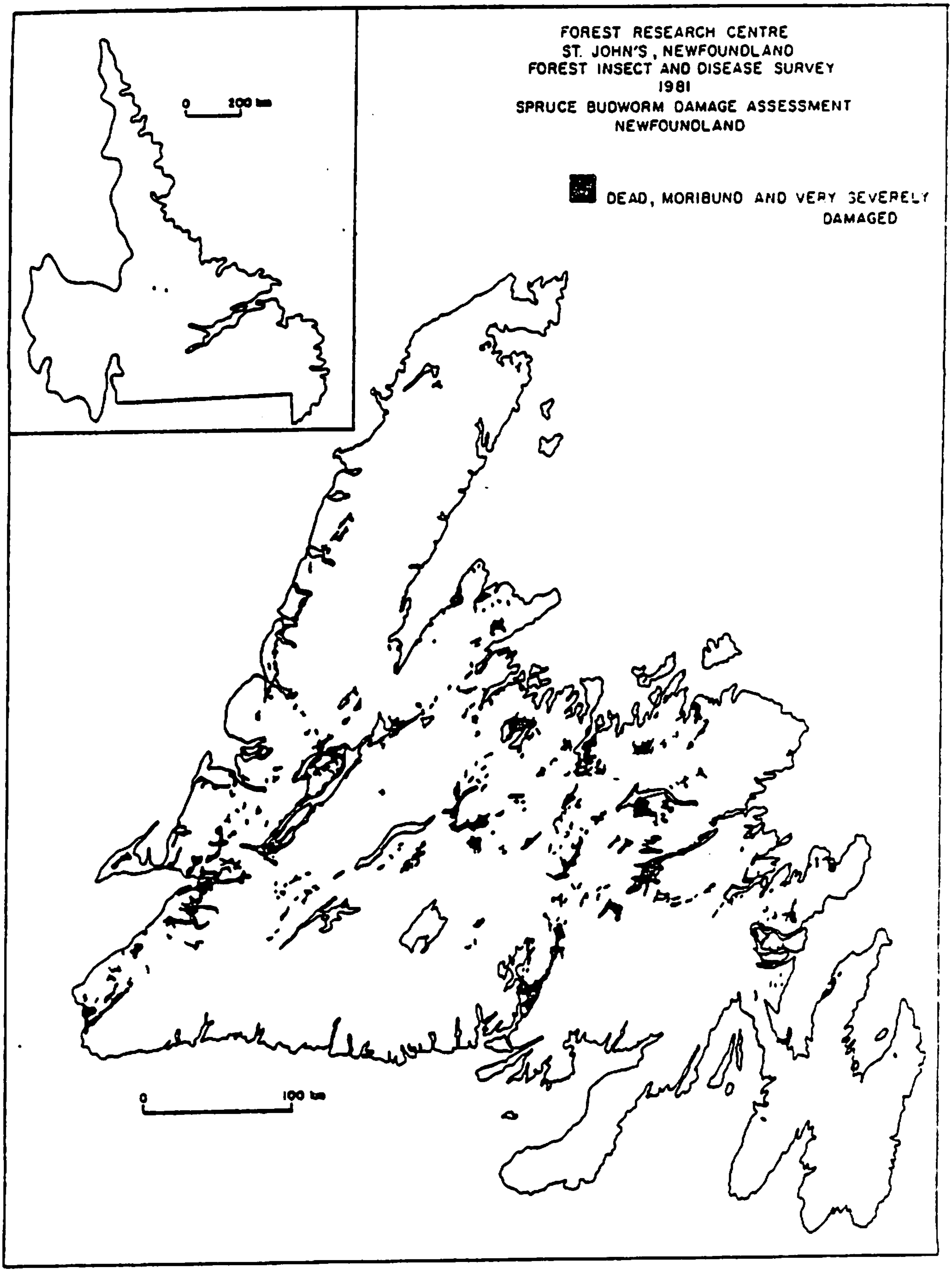

Figure 2. Areas of tree mortality from spruce budworm in Newfoundland in 1981.

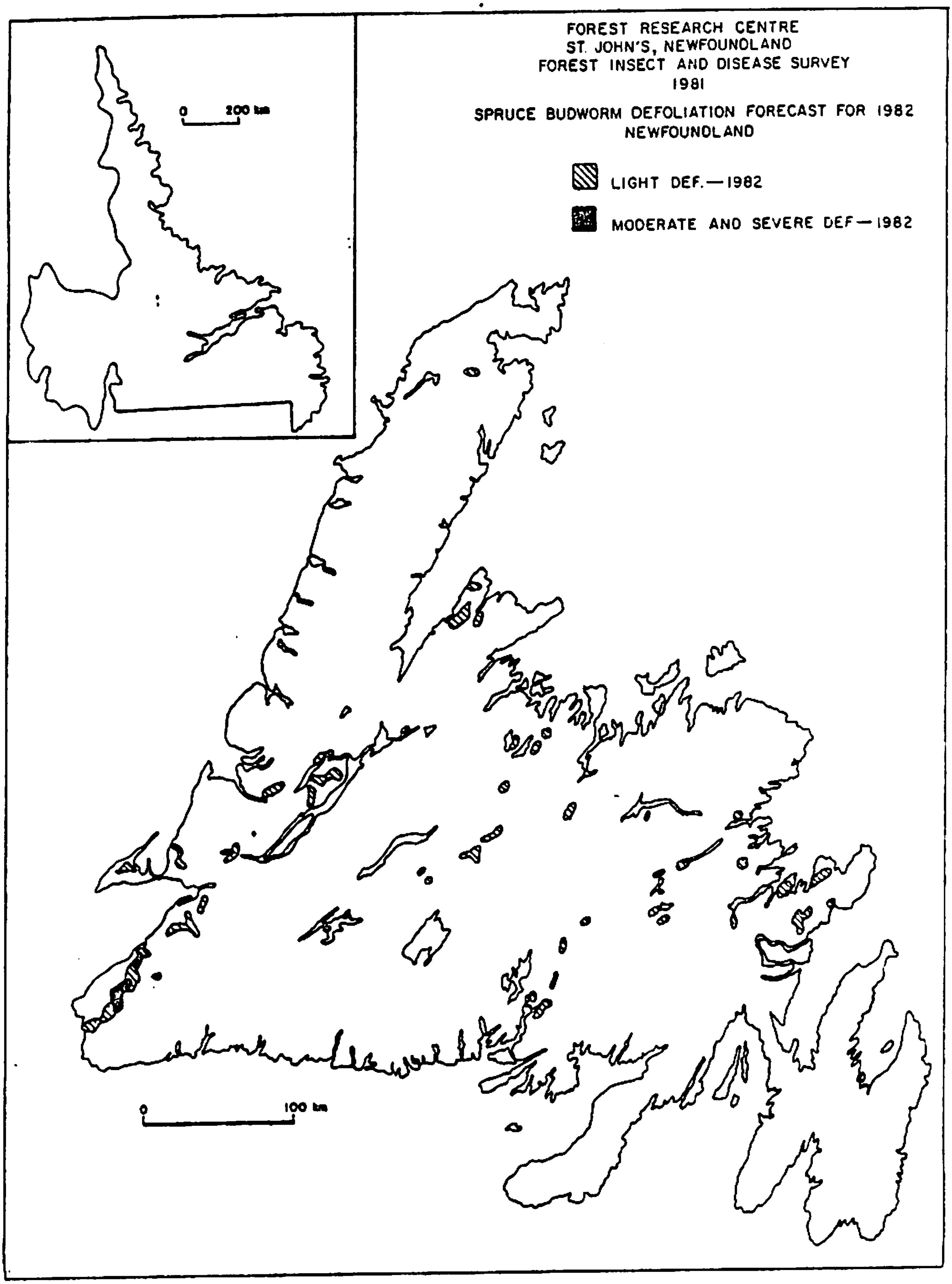

Figure 3. Areas of light, moderate and severe defoliation by the spruce budworm forecast for 1982.

INFORMATION ON NEWFOUNDLAND'S 1981 SPRAY PROGRAM*

(prepared by N. Carter)

1. Original area to be treated consisted of:

   330 683 ha with Matacil
   6 598 ha with Bt

2. Total area treated was:

   238 063 ha with Matacil
   1 920 ha with Bt

3. Matacil area treated represents 72% of original target area but 87% of priority areas set during program.

4. 146 395 ha received a second treatment of Matacil. This represents 44% of original area intended to receive two applications (i.e. 54% of revised priority areas).

5. Bt area treated represents 29% of original target area but 100% of priority areas set during program.

6. 720 ha received a second treatment with Bt (Thuricide 16B) due to rain shortly after first treatment. 1 200 ha received one treatment with Dipel 88.

7. (a) Matacil was intended to be applied at 2 X 70 g AI/1.46L/ha.
   (b) Bt was intended to be applied at 1 X 20 BIU/7.0L/ha.

8. Due to delays because of adverse weather, equipment problems and navigation difficulties not all areas were expected to

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* Essential operational elements prepared for the 1981 Annual Forest Pest Control Forum, Dec. 1 - 3, Ottawa.
Full report available from: Dept. Forest Resources and Lands, Building 810, Pleasantville, St. John's, NF, A1A 1P9

receive intended treatments. Therefore, dose of Matacil was increased to 86 g AI/1.46L/ha. As a result the following areas received treatments as indicated:

1 X 70	-	17 990 ha
2 X 70	-	54 123 ha
1 X 86	-	73 678 ha
1 X 70 + 1 X 86	-	79 064 ha
2 X 86	-	13 208 ha

146 395

9. Dipel 88 was applied to 1 200 ha with no mixing or spraying problems like last year. In fact it was last year's technical Dipel 88 which was used. It was filtered before mixing and more care was taken to ensure the mix was done by adding 25 - 30% water first, then required Dipel and balance of water.

10. Thuricide 16B was applied in two applications to the 720 ha block with no mixing or spraying problems.

11. Initially 3 DC-4s were used for Matacil and 2 Ag Cats for Bt. Late in the program 2 more DC-4s and one Constellation were brought in by the contractor (Conifair Aviation Inc. of St. Jean, Quebec). Also the Ag Cats were converted to spray Matacil once they finished spraying Bt.

12. (a) The DC-4s used the Litton LTN-51 Inertial Navigation System. Problems were encountered with some system malfunctions and apparent pilot inexperience with the use of the system under operational forest spraying conditions.

b) The Ag Cats were guided by a Bell Jet Ranger 206B helicopter using color aerial photographs (1:12500) with flight lines on them. Topographic maps (1:50000) were used when they were spraying Matacil.

13. (a) Swath width for all 4-engine spray planes was 610 m.
(b) For Bt, the Ag Cats used a combined swath of 60 m.
(c) For Matacil this was increased to a combined swath of 150 m.

14. (a) Large spray planes used boom and nozzles with 8010 tee jet tips.
(b) Ag Cats used boom and nozzles with 8004 tee jet tips.

15. Besides the Jet Ranger helicopter, two Cessna 337s and one Shriek Commander twin-engine aircraft were used for aerial supervision.

16. Spray activities began the evening of June 9th and finished the morning of July 11th. Spray took place on only 40% of maximum number of combined morning and evening spray periods due to adverse weather, equipment failure (hydraulics, etc.) and navigation difficulties.

17. On evening of June 25th, one tanker had to jettison a load (9,850 L) of Matacil due to fire in one of the engines. The aircraft returned to base and landed safely.

18. Population levels were extremely variable but mainly within the moderate range (5 - 20/45-cm tip). These levels, however, were still considered to be serious in light of past damage and general poor tree condition.

19. Spring conditions resulted in uniform emergence with larvae quickly and uniformly passing through each instar.

20. Frost damage on balsam fir shoots was evident in many sampling locations.

21. Final larval mortality due to treatment was masked due to a natural population decline noted in most untreated check plots.

22. Foliage protection based on branch estimates in treatment and check plots were not significantly different.

23. Based on the aerial defoliation survey,

(a) 65 percent of the overall area treated was classed in the light category.

(b) 65 percent of the combined area in blocks 201 and 214, which had moderate to high populations and were not treated due to delays, had moderate and severe defoliation.

(c) only 22 percent of the area in the low priority blocks not treated, had moderate and severe defoliation.

24. Evidence of population decline collected during the program suggest a less extensive forecast for 1982.

Newfoundland and Labrador Royal Commission on Forest Protection and Management (1980)*

Last year it was reported at the Forum that the Provincial Government of Newfoundland and Labrador had established a Royal Commission on Forest Protection and Management to investigate the budworm/forest management dilemma in this Province. The Commission presented the first report dealing with the Protection aspect in February, 1981.

The Commission concluded that the spruce budworm infestation in the Province during the last decade has been unprecedented in its magnitude and duration and consequently has left the Newfoundland forest resource in a dire state of depletion. There will be serious shortages of wood supply to the Newfoundland forest industry within 10 years which will last for decades if not corrected. Over 18,000 people are directly or indirectly employed in the forest industry which translates to 50,000 people dependent on this sector of the economy. This contribution will increase with the opening of the Stephenville Mill (official opening September 9, 1981).

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* Summary statement prepared for the Annual Forest Pest Control Forum (December 1 - 3, 1981) by N. Carter, Dept. Forest Resources and Lands, Building 810, Pleasantville, St. John's, NF A1A 1P9

The Commission has expressed the opinion that loss of a significant number of jobs if the forest industry is forced to cut back or close down would result in serious stress to the health of the Newfoundland people. It has quoted evidence of a direct relationship between changes in unemployment and death rate in the United States and elsewhere.

The Commission has also examined all options of budworm control and forest management. In its opinion, any forest management and silviculture can not be successful without adequate protection. The Commission was satisfied that the spraying of the forests with aminocarb, fenitrothion or acephate poses no significant or unacceptable risk to human health. Aerial spraying is both necessary and urgent.

A total of 13 recommendations were made by the Commission. Briefly these include the following:

1. A long-term policy on protection of the forest from losses to insect pests that is similar to established policy on fire protection.

2. A forest spraying operation using a chemical insecticide either aminocarb, fenitrothion, or acephate to be undertaken in 1981 and continued annually for as long as is required to prevent serious losses from spruce budworm attack. The use of Bt was recommended for protection of forests in the immediate vicinity of communities and municipal water supply intakes.

3. An accelerated program of intensive silviculture to overcome wood supply shortages but suspension of all silvicultural activities if the decision is made not to provide forest protection.

4. Other recommendations provided:

- criteria for establishing the protection requirements of forests;
- salvage and export of dead and dying timber surplus to local needs;
- continuation of annual insect surveys;
- guidelines for spray operations;
- development of trained personnel for handling protection operations;
- strengthening of research efforts;
- expansion of Pesticide Advisory Board membership;
- environmental and human health monitoring safegurards;
- public information; and
- contingency plans.

In addition to these recommendations, the Commission provided some guidelines for conducting and monitoring the spray program. It also expressed opinions on a number of contemporary issues related to forest protection and management. In brief, the Commission recommended an integrated forest management and protection program.

Government has recently received part two of the Commission's effort. This, of course, is currently under review and assessment.

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

Report to the Ninth Annual Forest Pest Control Forum
Ottawa, Ontario, December 1981

by

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Research and Resource Services
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

THE PURPOSE

The purpose of the project is to determine the long-term effects of aerially applied pesticides on aquatic ecosystems.

We are 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 is being given to effects changing the value of the fishery resource.

In order to attain the objective we are taking two major experimental approaches.

EXPERIMENTAL DESIGN

The first approach involves 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 will 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 fifth year of data collection on the Spruce Pond system is 1981. It is hoped that a comparison of pre-spray to post-spray data will reveal any changes occurring as a result of the spray.

The second approach is the collection of biological data on the Spruce Pond and Headwater Pond systems during which time Spruce Pond will be experimentally sprayed and Headwater Pond will 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 third year of data collection on the Headwater Pond system is 1981. It is intended that an understanding of the similarities and differences between the two systems be had prior to experimental spraying. It is hoped that a comparison of the sprayed system to the unsprayed system will reveal changes caused by the spray.

DATA COLLECTED TO DATE

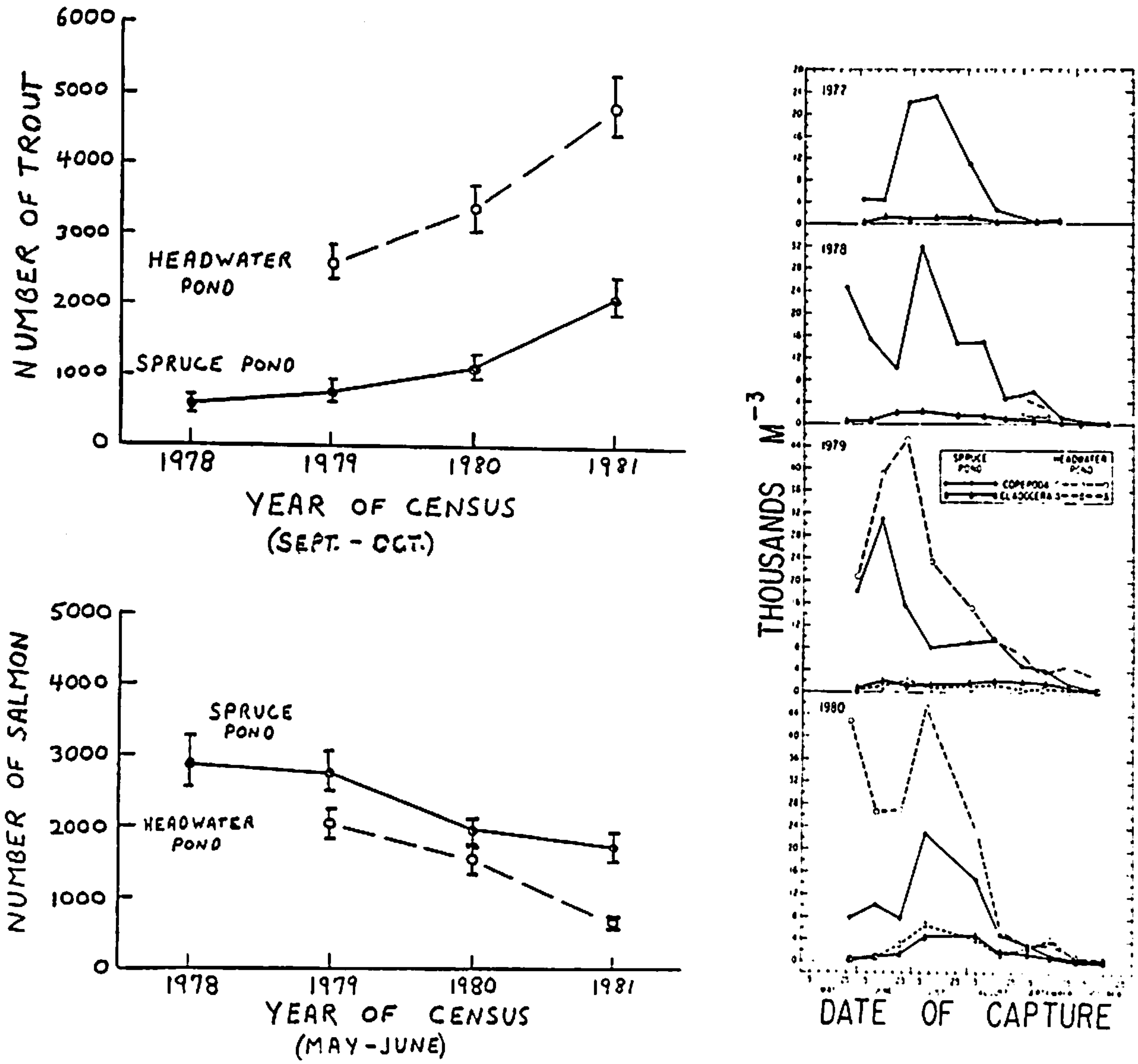
Data are collected on both pond systems from the last week in May to the first week in October. Stream counting fences are installed adjacent to the ponds and the kinds and numbers of migrating fish are monitored. Present in the ponds are brook trout, Atlantic salmon, American eels, and threespine sticklebacks.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

TIMING OF FUTURE ACTIVITIES

So far, much fluctuation in the aquatic biology of both systems has been observed on a year-to-year basis. Less variation has been observed between the two systems. The causes of year-to-year and between-pond variations are becoming better understood but a predictive capacity is not sufficiently developed to allow for an experimental spraying of one of the systems in 1982. The decision of whether or not to spray Spruce Pond in 1983 will be made on the basis of data collected up to that time. If the experiment will not provide a reasonable understanding of the long-term effects of Matacil on the aquatic environment, we will modify it.

PARTICIPATION FROM OTHER GROUPS

The Forest Pest Management Institute of Sault Ste. Marie, Ontario has expressed the wish to conduct an experimental spray and a short-term environmental study. The participation of other groups who wish to study aspects of the Experimental Ponds Area is welcome.



Examples of fluctuations in the abundance of fish (with 95% confidence intervals) and crustacean zooplankton in the Experimental Ponds Area.

MARITIMES FOREST RESEARCH CENTRE

TECHNICAL NOTE NO. 44

NURSERIES

PLANTATIONS

SILVICULTURE

UTILIZATION

ECONOMICS

TREE IMPROVEMENT

INSECTS AND DISEASES

OVERVIEW OF FOREST PROTECTION OPERATIONS AND SPRUCE BUDWORM SURVEYS IN NEW BRUNSWICK, 1981

This report reviews the efficacy of spray operations conducted by Forest Protection Ltd. in 1981 to provide foliage protection from spruce budworm feeding in selected areas of forest in New Brunswick and forecasts spruce budworm infestation levels and tree hazard for 1982.

Treatment areas were selected by the Department of Natural Resources of New Brunswick, using the egg-mass infestation and hazard map (Figure 1) as a guide, in consultation with the forest industry, Forest Protection Ltd. and the Canadian Forestry Service. Assessments of the results of spraying and forecasts of infestations and hazard are based on information gathered by field and laboratory personnel of Forest Protection Ltd. under the supervision of the Maritimes Forest Research Centre of the Canadian Forestry Service.

AREA SPRAYED

Spray operations (Figure 2) conducted by Forest Protection Ltd. covered some 1 900 000 hectares. Included were 30 000 hectares of private woodlots in what was once referred to as the "one mile set-back zone". Spraying in this area was limited to only small agricultural type aircraft. A synopsis of all the areas treated by dosage and aircraft type is shown in Table 1. A new type of aircraft, the M-18

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ENVIRONMENT CANADA

(manufactured in Poland) was used on the project and the small area treated by them was listed in areas treated by TBM's. The insecticide Fenitrothion was used at a dosage of 210 Gm/ha per application.

Spray operations commenced on May 19 and ended on June 20. Some 116 000 hectares in the large scale operation received only one application at the recommendation of C.F.S. because of low budworm populations remaining after the first application. Some 3 000 hectares in the private woodlot operation received only one application because the second application would have been too late to provide any further foliage protection.

RESULTS OF SPRAYING

The effectiveness of spraying is evaluated from:

1) extensive aerial surveys of current defoliation

and 2) from intensive surveys for pre-spray larvae, post-spray pupae and defoliation in treated and control plots.

The results of egg-mass surveys are not used to evaluate spray efficacy because such surveys reflect the population level of next years infestation. This population is usually the result of many factors other than spraying. Spray operations, such as the one in New Brunswick are only Crop Protection tools, conducted to save foliage not eradicate insects and are carried out over only a portion of the general area infested by the pest insect. As a result they have little influence over the general population trends of widespread infestations such as the present budworm epidemic.

LARGE SCALE OPERATIONAL SPRAYING

Operations were affected to some degree by "bad" spray weather, particularly in north-western New Brunswick. Nevertheless, protection was generally good to excellent with an average of 50% of the foliage crop saved, and survival of budworms was generally low (less than 5%) compared to a survival rate of 25% in the non-treated areas. Analysis of aerial surveys of defoliation show that only 17% of the treated area received a detectable level of defoliation (Table 2). A significant portion of this defoliation coincided with areas along water courses over which aircraft were required to shut off the spray booms. No differences in spray efficacy were detected between aircraft type, and in general, areas treated twice had a higher level of protection than areas treated once.

The 1981 results are very similar to those obtained over the past six years and confirm the effectiveness of fenitrothion in such a crop protection program.

PROTECTION TO PRIVATE WOODLOTS

The spraying of small woodlots was also affected by bad spray weather, but assessment of 29 of the 105 woodlots treated in the 1 mile buffer zone showed acceptable levels of protection in 26 (or 90%) of the woodlots sampled. This is a significant increase in protection over the 1980 B.t. spray program when only 35% of the areas treated received adequate protection. However, in two areas of the province, one west of Fredericton, the other in Madawaska County, the level of foliage protection was somewhat less because of the lateness of the second application of insecticide.

RESULTS OF DEFOLIATION SURVEYS

A cooperative aerial survey to map the nature and extent of spruce budworm defoliation (Figure 3) was conducted with personnel of Forest Protection Ltd., Dept. Natural Resources, and the Maritimes Forest Research Center. Some 1 374 000 hecatares outside and within the treated areas were classified as moderate to severe defoliation, which is an increase over 1980 when 673 000 hectares of moderate to severe defoliation were detected. This increase in defoliation was predicted from the 1980 egg-mass survey.

Only 268 000 hectares of the moderate to severe defoliation were recorded inside the general boundary of the 1981 spray program.

FORECAST OF INFESTATIONS AND HAZARD FOR 1982

In 1981 1 722 locations in New Brunswick were sampled for spruce budworm egg-masses and hazard. This was a significant increase in the level of sampling over 1980 when 1 200 locations were sampled. The increase in sampling was done at the request of Dept. Natural Resources of New Brunswick to ensure that the "buffer" zones were sampled adequately.

The results of the egg-mass survey (Figure 4) show that there are moderate to high infestations in all sectors of the Province (Table 3) and that in five of the six regions egg-mass infestations are higher in the "buffer" zone than in the protection zone. Further, 1981 infestation levels in the "Protection Zone" compared to 1980 are significantly higher in the eastern half of the province, about the same in the north and central west sectors, and substantially lower in the south west sector (Figure 5). Continuing moderate to severe budworm infestations over most of the forest area of New Brunswick are forecast for 1982.

Hazard ratings are based on forecasts of infestation and on the past and current history of tree damage. The map (Figure 4) is based on information gathered during egg-mass surveys and aerial surveys of defoliation. Most of the forest in the protection and buffer zones are generally in moderate to high hazard due primarily to the increase of infestations and the amount of defoliation in 1981.

In many respects the current situation in the forest parallels that of 1974. An insufficient control effort the following year resulted in a very serious decline in the health of the forest. Similarly, if the forest is allowed to deteriorate in 1982 because of budworm feeding a crisis situation is almost a certainty for 1983.

Edward G. Kettela
Canadian Forestry Service
Maritimes Forest Research Center

Table 1. A synopsis of the area sprayed in 1981 by Forest Protection Ltd, by hectares and acres, dosage, application rate, aircraft type and carrier.

Operational	Hectares Thousands	Acres Thousands	Aircraft Type
One Application			
(a) 210 G/Ha Fenitrothion in 20 U.S. Fl. oz./Ac. - Water Base	70	174	TBM-3
(b) 210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac. - Oil Base	46	113	DC-6
Two Applications			
(c) 210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac.+210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac. - Water Base	1 481	3 659	TBM-3
(d) 210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac.+210 G/Ha Fentrothion in 20 U.S. fl. oz./Ac. - Oil Base	222	549	DC 6
(e) 210 G/Ha Fenitrothion in 10 U.S. fl. oz./Ac.+210 G/Ha Fenitrothion in 10 U.S. fl. oz./Ac. - Oil Base	51	125	Thrush[1]
TOTAL	1 870	4 620	

Private Woodlots	Hectares Thousands	Acres Thousands	Aircraft Type
One Application			
210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac. - Oil Base	3	8	Ag-Cat Ag-Truck Pawnee
Two Applications			
210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac.+210 G/Ha Fenitrothion in 20 U.S. fl. oz./Ac. - Oil Base	27	66	Ag-Cat Ag-Truck Pawnee
TOTAL	30	74	
GRAND TOTAL	1 900	4 694	

[1] Thrush areas were sprayed by Forest Patrol Limited under contract to Forest Protection Limited.

Table 2. Spruce Budworm Defoliation in New Brunswick from 1978 to 1981 (hectares x 1000)

Defoliation Category	1978	1979	1980	1981 Total Province	1981 In Sprayed Area*
Light	141	105	176	137	52 (38%)
Moderate	219	235	226	388	104 (27%)
Severe	450	1085	447	849	164 (19%)
TOTAL ALL CATEGORIES	810	1425	849	1374	320

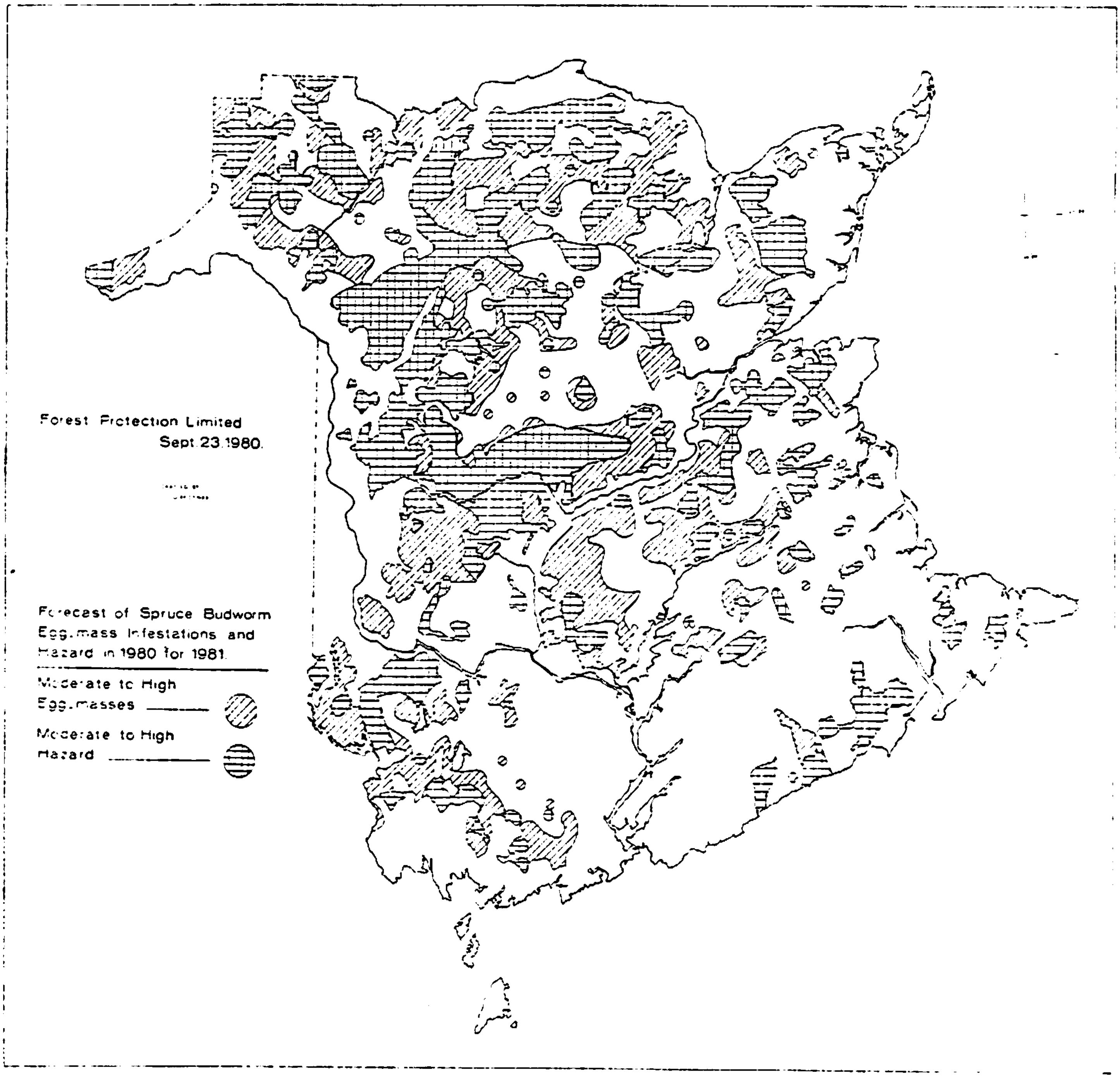
*The area treated in 1981 by Forest Protection Limited was 4.690 million acres or 1.9 million hectares. Some 320 000 hectares of defoliation were detected in the treated area which means that 83% of the area treated had no detectable level of defoliation.

Table 3. Summary of Mean Spruce Budworm Egg-mass Infestations In Six Regions of New Brunswick

Region	1981 Mean Egg-Mass Infestation (egg-masses/$10m^2$)		1980**
	Set Back Zone	Protection Zone	
North West	429 (46)*	245 (358)	223
North East	457 (55)	361 (155)	168
Central West	278 (93)	220 (222)	234
Central East	409 (113)	302 (206)	197
South West	211 (149)	142 (115)	215
South East	187 (128)	251 (81)	155

*no. of sample points (   )

**set back zone - not sampled in 1980, so 1980 figures apply to protection zone only.



Forest Protection Limited
Sept.23.1980.
Forecast of Spruce Budworm
Egg-mass Infestations and
Hazard in 1980 for 1981.
Moderate to High
Egg-masses
Moderate to High
Hazard

Figure 1

ACTUAL AREA SPRAYED IN 1981

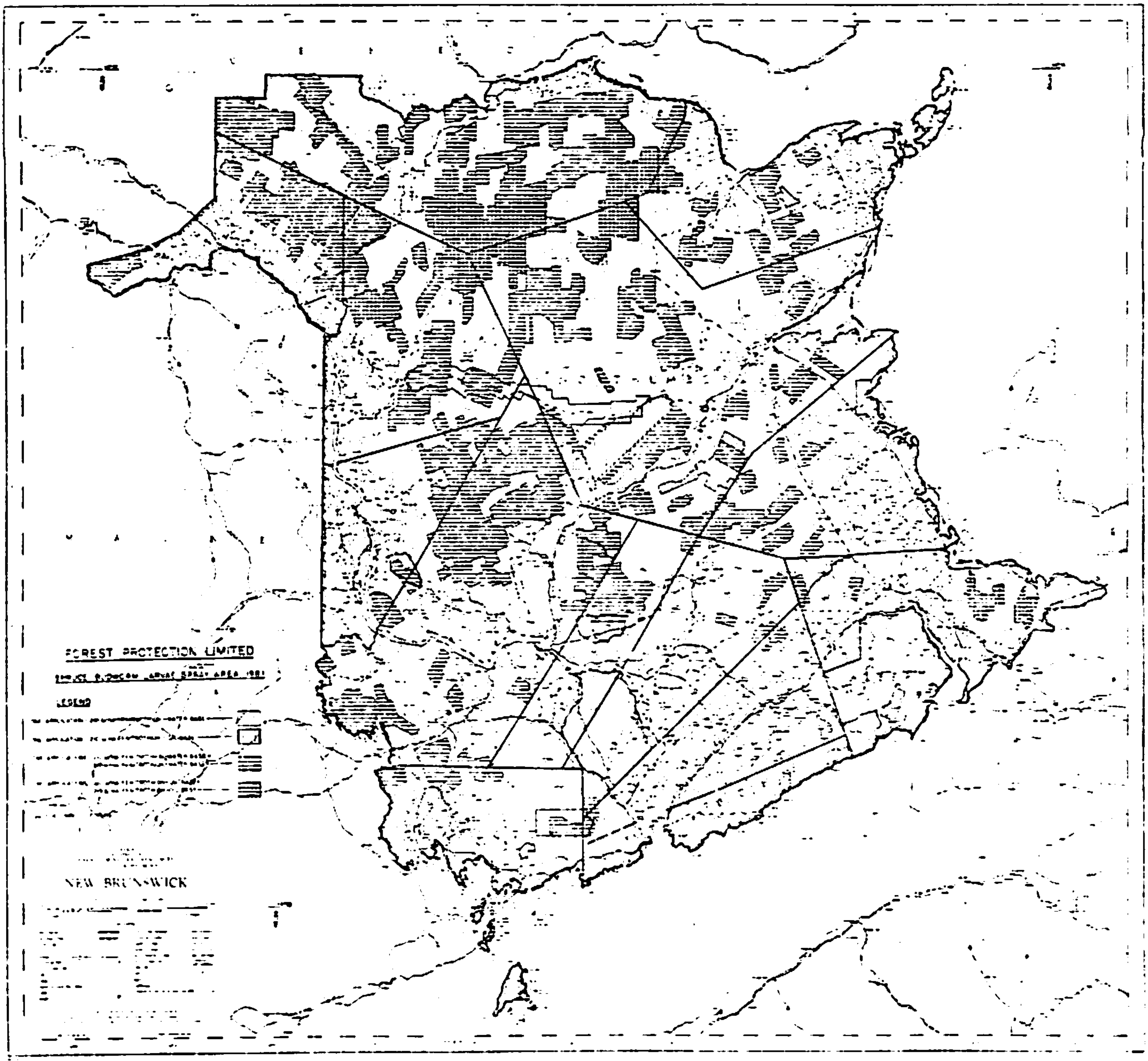


Figure 2

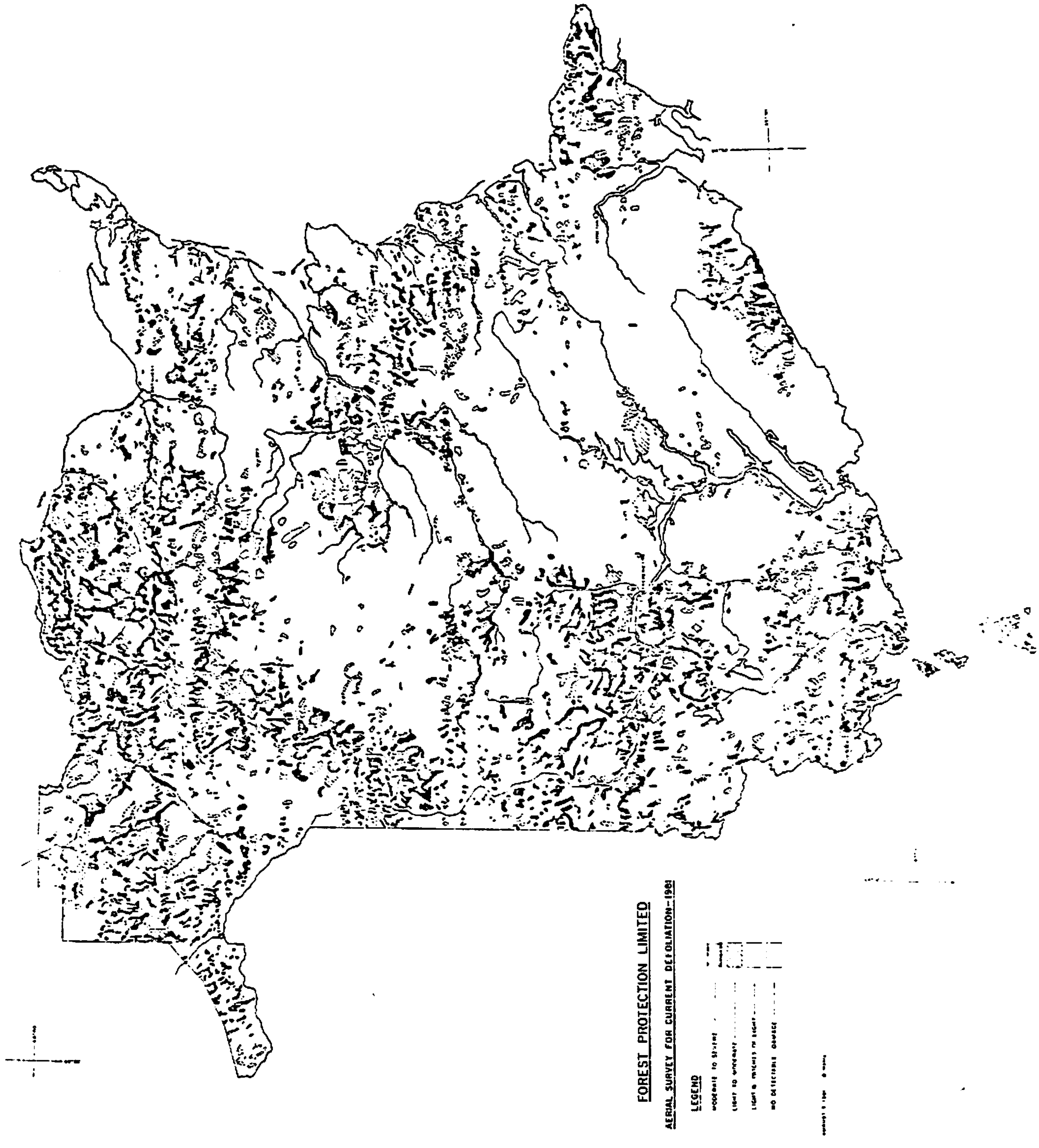

FOREST PROTECTION LIMITED
AERIAL SURVEY FOR CURRENT DEFOLIATION-1981
LEGEND

Figure 3

FORECAST OF SPRUCE BUDWORM EGG MASS INFESTATIONS AND HAZARD IN 1981 FOR 1982

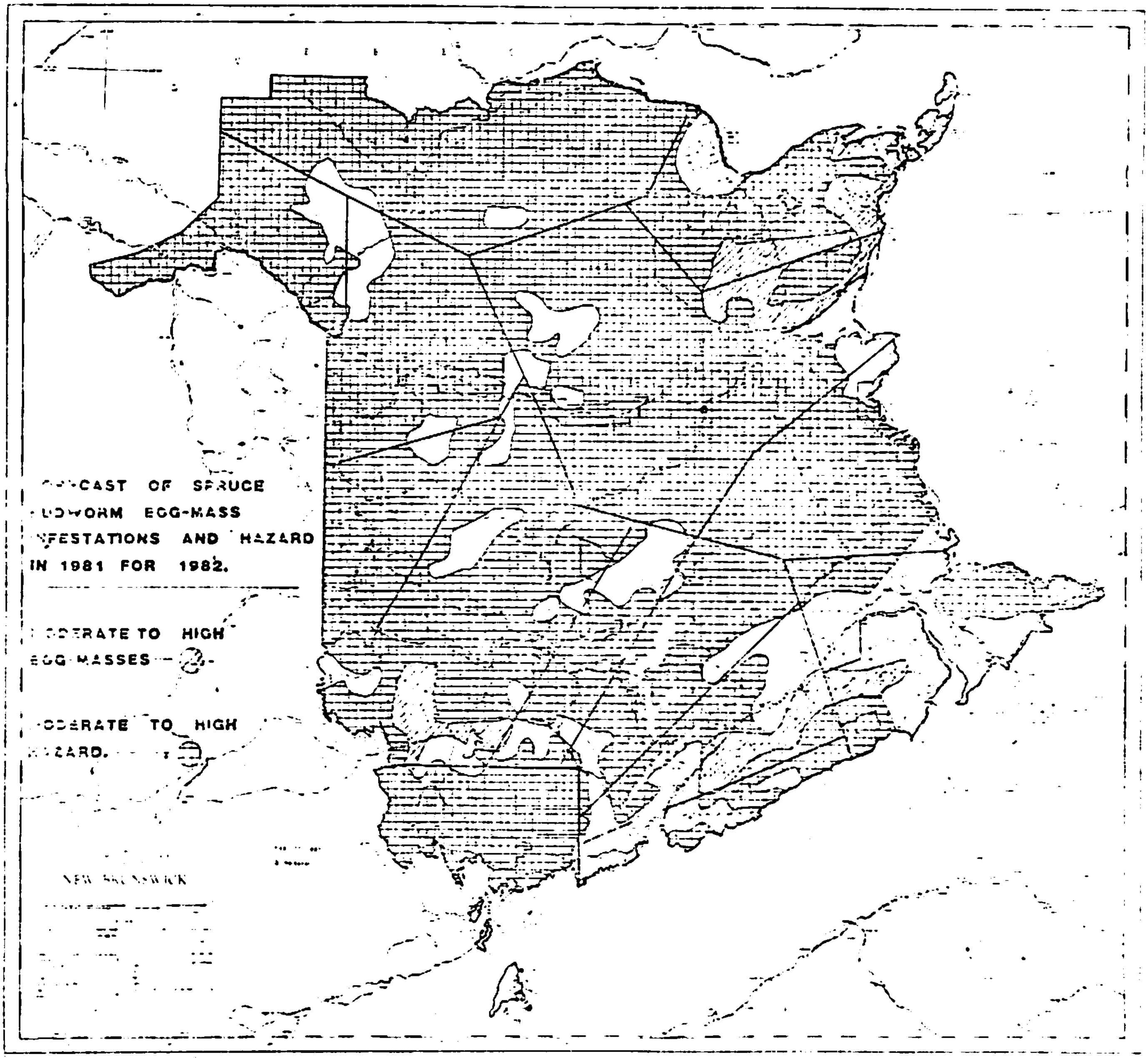


Figure 4

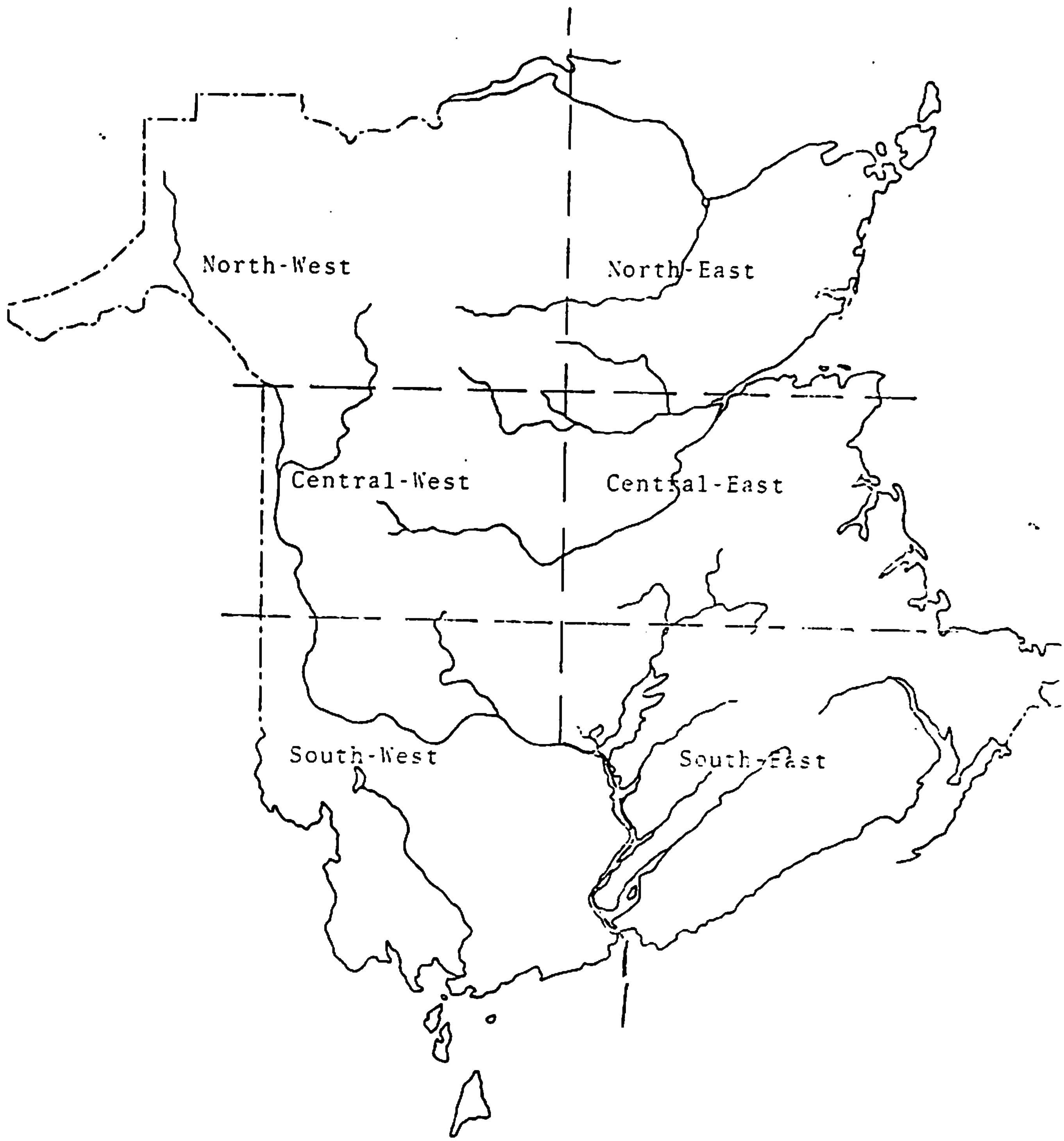


Figure 5 Sectors of New Brunswick.

MARITIMES FOREST RESEARCH CENTRE
TECHNICAL NOTE NO. 38

SPRUCE BUDWORM INFESTATIONS IN NOVA SCOTIA IN 1981 AND A FORECAST FOR 1982

Spruce budworm defoliation and egg-mass Surveys in 1981 were largely a joint effort of the Department of Lands and Forests of Nova Scotia and the Maritimes Forest Research Center. Additional information on egg-mass infestations in western Nova Scotia was acquired because of Bowater-Mersey Paper's involvement in the collection of additional samples in that region. Further, the Maritimes Forest Research Center has had considerable input into spruce budworm damage appraisal in Nova Scotia through the Forest Insect and Disease Survey. The information gathered in damage appraisal surveys is reported elsewhere.

This Technical Note reports on the results of surveys for current defoliation and forecasts infestations for 1982 based on egg-mass surveys.

Aerial Survey for Defoliation

The feeding habits of the spruce budworm result in partially eaten fir and spruce needles turning a distinctive red-brown colour. This colouration is distinctive and as a result stands of trees defoliated by the spruce budworm are easily identified and mapped from the air. Aerial surveys in Nova Scotia covered all of Cape Breton Island, Cumberland, Colchester, Pictou, Antigonish, and parts of Guysborough County, all of the Annapolis Valley region and parts of Queen, Shelburne and Hants County. The results of this survey (Figure 1, Table 1) show that 700 000 hectares of forest had a detectable level of defoliation which is a decrease in the area of defoliation from 1980 when 1 380 000 hectares were defoliated.

NURSERIES ☐
PLANTATIONS ☐
SILVICULTURE ☐
UTILIZATION ☐
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ENVIRONMENT CANADA

MARITIMES

This level of defoliation adequately reflects the predictions of egg-mass surveys in 1980 (Technical Note 19). For example, the defoliated area increased significantly in the Annapolis Valley (which was predicted) and the level of severe defoliation on Cape Breton Island though less extensive than 1980, still covers a significant portion of the Island. Similarly, the extent of defoliation in Cumberland, Pictou and Antigonish Counties was as predicted. As a point of interest, this is the eleventh year of extensive moderate to severe defoliation in the Chignecto Penninsula of Cumberland county and the seventh year on Cape Breton Island.

Forecast of Infestations for 1982

The results of the egg-mass survey (Table 2, Figure 2) show that there is a significant decrease of infestations on Cape Breton Island and that moderate to severe defoliation will occur in a limited number of small areas in 1982. There is a similar significant reduction of infestations in Pictou, Antigonish, Kings, Annapolis, Hants and Digby Counties. In Cumberland County infestation levels are only slightly reduced and moderate to severe defoliation can be expected to occur over a significant area of the Chignecto Peninsula. Elsewhere on Mainland Nova Scotia, spruce budworm infestation are forecast to be low and of no particular threat to the forests in 1982.

These results, based on some 328 samples, 266 from Nova Scotia Lands & Forests and 62 from Bowater-Mersey, were processed to obtain counts of spruce budworm egg-masses. Counts of budworm egg-masses per unit area of host tree foliage are used to forecast infestations. The infestation categories are: light ($1-108/10^2m$), moderate ($109-260/10^2m$), and high ($261+/10^2m$).

Summary: There are many probable reasons for infestation reductions. For Cape Breton Island there had to be a population reduction because of the extensive area of dead and dying forest. For the mainland the reasons for reductions in infestation are not apparent and were not due to the activity of parasites, predators and diseases. Whatever caused the reduction in infestation in the Annapolis Valley and Pictou and Antigonish counties did so after the larval feeding phase. Such phenomena have occurred elsewhere and remains one of the mysteries of spruce budworm infestation dynamics.

E.G. Kettela
Technical & Information Services
October, 1981

Reference:

Kettela, E.G. Nov. 1980. Spruce Budworm Infestations in Nova Scotia in 1980 and a Forecast for 1981. Technical Note 19.

Table 1. Summary of areas of spruce budworm defoliation* in Nova Scotia from 1978 to 1981.

Sector of province	Year	Defoliation categories (hectares x 1000) light	moderate	variable	severe
Mainland					
Cumberland Colchester	1978	3.2	20.3	0	74.5
	1979	3.6	17.8	0	77.0
	1980	3.2	66.0	45.8	102.1
	1981	40.8	31.8	-	69.0
Northumberland Coast	1978	10.9	11.7	0	1.2
	1979	31.6	8.9	0	15.8
	1980	13.8	1.2	56.3	7.3
	1981	13.5	11.0	-	1.6
Annapolis Valley	1978	0	0	0	0
	1979	20.7	11.3	0	9.7
	1980	40.1	36.0	0	21.5
	1981	46.9	42.0	-	47.3
Cape Breton Island	1978	0	68.9	203.3	376.7
	1979	164.4	129.6	339.4	256.8
	1980	47.4	121.1	456.8	361.3
	1981	31.8	71.4	-	292.9

Total area of all categories of defoliation (thousand of hectares)	1978	1979	1980	1981
	771	1 087	1 380	700

* from maps developed from aerial surveys of spruce budworm defoliation.

Table 2. Spruce budworm egg-mass infestation counts per $10^2 m$ in Nova Scotia by county from 1974 to 1981.

County	Year 1974	1975	1976	1977	1978	1979	1980	1981
Richmond	125	203	430	649	364	403	423	51
Cape Breton	-	496	1608	524	437	349	378	17
Inverness	468	552	1319	758	389	316	308	50
Victoria	370	676	1832	771	435	647	258	27
Cumberland	293	263	191	71	218	307	235	197
Colchester	24	20	104	23	165	52	10	22
Pictou	-	23	29	125	140	214	116	13
Antigonish	204	135	196	182	252	65	136	79
Guysborough	0	0	6	78	-	8	0	8
Kings	14	12	12	25	73	183	245	86
Annapolis	19	16	18	27	121	165	224	72
Hants	36	11	6	6	0	19	61	12
Digby	12	6	11	20	-	3	86	36
Halifax	0	37	0	5	-	0	30	24
Lunenburg	0	6	0	6	9	16	10	15
Shelburne	0	3	0	12	-	8	28	4
Queens	0	3	4	4	0	0	-	6
Yarmouth	0	0	16	20	-	28	29	4

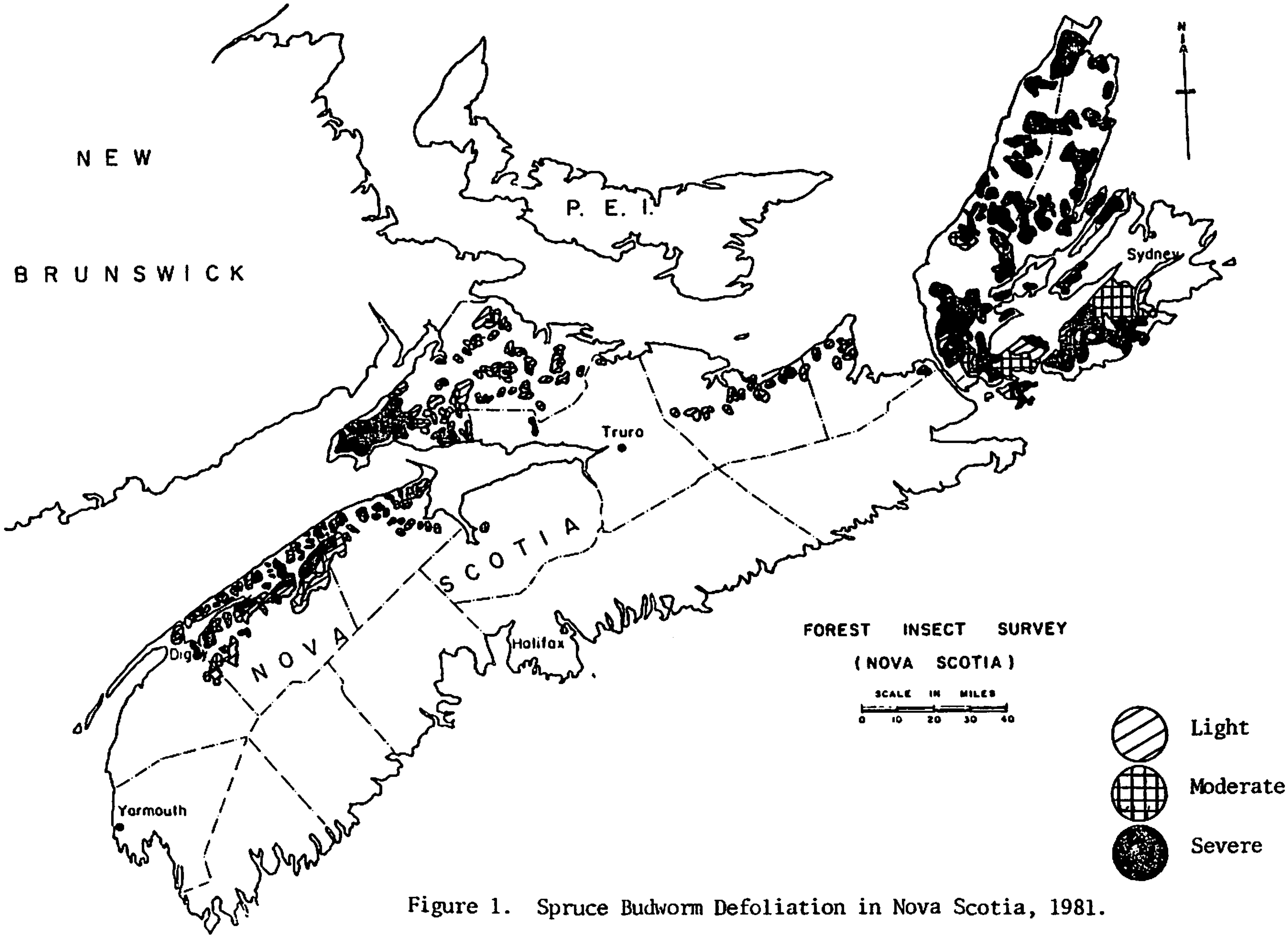


Figure 1. Spruce Budworm Defoliation in Nova Scotia, 1981.

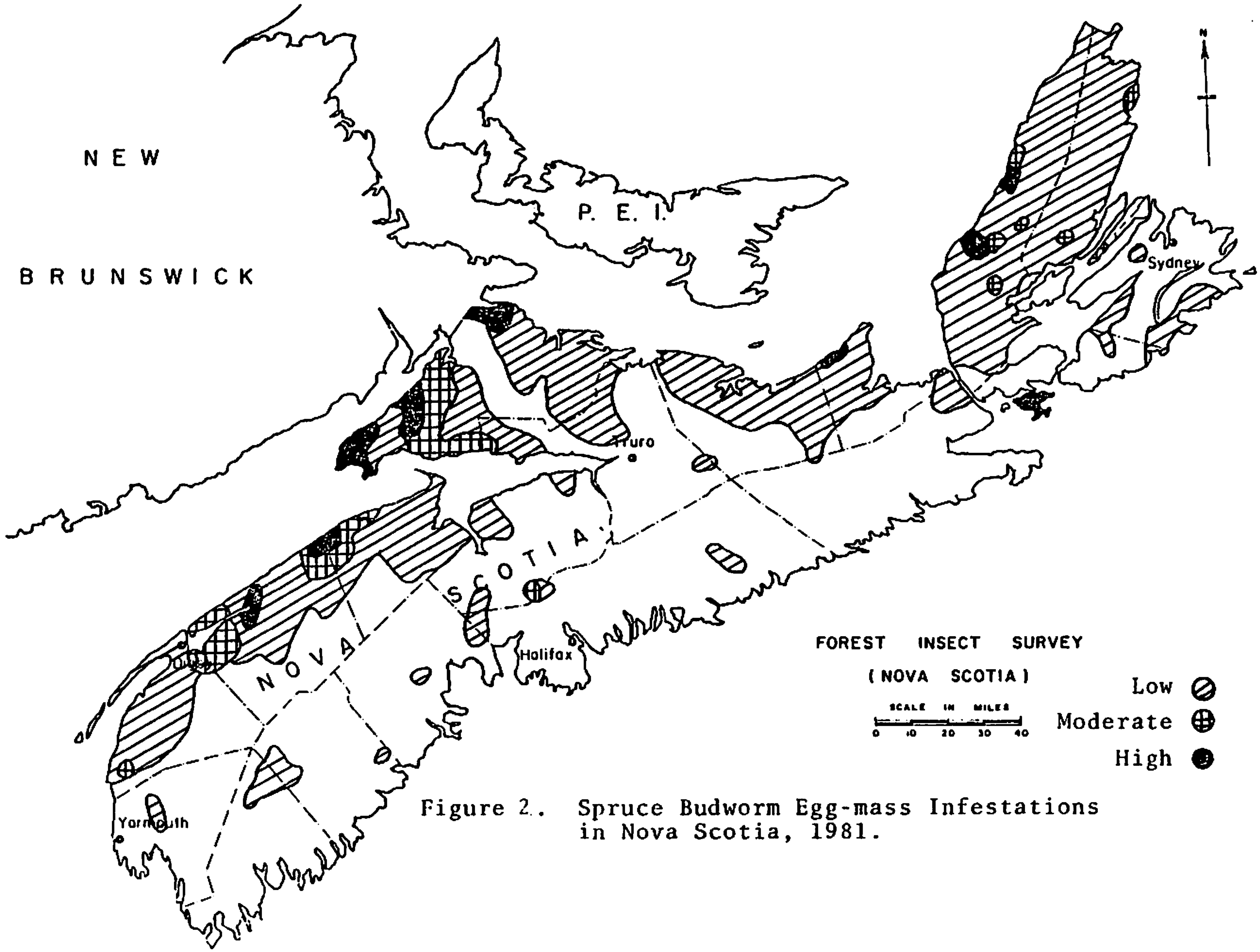


Figure 2. Spruce Budworm Egg-mass Infestations in Nova Scotia, 1981.

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, 1981.

Introduction:

This report was prepared to provide a synopsis of the results of spraying with a microbiological biocide (*Bacillus thuringiensis kurstaki* *B.t.k.* to reduce population densities of spruce budworm in selected high value spruce and/or fir stands in Nova Scotia in 1981.

Objective:

The objective of the 1981 *B.t.k.* spray project was to maintain fifty percent or more of the current foliage on spruce and/or fir trees in the treatment areas.

Weather:

As with last year, the predominant factor affecting the conduct of the *B.t.k.* project was weather. Poor flying conditions out of the Parrsboro airport caused a loss of approximately 33% of flight time. Overall weather conditions in Cape Breton were acceptable with no delay for spray aircraft.

Area Treated:

The total area treated was 31 195.0 ha., 20 666.2 in the Cape Breton Highlands and 10 528.8 ha on the Mainland. The biocides used were commercial preparations of *Bacillus thuringiensis kurstaki* (*B.t.k.*) known as Thuricide 16B, and Dipel 88.

Thuricide 16B was applied at a rate of 20 BIU ha^{-1} in 7.1 $l \cdot ha^{-1}$ of formulation. Dipel 88 was applied at a rate of 22 BIU ha^{-1} in 5.3 $l \cdot ha^{-1}$ of formulation.

The amount of Thuricide 16B biocide used from Parrsboro was 33 218.7 L and from Crowdis was 69 192.7 L. The amount of Dipel 88 used from Parrsboro was 5 040.0 L and from Crowdis 5 472.0 L. The total amount of Thuricide 16B used for the project was 102 411.5 L and the total amount of Dipel 88 used for the project was 10 512.0 L.

Results:

In general the results of the 1981 B.t.k. project can be considered as acceptable.

On the Mainland the percent of foliage for spruce saved ranged from 63% in Advocate to 77% in the Economy Mountain block. The percent of balsam fir saved from defoliation in Economy Mountain block was 71%. All areas on the Mainland had acceptable foliage protection as defined by the program's objective.

Larval population densities varied from 9.2 to 19.2 per 45 cm branch.

The percent larval mortality ranged from 79.3 to 84.7 in treatment areas (Table 1). Spraying for the Mainland began on 2 June 1981 and ended on 25 June 1981.

The situation in Cape Breton is somewhat more complex than that of the mainland. The effect of the spray is difficult to determine because of the loss of check plots due to high defoliation outside of the treatment areas. The data must be analysed and studied in a different manner before any conclusion can be drawn.

All that can be said at this point (subjectively) is that foliage has been saved in the treatment areas.

Expenditures:

The total expenditure of the B.t.k. project from 30 September 1980 to 30 September 1981 was $1,099,378.60. The cost per hectare was $35.54 and the cost per hectare flown was $33.08 (Table 3).

Summary:

The treatment areas on Mainland Nova Scotia received acceptable foliage protection by protecting 50% or more of current foliage (63-77%). The situation in Cape Breton is more complex as the majority of the trees in the control areas are moribund making quantitative analysis of foliage protection difficult. Subjectively foliage protection seems acceptable on the majority of the treatment areas in Cape Breton.

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 it imply that the used discussed here have been registered. All uses of pesticides must be registered by appropriate Provincial and/or Federal agencies before they can be recommended.

Table 1. Percent foliage protection and percent larval mortality of spruce budworm larvae (*Choristoneura fumiferana* (Clemens, 1865)) obtained by aerially applying a microbiological biocide, *Bacillus thuringiensis kurstaki*, at 20 BIU ha^{-1} on Mainland of Nova Scotia for the month of June 1981

Name	No.	Cover Type[1]	Function[2]	Areas[3]	Number of Application	Area Flown[3]	Larvae Instar	Mean No. of Larvae 43 cm	Foliage Protect % Saved	Foliage Protect Accept	% Larval Mortality
Advocate	1	rS	1	1665.0	1	1752.5	9-5	17.6	63	yes	79.3
Shulie	2	rS	1	1421.3	1	1869.0	4-5	19.2	69	yes	80.0
Moose R.	3	rS	1	4387.5	1	4586.0	4-5	16.7	68	yes	80.7
Economy	4	rS	1	2463.4	2	2321.5	3-5	9.0	77	yes	81.4
		bF	1	-	-	-	-	9.2	71	yes	84.7

1. Cover type based on Quebec system, wS - white spruce, bF - balsam fir, rS - red spruce
2. "1" is foliage protection areas, "2" is seed protection area
3. Determined from Navigator reports.

Table 2. Subjective foliage protection obtained with the aerial application of a microbiological biocide *Bacillus thuringiensis kurstaki* (20 BIU·ha^{-1}) against spruce budworm larvae (*Choristoneura fumiferana* (Clemens, 1865)) Cape Breton Island, Nova Scotia, 1981.

Name	Block Numbers	Cover Type[1]	Function[2]	Number of Application	Area[3] Flown ha	Larval Instar	Foliage Protection
Hume Bk.	5	bS	1	1	809.9	3-4	+ve
Gairloch Mtn	6,7,8	bS+bF	1	1	9713.9	3-4	+ve
Round Mtn	9	bF	1	1	942.0	3-4	?
Christie	10,11	bF	1	1	487.5	3-4	?
Crowdis Mtn	12	bF	1	1	2997.4	3-4	+ve,?
Bell Lake	13,14	bF	1	1	3982.1	3-4	+ve
Spaced Stands	15,16, 18,19,21	bF	1	1	1250.9	2-4	+ve
Miners Rd N	20	wS	2	2	261.1	3-4	-ve
Muskrat Bk	22	bS	2	2	48.0	3-4	+ve
Hume Rd	23	bS	2	2	64.8	2-3	+ve
Gairloch Rd.	24	wS	2	2	137.7	2-3	+ve
Miners Rd S	17	wS	2	1	94.8	2-3	+ve

1. Cover type based on Quebec system, wS - white spruce, bF - balsam fir, rS - red spruce
2. "1" is foliage protection, "2" is seed protection areas
3. Determined from navigator reports

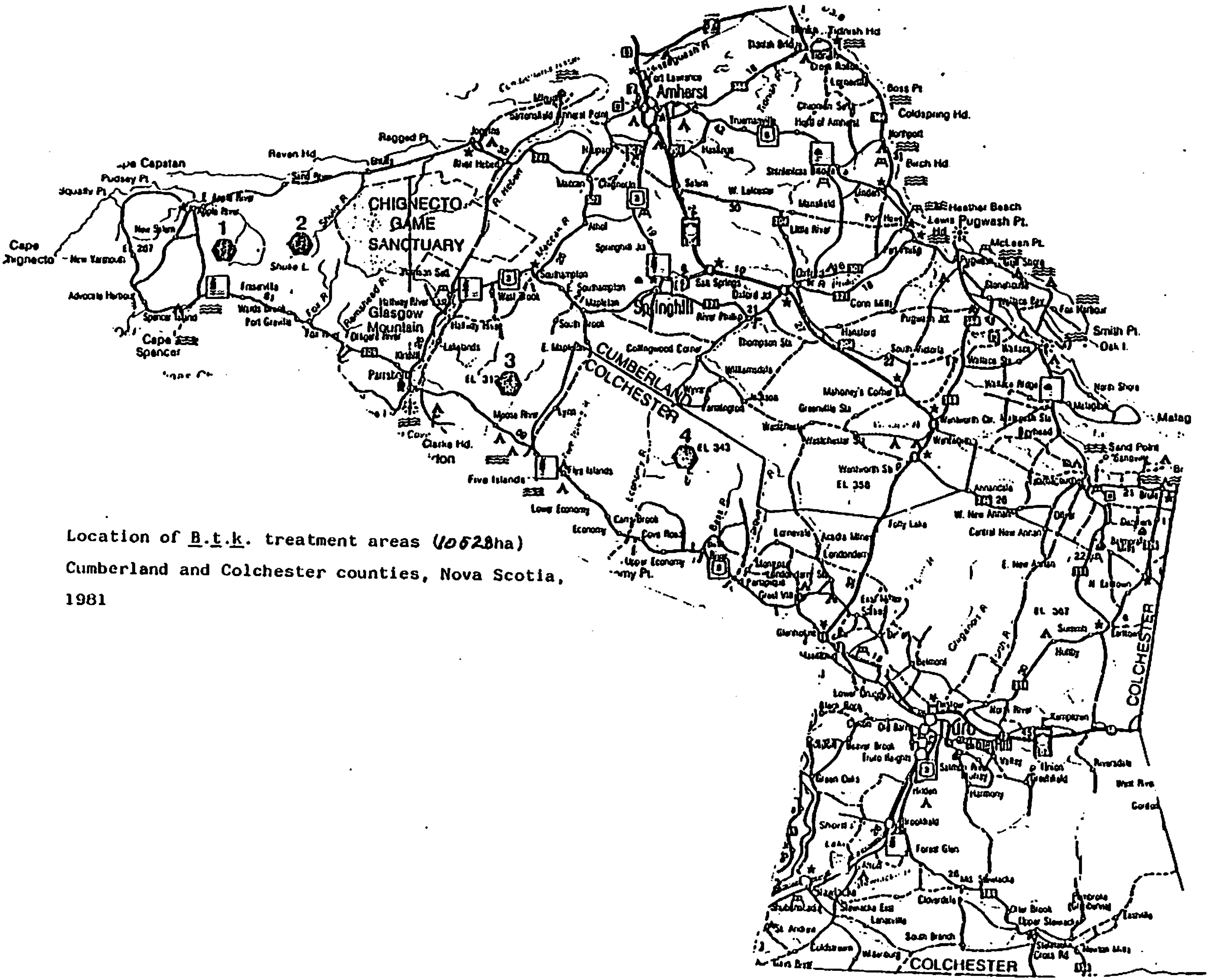
Table 3. Expenditures of the operational project to suppress spruce budworm (*Choristoneura fumiferana* (Clemens, 1865)) in selected areas by aerially applying (*Bacillus thuringiensis kurstaki* (20 $BIU\text{-}ha^{-1}$) Nova Scotia, September 30, 1980 to September 30, 1981.

Category	$	%	Area	Flown
Salaries	173,113.98	15.75	5.62	5.55
Travel	17,057.45	1.55	0.55	0.55
Special Services	71,467.71	6.50	2.32	2.29
Supplies & Services	760,439.00	69.17	24.72	24.38
Biocide	267,130.48	24.30	8.69	8.56
Aircraft	429,847.05	39.10	13.98	13.78
Lodging	31,095.46	2.83	1.01	1.00
Rentals	16,543.79	1.50	0.54	0.53
Trucking	15,822.22	1.44	0.51	0.51
Equipment	21,266.45	1.93	0.69	0.68
Others	56,034.01	5.10	1.82	1.80
Total	1,099,378.60	100.00	35.54	33.08
Total Area			30 752.4	31 195.0

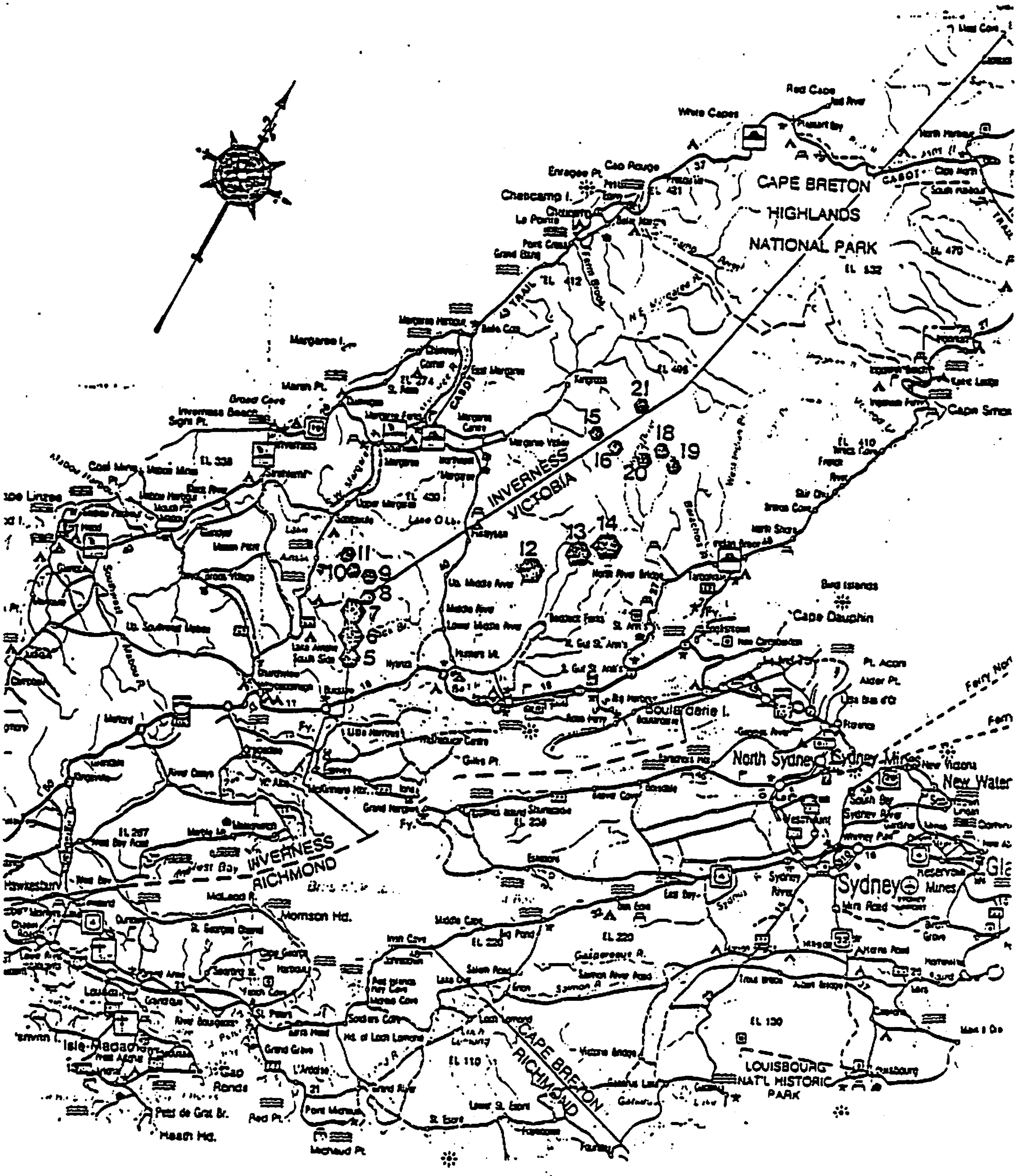
Thomas D. Smith

By: Dr. T. D. Smith
N.S. Dept. of Lands & Forests

27, November, 1981



Location of B.t.k. treatment areas (10628ha)
Cumberland and Colchester counties, Nova Scotia,
1981



Location of B.t.k. treatment areas, (20666 ha)
Cape Breton Island, Nova Scotia, 1981

Nova Scotia
Department of
Lands and Forests

Treatment Area Report 1981

Area Number 1

Area Name Advocate

1.	Province	Nova Scotia
2.	Area (ha)	1752.4
3.	Status - operational or experimental	operational
4.	Pre-spray larval density per 45 cm tip	17.6
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV:40, V:49, VI:11
7.	Percent bud flush at spray time (species)	100 balsam fir, 80 red spruce
8.	B.t.k. formulation and Trade name	Flowable, Thuricide 16 B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (A)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Red spruce species complex
17.	Date spray started	15 June
18.	Date spray finished	19 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	6.3 colonies per cm²
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	82
24.	Percentage defolaition (treated/check)	18 ÷ 42
25.	Percentage foliage protection[3]	57
26.	No Pupae/45 cm tip (treated/check)	1.0 ÷ 4.9

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 2

Area Name Shulie

1.	Province	Nova Scotia
2.	Area (ha)	1869.0
3.	Status - operational or experimental	operational
4.	Pre-spray larval density per 45 cm tip	19.2
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV: 40; V 49; VI 11.
7.	Percent bud flush at spray time (species)	balsam fir 100; red spruce 80
8.	B.t.k. formulation and Trade name	Flowable, Thuricide 16 B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (model A)
15.	Nozzle system used	Boom - Nozzle (8004)
16.	Predominant tree species	Red spruce species complex
17.	Date spray started	15 June
18.	Date spray finished	19 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	6.2 colonies per cm^2
22.	Cost per hectare flown[1]	$ 33.08
23.	Percentage control[2]	50
24.	Percentage defolaition (treated/check)	16 ÷ 70
25.	Percentage foliage protection[3]	77
26.	No Pupae/45 cm tip (treated/check)	1.0 ÷ 5.1

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 3

Area Name Moose River

1.	Province	Nova Scotia
2.	Area (ha)	4586.0
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	16.7
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV: 5; V 40; VI: 55
7.	Percent bud flush at spray time (species)	balsam fir: 100, red spruce 100
8.	B.t.k. formulation and Trade name	Flowable, Thuricide 16 B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (model A)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Red spruce species complex
17.	Date spray started	13 June
18.	Date spray finished	25 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Fog
21.	Deposit rate	8.2 colonies per cm^2
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	58
24.	Percentage defolaition (treated/check)	15 ÷ 39
25.	Percentage foliage protection[3]	62
26.	No Pupae/45 cm tip (treated/check)	0.9 ÷ 3.3

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 4

Area Name Economy

1.	Province	Nova Scotia
2.	Area (ha)	2321.4
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	9.2
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	bF: III 8; IV 90; V 2 rS III 12; IV 88; V 0
7.	Percent bud flush at spray time (species)	Balsam fir 65; Red spruce 0,
8.	B.t.k. formulation and Trade name	Flowable, Dipel 88
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	5.85
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-Cat (Model A)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir 50%, Red Spruce 5%
17.	Date spray started	2 June
18.	Date spray finished	3 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Fog
21.	Deposit rate	2.6 colonies per cm^2
22.	Cost per hectare flown[1]	$33.08

		Balsam fir	Red spruce
23.	Percentage control[2]	86	66
24.	Percentage defolaition (treated/check)	8 ÷ 63	8 ÷ 61
25.	Percentage foliage protection[3]	87	87
26.	No Pupae/45 cm tip (treated/check)	0.6 ÷ 3.0	0.6 ÷ 3.5

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 5

Area Name Hume

1.	Province	Nova Scotia
2.	Area (ha)	809.9
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	Inaccessible
5.	Pre-spray bud density	Inaccessible
6.	Spray time larval development (%)	Inaccessible
7.	Percent bud flush at spray time (species)	Inaccessible
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir
17.	Date spray started	14 June
18.	Date spray finished	18 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Inaccessible
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Inaccessible
24.	Percentage defolaition (treated/check)	Inaccessible
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Ineccessible

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated - living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation - Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 6

Area Name Gairloch South

1.	Province	Nova Scotia
2.	Area (ha)	5570.0
3.	Status - operational or experimental	Operational.
4.	Pre-spray larval density per 45 cm tip	4.4
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	III: 35; IV 65.
7.	Percent bud flush at spray time (species)	balsam fir 85
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16E
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (800H)
16.	Predominant tree species	Balsam fir
17.	Date spray started	12 June
18.	Date spray finished	15 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	7.6 colonies per cm^2
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	67
24.	Percentage defolaition (treated/check)	2 ÷ 6
25.	Percentage foliage protection[3]	66
26.	No Pupae/45 cm tip (treated/check)	0.1 ÷ 0.2

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 7

Area Name Gairloch Mtn

1.	Province	Nova Scotia
2.	Area (ha)	3147.0
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	4.4
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	III: 7; IV: 70; V: 23.
7.	Percent bud flush at spray time (species)	Balsam fir 90
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir
17.	Date spray started	13 June
18.	Date spray finished	19 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	7.6 colonies per cm^2
22.	Cost per hectare flown[1]	$ 33.08
23.	Percentage control[2]	67
24.	Percentage defolaition (treated/check)	2 ÷ 6
25.	Percentage foliage protection[3]	67
26.	No Pupae/45 cm tip (treated/check)	0.1 ÷ 0.2

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 8

Area Name Gairloch North

1.	Province	Nova Scotia
2.	Area (ha)	9331
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	4.4
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV 25; V 75
7.	Percent bud flush at spray time (species)	Balsam fir 90
8.	B.t.k. formulation and Trade name	Flowable, Thuricide 16
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir
17.	Date spray started	20 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	7.6 colonies per cm²
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	33
24.	Percentage defolaition (treated/check)	3 ÷ 6
25.	Percentage foliage protection[3]	50
26.	No Pupae/45 cm tip (treated/check)	0.1 ÷ 0.2

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 9

Area Name Round Mtn

1.	Province	Nova Scotia
2.	Area (ha)	942.0
3.	Status - operational or experimental	operational
4.	Pre-spray larval density per 45 cm tip	4.4
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV 25, V 75
7.	Percent bud flush at spray time (species)	Balsam fir 90
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-Cat (Model B)
15.	Nozzle system used	Boom Nozzle (8004)
16.	Predominant tree species	Balsam Fir
17.	Date spray started	19 June
18.	Date spray finished	20 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not measured
22.	Cost per hectare flown[1]	$ 33.02
23.	Percentage control[2]	?
24.	Percentage defolaition (treated/check)	1 ÷ 6
25.	Percentage foliage protection[3]	83
26.	No Pupae/45 cm tip (treated/check)	0.03 ÷ 0.3

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated - living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation - Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 10

Area Name Christie South

1.	Province	Nova Scotia
2.	Area (ha)	336.3
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	Inaccessible
5.	Pre-spray bud density	Inaccessible
6.	Spray time larval development (%)	Inaccessible
7.	Percent bud flush at spray time (species)	Inaccessible
8.	B.t.k. formulation and Trade name	Flowable: Thuricide16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom+ Nozzle (8004)
16.	Predominant tree species	Balsam fir
17.	Date spray started	20 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Inaccessible
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Inaccessible
24.	Percentage defolaition (treated/check)	Inaccessible
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Inaccessible

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 11

Area Name Christie North

1.	Province	Nova Scotia
2.	Area (ha)	151.2
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	Inaccessible
5.	Pre-spray bud density	Inaccessible
6.	Spray time larval development (%)	Inaccessible
7.	Percent bud flush at spray time (species)	Inaccessible
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam Fir
17.	Date spray started	22 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Inaccessible
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Inaccessible
24.	Percentage defolaition (treated/check)	Inaccessible
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Inaccessible

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia
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Lands and Forests

Treatment Area Report 1981

Area Number 12

Area Name Crowdis Mtn

1.	Province	Nova Scotia
2.	Area (ha)	2997.4
3.	Status - operational or experimental	Operational
4.	Pre-spray larval density per 45 cm tip	17.8
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	II: 5; III 55; IV 35; VI: 5;
7.	Percent bud flush at spray time (species)	Balsam fir 95
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16 B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir
17.	Date spray started	14 June
18.	Date spray finished	20 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	9.4 colonies per cm^2
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	52 ?
24.	Percentage defolaition (treated/check)	17 ÷ 14 (majority of trees in checks dead
25.	Percentage foliage protection[3]	0 (?)
26.	No Pupae/45 cm tip (treated/check)	2.5 ÷ 2.3

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 13 + 14

Area Name Bell Lakes

1.	Province	Nova Scotia	
2.	Area (ha)	4851.9	
3.	Status – operational or experimental	Operational	
4.	Pre-spray larval density per 45 cm tip	3.5	
5.	Pre-spray bud density	N/A	
6.	Spray time larval development (%)	IV 8; V 66; VI 26	
7.	Percent bud flush at spray time (species)	Balsam fir	
8.	B.t.k. formulation and Trade name	Flowable (1) Thuricide 16B (2) Dipel 88	
9.	BIU·ha^{-1}	20	
10.	Tracer dye used	None	
11.	Applied volume rate (l·ha^{-1})	Thuricide 16B 7.1 Dipel 88 5.85	
12.	Number of applications	1	
13.	Time between applications	N/A	
14.	Aircraft type used	Ag Cat (Model B)	
15.	Nozzle system used	Boom + Nozzle (8004)	
16.	Predominant tree species	Balsam fir	
17.	Date spray started	24 June	
18.	Date spray finished	25 June	
19.	Met conditions at spray time	Acceptable	
20.	Met conditions following spray	Acceptable	
21.	Deposit rate	15.1 per cm²	5.0 per cm²
22.	Cost per hectare flown[1]	$33.08	$33.08
23.	Percentage control[2]	17	17
24.	Percentage defolaition (treated/check)	1 ÷ 15	2 ÷ 15
25.	Percentage foliage protection[3]	93	87
26.	No Pupae/45 cm tip (treated/check)	0.2 ÷ 0.7	—
		Thuricide 16B	Dipel 88

[1] Includes total cost of project

[2] Chi square – Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection –

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 15

Area Name Feilding Rd.

1.	Province	Nova Scotia
2.	Area (ha)	368.1
3.	Status - operational or experimental	Operational (regeneration)
4.	Pre-spray larval density per 45 cm tip	2.1
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	III 10; IV 70; V 20;
7.	Percent bud flush at spray time (species)[4]	85, Balsam fir
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir (regeneration)
17.	Date spray started	19 June
18.	Date spray finished	19 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	5.5 colonies per cm^2
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	N/A
24.	Percentage defolaition (treated/check)	2 ÷ 1
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	0.0 ÷ 0.0

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

4 50% of newly flushed shoots killed by frost

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 16

Area Name Junction

1.	Province	Nova Scotia
2.	Area (ha)	291.8
3.	Status - operational or experimental	Operational (regeneration
4.	Pre-spray larval density per 45 cm tip	2.1
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	III 5; IV 65; V 30,
7.	Percent bud flush at spray time (species)[4]	85, Balsam fir
8.	B.t.k. formulation and Trade name	Flowable, Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (800H)
16.	Predominant tree species	Balsam fir regeneration
17.	Date spray started	20 June
18.	Date spray finished	20 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	5.5 colonies per cm²
22.	Cost per hectare flown[1]	$33.02
23.	Percentage control[2]	N/A
24.	Percentage defolaition (treated/check)	2 ÷ 1
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	0.0 ÷ 0.0

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

4. 50% of newly flushed shoots ... [illegible]

Nova Scotia
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Treatment Area Report 1981

Area Number 17

Area Name Miners Rd. South

1.	Province	Nova Scotia
2.	Area (ha)	94.8
3.	Status - operational or experimental	Operational (Regeneration)
4.	Pre-spray larval density per 45 cm tip	2.1
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV 45, V 45, VI 10
7.	Percent bud flush at spray time (species)[4]	85, balsam fir
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	2.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir regeneration
17.	Date spray started	22 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	1 ÷ 1
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	0.0 ÷ 0.0

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

[4] 50% [illegible]

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 18

Area Name Do nut

1.	Province	Nova Scotia
2.	Area (ha)	70.5
3.	Status - operational or experimental	Operational (Regeneration)
4.	Pre-spray larval density per 45 cm tip	2.1
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV 45; V 45; VI 10
7.	Percent bud flush at spray time (species)	85 balsam fir
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	2.1
12.	Number of applications	1
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Balsam fir regeneration
17.	Date spray started	22 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	1 ÷ 1
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	0.0 ÷ 0.0

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 19

Area Name Kelly Road. *

1.	Province	Nova Scotia
2.	Area (ha)	116.0
3.	Status - operational or experimental	Operational (Cone area)
4.	Pre-spray larval density per 45 cm tip	Not determined
5.	Pre-spray bud density	Not determined
6.	Spray time larval development (%)	Not determined
7.	Percent bud flush at spray time (species)	Not determined
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	Two
13.	Time between applications	5.5 days
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Black spruce
17.	Date spray started	16 June ; 22 June
18.	Date spray finished	16 June ; 22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

* Area not monitored

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 20

Area Name Miners Rd North

1.	Province	Nova Scotia
2.	Area (ha)	154.6
3.	Status - operational or experimental	Operational (Cone area)
4.	Pre-spray larval density per 45 cm tip	10.1
5.	Pre-spray bud density	Not determined
6.	Spray time larval development (%)	1st: III 10; IV 60; V 30 2nd IV 30; V 47; VI 23
7.	Percent bud flush at spray time (species)	1st 90 white spruce 2nd 100 white spruce
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	Two
13.	Time between applications	5.5 days
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	White spruce
17.	Date spray started	16 June ; 22 June
18.	Date spray finished	16 June ; 22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	1st Not determined 2nd 10.9 colonies per cm²
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Unacceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 20

Area Name Miners Rd. North

1.	Province	Nova Scotia
2.	Area (ha)	154.6
3.	Status - operational or experimental	Operational (Cone Area)
4.	Pre-spray larval density per 45 cm tip	10.1
5.	Pre-spray bud density	Not determined
6.	Spray time larval development (%)	1st III 10: IV 60, V 30 2nd IV 30, V 47: VI 23
7.	Percent bud flush at spray time (species)	1st 90 white spruce 2nd 100 white spruce
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	Two
13.	Time between applications	5.5 days
14.	Aircraft type used	Ag-cat (Model B)
15.	Nozzle system used	Boom + Nozzle (800H)
16.	Predominant tree species	white spruce
17.	Date spray started	16 June / 22 June
18.	Date spray finished	16 June / 22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	1st not determined 2nd 10.9 per cm²
22.	Cost per hectare flown[1]	$ 33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Unacceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 21

Area Name Highland Rd.

1.	Province	Nova Scotia
2.	Area (ha)	234.0
3.	Status - operational or experimental	Operational (Regeneration)
4.	Pre-spray larval density per 45 cm tip	3.1
5.	Pre-spray bud density	N/A
6.	Spray time larval development (%)	IV 45; V 45; VI 10
7.	Percent bud flush at spray time (species)	85 balsam fir
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	BIU·ha^{-1}	20
10.	Tracer dye used	None
11.	Applied volume rate (l·ha^{-1})	7.1
12.	Number of applications	one
13.	Time between applications	N/A
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (800H)
16.	Predominant tree species	Balsam fir regeneration
17.	Date spray started	22 June
18.	Date spray finished	22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	N/A
24.	Percentage defolaition (treated/check)	2 ÷ 1
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	0.0 ÷ 0.0

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 22

Area Name Muskrat Brook[H]

1.	Province	Nova Scotia
2.	Area (ha)	24
3.	Status - operational or experimental	Operational (Cone Area)
4.	Pre-spray larval density per 45 cm tip	Not determined
5.	Pre-spray bud density	Not determined
6.	Spray time larval development (%)	Not determined
7.	Percent bud flush at spray time (species)	Not determined
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16 B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	Two
13.	Time between applications	4 days
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Black spruce
17.	Date spray started	1st 16 June; 2nd 20 June
18.	Date spray finished	16 June; 20 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Accepta.
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated} - \text{living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation} - \text{Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

H. Area within [illegible] (12)

Nova Scotia Department of Lands and Forests

Treatment Area Report 1981

Area Number 23

Area Name Hume Road.

1.	Province	Nova Scotia
2.	Area (ha)	32.4
3.	Status - operational or experimental	Operational (Cone Area)
4.	Pre-spray larval density per 45 cm tip	Inaccessible
5.	Pre-spray bud density	Inaccessible
6.	Spray time larval development (%)	Inaccessible
7.	Percent bud flush at spray time (species)	Inaccessible
8.	B.t.k. formulation and Trade name	Flowable: Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	7.1
12.	Number of applications	Two
13.	Time between applications	3.5 days
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom + Nozzle (8004)
16.	Predominant tree species	Black spruce
17.	Date spray started	18 June ; 22 June
18.	Date spray finished	18 June ; 22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{\text{(Living Untreated - living treated)}}{\text{(Living Untreated)}} \times 100$$

[3] Percent foliage protection -

$$= \frac{\text{(Expected defoliation - Observed defoliation)}}{\text{(Expected Defoliation)}} \times 100$$

Nova Scotia
Department of
Lands and Forests

Treatment Area Report 1981

Area Number 24

Area Name Gairloch Rd.[4]

1.	Province	Nova Scotia
2.	Area (ha)	625
3.	Status - operational or experimental	Operational (Cone Area)
4.	Pre-spray larval density per 45 cm tip	Not determined
5.	Pre-spray bud density	Not determined
6.	Spray time larval development (%)	1st III 7, IV 70; V 23 2nd IV 25; V 75
7.	Percent bud flush at spray time (species)	Not determined
8.	B.t.k. formulation and Trade name	Flowable Thuricide 16B
9.	$BIU \cdot ha^{-1}$	20
10.	Tracer dye used	None
11.	Applied volume rate ($l \cdot ha^{-1}$)	2.1
12.	Number of applications	Two
13.	Time between applications	6 days
14.	Aircraft type used	Ag cat (Model B)
15.	Nozzle system used	Boom & Nozzle (8004)
16.	Predominant tree species	White spruce
17.	Date spray started	1st 13 June ; 2nd 22 June
18.	Date spray finished	15 June ; 22 June
19.	Met conditions at spray time	Acceptable
20.	Met conditions following spray	Acceptable
21.	Deposit rate	Not determined
22.	Cost per hectare flown[1]	$33.08
23.	Percentage control[2]	Not determined
24.	Percentage defolaition (treated/check)	Not determined
25.	Percentage foliage protection[3]	Acceptable
26.	No Pupae/45 cm tip (treated/check)	Not determined

[1] Includes total cost of project

[2] Chi square - Abbott's formula

$$= \frac{(\text{Living Untreated - living treated})}{(\text{Living Untreated})} \times 100$$

[3] Percent foliage protection -

$$= \frac{(\text{Expected defoliation - Observed defoliation})}{(\text{Expected Defoliation})} \times 100$$

4. Area contained in Gairloch Mtn (7) and Gairloch North (8)

MARITIMES FOREST RESEARCH CENTRE
TECHNICAL NOTE NO. 41

WHAT HAPPENED TO ALL THE TREES?

(A POSTMORTEM ON PREDICTIONS OF TREE MORTALITY ON CAPE BRETON ISLAND)

In February of 1977, because of the controversy over whether to spray the forests of the Cape Breton Highlands, the then Minister of Lands and Forests, set up a Task Force on Wood Allocation and Forest Management. One of the first priorities of this Task Force was to arrive at some reasonable predictions for tree mortality under a no protection policy. I undertook this assignment and based on consultations with staff members at the Maritime Forest Research Centre and on models of budworm-caused mortality from past outbreaks in Ontario, Quebec and New Brunswick, a table of projected mortality 1977 to 1981 was produced (Table 1).

The projected mortality figures also reflected the state of the forest on Cape Breton Island in 1977, and the extremely high population levels which were expected in 1978.

How accurate were these predictions? MFRC Technical Note 39 by B.A. Pendrel, just released, lists the conditions of fir and spruce in the forests of Cape Breton Island. Table 2 is derived from the data from 140 survey plots and excludes the area sprayed with Bt.

For balsam fir/spruce on the Highlands, the major source of wood supply for the N.S. Forest Industries pulp mill, the predictions are very close to the actual results. Similarly, mortality of spruce in Cape Breton

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- PLANTATIONS ☐
- SILVICULTURE ☐
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ENVIRONMENT CANADA

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County was also predicted accurately. On the Inverness/Victoria lowlands balsam suffered more than predicted while that in Richmond and Cape Breton counties faired better. Spruce in the Inverness/Victoria lowlands and in Richmond faired considerably better than the predictions. It would be, however, premature to rejoice over the welfare of the spruce in the lowlands because of the spruce bark beetle which now ranks close in importance with the budworm in causing mortality in spruce. Most likely mortality in spruce due to the budworm and the bark beetle will continue for some time.

Table 1* Projected Estimates of Balsam Fir (bF) and White Spruce (wS) Mortality by Year for Counties of the Cape Breton Subdivision, 1977-81 (% of G.M.V.)

	Counties of Cape Breton Subdivision						
	Inverness/Victoria			Richmond County		Cape Breton County	
	Highlands	Lowlands					
Year	bF/wS	bF	wS	bF	wS	bF	wS
	(Percent)						
1977	10	5	-	5	-	5	-
1978	15	10	5	10	5	10	5
1979	25	15	10	15	10	15	10
1980	20	10	15	10	15	10	15
1981	10	10	10	10	10	10	10
Total Percent	80	50	40	50	40	50	40

* In: Report of the Task Force on Wood Allocation and Forest Management in Nova Scotia. February 1978.

Table 2. Mortality of Balsam Fir and Spruce for counties of Cape Breton Island (includes moribund trees).

	Inverness/Victoria			Richmond		Cape Breton	
	Highlands	Lowlands					
Year	bF/spruce	bF	spruce	bF	spruce	bF	spruce
	(Percent)						
1981	78	63	17	42	21	32	39

G. D. van Raalte
Maritimes Forest Research Centre
October 21, 1981

MARITIMES FOREST RESEARCH CENTRE
TECHNICAL NOTE NO. 39

CONDITION OF FIR AND SPRUCE IN FORESTS OF CAPE BRETON ISLAND, CUMBERLAND AND COLCHESTER COUNTIES - NOVA SCOTIA, 1981

Damage due to the spruce budworm and more recently extensive spruce bark beetle infestations in Nova Scotia continues to result in widespread tree mortality on Cape Breton Island and significant but relatively less mortality in north-western Nova Scotia.

Highlights of a ground survey of tree conditions conducted in August 1981, in 221 of softwood stands, are as follows:

BALSAM FIR

In the Cape Breton Highlands up to 78% of the balsam fir is dead or dying. In survey plots 54% of the trees were dead and 24% were beyond hope of survival. Although the remaining trees sustained little loss of needles produced in 1981, many suffer 70-90% total defoliation from past attacks of the spruce budworm and are expected to die as well.

In the Cape Breton Lowlands mortality has reached an average of 32% in Richmond County. Another 10% of the trees have lost more than 90% of their needles and are likely to die shortly. The least mortality in the Lowlands was in Cape Breton County where 21% of the trees are dead and an additional 11% are at the point of death. Budworm

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defoliation of 1981 foliage was generally greater in the Lowlands than in the Highlands as sufficient foliage remained in the Lowlands to sustain the infestation.

In Mainland Nova Scotia stand surveys in Cumberland and Colchester counties indicate rising mortality, now at about 13%. At least another 1.5% of the trees will die within the next year.

The many dead and dying trees made it difficult to map current defoliation during aerial surveys of Cape Breton Island. Trees which died in 1981 had a reddish cast from the few remaining needles, similar to that caused by current budworm feeding. Furthermore, many of the surviving trees had exposed twigs and branches and only a small portion of their normal complement of needles on which to judge defoliation.

In general, defoliation by the spruce budworm was reduced on Cape Breton Island in 1981 over that of the last few years. This is an expected consequence of the increase in tree mortality and is readily evident when mortality is compared with defoliation (Figures 1 and 2). Substantial defoliation generally occurred where at least half of the trees were still alive.

SPRUCE

Spruce mortality can be the result of either budworm defoliation or bark beetle attack, or a combination of the two.

The Lowlands of Cape Breton Island suffer the greatest, with a high of 34% of white spruce dead in Cape Breton County and a low of 15% dead in Inverness County. Red- and black-spruce, which are affected less than white spruce, sustained mortality varying from 13% in Inverness County to 4.5% in Cape Breton County. An additional 3% of all spruce can be expected to die within the year from defoliation alone.

Most spruce mortality in north-western Nova Scotia occurs in Cumberland County where 8% of the white spruce is dead.

The spruce bark beetle (*Dendroctonus rufipennis* (Kirby)) is most devasting in Cape Breton County where 74% of the spruce stands have one or more beetle infested trees. This insect now ranks close in importance with the spruce budworm and accounts for much of the spruce mortality seen in Figure 1. The beetle is a significant but less important pest in Cumberland and Colchester Counties where only 11% of spruce stands contain infested trees (c.f. Ostaff & Newell, 1981).

SAMPLING TECHNIQUES

Each stand was surveyed and trees selected by prism readings. Data for the figures were compiled based on the criteria that a minimum of 5 trees of a given species (balsam fir, red/black spruce, white spruce) be present for mortality estimates and a minimum of 4 live trees of that species for defoliation estimates. Thus, not all plot locations are represented for all species. An Information Report (in preparation) will give more detailed information including volume losses.

Data on the spruce bark beetle are from sample plots which contained a minimum of 10 spruce trees.

In previous surveys, mortality on Cape Breton Island has been measured from permanent sample plots. These are no longer typical of the forest, in the Highlands at least. Much of the surrounding forest has been salvaged, leaving the plots as islands in a barren landscape.

SUMMARY

The condition of the softwood forests in Nova Scotia continues to worsen. On Cape Breton Island the budworm epidemic flourishes where suitable foliage for food remains. In other parts of Nova Scotia budworm caused mortality is increasing and the infestation is spreading. Technical Note #38 (E.G. Kettela 1981), provides additional information on the extent of budworm infestation.

Spruce, and in particular white spruce is being killed by the spruce bark beetle in the Cape Breton Lowlands, adding to the budworm loss.

-B.A. Pendrel
Forest Insect and Disease Survey

October, 1981

References

Kettela, E.G. 1981. Spruce budworm infestations in Nova Scotia in 1981 and a forecast for 1982. Marit. For. Res. Cent. Technical Note No. 38.

Ostaff, D.P. and W.R. Newell, 1981. Spruce mortality in Nova Scotia caused by the spruce beetle Dendroctonus rufipennis Kby. Marit. For. Res. Cent. Information Report M-X-122.

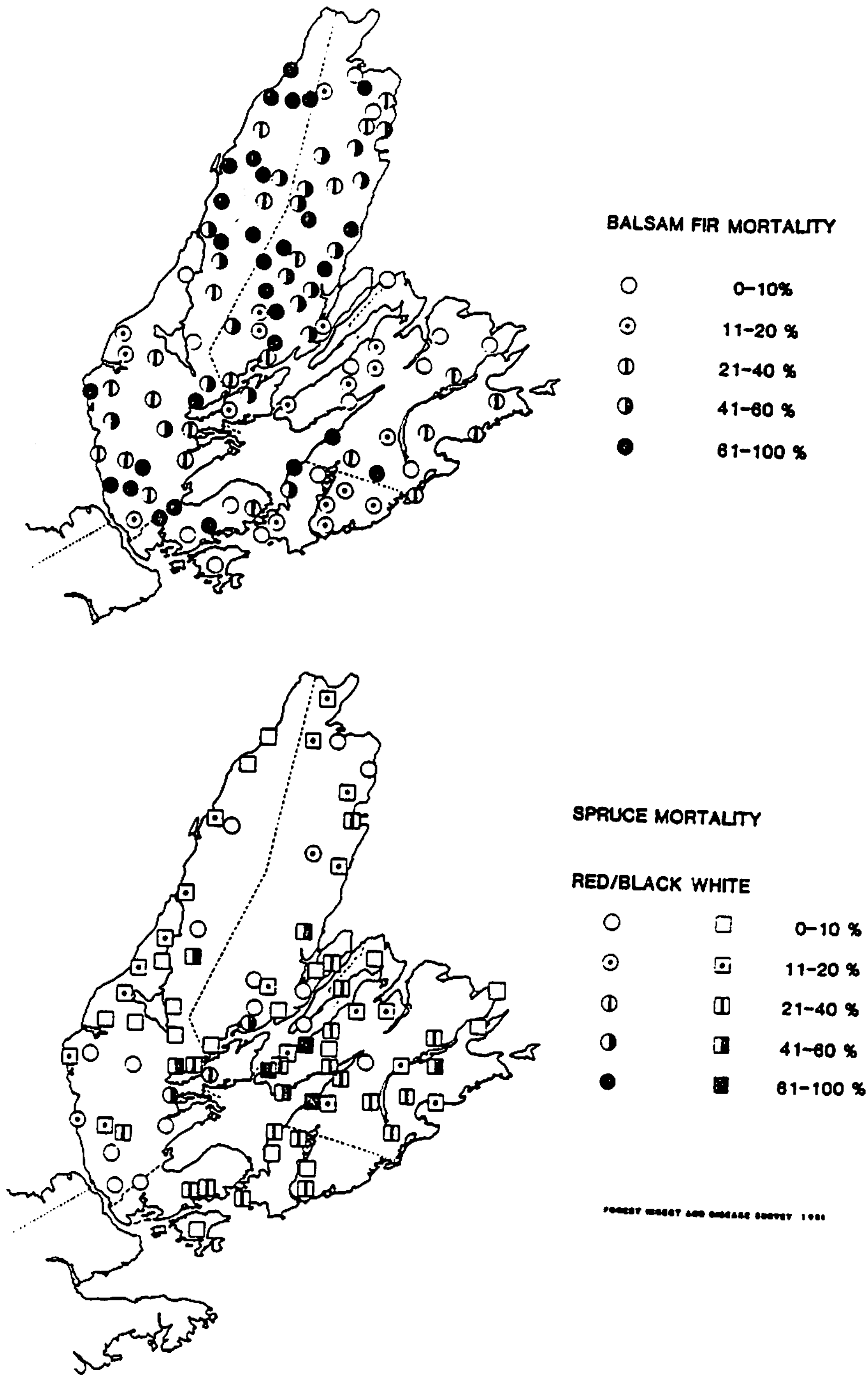

Figure 1. Mortality of fir and spruce on Cape Breton

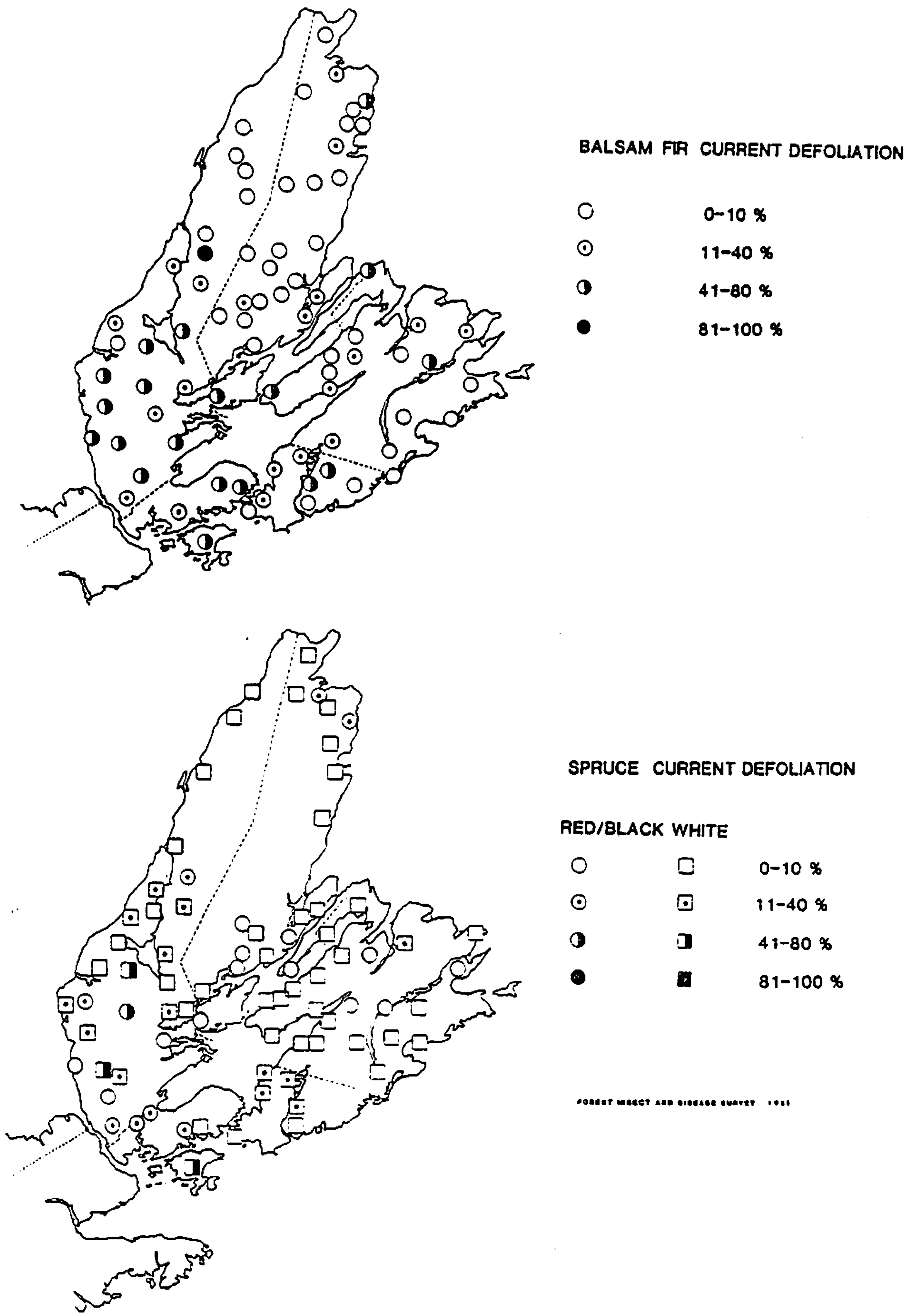

Figure 2. Current defoliation by the spruce budworm on Cape Breton Island, Nova Scotia, August 1981.

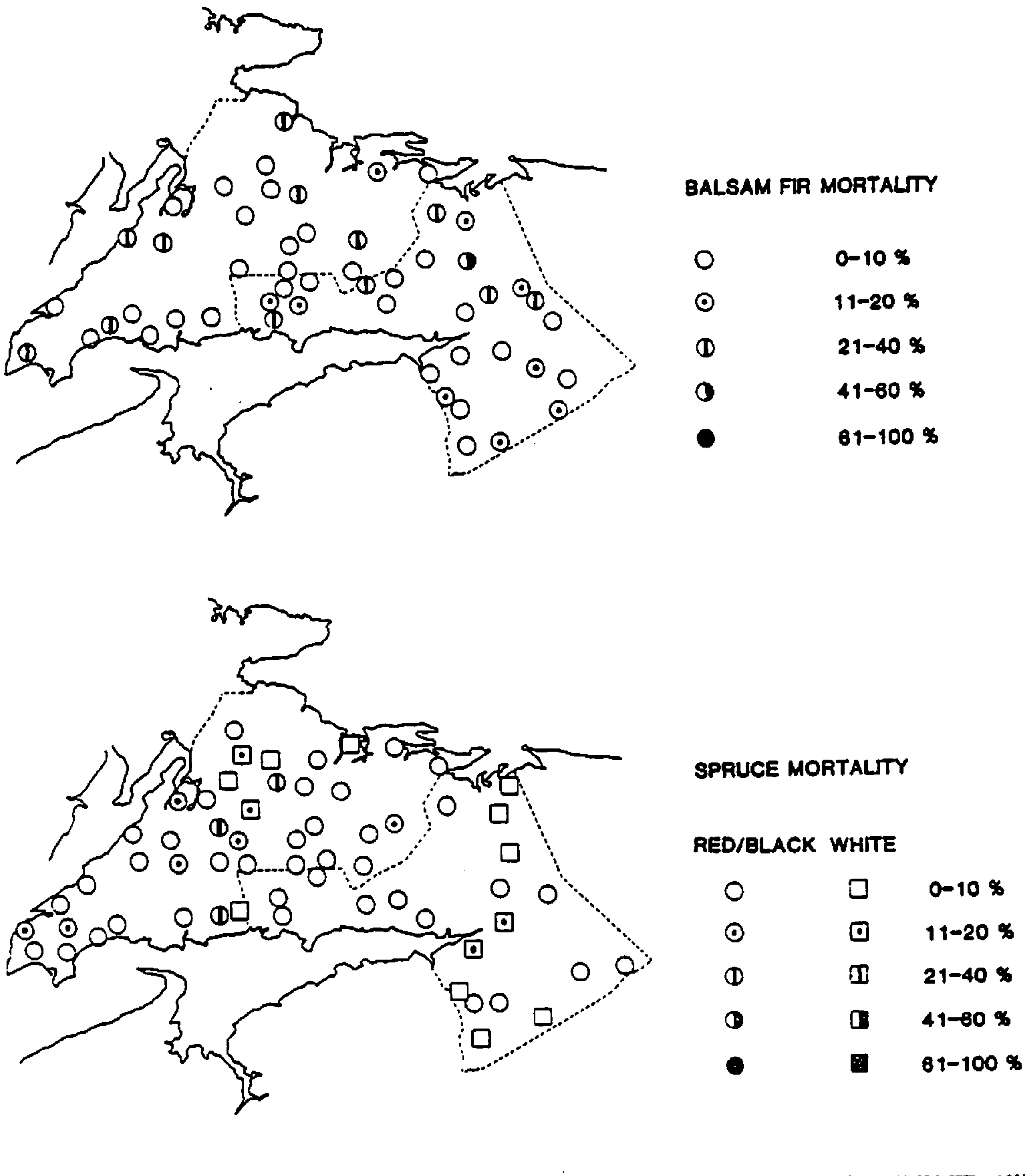

Figure 3. Mortality of fir and spruce in Cumberland and Colchester Counties, north-western Nova Scotia, August 1981.

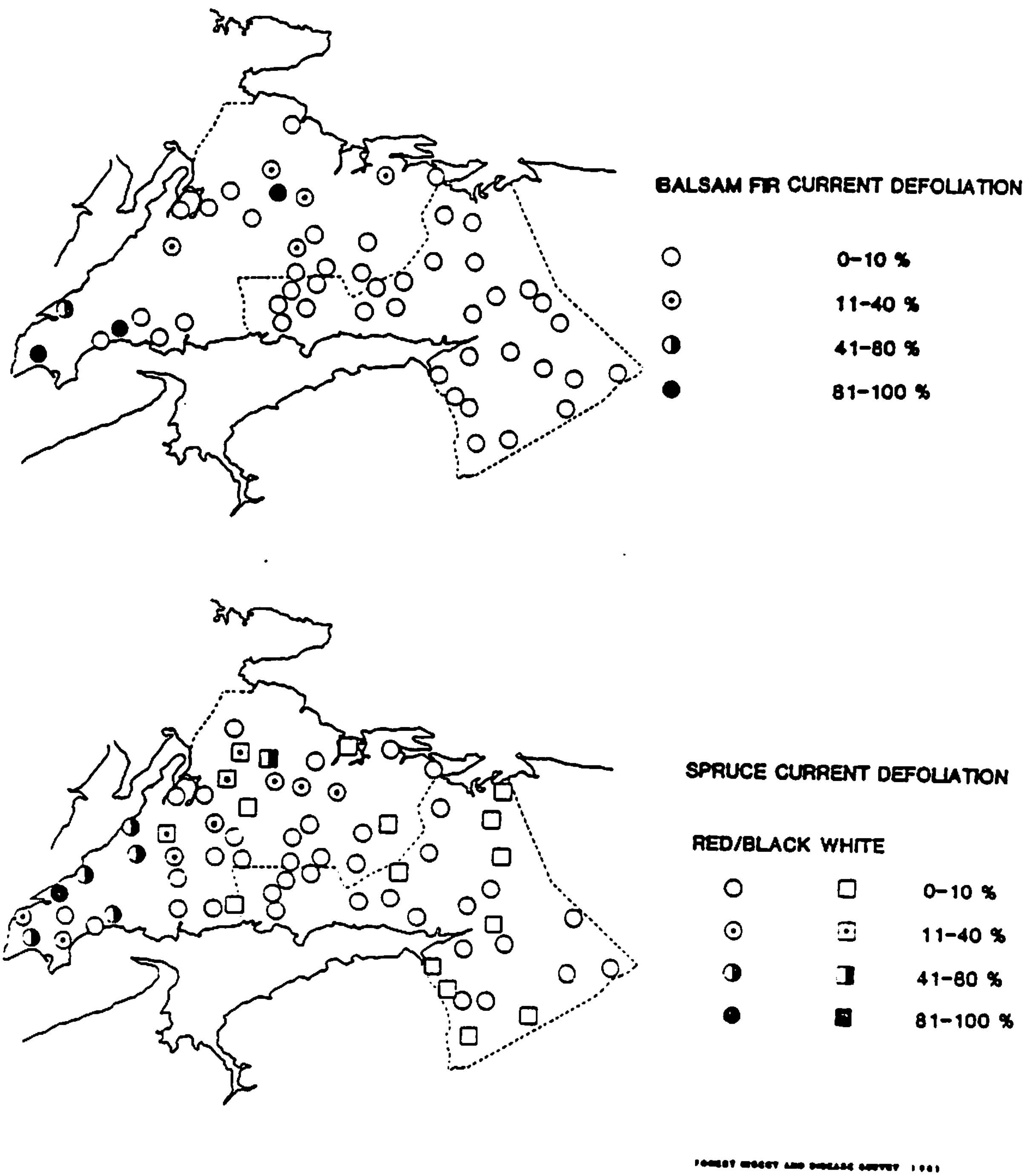

Figure 4. Current defoliation by the spruce budworm, Cumberland and Colchester Counties of north-western Nova Scotia, August 1981.

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FOREST PROTECTION LIMITED

RESEARCH AND DEVELOPMENT - 1981

A program of research and development was continued in 1981 aimed at stimulating work problems of immediate and long-term relevance to New Brunswick. Chief emphasis has recently been directed toward modelling spray emission behavior in the near- and far-field, developing predictive models of off-target contamination, and elucidation of the pathways of toxicity to the pest on various hosts and to "bystander" organisms. Each of these elements of research is an essential prerequisite to the development of improved application methods and emission technology as well as to more definitive studies of spray accountancy.

The importance of this R&D in the New Brunswick context has been pointed out by the New Brunswick Task Force on Long-Distance Drift of Forest Insecticides, the formal report of which is in final preparation. The report also points out the necessity that such background research and its eventual application be conducted in a fully-integrated, multi-disciplinary fashion. In response to this, the Company has encouraged and has so far underwritten the organization of the New Brunswick Spray Efficacy Research Group (SERG) as a mechanism through which the various R&D agencies interested in this general field can communicate in addressing the New Brunswick situation, and organize collaborative approaches. In addition to underwriting the expenses of the New Brunswick Research and Productivity Council in organizing SERG the Company has also engaged Research and Productivity Council as its consultant for scientific aspects of R&D contracts and other company subventions to this work.

H.J. Irving
Managing Director

November 30, 1981

Spray Efficacy against Spruce Budworm Larvae (I.W. Varty)

One requirement for advances in spray practice is a better understanding of the biological interface between spray emission and defoliation control. A field exercise in 1981 in New Brunswick was designed to describe the changing properties of the budworm microhabitat, to describe the differences between balsam fir and red spruce as spray targets and to test the drop-tray technique for measurement of off-target near-field drift per budworm mortality.

Buds and budworm develop earlier and faster on balsam fir than on red spruce: Thus each tree species has a different spectrum of targets (bud profile, instar distribution) on any one spray day, so the efficacy of a single spray may vary between tree hosts.

The temporal distribution of budworm fall-out following a spray leads to the hypothesis that dermal contact is the principal pathway to fenitrothion toxicity.

Relating tallies of dead budworm on drop-trays to surviving populations in the crown is difficult because of sampling problems in budworm population dynamics. Shoot attack rates suggest that a substantial part of the "spray window" is not utilized.

Off-target drift at 1/4 mile and 3/4 mile beyond the block was demonstrated by means of drop-tray tallies of fallen budworm. Discrimination between budworm populations on fir and spruce was shown. The data suggest that very small droplets may be most effective in locating the budworm micro-habitat.

The exercise underscores the need for better definition of the target and the efficaceous droplet diameter spectrum, and for a complete study of larval behavior and spray-day weather; it offers some promise of more efficient tactics.

Department of Fisheries and Oceans
(Scotia-Fundy and Gulf Region)
Activities, Studies and Research in the
Field of Aquatic Impacts of Forest Spraying
1981

Report to the Canadian Forest Pest Control Forum
December 1-3, 1981
Ottawa

C. J. Morry*
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* This paper contains exerpts from research reports and scientific assessments previously published elsewhere and produced by the following DFO staff: V. Zitko, D. McLeese, D. J. Wildish, M. F. Li, J. K. Elner (Fundy Isles Marine Enterprises, Ltd.). Further information may be obtained by consulting the list of references or by contacting individual researchers directly.

Introduction

1981 saw the completion of several lines of forest spraying impact-related research which had been undertaken by DFO. An overall normalization of forest spraying methodologies in recent years has reduced the need for advancement into many new areas of research. This has been taken by DFO to be a healthy sign and one which has permitted the deployment of resources into other more pressing problem areas. However,DFO scientists have continued to maintain an interest in innovations such as the aminocarb flowable formulation and new and improved methods of detecting hazards and impacts to aquatics. Some progress in the latter area is reported here.

Field Research

Since July 1979, Dr. Jan Elner of Fundy Isles Marine Enterprises, Ltd. has collaborated with Dr. David Wildish at St. Andrews on a series of aquatic microbial studies funded by CANUSA. This research was terminated in July 1981, having resulted in several publications. All of this work involved experimental spraying with the nonylphenol formulation of aminocarb.

A Solo back-pack sprayer was used to treat three of the four study ponds. As expected,and as probably also occurs following operational spraying,it was found impossible to achieve uniform theoretical aminocarb concentrations,consequently it was decided to carry out controlled experiments to determine some of the causative factors. The latter tests were designed to clarify the movement of formulated aminocarb through the surface microlayer in lentic systems.

Combining the results of the field and *in vitro* analyses, it appears that aminocarb moves through the water column achieving maxima at the surface instantaneously, at 0.2m within 22-64 hours, and at 0.4m after approximately 72 hours. In the *in vitro* experiment, residence times of aminocarb at the surface were brief, declining to undetectable levels in 29 hours. The transfer of aminocarb from upper to lower strata and the eventual diminishment of concentration were found to be dependent upon physical mechanisms such as wind.

In the field experiment, it was concluded that even at the maximum spray rate of 700 grams aminocarb ha^{-1}(equivalent to concentrations of up to 53 ppb in the pond) no discerable impact on microbial activity was evident. Carbon-14 assimilation experiments showed that aminocarb concentrations of 0.98 ppm were needed to cause a 50% reduction of carbon assimilation in natural pond algal communities. Concentrations of 1.5 ppm aminocarb were sufficient to cause total cessation of carbon uptake, yet, after exposure to 2.24 ppm, recovery of algal carbon-14 assimilation took place in 72 hours, probably as a result of the existence of insecticide-resistant algal cells.

Laboratory Studies

Last year at the Forum preliminary research results were presented on the work of Dr. M.F. Li in the field of cytological effects of Matacil. This work is now completed and the results were presented at the Thirty-second Annual Meeting of the Tissue Culture Association in Washington last June. In brief, Dr. Li's work demonstrated that at least part of Matacil's observed acute toxic effects are due to cellular destruction. The major toxicity observed in Matacil was due to the presence of nonylphenol. This work and related research indicating that Matacil may be a viral enhancer will not be pursued further unless it is likely that the nonylphenol formulation of aminocarb will once again be proposed for broadscale use.

Since the last Forum, Dr. McLeese and his colleagues at St. Andrews have published the results of their studies on the uptake and excretion of aminocarb, nonylphenol and diluent 585 by mussels. The method used in this research was a flow-through exposure system in which the test species could be subjected to known concentrations of the compounds in question for controlled periods. Low concentration factors combined with rapid excretion of all three compounds indicates that the accumulation coefficients of nonylphenol, aminocarb and 585 oil are all quite low in mussels and are unlikely to be of any significance to the test species under operational spray conditions.

New Developments

It was reported at the Forum last year that Dr. Zitko and others at St. Andrews were working on a format for hazard evaluation to be applied to pesticides based upon their physico-chemical properties and application rates. This protocol is available now as DFO Technical Report No. 985.

As well as being concerned with the comparison of hazards among pesticides the Department is also interested in detection of sub-lethal effects of environmental contaminants in order to understand fully the biological costs of various of man's activities. In this regard, Dr. Katsuji Haya has been assigned the task of developing a suite of chemical tests designed to detect abnormal reactions in the aquatic sphere. These techniques will be broadly applicable but should have specific relevance to the monitoring of forest spraying effects.

One particularly promising test which may be useful as a quick screen for sublethal effects of forest spraying is the determination of adenylate energy charge. So far the technique has proven very useful as a diagnostic tool in microorganisms and there is every reason to believe it will prove suitable in multi-cellular species as a sort of physiological condition factor to assess early reaction to abnormal stresses in the environment. It is hoped that it will be possible to report progress on the application of this biological effects technique at next year's Forum.

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McLeese, D. W., D. B. Sergeant, C. D. Metcalfe. V. Zitko, and L. E. Burridge. 1980. Uptake and excretion of Aminocarb , nonylphenol, and pesticide diluent 585 by mussels (*Mytilus edulis*). Bull. Environ. Contam. Toxicol. 24: 575-581.

Zitko, V., and D. W. McLeese, 1980. Evaluation of hazards of pesticides used in forest spraying to the aquatic environment. Can. Tech. Rep. Fish. Aquat. Sci. 985, iii + 21p.

PRELIMINARY REPORT OF THE ACUTE TOXICITY OF MATACIL 1.8 F ^{R}, ITS FORMULATIONS AND COMPONENTS TO AQUATIC FAUNA

Report to the 1981
Canadian Forest Pest Control Forum

December 1-3, 1981, Ottawa

Prepared by

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EPS, Atlantic Region, activity with regards to spruce budworm spray program consisted of a series of bioassay experiments as well as a small field project.

Bioassays

1. Aminocarb

The bioassay experiments were designed to test the toxicity of the new Chemagro flowable aminocarb formulation, and its components, to a number of aquatic species. The species tested included rainbow trout, the water flea *Daphnia pulex*, a marine bivalve, *Mytilus edulis* and a freshwater bivalve *Anadonta sp*.

Rainbow trout bioassays (Table 1) indicated that of all the 1.8 F formulation components tested (Sunspray 7N, 585 Diluent, Atlox and Technical Aminocarb) the technical aminocarb was the most toxic. In the case of the operational water formulation, which consisted of 25.7% 1.8 F concentrate 4.8% Atlox 3409 F and 69.5% water, the toxicity was due entirely to the aminocarb content. The operational oil formulation, on the other hand, which consisted of 26.7% 1.8 F concentrate and 73.3% 585 diluent oil was approximately twice as toxic as would be predicted on the basis of aminocarb content alone. The 1.8 F concentrate was also about ten times less toxic to rainbow trout than 1.8 D formulations which contained nonylphenol.

The 1.8 F formulations, both water based and oil based were also not particularly toxic to bivalve molluscs (Table 2). The most sensitive species was the freshwater species Anadonta which had a calculated 96 hr. LC50 of 15.6 mg/L of aminocarb.

Tests are also presently underway to determine if either of these filter feeding bivalves concentrate the particulate aminocarb to a greater extent than the soluble aminocarb. No results are available to date, however.

The 1.8 flowable formulation was, however, toxic to Daphnia pulex, having a calculated 48 hr. LC50 of 300 ppb aminocarb. There appeared to be little significant difference between the oil based and water based formulations in their toxicity to Daphnia.

In conclusion, the Matacil 1.8 F formulation would appear to be much less toxic to aquatic organisms than the 1.8 D formulations which contained nonylphenol. On this basis the registration of the formulation as a replacement for the 1.8 D formulation should be encouraged, and would be supported by EPS Atlantic Region.

2. Bt

The EPS microbiology laboratory also completed an experimental study on the effect of chlorination on Bt. and its longevity in marine and fresh waters. Preliminary examination of the data indicates that chlorination applied at the conventional water treatment plant rate of 0.5 ppm Cl_2 for 30 minutes does not completely inhibit Bt survivability.

The Bt persistence study also indicated that Bt are able to survive in both marine and fresh waters for at least 100 days at $20^{o}C$.

3. Field Project

A field project was also undertaken in an attempt to determine if operational applications of fenitrothion mixed with Cyclosol 63 had a greater impact on aquatic invertebrate benthic populations than the conventional fenitrothion formulations used in the past. The primary stimulus for initiating this program was the observation in bioassay experiments that there was a synergistic effect between technical fenitrothion and the Cyclosol 63 oil to some aquatic invertebrates. Results have been examined only preliminarily, however, there appear to be very severe increases in the drift of Diptera (*Simulidae* Sp.), Ephemeroptera (*Baetidae* Sp.), Trichoptera (*Brachycentridae* Sp.) and Plecoptera (Taeniopterycidae). It cannot be determined at this point, however, if the impacts on aquatic drift with the Fenitrothion/Cyclosol mixture are greater than those associated with previously used fenitrothion formulations.

TABLE 1 MATACIL 1.8 FLOWABLE FORMULATION TOXICITY TO *SALMO GAIRDNERI* (96 hr. LC50[a])

FORMULATION	LC50 (mg/L)	CONFIDENCE INTERVAL (P = .05)
1.8 F Oil[b]	226	150 - 302
1.8 F Oil	360	Range 180 - 560
1.8 F Water[c]	638	N/A
1.8 F Water	718	N/A
585 Diluent	519	166 - 872
Atlox 3409 F	748	56 - 100
Atlox 3409 F	748	56 - 100
Atlox 3409 F	53	Range 32 - 100
Matacil 1.8 F Concentrate	175	Range 100 - 320
Matacil 1.8 F Concentrate	122	77 - 167
Sunspray 7 N Oil	>10,000	N/A
Sunspray 7 N Oil	>5,600	N/A
Technical Aminocarb[e]	24-32.6	N/A
Technical Aminocarb[f]	32	N/A

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a 96 hr. static LC50's calculated on nominal concentrations and reported with calculated confidence intervals or range of 0-100% mortality.

b 1.8 F oil formulation = 26.7% Matacil, 1.8 F concentrate and 73.3% Shell 585 diluent.

c 1.8 F water formulation = 25.7 Matacil, 1.8 F concentrate, 4.8% Atlox 3409 F and 69.5% water.

e Values reported are those of Woodward, D.F. and W. L. Mauck, 1980. Bull.Environ. Contam. Toxicol. 25: 846-853.

f Values reported are those from unpublished data obtained in EPS, Atlantic Region Laboratory, 1979.

TABLE 2 MATACIL 1.8 FLOWABLE TOXICITY TO AQUATIC INVERTEBRATES

FORMULATION	ORGANISM	EXPOSURE DURATION	LC50 (mg/L)	CONFIDENCE INTERVAL (95%)
1.8 F Oil (Blended)*	*Anadonta* Sp.	96*	260	N/A
1.8 F Oil	" "	96	1,800	N/A
1.8 F Water	" "	96	260	141 - 478
1.8 F Water	*Mytilus edulis*	96	1,000	N/A
1.8 F Oil (Blended)	" "	96	1,000	N/A
1.8 F Oil	" "	96	1,079	204 - 1953
1.8 F Oil (Blended)	*Daphnia pulex*	48	0.38	Range 0.1 - 1.0
1.8 F Water	" "	48	1.1	Range 0.32- 3.2

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* "Blended" tests were run by homogenizing stock toxicant in a blender prior to introduction to exposure chambers.

Summaries of forest-spray related studies undertaken by Canadian Wildlife Service-Atlantic Region in 1981

D.G. Busby, P.A. Pearce.

Brain cholinesterase response in songbirds exposed to experimental aminocarb spraying in New Brunswick.

Food habits of nestling White-throated Sparrows.

Food habits of nestling White-throated Sparrows

In previous studies we have found that sub-lethal effects of fenitrothion spraying can produce perturbations in the reproductive activities of the White-throated Sparrow, a potentially useful spray indicator species. Those effects include desultory incubation, nest abandonment, singing irregularities and reduced nestling growth rates and fledging weights. Follow-up experimental dosing confirmed that small quantities (7 to 39 mg/kg)of fenitrothion could cause growth abnormalities in White-throated Sparrow nestlings. A study of fenitrothion in natural food resources of forest passerines revealed residues up to 17 mg/kg. The present study reports the food items eaten by White-throated Sparrow nestlings to set in context the findings of the above studies so that dietary exposure to fenitrothion under normal operational spray conditions can be assessed.

The study was conducted at the Acadia Forest Experiment Station during the 1981 field season. Nests were located, observed daily to determine when eggs hatched, and nestlings collected after being fed by an adult. The alimentary tract was removed and stored in formalin until dissection to determine contents. The quantity of food brought per adult feeding trip was estimated by weighing nestlings before and after the feeding. Lepidoptera larvae were the most frequently observed food eaten by nestlings, occurring in up to 50% of the samples. Of secondary importance were Diptera, Coleoptera and Hymenoptera. Nine orders of insects, Araneida (spiders) and Acari (mites) were observed in the samples. One-day-old nestlings were estimated to eat 176% of their body weight per day. Comparable figures for four-day- and seven-day-old nestlings were 72% and 77%, respectively. Our assumption that nestlings eat approximately their own weight daily thus appears to be valid.

A summary of our findings is as follows: (1) single experimental doses of as little as 7 mg/kg fenitrothion cause growth abnormalities in White-throated Sparrow nestlings, (2) the food resource of nestlings contains up to 17 mg/kg fenitrothion after operational spraying, and (3) nestlings eat approximately their own weight in food daily. Therefore, if nestlings eat their own weight in contaminated food, the daily exposure would be sufficient to produce the growth abnormalities observed in the experimental dosing study. We therefore conclude that the nestling growth reduction observed after operational fenitrothion spraying was a direct result of exposure to the pesticide. Although the implications of the slow growth rates and lower fledging weights are unknown, studies elsewhere indicate that fledging survival is reduced, especially at times of poor food supply or inclement weather conditions.

Brain cholinesterase response in songbirds exposed to experimental aminocarb spraying in New Brunswick

Continued spruce budworm (Choristoneura fumiferana) infestation of the fir-spruce forest of eastern Canada has been marked by a constant search for control strategies that are effective, environmentally acceptable, and that pose no threat to human health. Testing of the efficacy and safety of new chemicals, old chemicals in new formulations, and of development in spraying technology have been important elements in New Brunswick's approach to management of the budworm problem.

Determination of songbird responses to experimental spraying provides a preliminary indication of the hazard of a particular spray regime prior to adaption in full-scale operational spraying. In line with CWS intent to assess the hazard to migratory birds of forest spraying practices, the present study was carried out in the context of a series of spray trials of a new formulation of aminocarb known as Matacil^R 180 Flowable, conducted by FPMI primarily to determine efficacy against spruce budworm. The trials were of particular interest to us as there is little published information on the effects of aminocarb on brain cholinesterase (ChE) in forest songbirds and the logistical problems normally encountered in monitoring bird responses under operational spraying conditions were minimized by the relatively small scale of the probject.

Bird exposure to spraying was assessed by determination of brain ChE activity in five species of warblers: Blackburnian Warbler, an upper canopy dweller; Tennessee and Bay-breasted Warbler, mid-to-upper canopy dwellers; Yellow-rumped Warbler, a wide-ranging species; and American Redstart, a lower canopy dweller. ChE activities of birds collected in sprayed forest were compared with ChE activities of birds from unsprayed forest, a statistically significant decrease being considered as a detrimental impact. The study plots were located in fir-spruce forest about 25 km west of Bathurst, N.B. Each was 50 ha in area and was sprayed by a Cessna 188 Ag-Truck fitted with four Micronair AU3000 rotary atomizers. The plots were sprayed at a stated emission dosage of 70 g/ha of active ingredient. By volume, the formulation consisted of 25.93% Matacil^R 180F, 1.27% Atlox^R, 72.27% water and 0.53% Rhodamine Red dye. The emulsion was emitted at a rate of 1.5 L/ha and estimated VMD was 36 and 33 μm for the first and second spray, respectively (K.M.S. Sundaram, pers. comm.). Birds were collected with a .410 shotgun 2-48 hours after spraying. Brains were stored in liquid nitrogen until assayed, a maximum of 12 days later. ChE assays were performed in our laboratory in Fredericton using the colorimetric technique of Ellman et al. (1961).

None of the species sampled showed depression of ChE after spraying. There was no significant difference (t-test) between ChE activity in birds exposed to a morning spray and in those exposed to an evening spray application, nor in birds collected within the first 24 h post-spray and in those collected 24-48 h post-spray. Only four birds from spray plots exhibited ChE activity of more than 20% below the mean control value. They were a Tennessee Warbler, a Bay-breasted Warbler and two American Redstarts, in which ChE depression was 26.6, 26.2, 35.2 and 37.5%, respectively. No birds had ChE activity greater than 50% below that of the mean control value. This is in contrast to the results of a similar study (Busby et al. 1981) of the impact of the organophosphate insecticide fenitrothion on forest songbird brain ChE activity. Measurement of ChE activity has recently been widely adopted as a useful tool in determining exposure of birds to organophosphate and carbamate insecticides. The suggestion that 20% brain ChE inhibition is indicative of exposure and that 50% inhibition is sufficient for diagnosis of death has gained general acceptance. Under some circumstances, however, ChE inhibition can exceed 50% without mortality occurring. It is unlikely that any of the birds we collected were in danger of death through poisoning. There was no evidence of aberrant bird behavior that could be attributed to the spray. Only the four birds with more than 20% inhibition suggest exposure to the insecticide and potential minor sub-lethal effects.

We conclude that aerial spraying of Matacil® 180F at 2 x 70 g/ha over small plots had no significant inhibitory effect on brain ChE in songbirds exposed in the canopy and elsewhere in the forest. Further examination for potential hazard to birds of Matacil® 180F in other formulations and in the context of larger spray plots would be prudent before translation to full-scale operational use.

An article has been submitted for publication in the Bulletin of Environmental Contamination and Toxicology.

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Experimental aerial dispersions of an ultra-concentrated 3a3b *Bacillus thuringiensis* formulation (Futura) in the Province of Quebec, in 1981.

Report to the Canadian Forest Insect Pest Control Forum

Ottawa, December 1 - 3, 1981

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In 1978 and 1979, an ultra-concentrated 3a3b Bacillus thuringiensis formulation, Futura, was developed. The formulation disperses 20 x 10^9 International units per hectare (8 B.I.U./acre) which is required for the control of spruce budworm in a final volume of 2.5 L/ha (35 oz/acre). Calibration tests were carried out with Futura in 1979 and it was dispersed over territories, moderately infested by spruce budworm, in 1980 by means of an AgCat aircraft. The results were satisfying and they suggested this ultra-concentrated B. thuringiensis formulation should be tested on an operational level over highly spruce budworm infested territories to determine its efficiency and its economic feasibility for the control of this insect in forest.

In 1981 three series of field tests were carried out. The first consisted of treating 7 x 40 ha plots with Futura at 2.5 L/ha (20 B.I.U./ha) using a Grumman AgCat aircraft. In the second test 895 ha were treated with Futura at 2.35 L/ha (18.8 x 10^9 I.U./ha) by means of a Constellation L-749 aircraft.

Futura formulation for 1 ha is:

B. thuringiensis powder (80 000 I.U./mg)	250 g
Sorbitol solution (3 parts of sorbo + 7 parts water)	2.5 L
Chitinase (in nephelometric units)	10 000 N.U.
Chevron sticker	1.56 mL

The third test, carried out simultaneously as a companion, involved treatments using 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 aircraft. Population levels and conditions of the stands in treated and untreated territories were as follows:

Untreated: Pretreatment population levels; 21.1 larvae/45 cm, (ranging from 13.6 to 35.2 larvae/45 cm), foliage potential in the spring: 71.2%, ranging from 54.4 to 83.3%.

Treated with 32B/sorbo/water/chitinase/Chevron by means of AgCat: Pretreatment population levels; 17.9 larvae/45 cm (ranging from 13.6 to 22.2 larvae/45 cm), foliage potential in the spring 53% (ranging from 42.2 to 68.8%).

Treated with Futura by means of AgCat: Pretreatment population levels: 28.9 larvae/45 cm (ranging from 17.2 to 37.9 larvae/45 cm); foliage potential in the spring 57.5% (ranging from 44.2 to 79%).

Treated with Futura by means of a Constellation: Pretreatment population levels; 27.9 larvae/45 cm (ranging from 9.0 to 46.2 larvae/45 cm); foliage potential in the spring: 67.1% (ranging from 35.5 to 82.2%).

Deposit: Deposit at ground level was evaluated by determining the number of viable spores deposited/cm^2. Results were as follows:

32B/sorbo/water (AgCat): 355 000 ± 45 000 viable spores/cm^2

Futura (AgCat): 340 000 ± 39 000 viable spores/cm^2

Futura (Constellation): L-749: 295 000 ± 55 000 viable spores/cm^2

Larval mortality: Tables 1, 2 and 3 describe larval mortality. Table 2 reports results of dispersion by means of a Constellation L-749 aircraft. It shows that the efficiency of Futura is similar to that of the 32B/sorbo/water formulation since larval mortality 15 days after treatment reached more than 70% in both cases (Table 1). At pupation, population decrease varied from 85 to 99% (Table 3). Dispersion of Futura by means of Constellation, was inadequate over the first 3 lines due to uncontrolable mechanical problems. Larval mortality, excluding the 3 missed lines, reached 75.0 to 96.9% for a pretreatment population ranging from 9.0 to 46.2 larvae/45 cm (table 1).

Defoliation: Foliage protection as a result of treatment appears in tables 1, 2 and 3. Untreated plots were rapidly defoliated (Table 1). Futura protected as much foliage as the 32B/sorbo/water formulation, i.e. 73% (Table 1). Depending on pretreatment population, Futura dispersed by either a AgCat or a Constellation, protected 40 to 90% of current year foliage (Tables 2 and 3). Finally, foliage potential (next year buds formed in the fall) increased in all treated plots and decreased in untreated. Results were:

Treated with Futura	+ 23.5%
Treated with 32B/sorbo/water	+ 32.0%
Untreated	- 30.0%

In terms of current year foliage mass this means that each 100 cm branch form treated plots (Futura/AgCat) had, at the end of the season, 16.7 g of foliage, while in untreated plots there was only 5.9 g of foliage. In the block treated with Futura by a Constellation aircraft, the current year foliage mass averaged 15.1 g of foliage/100 cm branch. In untreated plots there was only 0.66 g of foliage/100 cm branch.

Conclusively the ultra-concentrated *B. thuringiensis* formulation dispersing 20 x 10^9 I.U. in a final volume of 2.5 L/ha, using either a small or large aircraft is efficient to control spruce budworm and assure an acceptable foliage protection. This is an important step forward since the final volume (2.5 L/ha) is even less than the volume used for 2 dispersions of chemical insecticide which are dispersed in 2 applications of 1.403 L/ha for a total of 2.806 L/ha. In this respect, the Futura formulation answers the main objection to using *B. thuringiensis*, i.e. the large volume to be dispersed which influences cost of application.

Operational aerial dispersions of Futura should be carried out to determine whether this formulation is able to help improve pre-death stands and assure an economical way of controlling spruce budworm.

TABLE 1

Spruce budworm larval mortality and foliage protection after dispersion of Futura by means of a Grumman AgCat

Formulation	Dosage ...X 10^9 I.U./ha	Final volume L/ha	Pretreatment larvae/45cm	Larval mortality 15 days after treatment %	Foliage Protection %
Untreated	-	-	21.1	5.0	0
32B/sorbo/water	20.0	4.7	17.9	70.3	73.0
Futura	20.0	2.5	28.9	72.0	72.1

TABLE 2

Results of dispersing Futura by means of a Constellation L-747 aircraft;

Dosage, 18.8 I.U./ha in a final volume of 2.34 L/ha; Deposit at ground level 295 000 viable spores/cm^2

Plot No.	Pretreatment populations larvae/45 cm	Larval mortality %	Defoliation %
1	24.6	31.7	87.1
2	30.2	77.5	83.0
3	36.2	61.3	67.4
4	46.2	91.3	63.7
5	43.8	95.4	70.5
6	20.8	91.3	65.5
7	19.2	96.9	20.2
8	17.6	92.0	19.6
9	9.0	75.0	44.5
Average	27.5	80.0	57.9
Untreated	29.5	30.5	98.7

TABLE 3

Efficiency of Futura for the control of *Choristoneura fumiferana*

Pretreatment populations larvae/45 cm	Larval mortality %	Foliage Protection %
Dispersion by AgCat: 20 x 10^9 I.U./ha Final volume: 2.5 L/ha		
10 to 15	99	90
15 to 20	95	70 to 80
25 to 35	92	50
Dispersion by Constellation L-749: 18.8 x 10^9 I.U./ha Final volume: 2.34 L/ha		
10 to 20	92	60 to 75
25 to 35	85	40 to 50

Determination of the current year shoot mass of balsam fir *Abies balsamea* (L.) Mill.) to evaluate damage by spruce budworm and treatment efficiency.

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Report to the Canadian Forest Insect Pest Control Forum

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Control measures in spruce budworm infested stands are applied mostly to insure enough foliage protection to keep trees alive. The methods of Fettes (1950) and Dorais and Hardy (1976) are presently used to measure defoliation. In conjuction with these methods, a sequential estimation of egg masses was proposed by Morris (1954) to predict spruce budworm damage the following year so that decisions could be made on the need for control measures. Up to now defoliation measurements quantify defoliation for a given year; a cumulative estimate is also possible. Nevertheless, to provide additional information of the degree of defoliation, tree response, critical point of damage beyond which spruce budworm larval populations are affected by starvation and to evaluate side effects of spruce budworm defoliation, evaluation of the current year shoots is proposed.

Current year defoliation was determined by classifying 20 shoots on full length branches, collected in the upper mid-crown section of trees at the end of the growing season, by referring to defoliation illustrations scaled from 0 to 12 (0 to 100% defoliation) (Fettes 1950) (Table 1, first column).

Samples and measurements were taken from August 15 when spruce budworm feeding had ceased, growth of current year shoots was terminated and buds for the coming year were formed. Fresh shoots were weighed, usually the day following collection. The total number and weight of shoots were determined with regards to defoliation levels obtained in treated and untreated areas. Figures were tallied for 100 cm branches.

Results showed that in treated plots number of shoots ranged from

43.7 to 138.5. The corresponding values for the weight of shoots were between 3.1 and 18.6. In untreated plots, number of shoots averaged 10.8 andweight of shoots was only 1.4 g. The precision of the method is evident in plot 05 and 08 which suffered from a sudden rainstorm immediately after treatment therefore, the freshly deposited B. thuringiensis was washed off the foliage. Consequently, defoliation was high, 85.1 and 98.9% for plot 05 and 08 respectively, and the weight of current year shoots remaining on 100 cm branch was low, 4.6 and 3.1 g for plots 05 and 08 respectively. Plots 06,07 and 09 where the B. thuringiensis remained on the foliage showed 17.2, 17.1 and 18.6 g of foliage protected per 100 cm branch. By comparing weight of shoots in treated and untreated plots it can be seen that the quantity of foliage protected in treated was up to 13 times the quantity of foliage remaining in untreated plots.

For instance, knowing that as a result of a B. thuringiensis treatment in 1981, 18.6 g of foliage was protected and remained on each branch, while in untreated areas only 1.4 g of foliage remained on the branch, is more important than knowing defoliation express in percentages. There is 13 times more foliage in treated plots than in untreated areas. With the method currently used, figures would be 38.9% defoliation in the treated area and 96.4% defoliation in untreated; 2.4 more times foliage in treated plots. Thus, data on current year shoot mass are essential for the quantitative evaluation of stand conditions and to determine, whether or not a stand is recovering after treatment.

To demonstrate the possibilities of current year growth mass evaluation, let us look at data obtained in plots established in 1976 and 1977.

(Smirnoff, 1979 and 1980) when established, these plots supported various stand degradation. Within each 40 ha treated and untreated plot, a 0.04 ha survey plot was set up. Survey plots provided data on stem/ha, d.b.h., number of branches/tree and percentage of tree mortality (Table 2). Over the last 6 years, current year growth mass and defoliation were determined for each plot, some of which were subjected to 1,2 or 3 year treatment sequences with _B. thuringiensis_. The results obtained with plots D and G are given as examples in table 3.

More precisely, data presented in table 3 reveales that over a 5 or 6 year period the total amount of current year foliage protected by _B. thuringiensis_ treatments was important and can be quantified with an acceptable precision. Analysis of table 3 reveals that after the first treatment period, in 1978, there were 14 416 and 12 964 kg/ha more foliage in plots D and G respectively. At the end of 1981, even if the spruce budworm was increasing after a certain breakdown in 1979 and 1980, there was still 24 657 and 11 514 kg/ha more foliage in treated compared to corresponding untreated plots. These data are easily obtained by a multiplying information collected each year, such as that reported in table 1 for 1981, and figures obtained in permanent survey plots (table 2). Plot G, in 1979, is given as an example: Weight of current year shoot per branch obtained at the end of the feeding season[1] (25.2g) X number of branch per tree (121.6) (Table 2) X number of stem/ha (1725) (Table 2) ÷ 1 000 = 5 285 kg/ha (Table 3).

Current year shoot figures indicate a permanent deletrious effect

[1]The weight of current year shoots is obtained by weighing all the current year shoots on all the full-length branches used to assess defoliation and egg masses.

of spruce budworm outbreak in untreated plots. This is confirmed by figures of tree mortality which were 10.2 and 3.2% in plots D and G respectively. Corresponding values in untreated plots were 38.6 and 40.5% (Table 2).

Data reported indicate that when balsam fir is exposed to spruce budworm attacks, the current year shoot mass is a valuable and different way to assess damage. The use of this method for determining treatment efficiency on balsam fir stands subjected to severe attack by spruce budworm can provide additionnal information which in turn might be valuable tools to determine such factors as; point tolerance before tree mortality, impact on tree physiology and photosynthesis etc...

Data obtained on current year growth mass raise sufficient questions to justify more research in this field to improve our evaluation of spruce budworm defoliation and to provide more background for decisions on application of control measures.

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TABLE 1

Results of the 1981 aerial experimental treatment with Bacillus thuringiensis against spruce budworm expressed by the current year shoot mass method

Plot No.	Treatment	Current year growth defoliation %	Length of branches cm	Width of branches cm	Number of shoots[1]	Weight[1] g	Weight; treated/ untreated
81-05	Futura 1	85.1 ± 7.7	108.7 ± 11.8	56.7 ± 4.4	39.2 ± 25.1	4.6 ± 3.2	3.2
81-06	Thuricide 32B/sorbo/eau	67.0 ± 16.8	98.4 ± 7.3	54.2 ± 5.7	138.5 ± 40.6	17.3 ± 5.6	12.4
81-07	Futura 1	58.8 ± 21.2	100.2 ± 13.4	54.8 ± 10.3	82.9 ± 56.6	17.2 ± 3.9	12.3
81-08	Futura 1	98.9 ± 0.6	109.1 ± 13.3	54.2 ± 7.8	43.7 ± 34.6	3.1 ± 2.3	2.2
81-09	Futura 1	38.9 ± 16.3	111.5 ± 15.7	52.0 ± 8.2	80.4 ± 36.2	18.6 ± 9.4	13.3
Untreated	-	96.[illegible] ± 0.9	111.2 ± 19.7	53.7 ± 7.1	10.8 ± 2.7	1.4 ± 0.8	-

[1] FIGURES TAILLED FOR A 100 CM LENGH BRANCH

TABLE 2

Data given by the 0.04 permanent survey plots established in Bacillus thuringiensis - treated and untreated experimental blocks

PLOT No.	Number of balsam fir stems/ha	D B H cm	Number of branches/tree	Dead balsam firs[1] %
		Lake La Mothe		
A	1 300	17.5 ± 6.6	145.2 ± 23.3	16.1
B	2 675	11.6 ± 5.1	158.0 ± 37.5	10.4
C	4 350	10.7 ± 3.8	135.3 ± 31.4	16.1
D	2 000	15.5 ± 5.3	139.5 ± 26.0	10.2
H	2 475	18.6 ± 1.9	148.3 ± 1.3	8.7
J	1 400	13.5 ± 7.4	165.5 ± 14.6	20.6
Untreated	1 475	10.0 ± 5.3	180.0 ± 45.2	44.0
Untreated	1 600	16.8 ± 6.6	116.0 ± 2.8	42.8
Untreated	1 625	18.3 ± 5.3	137.8 ± 7.4	28.9
		Bras du Nord		
E	1 200	15.9 ± 3.8	139.5 ± 36.1	9.8
F	1 600	14.4 ± 3.6	130.6 ± 18.6	14.4
Untreated	2 175	11.7 ± 2.8	157.0 ± 28.2	46.0
		Ferland		
G	1 725	10.7 ± 3.5	121.6 ± 26.9	3.2
Untreated	1 800	10.4 ± 4.3	148.0 ± 4.3	40.5

[1] Figures were for the year 1980

TABLE 3

Results given by application of the current year shoot mass method in Bacillus thuringiensis - treated and untreated plots over a 6 year period

Plot No.	Historic of spruce budworm defoliation	Foliage potential	Data reported	Years of experiment 1976	1977	1978	1979	1980	1981	Total amount of foliage on trees	Treated / Untreated
G	3 years severe 1 year moderate	4.5	Defoliation %	28.0[T]	46.5[T]	15.2[T]	19.3	41.0	75.6		
			Foliage protected (kg/ha)	4739	3521	5581	5285	3272	1866	24267	+ 11514
Untreated		4.8	Defoliation %	96.0	97.0	96.0	69.6	38.0	73.8		
			Foliage protected (kg/ha)	355	266	355	1998	7725	2051	12752	
D	2 years severe + one year moderate	37.7	Defoliation %	-	77.9[T]	7.4[T]	13.7	43.0	90.3		
			Foliage protected (kg/ha)	-	3264	13677	19697	6168	1035	43842	+ 24657
Untreated		54.9	Defoliation %	-	0	81.8	55.0	34.8	95.7		
			Foliage protected (kg/ha)	-	0	2524	10609	5648	403	19185	

T; Treated with Bacillus thuringiensis that year.

SPRUCE BUDWORM IN ONTARIO, 1981[1]

- Outbreak Status 1981
- Forecasts 1982
- Results of Spraying Operations
- Plans for 1982

by

G.M. Howse[2], J.H. Meating[2] and J.R. Carrow[3]

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OUTBREAK STATUS 1981

The gross area of forest infested by the spruce budworm in Ontario declined in 1981 (Fig. 1). A total of some 18 216 679 ha was infested this year in comparison with 18 850 294 ha in 1980. Aerial and ground surveys conducted by the CFS showed that infestations have declined in the three main geographical areas of the province where budworm outbreaks are present (Table 1).

Warmer than normal weather occurred in late February and March; however, unseasonably cool weather in April and early May delayed budworm emergence and slowed development considerably.

In general, larval populations were much lower in 1981 than in previous years. This was not unexpected since the 1980 egg-mass survey had forecast reduced populations in the order of 40-50%. However, in many instances in northeastern and southern Ontario, populations were much lower than expected and the resultant defoliation was quite variable and difficult to map. Aerial surveys, with flying time provided by the Ontario Ministry of Natural Resources (OMNR), are carried out from early to mid-July when the color of budworm-damaged foliage is at its peak. Data presented in this report are preliminary estimates and are subject to revision.

In Ontario, the spruce budworm feeds on balsam fir, white spruce, and black spruce growing on upland sites in mixed stands. The following data on area infested represent gross estimates of the area within which stands containing these host species suffered moderate-to-severe current defoliation.

In northwestern Ontario, the total area suffering moderate-to-severe defoliation decreased by some 66 765 ha. The bulk of this decrease occurred around the outer edges of the infestation between Kawnipi Lake in the Atikokan District and Lower Shebandowan Lake in the Thunder Bay District. Moderate-to-severe defoliation declined in this area by approximately 41 500 ha. A similar decline occurred in the infestation located mainly in the Fort Frances District between Bennett Township and Lower Manitou Lake. Here, a number of boundary changes are evident, with a net decrease of 10 000 ha. The smaller infestations near Wolseley Lake in the Atikokan District and in the Arrow Lake-Sandstone Lake area of the Thunder Bay District also declined appreciably in size. The infestation which was discovered in the Poshkokagan Lake area of Thunder Bay District in 1980 decreased by about 2 400 ha. This infestation extends to the northwest to the vicinity of Cheeseman and Geikie lakes and southeast into the Nipigon District between Disraeli and Leckie lakes. A small infestation found in 1980 at Umfreville Lake, Kenora District, increased in size as defoliation was mapped on the south side of the lake for the first time.

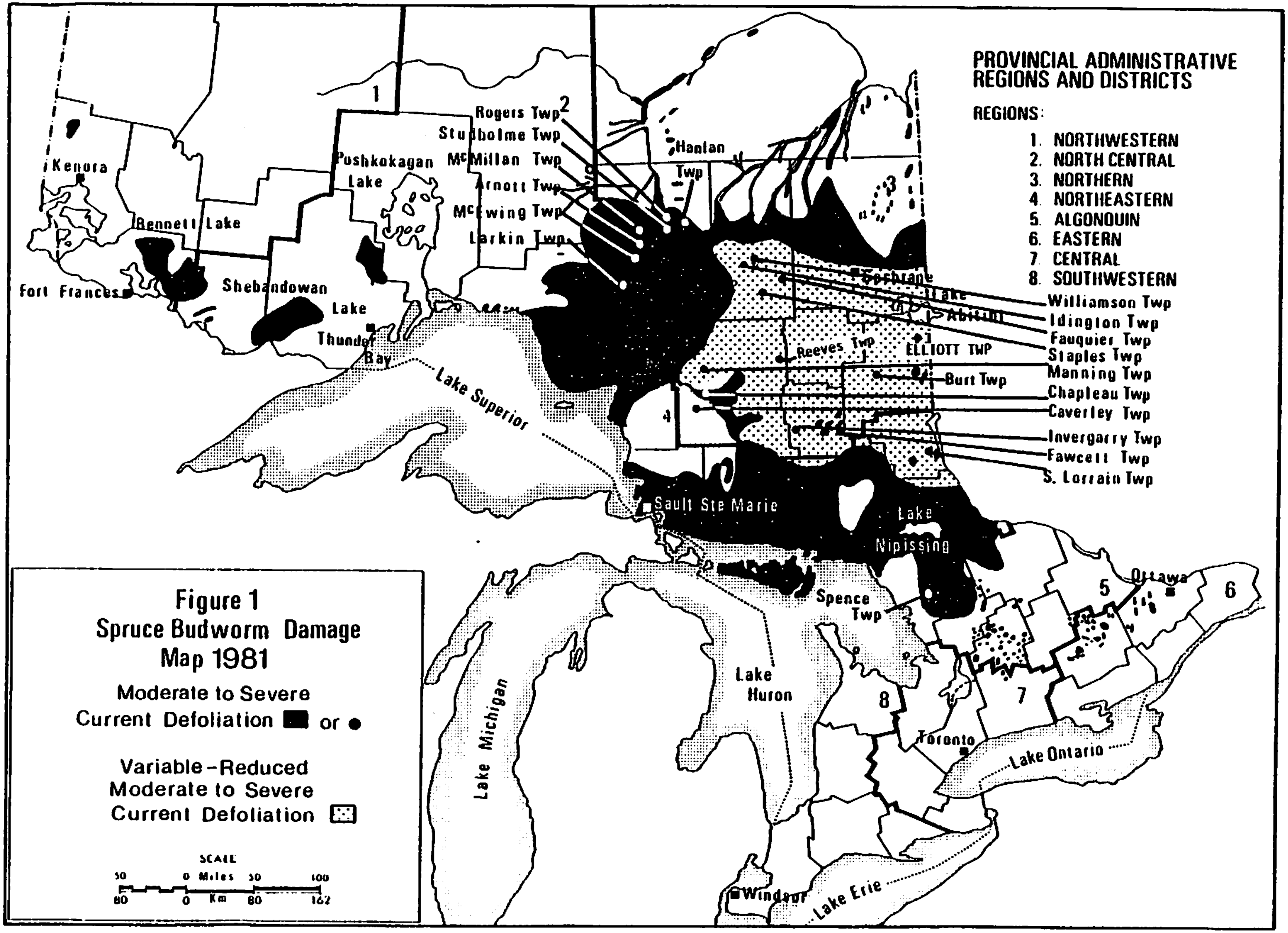

Figure 1
Spruce Budworm Damage
Map 1981

In the northeastern Ontario outbreak, a substantial increase occurred in the eastern Terrace Bay District where pockets of moderate-to-severe damage in the Manitouwadge and Davies townships area coalesced and merged with the main body of infestation to the east. In the southeast Terrace Bay District the infestation spread west to Coldwell Township and scattered pockets of moderate-to-severe damage occurred along the north shore of Lake Superior to Priske Township. These increases were more than offset by declines which occurred in a large area encompassing part of the southern Wawa, southeastern Chapleau, and northern Sault Ste. Marie and Blind River districts where stands were generally free of moderate-to-severe defoliation. Changes in the northern boundary of the infestation resulted in a net decline in area infested in the Kapuskasing District and increases in the Cochrane and Hearst districts. Moderate-to-severe defoliation was again mapped along the Albany, Moose and Harricanaw River systems as far north as James Bay in the Moosonee District. Damage in the remainder of the northeastern outbreak was moderate to severe but a large area in the central portion was much more variable than in recent years. This area encompassed the southern parts of the Cochrane and Kapuskasing districts, virtually all of the Timmins, Kirkland Lake, Gogama and Temagami districts, a large portion of the Chapleau District and small areas in the Sudbury and North Bay districts (Fig. 1). Within this area of more than 7 million ha, defoliation is extremely variable, with ground estimates ranging from a low of 5% to a high of 80% and averaging 27% less than those in surrounding areas of more consistent moderate-to-severe defoliation. The situation is further complicated by large patches of dead and dying balsam fir which make defoliation mapping extremely difficult. This is the same part of the province in which cold damage occurred in June, 1980 and caused varying degrees of spruce budworm larval mortality. Over all, areas of moderate-to-severe damage decreased by approximately 161 000 ha in northeastern Ontario in 1981.

This year the largest decrease in budworm-infested forest occurred in southern Ontario (Fig. 1). The most spectacular reduction occurred in the large infestation which was located in the Bancroft, Pembroke and northern Tweed districts. This infestation was reduced by over 190 000 ha or 98% and only a few scattered pockets of moderate-to-severe defoliation persist in the northern Tweed and southeastern Bancroft districts. Infestations in the northern Algonquin Park and southern Lindsay districts were reduced by 36 and 92%, respectively, or a total of 85 000 ha. A substantial decline was also reported in the infestation which occurred in the Bruce Peninsula, Owen Sound District. Small increases in area infested were mapped in the Parry Sound and Bracebridge districts.

As expected, the area of budworm-associated tree mortality continued to increase in 1981. The extent of tree mortality in 1981 is compared with that in 1980 in Table 2. A total of 11.210 million ha of tree mortality was mapped this year (Fig. 2). In southern Ontario, most of the area of new tree mortality occurred in Tweed and

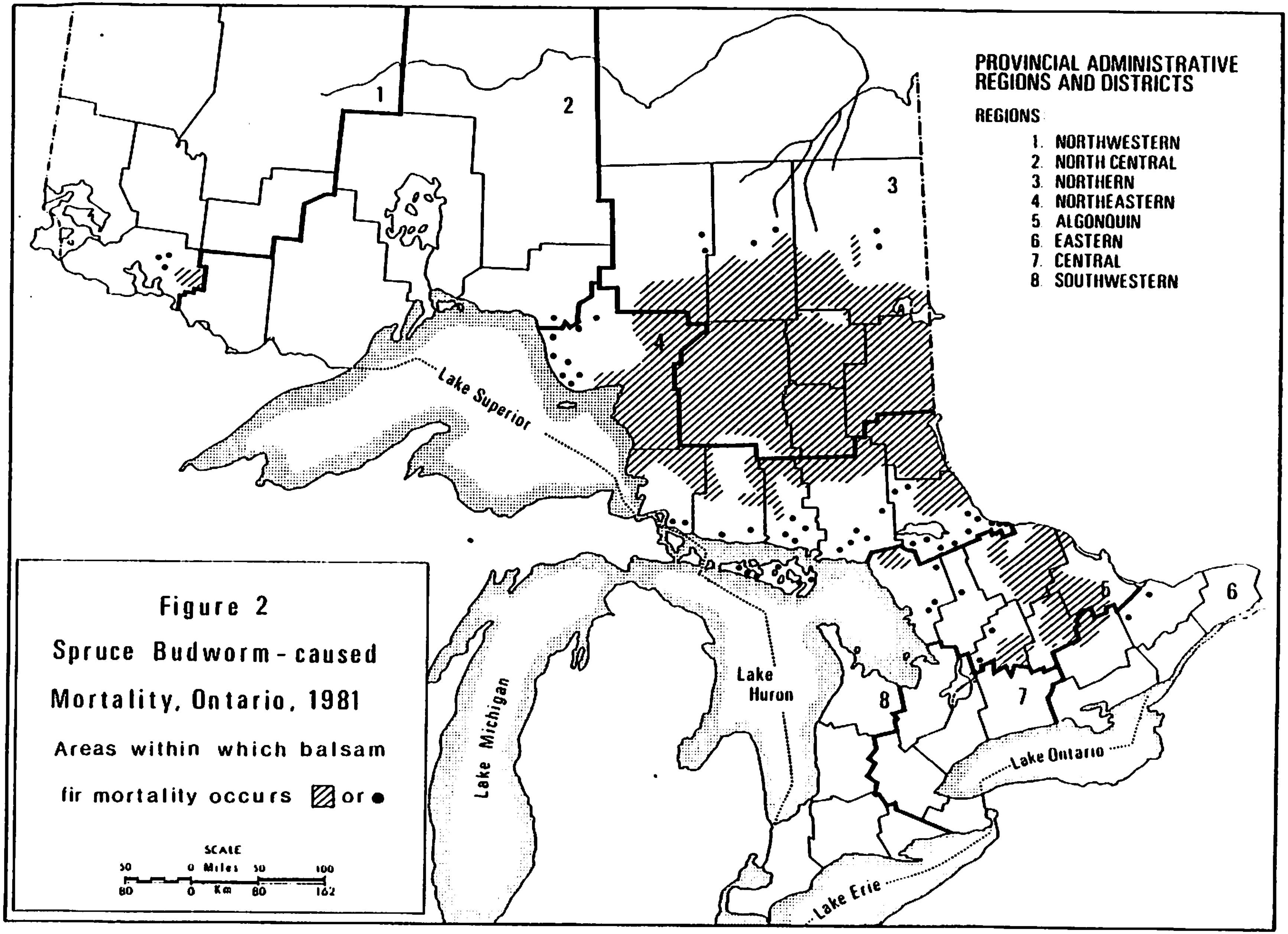

Figure 2
Spruce Budworm-caused Mortality, Ontario, 1981
Areas within which balsam fir mortality occurs ▨ or ●

Parry Sound districts. In northeastern Ontario, the extent of budworm-associated tree mortality increased by approximately 2.733 million ha as new mortality was mapped in virtually every district with the exception of Moosonee in the Northeastern and Northern regions. In northwestern Ontario tree mortality continued to increase in the Fort Frances District to some 88 000 ha in 1981, up from 24 000 ha in 1980.

FORECASTS 1982

Approximately 650 locations were sampled for egg-mass counts and defoliation estimates during August and September in a province-wide survey. On an overall basis, as in 1980, egg-mass densities declined by some 22%; however, there were major regional differences in that substantial increases occurred in some parts of Ontario in contrast to large declines in other parts of the province.

For the second consecutive year, the largest regional decline in egg-mass numbers, about 52%, occurred in southern Ontario. As a result, the total area of moderate-to-severe defoliation should continue to decline in 1982. Forecasts call for generally trace or light defoliation interspersed with numerous scattered small pockets of moderate-to-severe defoliation.

Similarly, in northeastern Ontario, egg-mass populations declined for the second consecutive year. An overall decrease of 46% occurred this year in comparison with 51% in 1980. All but two of the districts in the Northeastern and Northern regions showed significant decreases in egg-mass densities. The two exceptions were Hearst and Espanola, with 25% and 24% increases, respectively. Decreases in the other districts ranged from 18% to 90%. In the eastern part of the North Central Region, on an overall basis, egg-mass densities showed a slight increase of about 2% over those of 1980. A large decrease in Geraldton District was offset by increases in Terrace Bay and Nipigon districts. Forecasts call for moderate-to-severe defoliation throughout the area infested in 1981, with the exception that generally light defoliation with scattered pockets of moderate-to-severe defoliation should prevail throughout the central part of the outbreak. This would include most of Timmins, Chapleau and Gogama districts as well as large parts of Wawa, Blind River, Kirkland Lake and Cochrane districts. Some minor expansions of infestations may occur to the west and north in Terrace Bay, Geraldton and Hearst districts.

In northwestern Ontario, egg-mass densities more than doubled (i.e., the increase was 113% over all) in 1981. Large increases occurred in Atikokan, Fort Frances, and Thunder Bay whereas egg-mass populations in Kenora declined somewhat. It is expected that the area of moderate-to-severe defoliation will increase by some 30-40% in 1982 to approximately 1.0 million ha. The extent of accumulated tree mortality will likely increase to about 14.0 million ha in 1982.

RESULTS OF SPRAYING OPERATIONS

Aerial spraying operations were carried out in June to protect high-value areas in the districts of Hearst, Kapuskasing, Gogama, Chapleau, Kirkland Lake in the Northern Region, Temagami in the Northeastern Region and Parry Sound in the Algonquin Region. In total, approximately 10 233 ha were sprayed. Matacil was applied to a total of 3 225 ha, Thuricide 16B to 3 473 ha, Thuricide 32BX to 324 ha, Dipel 88 to 3 103 ha and NP virus to 108 ha. Areas sprayed included commercial forests, provincial parks, plantations, seed production areas, potential cone collection areas and a deer yard. A summary of aerial spraying conducted in Ontario in 1981 listing the location, area treated, date sprayed and treatment is provided in Table 3.

The results of the various spray treatments used in Ontario in 1981 are presented in Tables 4-18. Basic data such as pre- and post-spray population densities, larval mortality (due to treatment) and foliage protection are presented in each table.

For the second consecutive year an aerial spraying operation was carried out against the spruce budworm in Parry Sound District. On June 2, a 620 ha deer yard in Spence Township was treated with two different B.t. formulations. Results of these treatments were generally very good (Table 4). In terms of population reduction and defoliation, excellent results were achieved in the area treated with Dipel 88. Results in the area treated with Thuricide 32BX were not as good as in the Dipel treated area, especially on white spruce. This may be due, in part, to the poor spray deposits recorded for the morning application (Table 5). Generally, however, results of previous B.t. treatments have been less satisfactory on white spruce than on balsam fir.

In an effort to protect female flowers in Seed Production Areas from budworm feeding, an early or pre-emergence spray was planned for several white spruce and black spruce SPA's (Table 6). Originally Orthene was to be applied at the time of flowering on spruce and was to be followed by an application of either Permithrin or Matacil at the time of budworm emergence. However, permits for Orthene and Permithrin were denied and Matacil was used in their place. In all cases the budworm had emerged before the first application of insecticide. It is very difficult to measure the success of this program in terms of flower protection, as there was very little, if any, flower production on white spruce in these areas in 1981. Nevertheless, in terms of larval mortality and defoliation, excellent results were achieved in both SPA's in Temagami District. There was some population reduction and foliage protection on black spruce in Idington Township (#5) but results in the rest of the SPA's were poor. A check of larval populations in Arnott and Hanlon townships after the second Matacil treatment, revealed high budworm populations in both SPA's. Therefore, a third application of Matacil was given each SPA resulting in some foliage protection.

In Chapleau District three high value white spruce areas were treated with a single application of Thuricide 16B (Table 7). Plantations in Caverley and Manning townships were sprayed in 1981 for the third consecutive year as part of a field trial to determine the impact of budworm on young, planted white spruce trees. Unfortunately, budworm populations failed to increase significantly in treated areas or untreated check plantations throughout the duration (1979-81) of the trial. Very low pre-spray population densities and light defoliation in both the treated and untreated areas make it difficult to interpret the results of this operation.

For the second consecutive year a large area (5 260 ha) of mature (commercial) balsam fir and white spruce in Kirkland Lake District was treated to decrease damage until harvesting can take place (Table 8). Two B.t. formulations (Dipel 88 and Thuricide 16B) and Matacil were applied when the majority of budworm larvae were in the fourth instar (Table 9). Excellent results were achieved on balsam fir with all treatments (Table 8). Larval mortality due to treatment wasn't as good on white spruce but with such low population densities within the treatment area only very light defoliation occurred. Both Matacil and Thuricide 16B provided good to excellent population reduction and foliage protection on both tree species. Dipel 88 was quite effective on fir but less effective on white spruce.

Two other high value areas in Kirkland Lake District were treated with Thuricide 16B (Table 10). In both cases population reduction due to treatment was low but for some reason there was good foliage protection in the Swastika Nursery. In Kapuskasing District the same B.t. formulation was used to treat two spruce high value areas (Table 10). Pre-spray populations on both white and black spruce in both areas were quite low, thereby making it very difficult to make any significant statements as to spray efficacy.

In Hearst District over 3 000 ha of high value forests, including white and black spruce plantations and a provincial park, were treated with B.t. or Matacil. Five plantations in Rogers Township were treated with Dipel 88 (Table 11). Spraying began on June 7, when most larvae were in the fourth instar (Table 9), and was completed by June 12. Although foliage protection on balsam fir was quite variable, generally high population reductions were achieved in most areas. Results on white spruce were less encouraging in terms of larval mortality, however, in at least two plantations (#26 and #49) some foliage protection seems to have been afforded. In Nagagamisis Provincial Park a rather substantial jack pine and poplar overstory may have limited insecticide penetration, thus reducing treatment effectiveness. A different situation existed in Studholme Township where young (planted 1969) black spruce and white spruce were treated with Dipel 88 at 20 BIU in 2.4 ℓ. per ha. Again, because of extremely low populations, spray effectiveness was difficult to assess. Matacil was used very effectively in plantation 43 in Rogers Township (Table 12), but in contrast, because of extremely low pre-spray populations in MacMillan Township, the effect of Matacil on budworm cannot be determined.

In an effort to further the development of biological control agents, three high value areas in the Northern Region were treated with nuclear polyhedrosis virus (NPV). These virus applications were done by OMNR with the help and cooperation of the Forest Pest Management Institute (Dr. J.C. Cunningham) and GLFRC. The virus was applied at the peak of fifth instar and, as expected, foliage protection was limited. Larval mortality, while quite variable, was, in the case of Reeves Township, very encouraging (Table 13). Excellent larval mortality was achieved on white spruce, which, in this SPA, were quite large and generally overtopped the balsam fir. This fact may account for the lower population reduction observed on this species. Also the high defoliation observed in this SPA can be explained, in part, by the large numbers of spruce coneworm larvae (*Dioryctria reniculelloides*) observed during pre-spray sampling. Each area will continue to be monitored during the next two or three years for the effects of virus carryover on budworm control. Please refer to the 1981 Forum report by Dr. J.C. Cunningham *et al.* for further details concerning these trials.

In 1979 several compartments of black and white spruce in the Bonner Tree Improvement Centre were treated with Orthene followed by NPV. Since then these plots have been monitored to determine the beneficial effects, if any, of this treatment. Results of the 1981 effort are given in Tables 14 and 15. While results were variable, some protection seems to have been afforded a few compartments. However, in the absence of virus infectivity information for 1981 and in the face of low populations, it is difficult to assess the degree and impact of NPV carryover.

Results of ground spraying operations in Ontario in 1981 are given in Tables 16, 17 and 18. In Cochrane District the results of the B.t. treatment at Greenwater Provincial Park were good in terms of population reduction (Table 16). Populations were such, that only light defoliation occurred in both the treated and untreated areas. At Barbara Lake SPA, Orthene was used quite successfully to limit budworm damage on white spruce even though budworm larval mortality due to treatment was not exceptionally high (Table 16). Orthene was also used in several compartments of white and black spruce at the Bonner Tree Improvement Centre (Tables 17 and 18). Initial populations on both species were generally quite low resulting in very light defoliation in both treated and untreated areas. Excellent population reduction was achieved in most compartments.

PLANS FOR 1982

Spraying in 1982 may be limited to about 2 000 ha in the Hearst District, Northern Region. The reduced level of spraying anticipated in 1982 is due to decreased budworm populations in a large portion of northeastern Ontario.

Table 1. Comparison of the area of forest in Ontario defoliated by spruce budworm in 1980 and 1981.

Outbreak Region in Ontario	Gross area of moderate-to-severe defoliation in millions of hectares 1980	1981	Change
Northwestern	.724	.657	- .067
Northeastern	17.119	16.958	- .161
Southern	1.007	.601	- .406
Total	18.850	18.217	- .634

Table 2. Comparison of the area of budworm-associated tree mortality in Ontario in 1980 and 1981.

Region in Ontario	Gross area of budworm-associated tree mortality in millions of hectares 1980	1981	Change
Northwestern	.024	.088	+ .064
Northeastern	6.839	9.572	+2.733
Southern	1.493	1.550	+ .057
Total	8.356	11.210	+2.854

Table 3. Summary of aerial spraying in Ontario against spruce budworm in 1981

Location	Hectares	Date Sprayed	Treatment
Parry Sound District			
Spence Twp	296	June 2	Dipel 88, 24 BIU/7.0 L/ha, sprayed once
	124	June 2	Thuricide 32BX, 20 BIU/4.7 L/ha, sprayed once
	620		
Hearst District			
Rogers Twp	547	June 7	Matacil, 86 g/3.0 L/ha, sprayed once
	1099	June 7 to 9	Dipel 88, 20 BIU/5.9 L/ha, sprayed once
	28	June 12	Virus, 741 billion PIB/9.4 L/ha, sprayed once
Studholme Twp	862	June 9 & 10	Dipel 88, 20 BIU/2.4 L/ha, sprayed once
Arnott SPA	16	May 28, June 2	Matacil, 86 g/9.4 L/ha, sprayed 3 times
Hanlan SPA	8	and June 19	Matacil, 86 g/9.4 L/ha, sprayed 3 times
McMillan SPA	40	June 19	Matacil, 86 g/4.7 L/ha, sprayed once
Nagagamisis Provincial Park	670	June 10 & 12	Thuricide 16B, 20 BIU/7.2 L/ha, sprayed once
	3270		
Kapuskasing District			
Idington Twp Plantation #5	64	May 28, June 3	Matacil, 86 g/9.4 L/ha, sprayed twice
Idington Twp Plantation #7	68	June 17	Virus, 741 billion PIB/9.4 L/ha, sprayed once
Williamson Twp	77	June 17	Matacil, 86 g/4.7 L/ha, sprayed once
Fauquier Twp	81	June 17	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
Staples/Casselman	385	June 19 & 20	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
	675		
Kirkland Lake District			
Elliott Twp	2424	June 11, 12 & 20	Matacil, 86 g/30 L/ha, sprayed once
	846	June 13	Dipel 88, 20 BIU/5.1 L/ha, sprayed once
	1731	June 14, 17 & 20	Thuricide 16B, 16 BIU/6.2 L/ha, sprayed once
	262	June 20	Thuricide 16B, 16 BIU/6.2 L/ha, sprayed twice
Swastika Nursery	97	June 7	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
Burt Twp SPA	123	June 7	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
	5221		
Gogama District			
Fawcett Twp SPA	29	May 22	Matacil, 86 g/9.4 L/ha, sprayed twice
Invergarry Twp SPA	6	and May 28	Matacil, 86 g/9.4 L/ha, sprayed twice
	35		
Chapleau District			
Chapleau Nursery	2.5	June 10	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
Caverley Twp	32.5	to	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
Manning Twp	89	June 14	Thuricide 16B, 20 BIU/7.0 L/ha, sprayed once
Reeves Twp SPA	12	June 14	Virus, 2470 billion PIB/18.8 L/ha, sprayed once
	136		
Temagami District			
Friday Lake SPA	8.5	May 20	Matacil, 86 g/9.4 L/ha, sprayed twice
Matabitchuan SPA	6.0	and May 25 & 26	Matacil, 86 g/9.4 L/ha, sprayed twice
	14.5		

Program Total 10 233 ha

Table 4. Population reduction, pupal survival and foliage protection attributable to *B.t.* aerial treatments in a deer yard in Spence Township, Parry Sound District. Sprayed June 2, 1981

	Host	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
<u>Dipel 88, 24 BIU/7.0 L/ha</u>					
Treated	bF	7.2	0	100	2
Check	bF	8.2	0.8		31
Treated	wS	15.9	0.3	81	7
Check	wS	23.2	2.3		29
<u>Thuricide 32 BX, 20 BIU/4.7 L/ha</u>					
Treated	bF	5.5	0.2	63	3
Check	bF	8.2	0.8		31
Treated	wS	17.4	1.2	30	25
Check	wS	23.2	2.3		29

Table 5. Summary, Spray Deposit, 1981 (Krome Kote cards)

Location and Treatment	Date	Time	No. of Cards	Average No. of Droplets/cm^2	Range
Spence Twp Thuricide 32 BX	June 2	a.m.	10	.4	0- 1.6
Spence Twp Thuricide 32 BX	June 2	p.m.	40	35.9	12.8-94.2
Spence Twp Dipel 88	June 2	a.m.	34	8.8	2.0-16.6
Spence Twp Dipel 88	June 2	p.m.	17	33.1	16.0-57.4
Rogers Twp Dipel 88	June 9	a.m.	50	32.9	18.2-66.4
Studholme Twp Dipel 88	June ?	p.m.	50	12.9	3.0-29.6
Nagagamisis Prov. Park Thuricide 16 B	June 12	a.m.	50	16.5	0-91.6

Table 6. Population reduction, pupal survival and foliage protection attributable to pre-emergence treatments of aerially applied Matacil (.86 g/9.4 L/ha) on high value stands, 1981.

	L_2 per branch[a]		Surviving pupae per 46 cm branch tip		% Population reduction due to treatment		% 1981 Defoliation	
	bS	wS	bS	wS	bS	wS	bS	wS
Gogama District								
Invergarry SPA		22.6		1.3		0		42
Check		10.3		0.4				23
Kapuskasing District								
Idington Twp #5 (Pipeline)	5.7		0.8		40		7	
Check	1.6		0.4				19	
Hearst District								
Arnott Twp SPA[b]		36.1		1.5		20		44
Check		25.1		1.3				86
Hanlan Twp SPA[b]		17.7		0.6		0		8
Check		13.9		0.2				21
Temagami District								
Friday Lake SPA		29.5		3.0		76		20
Check		20.1		8.4				50
Matabitchuan SPA		30.8		2.5		81		8
Check		20.1		8.4				50

[a] L_2 per branch was determined by collecting foliage in March and forcing and/or washing larvae.
[b] Three applications of Matacil.

Table 7. Population reduction, pupal survival and foliage protection attributable to *B.t.* treatments (20 BIU/7.0 L/ha) on high value stands in Chapleau District, 1981.

	Host	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
Chapleau Nursery	wS	1.2	0.3	0	4
Check	wS	5.5	0.4		7
Caverley Twp	wS	1.0	0.1	60	1
Check	wS	0.4	0.1		2
Manning Twp (plantation)	wS	0.1	0	0	1
Check	wS	0.3	0		3

Table 8. Population reduction, pupal survival and foliage protection attributable to various aerial treatments in Elliott Twp, Kirkland Lake District, 1981.

	Host	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
<u>Matacil, 86 g/3.0 L/ha</u>					
Treated	bF	5.7	0.1	94	4
Check	bF	6.1	1.8		34
Treated	wS	8.7	0.4	61	7
Check	wS	15.4	1.8		22
<u>Thuricide 16B, 16 BIU/6.2 L/ha</u>					
Treated	bF	0.7	0	100	1
Check	bF	6.1	1.8		34
Treated	wS	1.7	0.1	50	4
Check	wS	15.4	1.8		22
<u>Dipel/88, 20 BIU/5.1 L/ha</u>					
Treated	bF	3.4	0.2	80	4
Check	bF	6.1	1.8		34
Treated	wS	5.6	0.4	39	10
Check	wS	15.4	1.8		22

Table 9. Spruce Budworm Development, 1981

Area	Sampled	Species	Larval Development (%) II	III	IV	V	VI	Date Sprayed
Parry Sound Dist., Spence Twp	May 21	wS	86	14				June 2
		bF	92	8				
	May 28	wS	24	64	12			
		bF	44	50	6			
Hearst Dist., Rogers Twp	June 4	wS	37	28	35			June 7-12
		bF	28	56	16			
	June 5	wS	24	38	36			
		bF	18	16	66			
	June 9	wS	6	22	71			
		bF	10	23	67			
	June 11	wS	22	8	67	2		
		bF	3	6	89	1		
Hearst Dist., Nagagamisis Provincial Park	June 1	wS	72	28				June 12
		bF	48	52				
	June 10	wS	2	8	24	46	20	
		bF	6	16	48	18	12	
Kirkland Lake Dist., Elliott Twp	June 2	wS	100	Buds				June 11-20
		bF	100	Tight				
	June 10	wS	6	23	65	6		
		bF	6	28	66			
	June 11	wS	23	36	36	4		
		bF	14	16	64	5		

(Continued)

Table 9. Spruce Budworm Development, 1981 (CONTINUED)

Area	Sampled	Species	Larval Development (%)					Date Sprayed
			II	III	IV	V	VI	
Kirkland Lake Dist., Elliott Twp (continued)	June 13	wS	7	20	57	17		June 11-20
		bF	2	16	63	19		
	June 15	wS		4	62	32		
		bF		7	39	32	9	
	June 17	wS		9	62	30		
		bF	14	11	46	29		
Cochrane Dist., Greenwater Provincial Park	June 3	wS	70	30				
	June 10	wS	19	12	67	2		
Kapuskasing Dist., Bonner T.I.C.	June 2	wS	52	36	12			May 26-June 26
		bF	64	24	12			
Kapuskasing Dist., Fauquier Twp	June 9	bS	64	36				June 17

Table 10. Population reduction, pupal survival and foliage protection attributable to *B.t.* (Thuricide 16B, 20 BIU/7.0 L/ha) aerial treatments in high value areas in Kapuskasing and Kirkland Lake districts, 1981.

	Prespray larvae per 46 cm branch tip		Surviving pupae per 46 cm branch tip		% Population reduction due to treatment		1981 Defoliation	
	bS	wS	bS	wS	bS	wS	bS	wS
<u>Kapuskasing District</u>								
Fauquier Twp SPA	0.9	3.5	0.3	1.3	0	0	5	9
Check	1.6	10.8	0.4	1.2			10	16
Staples/Casselman	0.4		0		100		0	
Check	0.2		0.2				3	
<u>Kirkland Lake District</u>								
Burt Twp SPA		14.2		3.0		0		59
Check		7.5		1.5				45
Swastika Nursery		7.3		1.2		18		9
Check		7.5		1.5				45

Table 11. Population reduction, pupal survival and foliage protection attributable to *B.t.* aerial treatments in Hearst District, 1981.

	Prespray larvae per 46 cm branch tip		Surviving pupae per 46 cm branch tip		% Population reduction due to treatment		% 1981 Defoliation	
	bF	wS	bF	wS	bF	wS	bF	wS
Dipel 88,20 BIU/5.9 L/ha								
Rogers Twp #26	28.0	25.2	4.8	1.1	69	71	43	16
Check	8.3	10.7	4.6	1.6			56	9
Rogers Twp #30	14.3	24.1	4.0	7.1	50	0	44	30
Check	8.3	10.7	4.6	1.6			56	9
Rogers Twp #37	8.7	8.5	0.5	0.7	90	45	60	2
Check	8.3	10.7	4.6	1.6			56	9
Rogers Twp #43 (east side of road)	11.7	11.6	0.5	1.3	92	25	18	7
Check	8.3	10.7	4.6	1.6			56	9
Rogers Twp #49	14.2	23.1	1.4	1.5	82	56	35	9
Check	8.3	10.7	4.6	1.6			56	9
Thuricide 16B, 20 BIU/7.2 L/ha								
Nagagamisis Prov. Park	7.4	18.4	1.6	3.1	42	55	33	63
Check	11.8	4.0	4.4	1.5			77	64
Dipel 88, 8 BIU/2.4 L/ha								
Studholme Twp #37	0.1[a]	3.1	0	0	100	100	1	1
Check	0.1	10.7	0.1	1.6			10	9

[a] Black spruce.

Table 12. Population reduction, pupal survival and foliage protection attributable to Matacil aerial treatments in Hearst District, 1981.

	Host	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
<u>Matacil, 86 g/3.0 L/ha</u>					
Rogers Twp #43					
(west side of road)	bF	11.7	0	100	4
Check	bF	8.3	4.6		56
Rogers Twp #43	wS	16.2	0.2	92	3
Check	wS	10.7	1.6		9
<u>Matacil, 86 g/4.7 L/ha</u>					
McMillan Twp	bS	0	0	0	2
Check	bS	0.1	0.1		10

Table 13. Population reduction, pupal survival and foliage protection attributable to NP Virus aerially applied on high value stands, 1981.

	Host	Prespray larval population	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	1981 Defoliation
Kapuskasing District (741 billion PIB/9.4 L/ha)					
Idington Twp #7					
Beartooth L.	wS	5.7	0.4	35	8
Check	wS	7.0	0.7		11
Idington #7	bS	1.2	0.2	33	5
Check	bS	1.6	0.4		19
Chapleau District (2,470 billion PIB/18.8 L/ha)					
Reeves Twp SPA	bF	14.7	2.2	40	61
Check[a]	bF	11.8	4.4		77
Reeves Twp SPA	wS	9.1	0.6	90	61
Check	wS	6.3	3.7		41
Hearst District (741 billion PIB/9.4 L/ha)					
Rogers Twp #31	bF	19.9	8.9	19	82
Check	bF	8.3	4.6		55
Rogers Twp #31	wS	19.3	5.6	0	43
	wS	10.7	1.6		9

[a] Check data from Nagagamisis Provincial Park, Hearst District.

Table 14. Population reduction, pupal survival and foliage protection to black spruce attributable to NPV carryover from 1979 spray applications at the Bonner Tree Improvement Centre, Kapuskasing District, 1981.

Compartment	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to NPV carryover	% 1981 Defoliation
6B	.2	0	0	7
Check	1.6	0		3
19C	3.2	0.2	67	5
Check	2.9	0.5		5
21B	3.8	1.2	0	7
Check	2.9	0.5		5
21D	5.0	0.4	56	8
Check	2.9	0.5		5
Overall	3.1	0.4	20	7
Check	2.6	0.4		4

Table 15. Population reduction, pupal survival and foliage protection to white spruce attributable to NPV carryover from 1979 spray applications at the Bonner Tree Improvement Centre, Kapuskasing District, 1981.

Compartment	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to NPV carryover	% 1981 Defoliation
19C	6.3	0.2	78	4
Check	4.7	0.7		2
21D	4.5	0.4	43	3
Check	4.7	0.7		2
22A	3.2	0.5	0	2
Check	4.7	0.7		2
Overall	4.7	0.4	43	3
Check	4.7	0.7		2

Table 16. Population reduction, pupal survival and foliage protection attributable to treatments applied by mistblower on white spruce in Cochrane and Terrace Bay districts, 1981.

	Prespray larvae per 46 cm branch tip	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
Cochrane District Thurieide 16B				
Greenwater Provincial Park	10.2	0.05	59	18
Check	5.0	0.06		5
Terrace Bay District Orthene				
Barbara Lake SPA	48.3	2.60	43	12
Check	34.7	3.30		38

Table 17. Population reduction, pupal survival and foliage protection attributable to Orthene applied by mistblower on white spruce at the Bonner Tree Improvement Centre, Kapuskasing District, 1981.

Compartment	L_2 per branch[a]	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
Orthene, 2 applications				
10B	5.2	0.4	60	4
Check	3.6	0.4		2
Orthene, 3 applications				
16A	15.2	0.1	96	11
Check	3.6	0.7		2
22C	5.0	0.2	80	2
Check	3.6	0.7		2
26D	5.6	0.6	45	3
Check	3.6	0.7		2
Overall (Orthene 3X)	8.6	0.3	82	5
Check	3.6	0.7		2

[a] L_2 per branch was determined by collecting foliage in May at time of emergence and visual examination and washing of larvae.

Table 18. Population reduction, pupal survival and foliage protection attributable to three applications of Orthene applied by mistblower on black spruce at the Bonner Tree Improvement Centre, Kapuskasing District, 1981.

Compartment	L_2 per branch[a]	Surviving pupae per 46 cm branch tip	% Population reduction due to treatment	% 1981 Defoliation
16E	7.8	0	100	1
Check	11.0	0.5		5
17A	1.2	0	100	1
Check	4.0	0.9		7
26B	2.0	0	100	1
Check	4.0	0.9		7
Overall	3.7	0	100	1
Check	6.3	0.8		6

[a] L_2 per branch was determined by collecting foliage in May at time of emergence and visual examination and washing of larvae.

1981 PEST CONTROL FORUM

SPRUCE BUDWORM SPRAYING IN ONTARIO

OPERATIONAL REPORT

The Ministry of Natural Resources protection spraying program against spruce budworm in 1981 included about 5,200 hectares of commercial forest and about 5,000 hectares of high value forest. There were three components to the program:

1. 5,200 ha. of commercially-operable balsam-spruce forest in the Kirkland Lake district. This was the same area treated in 1979 and 1980.
2. 4,350 ha. of high value spruce seed production areas, regeneration, and parks located in six districts within our Northern Region.
3. a 620 ha. wildlife management area in Parry Sound, considered as part of our high value forest program.

1. Kirkland Lake

The spray program in Kirkland Lake was carried out with 3 Ag Cats, equipped with Micronair atomizers. These aircraft were controlled by a guidance aircraft, staffed with a Ministry navigator, and equipped with the Flying Flagman guidance system. About 54% of the area was treated with Thuricide 16B at 16 BIU/6.2 ℓ/ha. or Dipel 88 at 20 BIU/5.9 ℓ/ha. The remaining area was treated with Matacil at a rate of 86 gm a.i./3.0 ℓ/ha. This spraying program was started June 11th and finished on June 20th. The operational spraying costs (materials & aircraft) were $9.43/ha. for Matacil, $21.44/ha. for Dipel and $16.71/ha. for Thuricide (single application).

2. High Value Forests

Twenty-three areas, including white spruce and black spruce seed production areas, white spruce regeneration, nurseries, and a provincial park were treated using two Bell G4A helicopters equipped with boom & nozzle systems and two Cessna Ag Trucks equipped with Micronair units. The plan was to treat the seed production areas with Orthene at the time of flowering, prior to larvae emergence and follow this with a post-emergence treatment of permethrin or Matacil. The objective was to preserve the flowers rather than just vegetative growth.

However, Agriculture Canada refused to issue a research permit for permethrin or to renew the temporary registration for Orthene, thus leaving the Ministry with no alternative but Matacil or B.t. Matacil was applied at a rate of 86 gm a.i./9.4 ℓ/ha., (1-3 applications) Thuricide at 13-20 BIU/6.0 to 7.0 ℓ/ha. and NP virus was applied to two seed production areas. The other areas — cone collection areas, plantations, parks and nurseries, were treated with Matacil, Dipel or Thuricide. Treatment costs for high value forests (materials & aircraft using fixed-wing aircraft ranged from $12.86/ha. for Matacil to $24.44/ha. for Thuricide. In the helicopter program, in which the operator provided mixing and loading, treatment costs ranged from $36.20/ha. for Matacil to $45.73/ha. for Thuricide (single application).

In addition, a 620 ha. deer yard in Parry Sound was treated for the second year, using one Stearman and one Pawnee, [redacted]. Dipel 88 was used at 24 BIU/7.0 ℓ/ha. and Thuricide 32BX at 20 BIU/4.7 ℓ/ha. The treatment cost for Dipel was $32.79/ha. (aircraft, material, mixing and loading).

3. Environmental Monitoring

The only environmental monitoring undertaken this year was a sampling program to determine residues of Matacil remaining one year after application. Results are not yet available.

4. <u>Publication of Manual on Aerial Spraying</u>

The Ministry published a manual entitled "Aerial Spraying for Forest Management — an Operational Manual". This will be used by unit foresters and resource technicians to plan and carry out all Ministry aerial spraying programs, in conjunction with Ministry policies and procedures on aerial spraying of insecticides and herbicides. Copies are available from the Ministry upon request.

Pest Control Section
December 1981

NINTH ANNUAL FOREST PEST CONTROL FORUM MEETING

December 1 - 3, 1981, Ottawa

6.7 Report on Spruce Budworm in the Prairie Provinces & NWT

Spruce budworm conditions in the three prairie provinces and Northwest Territories were much reduced in 1981, compared to 1980. In Alberta, a few small patches of moderate to severe defoliation occurred again within the city of Edmonton in natural white spruce stands along the Saskatchwan River valley. Some aerial and ground spray applications were undertaken by the city.

Aerial surveys conducted over northern Alberta, Wood Buffalo National Park and along the Slave River to Great Slave Lake, N.W.T., revealed no evidence of spruce budworm defoliation. Similarly, no areas of defoliation were reported in Saakatchewan.

In Manitoba two main areas were reported with moderate to severe defoliation, both in mixed spruce-fir stands. At Hecla Island in the Interlake region, several hundred *ha* were defoliated and received pesticidal treatment (see report by K. Knowles). The second location was at Whiteshell Provincial Park where only a few *ha* were defoliated.

Egg mass surveys to predict the 1982 budworm levels were conducted in Manitoba only and included four locations: Hecla Island, Whiteshell Provincial Park, Riding Mountain National Park and some of the Agricultural zone in the Interlake area. All results thus far indicate a continuation of the trend toward low populations.

A series of prism plots were established at Hecla Island, Whiteshell Provincial Park and Spruce woods Provincial Forest in 1981 to obtain information pertinent to estimating spruce budworm impact and depletion loss estimates.

Aerial Application of

Bacillus thuringiensis

for the Control of Spruce

Budworm, Choristoneura, fumiferana

Hecla Island - 1981

Prepared for the Ninth Annual

Forest Pest Control Forum

by

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ABSTRACT

The spruce-fir forests of a high use recreation area at Hecla Island, Manitoba have been under stress following 5 consecutive years of spruce budworm infestation (1976-1980). The 1980 egg mass survey predicted moderate to severe defoliation for 1981. Control measures were carried out with the bacterial insecticide, Bacillus thuringiensis. Dipel 88 was aerially applied to 365 hectares in a single application of 20 BIU per hectare in 5.6 litres of solution. The treatment was successful in reducing larval population densities by 68.4% and limiting defoliation of the current year's foliage to only 11%.

INTRODUCTION

Hecla Island Provincial Park is located at 51° latitude in Lake Winnipeg. Approximately 365 hectares at the north end of the Island are developed extensively for recreational use. Balsam fir and white spruce are major components of the forest cover. A spruce budworm infestation has persisted in this area for five consecutive years, 1976-1980, placing considerable stress on the spruce-fir vegetation. Protection of the vegetation within this area is a concern of the Provincial Parks Branch. An egg mass survey was conducted by Forest Pest Management in September, 1980 to predict the level of defoliation for 1981 (Morris, 1954). Egg mass counts yielded an average of 194 egg masses/$10m^2$, indicating moderate to severe defoliation for 1981. An aerial spray program was undertaken to maintain the spruce-fir vegetation in a healthy, vigorous condition. Considering the high public use of this area, Parks Branch elected to use the bacterial insecticide, *Bacillus thuringiensis*.

The product used was Dipel 88. It is an emulsifiable suspension of *B. thuringiensis* insecticide suspended in a non-aqueous medium. Dipel 88 disperses readily into water or oil based carriers. It contains 8.454 billion International Units of potency per litre (32 BIU/U.S. gallon). Dipel 88 is registered for spruce budworm control under the Pest Control Products Act.

METHODS

Pre-Spray Sample (June 9 & 10)

Branch samples, 45cm in length were collected from balsam fir and white spruce. Two branches were taken at mid-crown from opposite sides of each sample tree. Samples were collected from 9 locations in the treated area and 5 locations in the untreated area. Five trees were sampled at each location. Branches were examined for budworm larvae. Collected larvae were separated into various instars. The index of larval development, a weighted average, was calculated. The mean number of larvae per 45cm branch tip was used to compare pre and post-spray samples.

Application (June 11)

Dipel 88 was aerially applied by a Cessna Ag Wagon equipped with a micronair spray system. A single application was made at a rate of 20 BIU per hectare in 5.6 litres of solution. Water was the carrier. The aircraft swath was 15.2 metres (50 ft). Helium filled meteorological balloons guided the aircraft. The wind speed throughout the application period averaged 8 km per hour with gusts up to 16 km per hour. The temperature ranged from $10^{\circ}C$ to $12^{\circ}C$. Weather conditions remained warm and sunny for two days following the application.

Post-Spray Sample (June 29)

Samples were collected according to the same procedures used for the pre-spray sample. The post-spray sample was taken 18 days after the B.t. application.

Defoliation Assessment

All branches collected for the post-spray sample were assessed for defoliation. Current year's shoots were examined and placed into one of twelve defoliation categories, ranging from 0% to 100% defoliation (Fettes, 1950).

RESULTS

Pre-Spray Sample

Pre-spray larval development was peak 3rd-4th instar. The larval development index just prior to application was 3.6. The average number of larvae per 45cm branch tip was 9.3 in the treated area and 14.2 in the untreated plots. Population densisties were not at a severe level. However, the present condition of the host trees and the need to maintain the aesthetics of this high use area warranted insecticide treatment.

TABLE I - Pre-Spray Sample

Treatment Area

Larval Instars

Plot Number	II	III	IV	V	VI	Total	Average No. of Larvae Per 45cm Branch
1	45	41	39	12	0	137	13.7
2	28	59	32	4	0	123	12.3
3	11	41	31	27	10	120	12.0
4	19	24	26	23	11	103	10.3
5	24	29	22	41	49	165	16.5
6	4	12	9	5	2	32	3.2
7	34	17	9	4	3	67	6.7
8	0	3	5	2	0	10	1.0
9	17	27	28	5	1	78	7.8
	182	253	201	123	76	835	9.3
% of Total	21.8%	30.3%	24.1%	14.7%	9.1%		

Untreated Area

Larval Instars

Plot Number	II	III	IV	V	VI	Total	Average No. of Larvae Per 45cm Branch
10	27	46	83	34	8	198	19.8
11	38	86	60	15	2	201	20.1
12	27	77	32	12	3	151	15.1
13	5	31	49	24	5	114	11.4
14	22	11	7	4	0	44	4.4
	119	251	231	89	18	708	14.2
% of Total	16.8%	35.5%	32.6%	12.6%	2.5%		

Post-Spray Sample

Feeding had not been completed at the time of the post-spray sample. The percentage of pupae was 19.7% in the sprayed area and 44.4% in the untreated area. The average number of larvae and/or pupae per 45cm branch tip was reduced from 9.3 to 2.6 in the sprayed area. In the untreated area larval numbers decreased from 14.2 to 12.6 per 45cm branch tip. Mortality due to insecticide was calculated to be 68.4% (Abbott, 1925).

$$\text{Corrected Mortality} = \frac{\text{Mortality in treated area} - \text{Mortality in untreated area}}{100 - \text{Mortality in untreated area}} \times 100\%$$

TABLE II - Post-Spray Sample

Treatment Area

Larval Instars

Plot Number	II	III	IV	V	VI	Pupae	Total	Average No. of Larvae Per 45cm Branch
1	2	2	4	5	0	2	15	1.5
2	3	3	1	0	7	0	14	1.4
3	0	0	2	4	6	0	12	1.2
4	0	0	2	6	25	19	52	5.2
5	0	0	1	12	2	9	24	2.4
6	0	1	2	2	5	2	12	1.2
7	2	0	2	2	4	0	10	1.0
8	2	0	4	4	0	4	14	1.4
9	1	6	10	16	37	10	80	8.0
	10	12	28	51	86	46	233	2.6
% of Total	4.3%	5.2%	12.0%	21.9%	36.9%	19.7%		

Untreated Area

Larval Instars

Plot Number	II	III	IV	V	VI	Pupae	Total	Average No. of Larvae Per 45cm Branch
10	4	4	11	11	69	32	131	13.1
11	0	1	7	40	49	83	180	18.1
12	1	0	17	36	72	102	228	22.8
13	0	0	2	12	9	55	78	7.8
14	0	0	0	1	5	8	14	1.4
	5	5	37	100	204	280	631	12.6
% of Total	0.8%	0.8%	5.9%	15.8%	32.3%	44.4%		

Defoliation Assessment

Defoliation on current shoots in the B.t. treated area was only 11%, whereas more than 30% defoliation occurred in the untreated plots.

DISCUSSION AND CONCLUSION

Conditions at the time of application were ideal. Wind velocity was low and warm, sunny weather prevailed. The timing of the application, peak 3rd-4th instar, appears to have been appropriate. Shoot elongation was near completion and bud caps had been shed from the white spruce. As well, good larval mortality was achieved. A single application of Dipel 88 (20 BIU/ha) proved to be effective on spruce budworm at moderate population levels.

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Pacific Region

1981

Status of Important Pests

and

Experimental Control Projects

Compiled by

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Prepared for

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Summary of Important Pests

In 1981, the mountain pine beetle continued to spread and intensify affecting pine forests from the International border north to Prince George and Prince Rupert. Current mortality of mature lodgepole pine occurs over more than 158 000 ha and an additional 59 000 ha contains predominantly dead, unsalvageable trees from earlier attacks. More than 19 million mature trees were killed by attacks in 1980, and an estimated 32 million were green but attacked in 1981. Large scale salvage and rescheduled harvesting operations are in progress.

Spruce beetle infestations continued over more than 82 000 ha, primarily in the Prince George - Cariboo regions, with more than 4 million m^3 of mature white and Engelmann spruce killed in 1981. As the beetle usually has a two-year life cycle, the 1981 attack was generally lighter and the majority of the beetles will remain in the 1980 attacked trees until the spring of 1982. Rescheduled harvests and trap tree programs are widely used control measures.

Western budworm defoliation of Douglas-fir declined, possibly due to cool wet weather in June and July. Mostly light defoliation occurred over 21 000 ha, down from 81 000 in 1980. Significant numbers of moths were captured in pheromone baited traps indicating that, although reduced in numbers, the budworm is still widespread. Based on egg counts, populations in 1982 should remain at low levels with generally light defoliation except for some heavier patches.

The two-year-cycle budworm which normally feeds most heavily in even numbered years caused light to moderate defoliation of alpine fir and white spruce over 350 000 ha in 1980. In 1981 the only significant feeding occurred over 38 000 ha in the Prince Rupert region where larval development indicated a portion of the population was in a one-year cycle. In the Nelson region, limited defoliation was caused by "off phase" larvae completing their life cycle in 1981.

Douglas-fir tussock moth defoliated trees in numerous patches over 1 060 ha in four areas in central B.C. In about half the area, defoliation was severe with top stripping and some trees completely defoliated, particularly near Kamloops. A previous infestation involving more than 9 000 ha ended in 1976. The present infestation could be the initial stage of a wider spread outbreak encompassing many of the stands previously infested. Larvae and pheromone trap catches indicate the presence of the insect over a large area from Hedley to Cache Creek. Egg surveys beyond areas defoliated in 1981 indicate that greater than 20% defoliation will occur in 22 of the 28 stands sampled, and it may be moderate or severe in about half of them. Associated with the tussock moth were increasing numbers of the western false hemlock looper, particularly in the Armstrong - Salmon Arm area.

Root diseases, dwarf mistletoes and stem rust or cankers are widespread perennial problems in western coniferous forests, causing mortality, growth loss and understocking in many productive stands. In addition, forest management planning, thinning, spacing and reforestation are frequently affected.

Although larch casebearer populations declined and caused only light defoliation at scattered locations, two larch needle cast fungi were common, and at some locations, severe. Parasitism of the larch casebearer has been monitored since 1969; the occurrence of Agathis pumila is now negligible and although parasitism levels up to 57% by Chrysocharis laricinellae were recorded in 1980, few were recovered in 1981. Instead, parasitism by Dicladocerus averaged 35%.

The wet cool spring weather favoured fungal development. Sirococcus blight was prevalent in coastal container nurseries and damping-off losses were higher than normal; 30% losses were not uncommon especially in new bareroot nurseries. Some soil fumigation and seed treatments will be initiated in 1982.

Currently minor pests, but with damaging potential, include the Douglas-fir bark beetle which is best managed through sanitary logging. Slight increases have resulted in recent years due to predisposition by drought, root rot, mechanical injury, defoliation and in some cases, lower utilization standards. Also, the western oak looper, which was last active in the Victoria area during 1958 - 61, severely defoliated Garry oak and Douglas-fir over 16 ha in an ecological reserve on Salt Spring Island. Cone and seed pests, usually a major concern in seed orchards and collection areas, were minimal in 1981 because of the generally poor cone crops.

Experimental Control Projects

A wide range of experimental control projects were initiated or continued in 1981, many with the co-operation of British Columbia Ministry of Forests, forest companies or British Columbia Ministry of Agriculture.

Mountain pine beetle - *Dendroctonus ponderosae*

Earlier water sprinkling experiments with log bolts were expanded to industrial log decks which were watered for six weeks using soaker hoses on the deck surface. Progeny survival was 5% compared to 93% in the untreated deck.

The use of pine oil as a repellant to prevent attack, again protected the treated trees as well as trees within 10 m. The protection was still effective during a second flight period one year later, but alpha-terpineol was not.

Work is continuing to evaluate the potential of *Beauveria bassiana* for direct control of the mountain pine beetle. Current emphasis is on determining the minimum dose of fungus spores to produce a lethal infection on an adult beetle boring into a living lodgepole pine.

Root Diseases - *Phellinus weirii* and *Armillaria mellea*

The effectiveness of removing stumps and large roots which are the major source of root rots infecting the next rotation, has been evaluated. After 12 years, only 1 tree (0.09%) has been killed in a 1.25 ha plot in interior B.C. In a 2 ha coastal plot, 5 trees died within 4 years and none in the subsequent 5 years. To date, stumping has been completed in the interior on 5 ha infected by *Armillaria* and on 24 ha with *Phellinus*. Ten *Phellinus* infected coastal stands totalling about 500 ha have been treated. Costs averaged about $500/ha for stump removal, and up to $1,000 if they were piled and burned.

In immature stands, the management recommendations are:

- Do not space if there are more than 10 root rot centres per hectare at 15 - 20 years;
- Salvage current and expected short term mortality during commercial thinnings;
- Avoid diameter limit or selection cuttings in heavily infested stands; and,
- Favour the most resistant species for the site.

Cone, seed and nursery pests -

The widespread poor cone crop in 1981 virtually averted the need for control of most cone pests. In one industrial seed orchard a 0.75% dimethoate spray to run-off achieved only 57% reduction of the Douglas-fir cone gall midge (*Contarinia*). In addition, 24% of the seed was lost to a seed chalcid (*Megastigmus*). Elsewhere a 0.5% application achieved 84% control and other insects were not significant.

Heat treatment studies are being initiated for the *Sirococcus* blight pathogen which has been shown to be seed borne in spruce.

Douglas-fir tussock moth - *Orgyia pseudotsugata*

Outbreaks of Douglas-fir tussock moth occur suddenly with complete defoliation possible within 6 weeks. The pest management system for this insect depends on early detection by pheromone traps, population density assessments by sequential egg mass sampling, and early treatment before severe defoliation occurs. To evaluate such an early treatment a nuclear polyhedrosis virus (NPV) was applied in 1981 from the ground and by helicopter in south central B.C. (at 2.4×10^{10} PIB/ha and 2.2×10^{11} PIB/ha, respectively). Moderate and low populations had been detected in 1980 and defoliation was then minimal. This was a joint operation between the British Columbia Ministry of Forests, Pacific Forest Research Centre and the Forest Pest Management Institute. Operational specifics will be presented by a BCMF representative.

Preliminary results indicate that a viral epizootic was initiated by both the ground and aerial applications. Although a natural virus did occur in untreated moderate and low (but not very low) tussock moth populations, infection levels were considerably higher and evident much earlier in all population densities sprayed. Foliage protection was less than expected, perhaps due to the cool weather which slowed viral development (insect development was 2 - 3 weeks later than in normal years).

Viral spread studies indicated that individually ground - treated trees scattered in a line may be sufficient to initiate an epizootic up to 100 m on either side of the line. This suggests that interrupted swath-spraying may be possible with considerable savings on the cost of virus used.

Douglas-fir tussock moth populations in all plots will be monitored for the next few years to determine treatment effect on the developing outbreak.

A pheromone disruption trial against the Douglas-fir tussock moth was conducted near Kamloops by staff of the U.S. Forest Service. ConRel fibers were applied at 24.7 and 7.4 g/ha over 8 ha plots and replicated three times. Preliminary results indicate, respectively, 72 and 61%, fewer matings relative to the check plots. These percentages will likely increase by about 10% after eggs are cold treated and reared so that numbers of sterile egg masses can be deducted. This is very encouraging, but the level of control is not adequate for the population densities and damage of the tussock moth.

Winter Moth - *Operophtera brumata*

The winter moth, a European pest, has been an increasing problem of native Garry oak and ornamental shade and fruit trees since it was first collected in the Greater Victoria area in 1972. This insect was also introduced into Nova Scotia about 1935 but has not been a major problem following the buildup of two of six parasites introduced in 1964.

In co-operation with the British Columbia Ministry of Agriculture, Canada Agriculture and the Maritime and Pacific Forest Research Centres, collections of *Agrypon flaveolatum* and *Cyzenis albicans* from Nova Scotia have been released in Victoria. The parasites were kept in cages for one to three days before released to ensure mating.

Cyzenis releases:	1979	1996	male,	2018	female	at	14	locations
	1980	5355	"	5718	"	"	24	"
	1981	1208	"	1253	"	"	9	"
		8559		8989				
Agrypon releases:	1979	1654		1700			33	
	1980	2213		2813			25	
	1981	924		957			9	
		4791		5470				

To date, there have not been any positive recoveries of either parasite species. Further parasite releases will not be made in 1982, but monitoring for parasite establishment will continue.

SUMMARY OF PEST MANAGEMENT ACTIVITIES IN BRITISH COLUMIBA

Pest control operations have been extensive in British Columbia during the 1981/82 fiscal year and continued activity on a variety of fronts is being planned for next year.

The pest management section of the Ministry of Forests Protection Branch is now fully staffed and functioning. A forest pathologist and a pest control agents specialists have been added to the section so there is now a manager, four professionals and two technicians based in Victoria headquarters. Victoria Branch staff are active in providing technical information to the regions, drafting provincial pest management policies and guidelines and monitoring ongoing pest management activities. Victoria Branch is also responsible for initiating pest management programs which are implemented in the regions. There is a pest management coordinator in each of the six forest regions of the province and most of these coordinators have either a regional entomologist or pathologist reporting to them to provide expertise, training of field staff and supervising regionally run operational and experimental programs. The base operating budget for the Branch and Regional pest management operations for fiscal year 1981/82 is approximately 2.7 million dollars.

Dr. Van Sickle of the Canadian Forestry Service Insect and Disease Survey has given an overview of the various pest occurrences in the province: the extent of attack, the causal agent and the general locations. It is the

Report presented on behalf of the Ministry of Forests by P.M. Hall at the Annual Forest Pest Control Forum, Ottawa, December 2, 1981.

responsibility of the Provincial Ministry of Forests to supplement and refine these C.F.S. surveys to obtain information with resolution adequate for management decisions. At this time Ministry priorities and resources are directed toward minimization of losses caused by the more spectacular infestations - notably mountain pine beetle, spruce beetle and Douglas-fir tussock moth. Activities are also directed toward reducing losses caused by various dwarf mistletoes, pathogens and vegetative weed species.

Mountain pine beetle is by far the most serious of the insect pests currently epidemic in the province. Large areas have been killed affecting present and future wood supply to several communities. Beetle population size and the ready availability of mature and overmature susceptible pine stands have caused great concern in the forestry sector. Because of the extent of the present losses and potential future losses an additional allotment of funds for bark beetle control has been generated. This fund of 11.4 million dollars is to be spent over a two year period on bark beetle control programs. At present, licensees in the province have been directed into areas with high amounts of fresh attacks - removing these trees prior to the insect flight period also removes a portion of the beetle population and reduces subsequent attacks. The timber removed is also more commercially valuable and supplements harvesting of old dead salvage material. The fund of 11.4 million dollars is allocated to control projects in areas where beetle populations are not too extensive. i.e. - those areas where control operations will delay the spread of the beetle so that more long-term management can be imposed. Projects funded include: building or upgrading of access roads into highly susceptible stands or high priority areas, cruises and probes to determine the exact extent of infestations so that appropriate treatment alternatives may be exercised, single tree disposal of infested trees in lightly or moderately infested stands and construction of heliports in remote suscepitble stands to facilitate access. Over 70 individual projects are now approved and funded with slightly more than six million dollars committed for this fiscal year. In one region alone approximately 10,000 individual trees have been felled and disposed of at a cost of over 200,000 dollars - this was for mountain pine beetle only. Other regions have spent at least equivalent amounts on similar projects. The Ministry is also funding research into mountain pine beetle pheromones and supporting some studies being conducted by C.F.S. scientists at the Pacific Forest Research Centre.

Additionally the B.C. Ministry of Forests is involved with the Interagency Committee on Mountain Pine Beetle in conjunction with the Alberta forest service, Parks Canada and the C.F.S. Funds have been supplied for beetle control programs on the B.C./Alberta border to help prevent further spread of the insect east of the Rockies.

Spruce beetle is also included under the emergency funding allotment. Significant infestations of this bark beetle exist in five of the six regions. Those licensees able to do so have been directed into areas for salvage and control purposes. As well, trap tree programs have been instituted in several areas. Over 11,000 trees have been felled to attract flying spruce beetles. These trees are either lethal trap trees (treated with MSMA prior to attack to kill arriving beetles) or are extracted and processed prior to the next beetle emergence. These programs are being studied to determine their cost effectiveness but will be continued for next year at the very least. Again, we have large areas of susceptible spruce type and if the losses were to continue at the present rate the result would be catastrophic.

The greatest problem we face in regards to the control of bark beetles is the poor market for forest products that exists at this time. The most effective control measure is the rapid harvesting and processing of newly infested trees. The activity of the major licensees in the province has been curtailed due to the poor market and so many areas have not been harvested as planned. This situation must change if we are to reach our original program objectives.

The defoliator of concern in B.C. is the Douglas-fir tussock moth. The infestations are cyclical, occurring approximately every 12-15 years and subsiding after about five years due to the natural occurrence of a nuclear polyhedrosis virus. During the course of the infestation, however, significant increment loss, top-kill and mortality are sustained. This insect appears to be on the increase at this time. The Forest Insect and Disease Survey detected an incipient infestation in the Hedley/Princeton area of the province in 1980. The Ministry of Forests, in conjunction with the C.F.S., decided to conduct a program of applying the virus early in an infestation to limit the losses and cause an immediate collapse of the insect. The virus was produced by the Forest Pest Management Institute for the province and was applied by helicopter and ground application to approximately 40 hectares in May, 1981, when the tussock moth larvae were in the 1st or 2nd instar. The results of this operational trial have been described by Dr. Van Sickle. During this project the Ministry also funded a human health study - collecting information on the allergic reaction to tussock moth setae and blood samples from workers for analysis for antibodies to the virus. This study should aid in registration of the DFTM virus. This project cost the Ministry about 110,000 dollars or around 2750 dollars a hectare. Most of the cost was attributable to the research associated with the trial - the NPV is not registered for use at this time. This trial is considered as a success by the Ministry, the information obtained will be invaluable in the future and further work along these lines will be supported by the Ministry. We must have treatment alternatives to apply in a variety of local situations. Such treatment alternatives, both for tussock moth and for western spruce budworm, should include pheromones, virus, Bt and chemical insecticides.

Next year will see continued action against the bark beetles, using both the remainder of the emergency funding and an increased base funding. Programs should be mostly continuations of present programs with few additions. Further suveys have indicated that the Douglas-fir tussock moth exists in significant numbers on over 4000 hectares, most of which is on private land. Although no firm plans have been made, several areas will be treated. Ideally the program should go as:

1) use of NPV on areas not defoliated in 1981 but that have high egg mass counts and the potential for defoliation in 1982.
2) use of Bt (eg - the oilbase DIPEL88) on areas of light to moderate defoliation in 1981 and with the potential for increase in 1982.
3) use of a fast-acting chemical insecticide (eg - Orthene - acephate) in areas of high defoliation in 1981 and potential mortality in 1982.

What is required is the availability of the above agents.

Political, resident and pest management needs require the above treatment alternatives.

The B.C. Ministry of Forests has identified pest management as a priority. We have committed ourselves to a variety of programs encompassing entomology, pathology and vegetation management. We are charged with the responsibility of implementing programs to reduce losses to currently known pests and to provide input to the silviculturists so that the massive investment into intensive forestry is protected.

Along with the traditional pest management techniques, we require new alternatives for treatment of all pest situations. In B.C. we are lacking, in many instances, in any alternative - and this must change.

PRELIMINARY RESULTS

MAINE SPRUCE BUDWORM SUPPRESSION PROJECT - 1981

AND PRELIMINARY FORECAST FOR 1982

Prepared by Henry Trial, Jr.

November, 1981

PRELIMINARY RESULTS

MAINE SPRUCE BUDWORM SUPPRESSION PROJECT - 1981

Prepared by Henry Trial, Jr.

Introduction

In May and June of 1981, the Maine Bureau of Forestry conducted an aerial spraying program against the spruce budworm on approximately 1,172,600 acres. Most of the area, 1,015,100,was treated with Sevin-4-Oil (Carbaryl). Approxiamtely 126,500 of the remaining acres were treated with Bt formulations (Dipel and Thuricide) and the balance of the acreage, 31,000, was treated with Orthene (Acephate). Operational data and a 1981 spray map are found in Appendix A.

Much of the area sprayed in 1981 has been sprayed one to three times since 1978 and was in fair condition. Most of these stands had nearly normal bud potential; a bud crop in numbers and bud size near that of an undamaged host tree. Exceptions to this generally favorable tree condition were found in southwestern Maine where treatment over the last few years has been less effective, and blocks in Washington County area which had never been treated. Blocks in this area had some fir mortality and high volumes of spruce and hemlock in poor or critical condition.

Many application variations were tested in 1981. These variations included split applications of Sevin timed for spruce protection, split applications of Sevin timed to protect spruce, fir and hemlock, increased dosages of Bt (Dipel and 24B Thuricide), a high dosage split application of Dipel, Dipel applied for spruce protection, and Orthene applied from large jet helicopters.

Larval and Host Development

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 twelve permanent development locations throughout the State. Each sample when evaluated 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 1.

Conditions in 1981 were favorable for a successful spray operation. Larvae emerged ten days to two weeks earlier than normal throughout the State, but shortly after emergence, a prolonged cool period began. This cool weather was not severe but did slow development so that by the fourth instar, larvae were less than a week ahead of normal.

Bud development, though slower than larval development during the needle-mining stage, progressed rapidly in late May. By the fourth larval instar, the bud index was well ahead of the larval development index. Rapidly expanding buds and relatively small, slow developing insects meant a large food source and a slow progression of defoliation. In nearly all areas, spray was applied before high levels of defoliation were reached.

The statewide progression of development was also favorable in 1981. Blocks in the south and warmer areas were released well before blocks in the cooler and high elevation portions of the interior. With this type

TABLE 1.
Planned Development Release Points For Insecticides
Used In The 1981 Maine Spruce Budworm Control Project.

INSECTICIDE	DESIRED BUD INDEX[1] Population > 20	< 20	DESIRED LARVAL INDEX[2] Population > 20	< 20
Sevin				
0.75 lbs/in 30 oz. once	3.8	4.2	3.7	4.2
0.46 lbs/in 30 oz twice Spruce and Spruce/ Fir/Hemlock				
1st app.	1.2 on Spruce	1.2	3.5	3.5
2nd app.	3.5 on Spruce	4.5	5.0	5.8
Orthene				
0.50 lbs/64 oz. once	4.0	4.5	3.7	4.8
BT (Dipel & Thuricide)				
8 BIU once	3.7	4.0	3.5	4.0
12 BIU (Fir) once	3.7	---	3.5	---
12 BIU (Spruce) once	1.2	---	3.3	---
8 BIU Twice 1st. app.	3.7	---	3.8	---
2nd. app.	4.0	---	4.0	---

1. Bud index derived by the Quebec index method.
2. Larval index derived by the Quebec index method.

of phased block release, most blocks were sprayed relatively near the desired release date.

Bad spray weather delayed some Bt applications, as well as some late released chemical blocks. These delays resulted in some additional defoliation prior to spray, but the losses were not significant.

Pre-Spray Population Levels

Population levels in all spray blocks were evaluated prior to spraying (Figure 1). These evaluations confirm the need to treat areas, allow for deletion of low population blocks, establish the most effective block release timing; and in some cases, indicate a need to change spray dosages to higher or lower levels.

Significant features of the 1981 population include very high numbers in southeastern Aroostook County, northeastern Aroostook County, and small areas in the northwest. Heavy 1980 moth activity in these areas contributed to the high levels. Relatively low, but variable counts were found in the southwestern portion of the spray area. Moderate levels were found in large areas of the northwest and north central area where much acreage has been treated in the previous three seasons.

As a direct result of the 1981 prespray evaluation, three blocks in southwestern Maine were not sprayed. Another result of the survey was that most 12 BIU applications of Bt were moved from areas of low population in the southwest to higher population areas in the northeast. Finally, spray timing was adjusted to allow areas of lower population in the northwest to develop more completely. This late timing provided large insect and foliage targets.

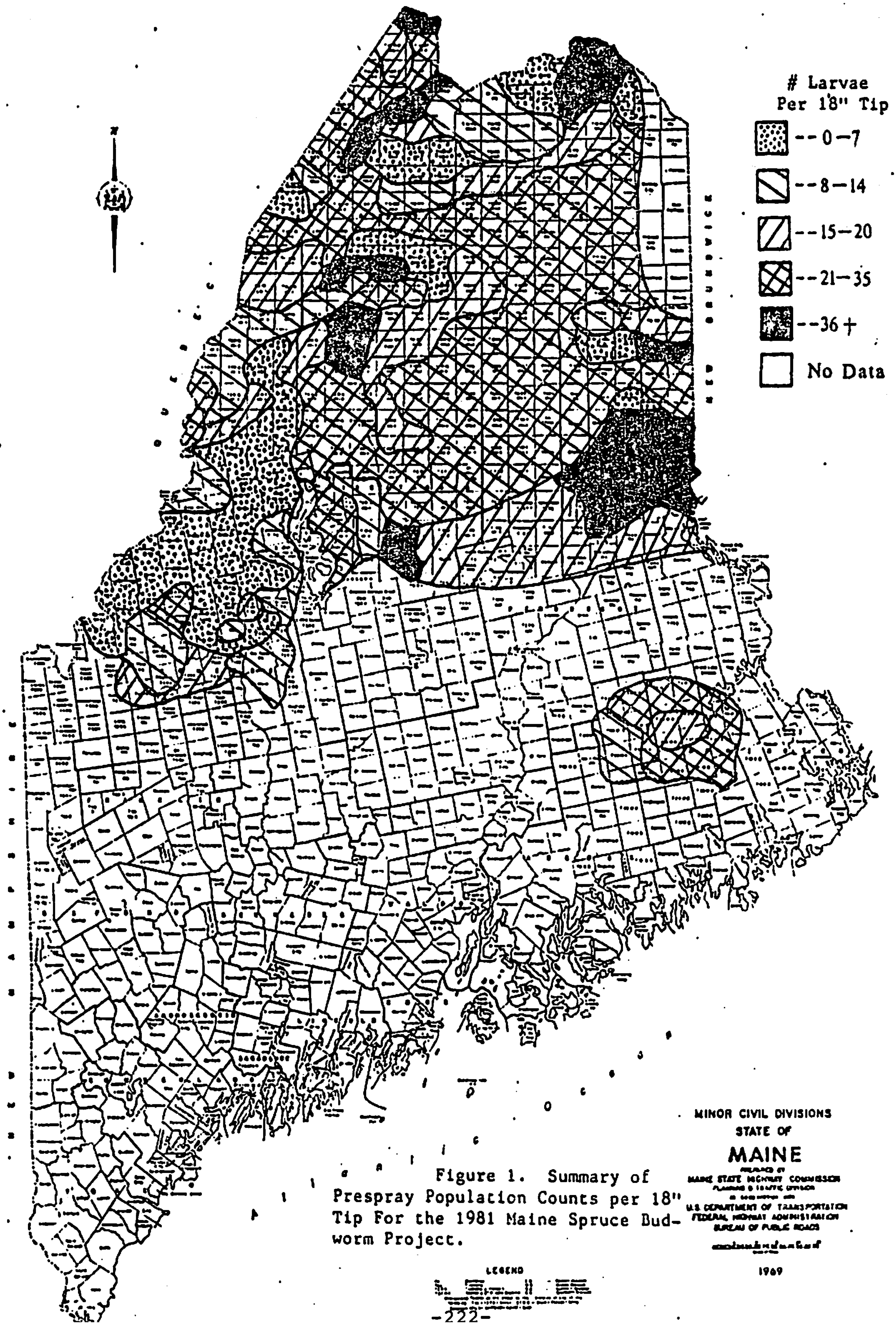


Figure 1. Summary of Prespray Population Counts per 18" Tip For the 1981 Maine Spruce Budworm Project.

Pre-Spray Host Condition

Most 1981 blocks in northwest and north central Maine have been treated once or twice since 1978 and trees were in fair condition with nearly normal 1981 foliage potential. Another area with nearly normal 1981 foliage potential was the portion of Aroostook County south of Presque Isle to the southern County line. These blocks had received good spray protection in 1979 or 1980. All blocks with a high foliage potential and populations less than 20 were expected to receive excellent spray protection.

Blocks in the southwest, north of Caribou, and northwest of Allagash were treated in recent seasons, but results have been variable and trees remained in poor condition. In these blocks, foliage potential was greatly reduced and good results required a timely and extremely effective spray operation.

Some blocks near Millinocket were scheduled for spruce protection either because fir in the blocks was dead or because fir was a minor stand component. Spruce in these blocks was in fair or poor condition.

Finally, blocks in Washington County were generally untreated in the past three seasons and fir and hemlock trees were in critical condition. Spruce was generally in poor condition. All host species had only a small fraction of normal foliage potential. These trees required excellent spray protection in 1981 and certain retreatment in 1982, barring a complete collapse of the budworm population.

Spray Results

Spray results will be reported for each treatment variation employed in the 1981 operation. Many variations were tested in several areas and are listed by area. Tables 2, 3, and 4 lists the number of survivors per 18" tip, unadjusted mortality, adjusted mortality, defoliation in sprayed areas, and foliage saved for fir, spruce and one area of hemlock.

Methods for efficacy determination of the 1981 project are the same as those used in 1980. Methods for detailed comparisons of materials are given in SAMPLING AND ANALYSIS DESIGN FOR EXPERIMENTAL INSECTICIDE MONITORING (Maine Forest Service Technical Report No. 12, Kemp, et. al., 1979).

Data presented is preliminary since analysis of spray deposit, weather conditions, and other factors effecting efficacy have not been analyzed. Population reduction and defoliation figures could change in final reports due to consideration of the above factors. Also, these preliminary data include general block assessments which are not part of the experimental design established to compare chemicals, various dosages of the two Bt products, and untreated check areas.

DISCUSSION

The general results of the 1981 budworm suppression project were high levels of foliage protection and high unadjusted mortality in most of the sprayed area. Most of the area treated with Sevin experienced total defoliation of less than 40% on fir and 30% on spruce. Foliage saved on fir was generally greater than 40%. It should be noted that defoliation in the check areas was generally less than 100% even with populations greater than 25. This lack of complete defoliation was due to rapid development of foliage relative to the budworm.

TABLE 2. Results of Sevin-4-Oil Treatment Variations By Area for the 1981 Maine Spruce Budworm Control Project.

TREATMENT	AREA	HOST	# SUR. PER 18" TIP	% RED. UNADJ.	% RED. ADJ.	% DEF.	% FOL. SAVED
Sevin							
0.46 + 0.46 lbs.	Washington County	Fir	0.1	99.3	96.5	25	56
in 30 oz.	Spruce/Fir/Hemlock	Spruce	2.1	80.6	39.2	28	36
		Hemlock	0.4	97.7	87.2	16	64
	Millinocket Area	Fir	0.5	98.6	86.0	37	40
		Spruce	0.9	93.3	71.4	27	19
0.75 lbs.	Northeast* Plate 13	Fir	1.8	96.6	51.4	40	60
in 30 oz.		Spruce	1.6	92.5	30.5	26	25
	Southwest**	Fir	0.2	98.1	86.0	25	22
	Plates 20,21,22	Spruce	0.9	89.7	78.9	15	2
	Westcentral**	Fir	0.1	98.7	88.6	8	20
	Plate 9	Spruce	0.4	94.9	86.4	13	3
	Northwest	Fir	0.3	98.2	79.8	54	40
	Blocks 3-3,3-1,4-4,14-1	Spruce	0.0	99.8	50.0	42	19
	Northcentral	Fir	2.2	90.7	23.8	25	47
	Plate 6	Spruce	1.3	93.0	0.0	13	35
	Telos	Fir	1.1	96.8	78.4	33	47
	Plate 16	Spruce	0.8	93.6	0.0	25	42
0.75 lbs. in	Northwest Plates 1,2,3,4					33	59
30 oz. Area	Westcentral Plates 14,9,GW					18	20
Defoliation	Central Plates 10,11					55	37
Means	Eastcentral Plate 13					22	60
	Chesuncook Plates 16,15					47	25

* Pre Count 35 or more
** Pre Count 10 or less

TABLE 3. Results of Orthene Treatment Variations By Area for the 1981 Maine Spruce Budworm Control Project.

TREATMENT	AREA	HOST	# SUR. PER 18" TIP	% RED. UNADJ.	% RED. ADJ.	% DEF.	% FOL. SAVED
Orthene 0.50 lbs. in 64 oz.	Blocks 4-3, 14-3	Fir	0.1	99.7	96.6	39	55
		Spruce	0.0	99.8	50.0	35	26
	Blocks 5-1, 5-3*	Fir	1.3	95.6	82.1	55**	37
		Spruce	0.8	97.4	63.4	48	33

* Pre Count 30 or more

** These blocks had 35% defoliation of Fir and 30% defoliation of Spruce at spray time.

TABLE 4. Results of BT Treatment Variations By Area for the 1981 Maine Spruce Budworm Control Project.

TREATMENT	AREA	HOST	# SUR. PER 18" TIP	% RED. UNADJ.	% RED. ADJ.	% DEF.	% FOL. SAVED
Dipel							
8 BIU in 80 oz.	Block 18-1	Fir	1.7	95.5	56.7	87	13
		Spruce	1.6	91.5	0.0	36	2
	Blocks 13-8,13-7,12-2	Fir	3.4	88.6	0.0	61	32
	West 22-16	Fir	0.6	97.4	95.0	58	30
		Spruce	0.6	93.3	86.3	13	25
	Southwest*	Fir	0.2	95.8	87.2	14	14
		Spruce	0.5	94.1	81.4	12	10
Thuricide							
8 BIU in 80 oz.	Block 18-2	Fir**	3.8	87.9	0.0	71	29
		Spruce	1.8	88.8	0.0	18	20
Dipel			***				
12 BIU in 120 oz.	Block 17-1	Fir	(0.8) 1.2	91.8	28.7	(24)34	31
	Spruce Protection	Spruce	(1.0) 1.7	85.2	25.3	(18)24	14
	5 Plate**	Fir	0.7	97.4	89.4	31	61
		Spruce	0.7	96.9	55.7	23	58
Thuricide							
12 BIU of 24B in 96 oz.	7 Plate	Fir	0.9	95.3	16.1	26	60
		Spruce	0.7	95.2	0.0	22	43
Dipel							
16 BIU 8 + 8 in 80 oz.	5 Plate	Fir	1.1	95.7	82.5	50	42
		Spruce	0.3	96.5	80.7	17	28

* Pre Counts less than 10.
** Pre counts 25 or more.
*** Number in () represents omitting of a sample line which received heavy rain shortly after spray.

Unadjusted mortality in the Sevin area was greater than 95% on both fir and spruce. Adjusted mortality was high in most areas but low survival in some fir checks and in many spruce checks caused lower adjusted levels. Low survival in spruce checks has been noted in several previous years.

Insect mortality rates on fir were generally higher than those for spruce in sprayed areas but these rates varied greatly. The range of survivors in assessment areas was 0.0 to 2.2. High levels of defoliation were prevented throughout this wide range.

In comparison with other recent spray projects, 1981 Sevin results were as good as any. High prespray bud potential and favorable development in 1981 may make this seasons project the most effective of three successful projects conducted since 1979.

Some problems were experienced in Sevin sprayed areas which decreased effectiveness. Spraying was delayed about one week in some of the northwest, resulting in loss of an additional 20 to 30% of the available foliage. Another notable problem was rainy weather occurring in scattered blocks before spray had dried on foliage. These conditions lowered efficacy but the degree of reduction is hard to measure. Rain did not completely neutralize spray efficacy in any area assessed.

Some general observations should be made regarding 1981 Sevin applications. First, split applications were more effective than single applications and were much more effective on spruce. Second, in 1981 all dosages of Sevin protected hemlock from high levels of budworm damage. Finally, successful treatment of spruce is hard to achieve and even harder to time and evaluate. Continued tests on spruce will be required in 1982.

Orthene results were better than those from previous uses of this material. In general survival, population reduction, and foliage saved were equal to levels seen with Sevin. In two Orthene areas, prespray defoliation levels were higher than desired because spraying was delayed by bad weather. Earlier applications may have resulted in lower defoliation levels. Population reduction was much more rapid with Orthene than with Sevin, occurring generally within three days of the spray application. Orthene areas were observed closely to determine the chemicals mode of action. Special note was made of contact toxicity and mortality of "hidden" insects. Results of these observations are not available at this time.

Results with Bt in 1981 varied with the dosage applied. Application of 8 BIU Dipel and Thuricide were generally not effective. Fir defoliation in these 8 BIU areas often exceeded 60 or 70% and foliage saved was generally low. Similar results were seen on spruce. Unadjusted mortality with 8 BIU's was slightly lower than with chemicals and survival was generally much higher.

Applications of 12 BIU's of Dipel and Thuricide gave much more encouraging results. In three separate areas treated with this higher dosage of Bt, all were found to have good results equivalent to those seen with either chemical. Defoliation in 12 BIU areas was generally less than 40% and foliage saved was high. Survival and population reduction was comparable to chemicals with both materials.

Three important factors were noted in areas sprayed with the high dosages. First, population reduction was extremely rapid with both materials. In many areas, three day post samples showed 60 to 70% reduction from prespray levels. Second, the 12 BIU rate was successful in three areas of high to very high population. Traditionally in Maine, Bt has been effective only in areas of low population. Finally, rain seemed to have much less effect on 12 BIU applications than on the low dosages.

This factor may be related to the rapid population reduction seen in nearly all 12 BIU areas.

Two applications of 8 BIU, totaling 16 BIU produced good results. Results were generally less consistent in the 16 BIU split application area than in 12 BIU blocks.

Finally, it should be noted that 12 BIU applications and 16 BIU split applications of Bt that were effective on fir were also effective on spruce. Final analysis may show that spruce protection was slightly better with high rates of Bt than with chemicals.

1981 SURVEYS AND FORECAST FOR 1982

Introduction

Following the 1981 project, surveys were begun to evaluate the 1981 situation and to predict the situation for 1982. Surveys included an aerial defoliation survey, an egg mass survey, a ground tree condition evaluation, and an aerial tree condition survey. Data gathered in these surveys was used to establish a hazard rating for 1982.

RESULTS

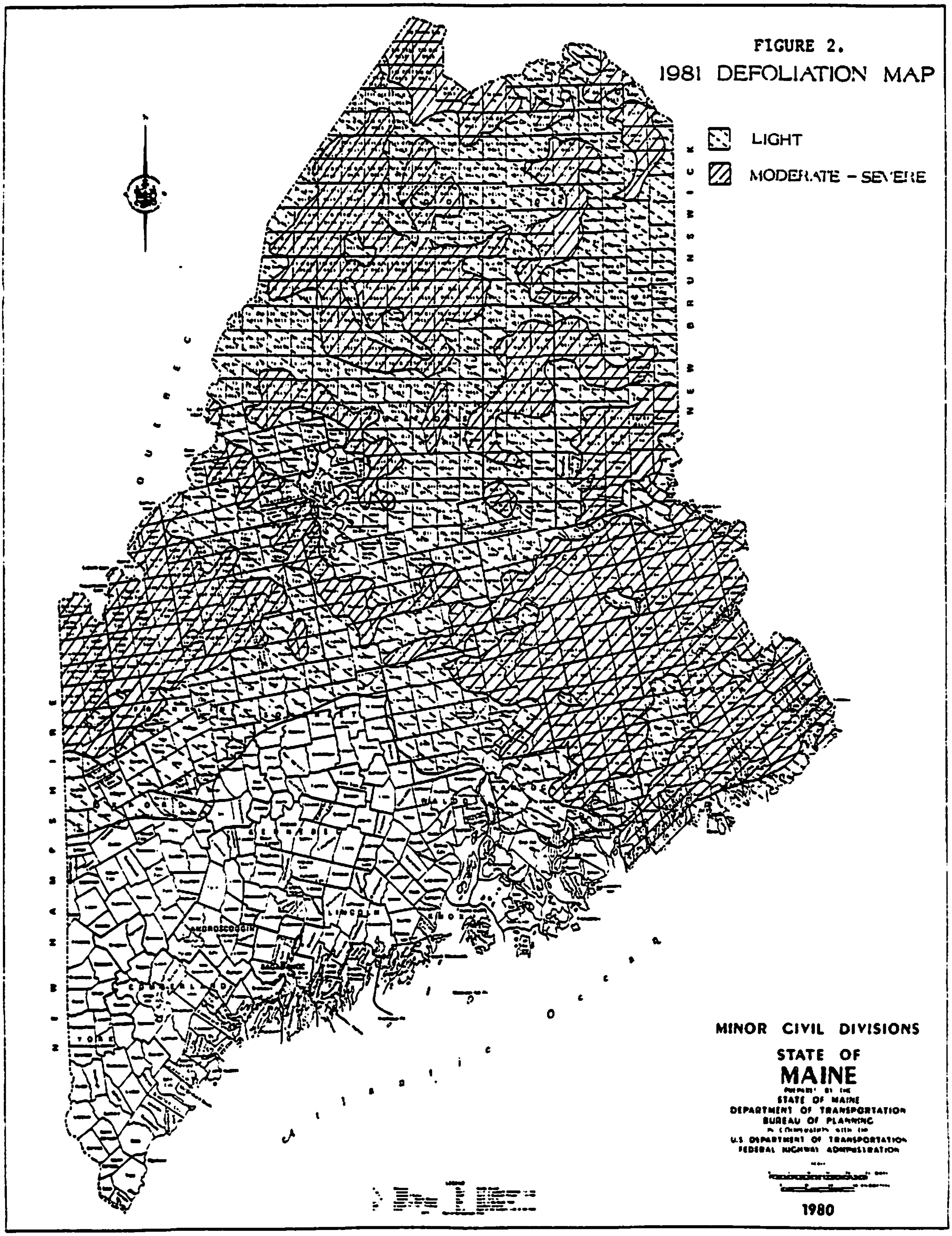
Aerial Browning Survey

An aerial survey conducted in late June and early July showed a reduction in the moderate to severe defoliation class compared to 1980 (Figure 2). Total area in this class was approximately four million acres in 1982 compared to five million in 1980. The reduction was due to a very successful spray project, lower populations, and favorable bud development.

Egg Mass Survey

The 1981 egg mass survey summarized in Figure 3, shows a striking decline from 1980 levels. More than 60% of the 1980 sample points were found to have egg deposits in the low category. Areas showing the most marked decline were the southwest and northeast. Populations remain high in the southeast and much of the northwest. Deposit analysis in the north-

FIGURE 2.
1981 DEFOLIATION MAP



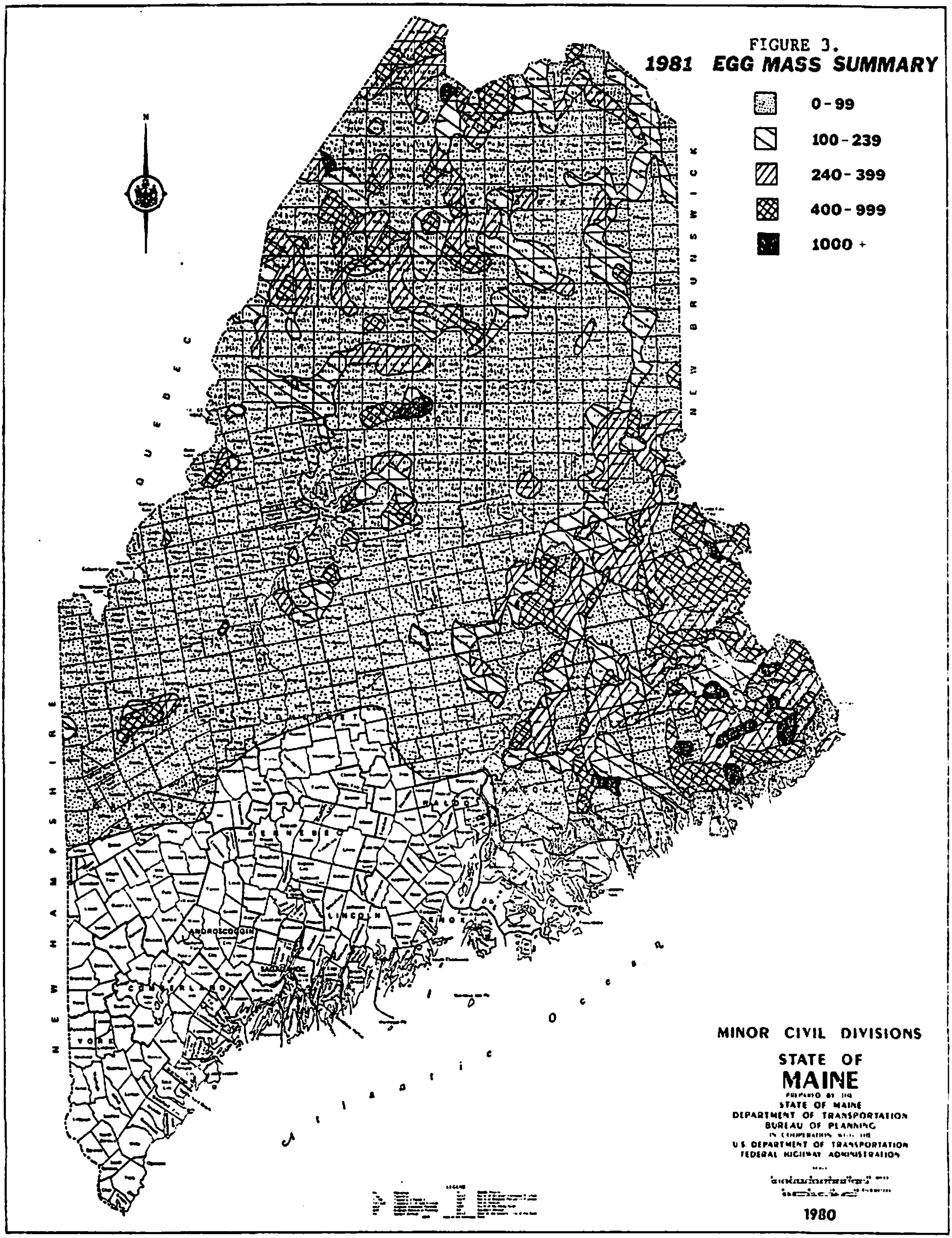


FIGURE 3.
1981 EGG MASS SUMMARY

west revealed a very low deposit in sprayed area compared to a deposit three to four times greater in unsprayed areas.

Egg deposit by zone for the past several years, and the deposit trend from 1980 to 1981 is shown in Table 5. All zones showed a reduction from 1980 to 1981 and many zones showed a sharp reduction. Deposit means in the southeast coastal zone remain high, these zones are in the moderate category, and two zones are low.

HAZARD FORECAST

A hazard rating was determined for each egg mass sample point using the same system used in Maine for several years. The rating includes predicted populations (from egg mass), current defoliation, past defoliation (2 previous years), and tree vigor. Hazard is classed as low, moderate, high, or extreme and is mapped as a summary of point conditions (Figure 4). An aerial damage survey is used in conjunction with point data to construct this summary.

The area in high and extreme hazard is reduced from five million acres in 1980 to 4.5 million acres in 1981. This reduction is due to effective spraying reducing defoliation and a general reduction in egg deposit.

Hazard was found to be greatest in unsprayed portions of the northwest and in the southeast. Tree condition is poor in the southwest but hazard was only in the high class due to a very low egg deposit. Tree condition is good in sprayed areas of the northwest and northeast.

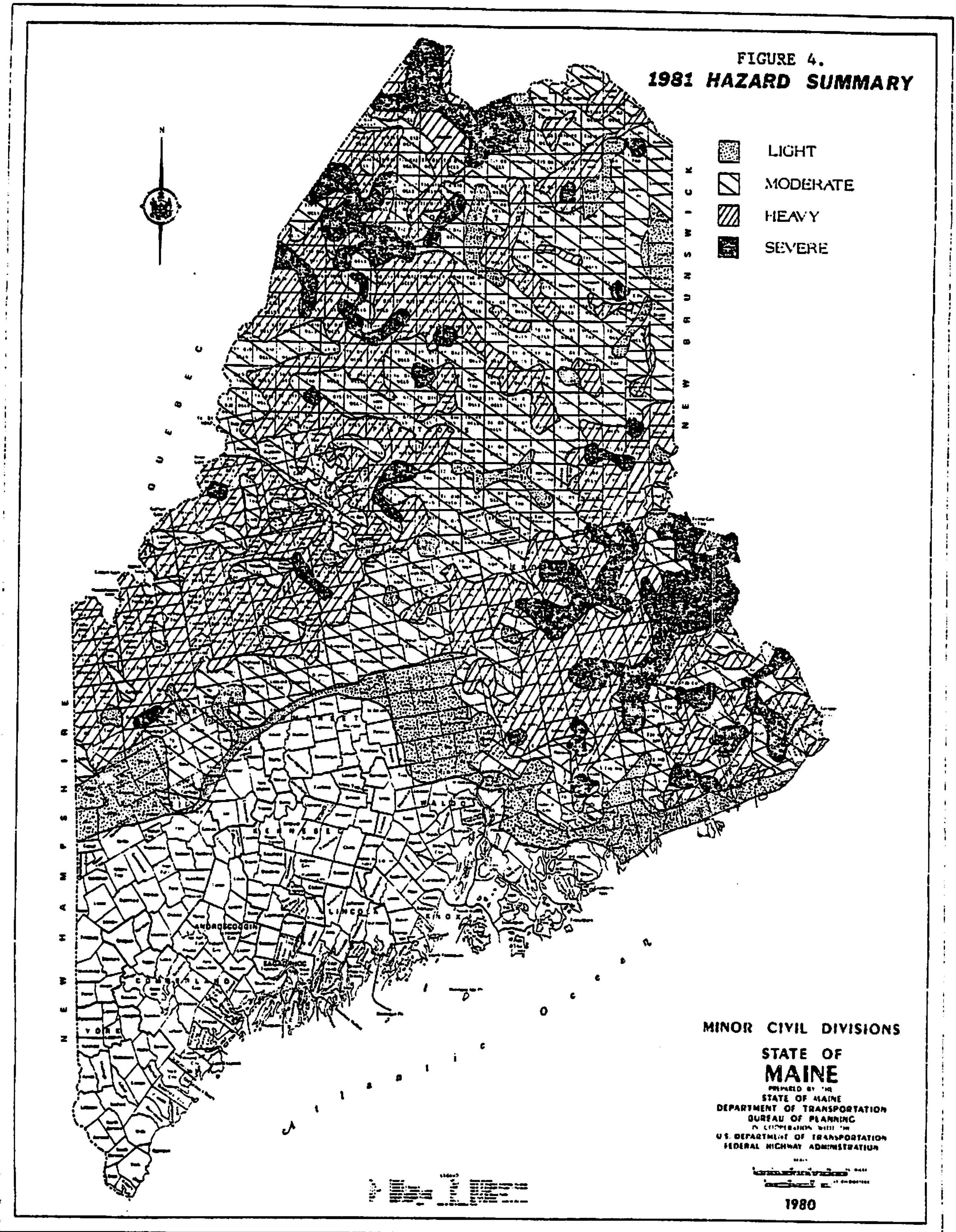
TABLE 5.

MEAN EGG MASS DEPOSIT AND

POPULATION TRENDS BY ZONES

Zone	Egg Masses/100 Sq. Ft. 1976	1977	1978	1979	1980	1981	1980 to 1981 Trends
Allagash-St. John	86	332	331	392	260	176	-
Northeast	145	312	824	374	254	109	--
Penobscot-Mattawamkeag	348	287	519	697	271	216	-
Southeast Coastal	722	155	469	292	493	331	--
Moosehead	253	110	210	287	185	43	--
Western Mountains	312	107	158	416	221	38	--
Totals for 1980 & 1981					261	163	--

FIGURE 4.
1981 HAZARD SUMMARY



HOST MORTALITY

A map of host mortality (Figure 5) was updated in 1981. Black areas on the map show concentrations of 100 acre plus patches of fir mortality. A total of 200,000 acres of these 100+ acre patches was mapped. Cross hatched areas on the map show areas of 5 to 100 acre patches of land where 10 to 25% of the stand is dead due to budworm.

Mortality is greatest in the southern half of the infested area where buffers to humans most influence spray policy. It is estimated that more than 90% of host mortality in Maine is in some sort of unsprayed buffer or generally unprotected area. Most mortality in protected areas occurred in 1978 due to a very poor spray year.

Mortality in the southeast include most of the fir, some hemlock, and a rapidly increasing volume of spruce.

FORECAST FOR 1982

A treatment area of from .5 to 1 million acres is expected. Land to be treated will be widely scattered throughout the infestation. As in 1981, Sevin, Orthene and Bt will be recommended for use. Bt will be used at the 12 BIU rate.

Heavy host mortality is expected to continue in unprotected areas.

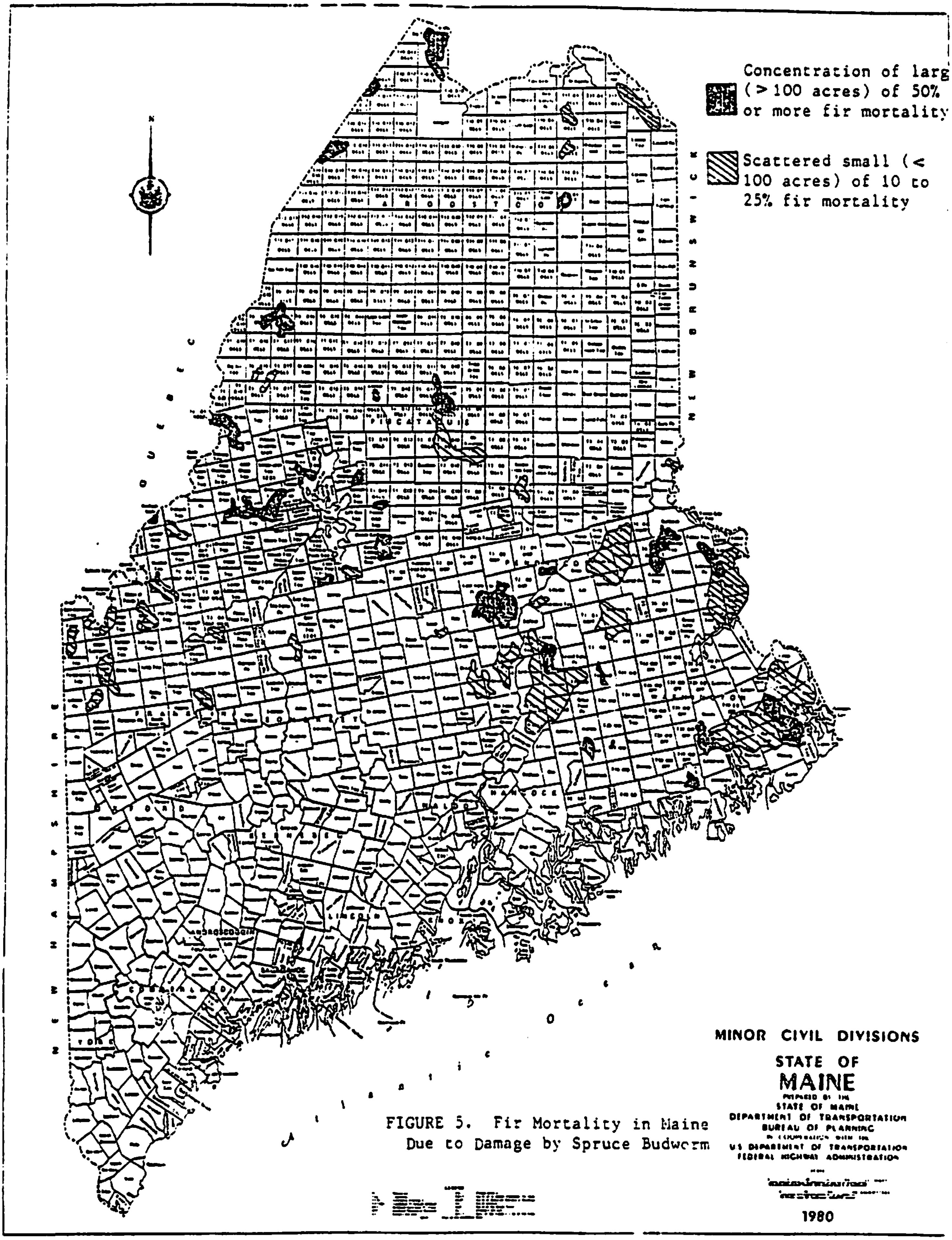
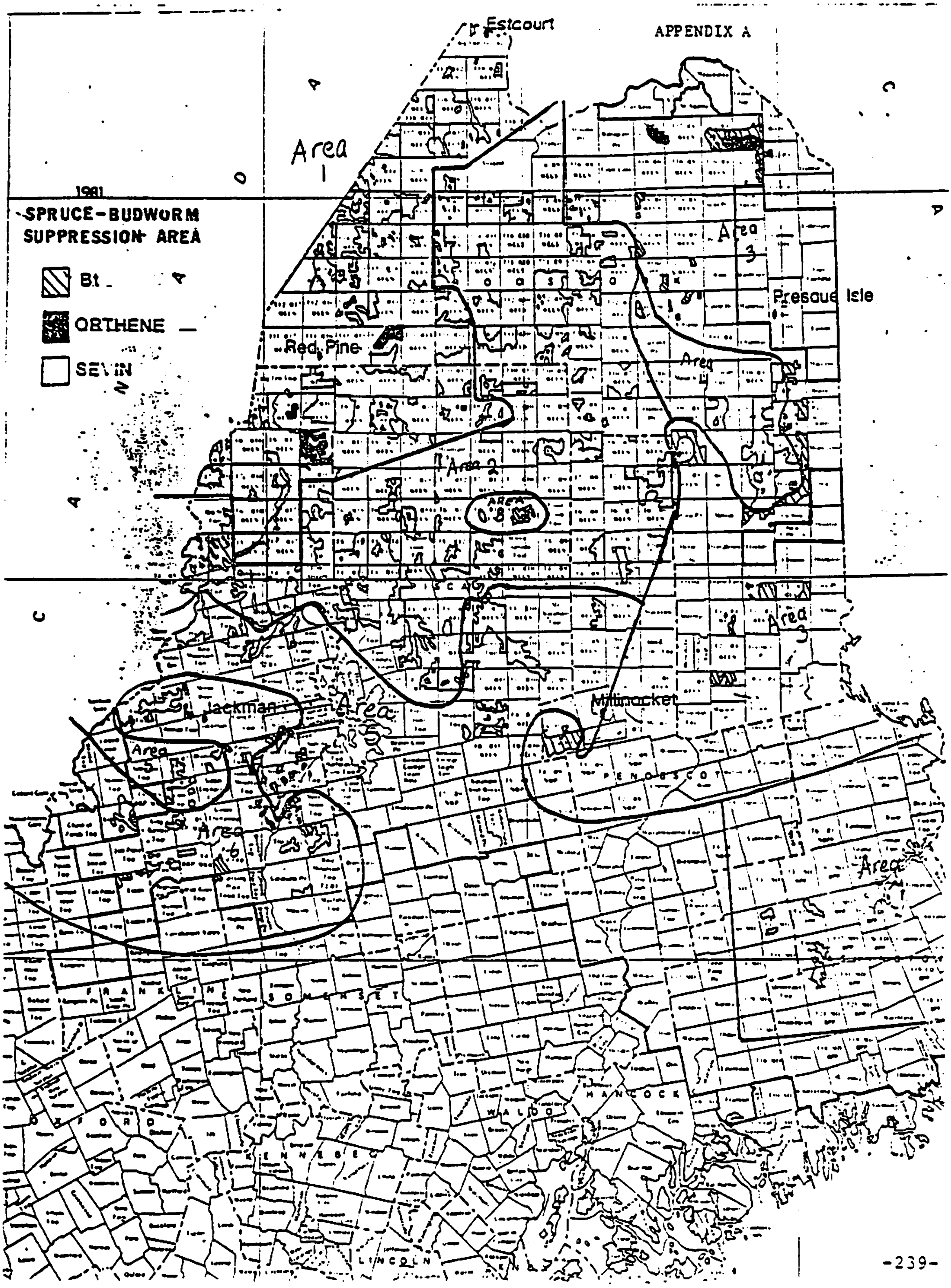


FIGURE 5. Fir Mortality in Maine Due to Damage by Spruce Budworm



1981
SPRUCE-BUDWORM SUPPRESSION AREA
Bt
ORTHENE
SEVIN
Estcourt
Area 1
Area 2
Area 3
Area 4
Area 5
Area 6
Area 8
Presque Isle
Red Pine
Jackman
Millinocket
PENOBSCOT
FRANKLIN
SOMERSET
HANCOCK
WALDO
OXFORD
KENNEBEC
LINCOLN

TABLE 1 - Aircraft, Equipment and Operational Guidelines for the Maine Spruce Budworm Suppression Program, 1981.1/

Aircraft Type 2/	Maximum application speed	Effective swath width (ft) 3/ Oil	Water	Nozzle Type 4/	Maximum Spray Release above canopy
ROTARY WING					
Bell 47	60	100	70	8002	50 ft.
Bell 205, 212	100	250	200	8006	50 ft.
Bell 206B	80	120	100	8003	50 ft.
FIXED WING					
AgCat, Thrush	100	125	100	8004	50 ft.
Turbo Thrush	150	200	100	8008	75 ft.
TBM	165	250	200	8008	100 ft.
PV-2	175	400	300	8008	100 ft.
DC-4	180	550	400	8015	150 ft.
B-17	155	500	350	8010	150 ft.
L-749	210	600	500	8015	150 ft.

1/ These guidelines are intended to improve effective spray coverage and to reduce drift from the target area. To help meet these objectives, the wind speed at tree top level during application should not be less than 2 mph or greater than 10 mph. The parameters listed in these guidelines should produce a volume median droplet diameter (VMD) of not less than 100 microns for chemical insecticides.

2/ These are the principal aircraft for use on the program. Other aircraft may be used.

3/ Calculated with zero cross winds, aircraft flying into the wind, for oil-based and water-based sprays. Effective cross-winds swath width calculations in a 10 mph cross wind are approximately 2.2 x greater than the figures listed above.

4/ Nozzles will be oriented 90° with respect to the line of flight for oil and water based sprays. For Bt, nozzles will be oriented 45° forward with respect to line of flight. Other nozzle types (or atomizers such as Becomists) may be used but at no time will these nozzles exceed the parameters set forth in #1 above.

TABLE II

BUFFER ZONES

MAINE SPRUCE BUDWORM SPRAY PROJECT, 1981

Sensitive Area	Light Aircraft (helicopters and LSU Thrush)			Large Aircraft (TBM, PV-2, DC-4, L-749 & B-17)		
	Sevin-4-Oil	Orthene	Bt	Sevin-4-Oil	Orthene	Bt
TERRESTRIAL:						
Permanent human habitation	1/2 mi.	1/2 mi.	1/4 mi.	1 mi.	1 mi.	1 mi.
Publicly-maintained roads	500 ft.	500 ft.	500 ft.	500 ft.	500 ft.	500 ft.
Apiaries	1/2 mi.	1/2 mi.	N. R.	1 mi.	1 mi.	N. R.
AQUATIC:						
Critical fisheries	500 ft.	250 ft.	N. R.	1,000 ft.	500 ft.	N. R.
Other waters	250 ft.	150 ft.	150 ft.	500 ft.	250 ft.	N. R.
Municipal water supply intakes	1 mi.	1 mi.	1 mi.	1 mi.	1 mi.	1 mi.

Other waters - This term includes rivers, streams, ponds, lakes and ephemeral streams and ponds with flowing or standing water visible from an aircraft flying at an altitude of one thousand feet above the terrain at the time of treatment.

Publicly-maintained roads - This term applies to any roads which are maintained with public funds.

N. R. - No distance restrictions (buffer zone).

Insecticide Information - Budworm 1981

	Oz/A	AI/BIU	Mix	Remarks
Sevin	30	.75	4:1	Single Application
Sevin	30 + 30	.46 + .46	1:1	Split Application
Orthene	64	.50	2/3 Orthene in 1 gal. water	Single Application
[1]Dipel 4L (D-4L)	80	8	60% H_2O 40% D-4L	Single Application
[1]Dipel 4L (D-4L)	80 - 80	8 + 8	60% H_2O 40% D-4L	Split Application
[2]Dipel 4L (D-4L)	120	12	60% H_2O 40% D-4L	Single Application
[3]Thuricide 16B (T-16B)	80	8	80% T-16B 20% H_2O	Single Application
[4]Thuricide 24B (T-16B)	96	12	66.7% + T-24B 33.3% H_2O	Single Application

1. Dipel 4L - 8 BIU/A - 48 oz. H_2O + 32 oz. D-4L = 80 oz/A.
2. Dipel 4L - 12 BIU/A - 72 oz. H_2O + 48 oz. D-4L = 120 oz/A.
3. Thuricide 16B - 8 BIU/A - 16 oz. H_2O + 64 oz. T-16B = 80 oz/A.
4. Thuricide 12 BIU/A - 32 oz. H_2O + 64 oz. T-24B = 96 oz/A.

Spruce Budworm Conditions in the United States in 1981

D.R. Kucera

USDA Forest Service,
Broomall, Pa.

With few exceptions the spruce budworms have increased from the 1980 conditions in the Western United States and declined in the Eastern United States. The following is a chronology by the U.S. Forest Service Regions.

Region 1 - Montana, N. Idaho, and Yellowstone National Park.

The Yellowstone National Park and the Gallatin National Forest have areas of dead or gray spruce-fir trees east of the divide. The southeast and southwest slopes are suffering the heaviest damage. Acres of defoliation is down slightly from 976,072 acres in 1980 to 932,128 acres in 1981.

Region 2 - Colorado, Wyoming

	Light	Mod-Heav.	Severe	Total
Colorado	300,000	1,300,000	110,000	1,710,00
Wyoming	10,000	48,000	0	58,000
				1,768,000

In general budworm infestations have increased over 1980 by 700,000 acres. Due to heavy to extreme populations in much of the area, a continuation of the outbreak at this level in 1982 is doubtful.

Region 3 - New Mexico and Arizona

Spruce budworm infestations have increased in New Mexico now covering 277,710 acres. In Arizona defoliations was detected on 117,325 acres. Because the stands of Douglas fir are sparse and scattered, acreage is not a good indicator of timber impact. Nevertheless, the acreage defoliated has increased by 100,000 acres over 1980.

Region 4 - Utah, Nevada & Central Idaho

Defoliation trends are up on all national forests and parks except on one forest in Wyoming and two forests in Idaho. In 1980, 1,322,000 acres of defoliation were reported while in 1981 it was 1,587,000 acres. Many new areas have been reported in South Central Idaho. For example the Challis N.F. went from 0 in 1980 to 30,000+ acres in 1981. Complicating matters is a suit against the U.S. Forest Service by Boise Cascade for not spraying in 1981. The claim was filed because the company has been spraying while the national forests have not. Consequently, company lands are being reinfested or so it is claimed. Population assessments and defoliation are being carefully assessed.

Region 5 - California Region

Since about 1974 the green form of the western spruce budworm (Modoc budworm) has caused little or no damage. Scientists at the University of California are using pheromones strictly as a detection tool. In addition, they are studying climatic conditions and other factors to determine why there is a difference between outbreak conditions in the Pacific Southwest Versus the Inter Mountain Region.

Region 6 - Oregon, Washington

In Oregon the outbreak has increased to 312,000 acres defoliated while in Washington State it covers 30,000 acres. Egg mass data indicate that defoliation in 1982 will far exceed that of this year (1981). The week of November 14, 1981 approximately 360 million BD. FT. of blowdown occurred which is well below the storm of the early 1960's where close to three billion BD. FT. was lost. Much of this year's blowdown is in the Cascades and is Douglas-fir type or spruce budworm susceptible trees.

Region 9 - Lake States, Michigan, Wisconsin, and Minnesota

Infestations declined markedly from a total of 1,331,410 acres in 1980 to 355,118 which is a reduction of 976,292 acres. Most of the decline is in the high to severe defoliation class. Tree mortality is scattered throughout and is not concentrated as it is in some of the western regions.

New England States - New Hampshire, Vermont, Maine

In both New Hampshire and Vermont, infestations are down due to the severe defoliation of the past few years. Acres of infested trees in New Hampshire is 42,000 and that of Vermont is 94,466.

Region 10 - Alaska Region

Infestations have been reported in the Anchorage Area since 1979 but no visible defoliation. Pheromonetraps for spruce budworm have not been effective, indicating that it may be another strain or species of budworm, i.e. western budworm.

Studies Carried Out by the Control Products Research and Development Program at the Forest Pest Management Institute

T.J. Ennis
Program Manager

The Control Products Research and Development Program at the Institute comprises 7 Projects that are concerned with the development of microbial control agents, Insect Growth Regulators and Pheromones for forest insect pest control. At present, the involvement in field testing and application varies greatly among projects, ranging from the extensive involvement with viruses, Insect Growth Regulators and pheromones through the beginnings of field investigation with fungi and protozoa to the predominantly laboratory-oriented but essential complementary research on cell biology, tissue culture and serology. The B.t. research in this program is primarily aimed at crystal toxicity and mode of action, but in the past year significant information has been obtained on effects of B.t. ingestion on mortality, feeding inhibition and survival.

Following are highlights of activities this past year in these projects. Detailed appendices prepared by the research staff have also been tabled for most projects.

FP-1 Mode of action of B.t.

Diet feeding studies have established that spruce budworm larvae exposed to sublethal doses of B.t. will continue to feed and gain weight albeit at a slower rate than normal. When transferred to B.t. free diet, feeding and weight gain return to normal, and larvae could pupate successfully. Continuous exposure to B.t. toxicant is required and therefore long leaf life would appear essential.

FP-2 Mycology

The 1981 budworm season in Ontario was very wet and levels of fungal infection were substantially higher than in 1980. The peak fungal incidence coincided with peak 6th instar larval development and as many as 20% of larvae that were alive when collected were infected with Entomophthora sphaerosperma and E. egressa.

Resting spores of Entomophthora sphaerosperma were successfully germinated after the spores had been matured at low temperatures for several months. Conditions for germination and growth of conidia for this species are being studied as a prerequisite to the determination of its pathology to the spruce budworm.

In a collaborative research program, material infected by E. sphaerosperma and E. egressa was supplied to Dr. K.P. Lim of Newfoundland Forest Research Center for field application. No transmission of E. sphaerosperma was obtained from disseminated conidia, but the disease did become established in certain populations treated with larvae infected by injection with E. egressa.

FP-3 Microsporidia

Studies with these parasites have concentrated on identifying methods of transmission within populations. It has been established that *Nosema fumiferanae* is transmitted perorally, transovarially or by injection among spruce budworm hosts. Increasing effort is being placed on host-parasite interactions and population effects. To this end, experimental plots have been established to determine effects of microsporidia on budworm populations.

FP-4 Viruses

1. Experimental application of spruce budworm polyhedrosis virus in Ontario.

   In collaboration with Ministry of Natural Resources staff, a total of 103 ha were sprayed in three high value stands, one each in Hearst, Chapleau and Kapuskasing districts. Dosages applied were 1.1×10^{12} PIB/ha in 9.4 L, 3.4×10^{12} in 18.8L, and 9.5×10^{11} in 9.4L, respectively. A fixed wing aircraft with Micronairs was used on the Hearst plot, while helicopters with boom and nozzle were used on the other two. Results in Chapleau and Kapuskasing were considered encouraging, with significant population reduction and some foliage protection.

2. Ground spray trials with NPV to control red headed pine sawfly *Neodiprion lecontei* (Fitch).

   Using sawfly NPV provided by the FPMI, Ontario Ministry of Natural Resources personnel conducted mistblower and hand sprayer applications in 65 red pine plantations in five districts. The results from these trials indicated that dosages ranging from 3.7×10^9 to 6.2×10^{10} PIB at application rates ranging from 0.9 to 50.0 L/ha were effective in controlling this pest when application timing was satisfactory.

   Nineteen plantations sprayed with this virus in previous years were sampled to determine incidence of the sawfly and its virus. Sawfly colonies were found in 5 of 19 plantations but no colonies were infected with NPV.

   A 3 ha red pine plantation near Thessalon, Ontario, was sprayed with 10^{10} PIB/ha at 30 L/ha when larvae were predominantly in the fourth instar. Subsequent harvesting and processing of diseased larvae yielded 2.2 kg of freeze dried powder. With a virus content of 10^{10} PIB/g this is enough to treat 4,400 ha at 5×10^9 PIB/ha.

3. Aerial applications of Nuclear Polyhedrosis Virus to Control European Pine Sawfly, *Neodiprion sertifer*

   In collaboration with Ontario Ministry of Natural Resources personnel and a private landowner, a 19.2 ha red pine plantation in Haldimand Twp. close to the Northumberland County Forest was aerially sprayed with *N. sertifer* NPV at a rate of 3.9×10^{11}

PIB in 9.4 ℓ per hectare. At time of application, egg hatch was complete and larvae were in 2nd and 3rd instars. At 13 days post spray almost complete larval mortality was observed, and the trees in the plantations suffered negligible defoliation.

FP-5 Pheromones

Identification of pheromones has continued, to develop a library of pheromones that can be used for survey purposes and/or for control experiments. The pheromone of the spruce coneworm *Dioryctria reniculelloides* has been tentatively identified but complete characterization awaits further field testing. For the eastern pine shoot moth, *Eucosma gloriola*, two chemical pheromone components have been identified which in the optimal ratio reduced trap catches by 50% in small scale field tests. Lures have been developed for the oak leaf shredder, *Croesia semipurpurana*, the maple leaf roller, *Cenopis acerivorana*, and the spruce seedworm, *Laspeyresia youngana*. These have proven useful in monitoring insect populations and are available for survey work.

FP-6 Insect Growth Regulators

Several new numbered compounds became available and were screened for activity against the spruce budworm in the laboratory and in greenhouse. All were less active than UC-62644 but three proved promising. Single tree test trials against the spruce budworm were also conducted with these compounds and their relative activity was similar to that found in greenhouse trials.

Single tree mistblower trials were conducted against the oak leaf shredder using Dimilin and Bay Sir 8514. Almost complete population reduction was obtained.

Using a mistblower, small Scots pine plots infested with white pine weevil were sprayed with Dimilin or Bay Sir 8514. Ovicidal effects were found with both compounds, indicating some potential for control of this pest.

Field Work Proposed for 1982

Field activities are planned in all of the projects described above. For viruses, fungi and protozoa, a significant component will be the determination of host-pathogen interaction in field populations. This study of the epizootiology of pathogens is considered essential to an understanding of how these pathogens exert their effect under natural conditions, leading to a much improved ability to manipulate them as effective population management tools. These studies will not be described in detail, as they involve no direct application of control agents on field populations.

Experimental field applications are planned for microsporidia, viruses, Insect Growth Regulators and pheromones.

The microsporidan Pleistophora schubergi has shown potential in the laboratory for the control of the larch sawfly, an insect for which no other biological control agent is available. In the coming year, this pathogen will be applied by hand sprayer to single trees infested with this sawfly to determine its efficacy in the field.

In previous years, second instar spruce budworm larvae have been found to be very susceptible to NPV. Because mortality is advanced due to earlier infection, foliage protection can be obtained. To determine the efficacy of early instar spraying, multiple applications will be made at pre-emergence, early emergence and mid-emergence. Other plans include follow up studies on plots sprayed with NPV in 1981, and comparison of the western with the eastern spruce budworm as a host for virus production. FPMI presently has reasonable supplies of both Granulosis virus and NPV, and these can be made available for experimental use against either eastern or western spruce budworm if requests are made by provincial governments.

Further ground sprays tests of virus against the red headed pine sawfly will be aimed at optimizing application rate dosages and timing to provide recommendations that maximum protection and minimize cost. The European pine sawfly, Neodiprion sertifer, is not presently an economically important pest in Ontario, but a supply of virus is maintained at the FPMI for future use if the need arises.

The pheromone blend identified for Eucosma gloriola has proven effective in reducing trap catches, and next year mating disruption tests will be carried in small (2-20 ha) isolated pine plantations. Additional work will also be carried out to refine the lure mixture developed for the spruce seedworm, Laspeyresia youngana.

Single tree tests have indicated that BAY SIR-8514 is an effective control agent for the oak leaf shredder. Three experimental applications will be made in the Huronia district of Ontario, at 35, 70 and 140 g AI per hectare. A fourth 20 hectare plot will be treated with Sevin-4-Oil at 350 g AI in 4.7ℓ 7-N oil per hectare as a positive control. For the white pine weevil, spring emergence will be closely monitored, in order that mistblower spray application can be fine tuned for optimal control.

In concluding, I would like to reaffirm a new emphasis that is being placed at FPMI in the development of the control agents discussed above. It is becoming abundantly clear that effective use of not only microbial agents but also pheromones and Insect Growth Regulators will require a much better understanding of the interaction of the agent with the pest insect in the field. For this reason we are initiating epizootiological studies with viruses, fungi and protozoa that will elucidate the host-pathogen interaction as well as identify how and where these organisms carry over in the field. With this knowledge we will be much better equipped to use these agents in a manner that takes into account their specific modes of action and requirements.

PROPOSED FIELD TRIALS FOR 1982

MICROSPORIDA	HAND SPRAYER APPLICATION OF *Pleistophora schubergi* AGAINST THE LARCH SAWFLY	FPMI STAFF
VIRUSES	PLANS	COOPERATORS
SPRUCE BUDWORM	MULTIPLE APPLICATIONS OF NPV ON SECOND INSTAR LARVAE AT PRE-EMERGENCE, FIRST EMERGENCE, MID-EMERGENCE.	FPMI STAFF
RED HEADED PINE SAWFLY	GROUND TRIALS TO OPTIMIZE APPLICATION RATES, TIMING AND DOSAGE TO PROVIDE SET OF RECOMMENDATIONS WHICH MAXIMIZE PROTECTION AND MINIMIZE COSTS.	OMNR STAFF
PHEROMONES	SMALL SCALE (2-20 ha) PINE PLANTATION TEST OF MATING DISRUPTION AGAINST THE EASTERN PINE SHOOT MOTH *Eucosma gloriola*.	FPMI STAFF
INSECT GROWTH REGULATORS -	AERIAL APPLICATION OF BAY SIR-8514 AT 35, 70 and 140 g AI/ha AGAINST THE OAK LEAF SHREDDER IN HURONIA DISTRICT.	GLFRC-FIDS TO LOCATE PLOTS
	GROUND APPLICATION OF BAY SIR-8514 AGAINST THE WHITE PINE WEEVIL. DOSAGE ABOUT 280 g/ha.	OMNR STAFF FOR PERMISSION AND ADVICE.

AERIAL APPLICATIONS OF NUCLEAR POLYHEDROSIS VIRUS TO CONTROL EUROPEAN PINE SAWFLY, *Neodiprion sertifer*, in Ontario in 1981

(Study Ref. No. FP-4)

Report to the Annual Pest Control Forum

by

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Sault Ste. Marie, Ontario

December 1981

EXPERIMENTAL APPLICATION

In collaboration with Lindsay District O.M.N.R. staff and the private landowner, a 19.2 ha red-pine plantation located in Haldimand Twp. close to Northumberland County Forest was treated experimentally with nuclear polyhedrosis virus (NPV) to control an outbreak of European Pine sawfly, *Neodiprion sertifer* Geoff. Preliminary assessment of the plantation revealed a moderate population level of sawfly having an average density of one larval colony per tree. Tree height ranged from 1.0 to 1.5 m.

On May 26, at 0625 hr (RH. 100% : 14°C) *N. sertifer* NPV was applied aerially at a concentration of 3.9×10^{11} PIB/ha by a Piper Super Cub equipped with a boom and nozzle spray system calibrated to deliver 9.4 ℓ/ha. The spray mixture consisted of an aqueous suspension of polyhedra plus 0.04% Rhodamine B dye as a tracer. At the time of application, all sawfly egg clutches had hatched and larvae were in the 2nd and 3rd instars.

Examination of Kromekote® cards placed throughout the plantation indicated that an average deposit of 16.5 ± 9.9 droplets/cm^2 was achieved with 65.5% of these droplets being below 250μ in size (range <75μ- 450μ). Assessment of the impact of the virus spray, carried out 13 days post-spray, revealed that almost complete larval mortality had been achieved. Larvae died in the 3rd and 4th instar, and those few colonies still present on the trees were observed to contain moribund larvae. Laboratory diagnosis of cadavers collected from the trees and of a number of living larvae confirmed the presence of virus infection. The trees in the plantation suffered negligible defoliation.

PLANS for 1982

European pine sawfly, at present, is not an economically important pest in Ontario. A supply of nuclear polyhedrosis virus is maintained at the Forest Pest Management Institute in collaboration with O.M.N.R. staff. When a need for control measures arises, this material can be made available.

EXPERIMENTAL GROUND SPRAY TRIALS WITH NUCLEAR POLYHEDROSIS VIRUS TO CONTROL RED-HEADED PINE SAWFLY, *NEODIPRION LECONTEI* (Fitch) IN ONTARIO

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

Report to the Annual Forest Pest Control Forum

by

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Forest Pest Management Institute

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Sault Ste. Marie, Ontario

P6A 5M7

December 1981

ANNUAL FOREST PEST CONTROL FORUM REPORT - 1981

Experimental ground spray trials with nuclear polyhedrosis virus to control red-headed pine sawfly, *Neodiprion lecontei*, in Ontario

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Forest Pest Management Institute
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SUMMARY

Ontario Ministry of Natural Resources personnel in five districts conducted ground spray applications with mistblowers and hand sprayers and treated 65 red pine (*Pinus resinosa* Ait.) plantations (total area 759.2 ha) with nuclear polyhedrosis virus to control red-headed pine sawfly. Generally, the results from these trials indicated that the virus is effective at dosages ranging from 3.71×10^9 to 6.18×10^{10} polyhedral inclusion bodies/ha and at application rates ranging from 0.9 to 50.0 L/ha.

Surveys were conducted on 19 plantations aerially sprayed between 1976 and 1980. Sawfly populations of 2 colonies/100 trees or less were found in five plantations. All colonies were observed to be virus-free.

INTRODUCTION

A nuclear polyhedrosis virus (NPV) which infects red-headed pine sawfly (*Neodiprion lecontei* Fitch) was discovered in Ontario in 1950. Since that time, ground and aerial spray trials have been conducted in Ontario and Quebec. It has been established that the virus is highly infectious to the sawfly, that it can be successfully introduced into a sawfly population, and that the virus can be transmitted to the next generation. From 1976 to 1980, Forest Pest Management Institute (FPMI) personnel conducted aerial spray trials to determine optimum application rates, dosages, formulations, and spray strategies. Results from these spray trials showed that a virus dosage applied at 5×10^9 polyhedral inclusion bodies (PIB) per hectare, whether formulated with or without a UV protectant, and whether applied at 9.40, at 4.70 or at 2.35 L/ha provided complete control of the sawfly, when larvae were in the 1st, 2nd or 3rd instar. Also, the virus has been found to be effective at dosages ranging from 1.25 to 6.25×10^9 PIB/ha, it can spread from diseased to healthy colonies and from treated to untreated areas, and complete coverage of a plantation is not necessary for the virus to give control.

Surveys of the areas aerially sprayed in Ontario have been undertaken since 1977 to determine the level of re-infestation of the sawfly, and if sawfly were present to ascertain if they were infected with NPV. All treated areas remained free from infestation in subsequent years until 1979 when low, virus-free populations were found in plantations treated in 1977. In 1980, three out of eleven previously treated plantations were found to have low sawfly population levels (less than 2 colonies per 100 trees), and of these, one plantation treated in 1977 contained one virus-infected colony out of 7 colonies found.

This report summarizes experimental ground spray trials using the NPV to control red-headed pine sawfly conducted in Ontario in 1981, and the results of a survey of the areas aerially sprayed in Ontario in previous years.

GROUND SPRAY TRIALS

Ground spray trials were conducted in 1981 with handsprayers and mistblowers by Ontario Ministry of Natural Resources (OMNR) staff in Algonquin, Bancroft, Parry Sound, Pembroke and North Bay Districts. FPMI staff supplied each district with a concentrated suspension of virus, along with general instructions for its use and methods for determining its effectiveness. OMNR staff conducted pre-spray surveys to determine which plantations required treatment, carried out the spray operations, and in most cases conducted a post-spray survey to ascertain the effectiveness of the virus treatment. Each district was asked to fill out a questionnaire (Figure 1) about the plantation (size, tree height and age), the spray application (date applied, total volume of virus concentrate used, application rate and equipment used, method of application, and predominant sawfly instar at time of application), and about post-spray results (percent virus-killed, number of colonies observed, and condition of living colonies remaining). Furthermore, each district was asked for an overall comment on the use of the virus and to provide suggestions for improvement. A summary of some of the results from this questionnaire is presented in Table 1.

The results obtained from the ground spray trials were very satisfactory. Virus-killed larvae were observed in many of the treated plantations. Even though a variety of dosages, application rates, equipment, and application techniques were used, the virus was still effective in controlling the sawfly. Complete sawfly control was not achieved in a few plantations. Incomplete control was attributed to two factors: (1) the plantations were sprayed when sawfly larval development was too advanced, and/or (2) the plantations were treated before complete adult emergence, oviposition and egg hatch had occurred. This second factor makes timing of the spray operation very difficult and in some cases two or more applications may be necessary.

SURVEY OF ACRES TREATED IN PREVIOUS YEARS

The results of a survey conducted to determine the level of sawfly re-infestation and virus persistence in plantations treated since

1976 are shown in Table 2. Sawfly colonies were found in five out of 19 plantations and no colonies were infected with NPV.

VIRUS PRODUCTION

A 3 ha red pine plantation in Rose Twp. north of Thessalon, Ontario, was selected by FPMI staff as a site for production of red-headed pine sawfly NPV. The trees were about 2 m high and several had as many as 6 colonies per tree. At the time of application on July 27, larvae were predominantly in the fourth instar. Mistblowers were used to apply the aqueous suspension, the dosage was 10^{10} PIB/ha and the emitted volume was about 30 L/ha. Collections of diseased and dead larvae commenced 11 days post-spray, reached a peak at 15 days, and continued for 30 days until all the larvae had died or pupated.

The larvae were picked-off the foliage and frozen immediately after collection. They were then freeze-dried and ground to a powder. A total of 2,200 g of this material was obtained with 10^{10} PIB/g. This is sufficient to treat 4,400 ha at a dosage of 5×10^9 PIB/ha and is more than adequate to fulfil client's requirements in 1982.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results obtained this year, and on trials conducted previously, it is quite clear that red-headed pine sawfly NPV is very efficaceous, and that it is a valuable alternative to chemical insecticides. The virus can be effectively applied with a mistblower or hand sprayer by directly spraying individual sawfly colonies or, indirectly, by spraying the trees either singly, in clusters or in rows. Depending on the wind speed, the row method takes advantage of the prevailing wind and lets the virus spray drift in to cover an additional 1 to 5 rows of trees.

The application volume can vary from a very low rate of 0.9 L/ha to a high rate of about 50 L/ha, depending on the level of infestation, larval development, and application equipment. High population levels, advanced larval development, and the use of mistblowers generally will require a higher application rate. The number of polyhedral inclusion bodies (active ingredient) applied will also vary with the application rate (from 3.71×10^9 to 6.18×10^{10} PIB/ha).

A problem that arose in many districts this year was one of early detection of the sawfly. There were several contributing factors, and of these, three seem to be the most significant: (1) inexperienced staff who did not recognize early feeding damage; (2) lack of staff to carry out the survey; (3) adult sawfly emerging from early June through to late September. These problems are not insurmountable, and can largely be corrected by having an adequate and properly trained staff to monitor the plantations.

In March 1981, a petition for the registration of this virus under the Pest Control Products Act (Canada) was submitted to the Plant Products Division, Agriculture Canada. This petition is currently being evaluated.

PLANS FOR 1982

1. Although the results from this year's ground spray application were satisfactory from an insect control point of view, it is felt that additional work on the timing, application rates, and dosages is necessary to optimize our recommendations for application of this virus from the ground. In essence, what we hope to achieve is a set of recommendations for a variety of stand conditions in which we maximize sawfly control, and crop protection, and at the same time minimize the cost of the operation.

2. A survey of the areas aerially sprayed since 1976 will be continued to determine red-headed pine sawfly population densities. In those areas where sawfly are found, epidemiological studies will be conducted to determine if the virus has persisted.

3. An attempt will be made to improve the formulation of the concentrated virus material which is distributed to clients. An emulsifiable oil formulation is currently being investigated.

4. Virus material will be available for use by provincial government forestry officials who have problems with red-headed pine sawfly infestations in their districts. If Registration has not been granted by that date, an application for an Experimental Permit must be made.

Fig. 1. RED-HEADED PINE SAWFLY VIRUS CONTROL PROGRAMME QUESTIONNAIRE

DISTRICT: ____________________

LOCATION: ____________________

Plot Number* ________ Township: ____________ Lot No.: ________ Conc. No.: ________

PLANTATION DESCRIPTION:

Year Plantation Established: ________ Species Composition (%): ____________

Aver. Tree Height: ____________ Size of Plantation (ac) ____________

Tree Spacing: ____________

SPRAY APPLICATION:

Date of Application: ________ Actual Area Treated (ac): ____________

Volume of Virus Concentrate Used (ml): ____________

Volume of Virus-spray Applied per Ac (gal/ac): ____________

Application Equipment Used: ____________

Method of Application (e.g. - spot spraying individual colonies or sprayed entire tree, etc.): ____________

Sawfly Instar Stages At Time Of Application (%)

L_1 ________ L_2 ________ L_3 ________ L_4 ________ L_5 ________ L_6 ________

Number of colonies observed to compute above: ____________

Average Number of Colonies Per Tree In Virus-treated Area: ____________

Number of Colonies Observed To Compute Above: ____________

POST-SPRAY RESULTS

(Conduct Survey Approximately 2 Weeks After Spray).

Date Surveyed: ____________

Number of Dead Colonies Observed: ____________

Number of Colonies Observed With Living Insects: ____________

(also note condition of living insects e.g., active, not feeding, pale, etc.)

Additional Comments: ____________

*Please attach map indicating location of plantation by Plot No.

Table 1. Summary of experimental applications of NPV for control of red-headed pine sawfly in Ontario in 1981

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	2	72.9	72.9	Mist Blower	Row Spraying	16.8 - 24.7	4.88×10^{9} - 7.98×10^{9}
Bancroft	20	236.6	56.8	Mist Blower Hand Sprayer	Row Spraying, spray entire tree and/or sawfly colony	3.9 - 49.4	4.94×10^{9} - 6.18×10^{10}
Parry Sound	37	392.5	392.5	Hand Sprayer	Spray entire tree and/or sawfly colony	No data available	4.66×10^{8} - 2.16×10^{10}
Pembroke	1	9.1	6.5	Hand Sprayer	Spray entire tree and/or sawfly colony	6.8	8.36×10^{9}
North Bay	5	48.1	47.3	Mist Blower Hand Sprayer	Row Spraying, spray entire tree and/or sawfly colony	0.9 - 7.4	3.71×10^{9} - 1.36×10^{10}
TOTAL	65	759.2	576.0				

Table 2. Survey of red-headed pine sawfly population densities in plots treated between 1976 and 1980.

Year treated	Plot No.	Location	No. of colonies/ no. of trees examined
1976	1	Lindsay	0/400
	2	Lindsay	3/400
	3	Lindsay	0/400
1977	1	Renfrew	3/400
	2	Renfrew	0/400
	3	Richmond	2/400
1978	1	Tweed	0/400
	2	Tweed	8/400
1979	1	Pembroke	0/400
	2	Pembroke	1/400
	3	Pembroke	0/400
1980	1	Minden	0/400
	2	Minden	0/400
	3	Minden	0/400
	4	Minden	0/400
1980	1	Bancroft	0/200
	2	Bancroft	0/200
	3	Bancroft	0/200
	4	Bancroft	0/200

EXPERIMENTAL AERIAL SPRAY TRIALS WITH SPRUCE BUDWORM NUCLEAR POLYHEDROSIS VIRUS IN ONTARIO

(Study Ref. No. FP-4-3 and GLC-09-042)

Report to the Annual Forest Pest Control Forum, Ottawa

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ANNUAL FOREST PEST CONTROL FORUM - 1981

Experimental aerial spray trials with spruce budworm nuclear polyhedrosis virus in Ontario.

Summary

In collaboration with OMNR staff, three high value stands, one each in Hearst, Chapleau and Kapuskasing Districts (total area 108 ha) were aerially sprayed with nuclear polyhedrosis virus at budflush to control spruce budworm. A fixed-wing aircraft fitted with Micronair® equipment was used to treat one area and the remaining two were treated with a helicopter fitted with boom and nozzle. The intended dosage on one area was 2.5×10^{12} polyhedral inclusion bodies (PIB)/ha in a volume of 18.8 L/ha and on the remaining two it was 7.5×10^{11} PIB/ha in a volume of 9.4 L/ha. The actual dosages were all slightly higher when the tank mixes were analysed. The aqueous suspensions of virus contained 25% molasses, 0.2% Chevron® sticker and 0.04% Rhodamine B dye.

To assess these treatments, pre-spray and post-spray population counts were made, levels of virus infection in larvae determined microscopically and current year's defoliation estimated. Generally, results were considered acceptable on the two areas treated with the helicopter and poor on the area treated with the fixed-wing aircraft.

Introduction

Four types of inclusion body viruses have been found to infect spruce budworm larvae. These are a nuclear polyhedrosis virus (NPV), a granulosis virus (GV), a cytoplasmic polyhedrosis virus (CPV) and an entomopoxvirus (EPV). Field trials have been conducted every year in Ontario since 1971 and all these viruses have been tested either alone or in combinations. The total area treated to date is about 2,400 ha. An additional 104 ha were treated with chemical insecticides followed by applications of virus.

Such parameters as dosage, emitted volume, formulation, timing of application, spray equipment and impact on balsam fir compared to white spruce hosts have been studied. Most of these trials have been conducted with NPV and following the trials in 1978, a dosage of 7.5×10^{11} PIB/ha was recommended. The best aqueous tank mix tested contained 25% molasses, 6% Sandoz Shade® (a U.V. protectant which is no longer available) and a sticker, with an application time at budflush on fourth and fifth instar larvae. Since then encouraging results were obtained with treatment of second instar larvae as they emerged from hibernacula.

In 1981, it was decided that, in collaboration with OMNR staff, semi-operational tests of NPV be conducted on high value stands in three Districts. These tests were carried out at the same time as other control operations when chemical insecticides and *B.t.* were applied.

Virus Production

Only GV was produced in the winter months of 1980/81. A total of 1.8 million fifth instar spruce budworm larvae were infected, harvested and processed. Most was produced in eastern spruce budworm, but some was produced in the western species, the latter being more uniform in size and easier to handle in laboratory culture because they produce less silk webbing. This operation produced 9.0 kg of powder, prepared from lyophilized, infected larvae, which contained 1.92×10^{12} capsules/g.

The NPV used in the 1981 trials was produced in 1978/79 and 1979/80. This material contained 10^{10} PIB/g. It also contained a trace of CPV with the ratio of NPV:CPV being about 300:1.

Treated Areas

1. Hearst District. The 28 ha plot in Rogers Twp. had been cutover and planted with white spruce which ranged in height from 1 m to 6 m. There were also naturally regenerated balsam fir trees which were 4 m to 6 m tall.

2. Chapleau District. The 12 ha plot in Reeves Twp. was a natural stand of mature white spruce which had been selected as a seed orchard. Some of the balsam fir had been cut, but others remained around the edges of the area. This stand has a history of chemical insecticide and *B.t.* treatments for spruce budworm control, but still had a high insect population. It was selected to test a dosage of NPV which was higher than the current recommendation.

3. Kapuskasing District. The 68 ha plot was part of a larger black spruce and white spruce plantation in Idington Twp. close to Beartooth Lake. Trees ranged in height from 3 m to 5 m.

Spray Operation, Results and Discussion

The virus preparations were formulated in an aqueous suspension containing 25% molasses, 0.2% Chevron® sticker and 0.04% Rhodamine B as a tracer. Two types of aircraft were used: a fixed-wing aircraft fitted with four Micronair® AU 3000 units and a helicopter with boom and nozzle equipment. A description of the plots, treatments, spray dates and deposits is given in Table 1. Counts of the actual number of PIB in the tank mixes revealed that the dosages applied were slightly higher than had been intended. In order to deliver 18.8 L/ha on plot #2, it was sprayed twice with flight lines of the second application being at right angles to the first.

The droplet sizes measured on Kromekote® cards differed considerably with the two types of equipment. With Micronair, 54% of the droplets were less than 75 mµ in diameter and the remainder were less than 250 mμ. With boom and nozzle equipment on the helicopter, the droplets were much coarser. Most were less than 450 mμ but they ranged in diameter up to 850 μm.

The applications were made at budflush on balsam fir and white spruce trees and budworm larvae were at the peak of the fourth instar. However, the buds on black spruce trees in plot #3 had not flushed and larvae were at the peak of the third instar.

Three methods were used to assess the impact of the NPV treatments:

(i) Larvae were removed from samples of foliage collected from treated and check plots about 14 days post-spray and smears of tissue were examined microscopically for the presence of viruses and microsporidia.

(ii) Population studies were conducted on 46 cm branch tips collected before the application (pre-spray) and when most of the larvae had pupated (post-spray). On plot #1, 15 branch samples were taken from balsam fir and 15 from white spruce. Fifty samples from each species were taken from the check plot. On plot #2, 25 samples were collected from each white spruce and balsam fir and the same number from the corresponding check plot. The same number of samples was taken from plot #3, but black spruce instead of balsam fir was sampled. Population reduction due to treatment was calculated using a modified Abbott's formula.

(iii) Defoliation estimates were made from foliage samples collected for the post-spray population count.

Forest Pest Management Institute and Great Lakes Forest Research Centre staff collaborated in conducting this assessment with FPMI staff recording (i) and GLFRC (ii) and (iii).

Results are shown in Table 2. The poorest results were obtained in Hearst District where levels of virus infection were low; 19% population reduction was recorded on white spruce hosts, none on balsam fir and no foliage protection was recorded. This plot was sprayed with Micronair equipment which gave more droplets/cm^2 than boom and nozzle, but these droplets were much smaller. Better levels of virus infection were recorded in Chapleau District where 40% population reduction was obtained on balsam fir hosts and 90% on white spruce. There was some foliage protected on balsam fir, but none on white spruce. There was a high population of spruce coneworm, *Dioryctria reniculelloides*, on the white spruce and a pre-spray examination showed the ratio of spruce coneworm to spruce budworm was 6:4. Spruce budworm NPV does not infect spruce coneworm, so the virus treatment had no effect on this species. Results in Kapuskasing District were also encouraging, although spruce budworm populations were quite low in this plantation. Considering that the buds on black spruce had not flushed at the time of application, a level of 46.5% NPV-infected larvae was surprisingly high. Small population reductions and some foliage protection were recorded on both black and white spruce hosts.

Although the NPV preparation which was applied contained traces of CPV, only very low levels of this virus were found in larvae from one tree species only in two of the plots. Generally, as a spruce budworm population ages, levels of infection with the microsporidian parasite *Nosema fumiferanae* increase. Levels of larval infection with microsporidia were lowest in Kapuskasing District, slightly higher in Hearst District and highest in Chapleau District where the spruce budworm infestations had been present for the longest time. It is suspected that the presence of microsporidia is antagonistic to NPV infection and this should be critically examined in the laboratory.

Conclusions and Recommendations

Results of the 1982 NPV trials were considered encouraging on two of the three areas treated. Since virus remains overwinter in cadavers, webbed-up in nests on the foliage and PIB may be gradually leached from these cadavers to contaminate foliage the following year, these areas will be re-examined in 1982 to determine the effects of persisting virus on the next generation of spruce budworm. There is no evidence of transmission of any spruce budworm virus by the adult female which is unfortunate since ovarial transmission may be a particularly effective means of initiating an epizootic and spreading the virus beyond the treated areas. To date, spread from treated areas has been observed to be very limited.

The 1981 trials were conducted in close cooperation with OMNR staff and applications of NPV were timed at budflush because aircraft were on site for chemical and *B.t.* applications. In 1979 and 1980, virus applications were made on second instar larvae. The timing was perfect in 1979 and larvae were sprayed as they emerged from hibernacula and wandered on the foliage. The application was a little too late in 1980 as most of the larvae had already mined into needles and buds. It is considered that early application may be the best timing for NPV because 1) second instar larvae are much more susceptible to virus infection than fourth and fifth instars, 2) there is a possibility that secondary infection will occur when these small larvae die, rupture and release PIB which contaminate the foliage, 3) at this time of year leaves on the hardwood overstory, frequently found in spruce/fir stands, have not flushed, and 4) it is possible that foliage protection will be obtained in the year of application. Timing of such applications is, of course, extremely critical, only small areas can be treated, they must be closely monitored and they must be accessible in late April.

Production costs of spruce budworm virus are still high. To prepare the recommended dosage of NPV of 7.5×10^{11} PIB/ha it is necessary to rear, infect, harvest and process 7,500 eastern spruce budworm larvae. Use of western spruce budworm larvae as hosts is currently being investigated. This may reduce costs, but not dramatically because the operation is labour intensive. With these high production costs, the use of NPV can only be justified if it exerts a regulating effect on the spruce budworm population for longer than the year it is applied. The high cost and limited availability restrict the use of NPV to high value stands and ecologically sensitive areas, and its development as a biocontrol agent is considered to be at the experimental stage. There is a continuing search for more virulent viruses and improved formulations. A long-term goal is the genetic manipulation of spruce budworm NPV to render it more virulent or the manipulation of another virus to render it capable of infecting spruce budworm.

Laboratory tests have shown that both NPV and GV are considerably more pathogenic to western spruce budworm than to the eastern species. This, plus the limited, clearly defined areas infested with western spruce budworm and the fact that it is virtually free from microsporidia, make it a more promising candidate than the eastern species for population regulation with viruses.

Plans for 1982

1. If suitable plots can be located close to Sault Ste. Marie, multiple applications of NPV on second instar larvae are planned. These will be made prior to emergence from hibernacula, when the first larvae are observed wandering on the foliage and then a few days after the second treatment, depending on temperature.

2. Follow-up studies are planned for the three areas treated with NPV in 1981.

3. Western spruce budworm larvae are in cold storage for NPV production during the winter months of 1981/82. It will be compared to the eastern species as a host for virus production.

4. There are reasonable stocks of both NPV and GV, produced in previous years. These can be made available for treatment of either eastern or western spruce budworm larvae if requests are made by provincial government forestry officials and Experimental Permits granted.

5. A laboratory study to determine the interaction of NPV and microsporidia in spruce budworm larvae was proposed last year, but was never undertaken. It is hoped to conduct this experiment in the winter months of 1981/82.

Table 1.
Plots sprayed with nuclear polyhedrosis virus to regulate spruce budworm in Ontario in 1981

Plot	OMNR District	Area (ha)	Virus dosage PIB/ha emitted and (intended)	Emitted volume L/ha	Spray equipment	Date of Application	Deposit droplets/cm²
1	Hearst	28	1.1×10^{12} (7.5×10^{11})	9.4	Fixed-wing with Micronair®	12 June evening	47
2	Chapleau	12	3.4×10^{12} (2.5×10^{12})	18.8	Helicopter with boom and nozzle	14 June evening	20
3	Kapuskasing	68	9.5×10^{11} (7.5×10^{11})	9.4	Helicopter with boom and nozzle	17 June morning	22

Table 2.
Impact of nuclear polyhedrosis virus sprayed on spruce budworm in Ontario in 1981

OMNR District	Plot	Tree species	Number of larvae examined microscopically	% larvae infected NPV	CPV	Microsporidia	Pre-spray larval population no./46 cm branch tip	Surviving pupae/ 46 cm branch tip	% Population reduction due to treatment	% Current year's defoliation
Hearst	1	bF	244	7.8	0	11.1	19.9	8.9	19	82
	Check 1	bF	88	0	0	18.2	8.3	4.6	–	55
	1	wS	199	6.5	0	17.1	19.3	5.6	0	43
	Check 1	wS	17	0	0	23.5	10.7	1.6	–	9
Chapleau	2	bF	190	25.3	2.6	42.6	14.7	2.2	40	61
	Check 2	bF	79	0	0	41.8	11.8	4.4	–	77
	2	wS	13	23.1	0	61.5	9.1	0.6	90	61
	Check 2	wS	41	0	0	56.1	6.3	3.7	0	41
Kapuskasing	3	wS	153	28.1	0	9.8	5.7	0.4	35	8
	Check 3	wS	38	0	0	7.9	7.0	0.7	–	11
	3	bS	71	46.5	1.4	8.5	1.2	0.2	33	5
	Check 3	bS	94	0	0	1.1	1.6	0.4	–	19

INSECT SEX PHEROMONES

(Study Ref. RP-5)

Report to the Annual Forest Pest Control Forum

by

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During the past year, sex pheromone work at FPMI has been involved with the development of a novel bioluminescent assay using bacterial luciferases for quantitatively measuring aldehyde sex pheromones of insects. In addition, pheromone identification studies have continued on the spruce coneworm, Dioryctria reniculelloides; the eastern pine shoot moth, Eucosma gloriola; the maple leaf roller, Cenopis acerivorana; the spruce seedworm, Laspeyresia youngana; and the western budworm, Choristoneura occidentalis, among others.

Results and Future Work

1. Bioluminescent Assay:

In collaboration with Dr. E.A. Meighen (McGill) and Dr. K.N. Slessor (Simon Fraser), we have discovered that bacterial luciferases can be used to quantitatively measure nanogram levels of aldehyde pheromones of 12-16 carbon chain lengths. This chain length specificity fortuitously encompasses the majority of aldehyde sex pheromones of Lepidoptera, including the sex pheromone components ((E)- and (Z)-11-tetradecenal) of the spruce budworm. The assay is now fully developed and has been used to measure the pheromone release rate of female spruce budworm moths (>40 ng/evening) or the pheromone release rate of lures used in budworm pheromone traps or pheromone formulations used for mating disruption of budworm. These measurements were achieved by coupling the assay with pheromone entrainment on Porapak Q or in cold traps. The advantages of the assay are its high sensitivity, accuracy and rapidity. A lure release rate can be obtained within 1-2 hours for rates as low as 10 ng/h.

2. Pheromone Identification:

(a) Dioryctria reniculelloides: The tentative sex pheromone components of this species, identified by GC in cooperation with Dr. K.N. Slessor, were field tested in 1981. The major component was attractive by itself and apparently was not synergized by the minor component. Since the major component was not as attractive as expected, additional field tests and GC analysis will be carried out in 1982 to complete the identification.

(b) Eucosma gloriola: Field screening tests of candidate pheromone compounds reveal two chemicals that in the proper ratio were highly attractive to this insect. The optimal ratio was determined and this mixture was used in a small mating disruption trial to determine the feasibility of controlling the insect. In 315 m^2 plots, very small quantities of the pheromone (equivalent to 0.03 g AI/ha) dispensed into the atmosphere reduced trap catch in the treatment area by 50% compared to check plots. Thus at much higher dosages, it is expected that both population and damage reduction can be achieved in small (2-20 ha) pine plantations. Such an experiment is planned for the near future.

(c) Croesia semipurpurana: Field tests in 1981 confirmed the 1980 results that the 85:15:100 mixture of (E)- and (Z)-11-tetradecenal and tetradecyl acetate is a highly attractive lure for this insect in Ontario. Cooperative studies are continuing with Dr. P. Silk, RPC, to identify all the components released by the female. In the meanwhile, the 85:15:100 lure is available for survey work.

(d) Cenopis acerivorana: Through collaboration with Dr. K.N. Slessor, the female sex pheromone of this pest of maples was shown to contain at least six chemicals. Only three of the components, (Z)- and (E)-11-tetradecenal and (Z)-11-tetradecenyl acetate, are necessary for optimal attraction. The pheromone mixture is available for monitoring the insect population.

(e) Laspeyresia youngana: The sex pheromone of this insect has not been identified but a mixture of (Z)-7-dodecen-1-ol and its congener acetate are attractive. However, in cooperation with Dr. W. Fogal, we have shown that other mixtures of dodecen-1-ol and dodecenyl acetate are equally attractive to this insect. Nonetheless, both mixtures have proved useful for monitoring this insect in Ontario. The trap catches are being correlated with insect emergence, levels of cone infestation and weather. This study will continue in order to produce a meaningful monitoring tool for this species. In addition, the anomalous trapping results with the different chemicals will have to be resolved.

INSECT GROWTH REGULATORS

(Study Ref. No. FP-6)

Report to the Annual Forest Pest Control Forum

by

Arthur Retnakaran

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INSECT GROWTH REGULATORS

by

Arthur Retnakaran

INTRODUCTION

Benzoyl ureas and juvenile hormone analogs can be used to disrupt the normal growth and development in insects and for this reason have been referred to as Insect Growth Regulators. Benzoyl ureas, directly orindirectly, inhibit chitin synthesis resulting in abnormal development of the integument and the effects are manifested during the moulting phase. Juvenile hormone analogs on the other hand, interfere with the larval-pupal metamorphosis of the last larval instar resulting in lethal, morphogenetic effects.

1. <u>Laboratory and Greenhouse Trials with New Moult Inhibitors</u>:

Several new moult inhibitors were available and they were tested against the spruce budworm in the laboratory and in the greenhouse for activity. When EL-413 (Eli Lilly & Co.), UC-70776, UC-70680 (Union Carbide), PH 60-43, and PH 60-44 (Duphar) were compared to UC-62644 (Union Carbide), they were all less active. EL-413, UC-70680, and PH 60-44 appeared promising.

2. <u>Single Tree Trials Against the Spruce Budworm at Hearst</u>

Using a spray unit attached to a pole, dosages equivalent to g in 4.7 l/ha (oz. in 0.5 U.S. gal/acre) were sprayed on single trees enclosed on all four sides. Several moult inhibitors were tested and the results are summarized in the following table.

Compound tested	Dosage g in 4.7 ℓ/ha (oz. in 0.5 U.S. gal /acre)	No. trees treated	$\bar{x}$ % Population reduction
UC - 62644	70 g (1 oz.)	10	97
UC - 70680	140 g (2 oz.)	10	84
PH - 60-44	280 g (4 oz.)	10	84
UC - 70680	70 g (1 oz.)	10	72
PH - 6043	280 g (4 oz.)	10	71
EL-413	70 g (1 oz.)	10	72
EL - 413	140 g (2 oz.)	10	65
UC - 70676	140 g (2 oz.)	10	61
PH - 6043	140 g (2 oz.)	10	51
UC - 70676	70 g (1 oz.)	10	41
PH - 6044	140 g (2 oz.)	10	Vandalized

. Ovicidal Control of White Pine Weevil

Benzoyl ureas such as Dimilin and BAY SIR-8514 when applied to adult weevils are transferred to the eggs resulting in the inhibition of the embryonic cuticle. Although the embryos develop fully, they are unable to eclose from the egg shell.

Laboratory studies indicated that when weevils were treated with Insect Growth Regulators, very few eggs hatched. Using a mistblower small Scots pine plots were sprayed with either Dimilin or BAY Sir-8514. There were very few larvae in the treated areas. This preliminary trial suggests that this method has potential. Further work, taking into account the biology of the insect, is planned.

Treatment (g in 0.75 ℓ/0.04 ha)	Population Estimate in 10 Trees: Trees with feeding punctures	Larvae and pupae
Dimilin 11.2 g x 2	3	26
Dimilin 11.2 g x 1	6	3
BAY SIR-8514 11.2 g x 2	7	46
BAY SIR-8514 11.2 g x 1	6	27
7 N oil (carrier)	8	163
No treatment	8	125

4. <u>Oak Leaf Shredder Trials</u>

All attempts to rear the Oak Leaf shredder in the lab area were unsuccessful. Therefore, based on the effect of IGRs on open feeders, preliminary trials were conducted using the mistblower. A 1% w/v suspension of the IGR in 7-N oil was sprayed to runoff. Population reduction was estimated using 46 cm branch tip samples prior to and after the spray operation. Branch samples from treated trees had virtually no Oak leaf shredder.

Treatment	No. Trees	Pre-Spray Sample	Post-Spray Sample	% Population reduction (Abbot formula)
Dimilin	10	8.6	0.05	99.4
BAY SIR-8514	10	11.7	0	100
Control	10	7.8	7.9	-

5. Proposed Trials for 1982 (Tentative)

i) Aerial spray application against the Oak leaf shredder with BAY SIR-8514. Three plots, 20 ha each in Huronia District will be sprayed in mid-May. The dosages will be 35, 70, and 140 g AI/ha. One 20 ha plot will be sprayed with Sevin-4-oil at 350 g AI in 4.7ℓ of 7-N oil per hectare as a positive control (Total = 4 plots).

ii) Ground spraying of BAY SIR-8514 for White pine weevil control. By closely monitoring the emergence of weevils from diapause, it is hoped that spray operation will be fine tuned for optimal control. The dosage will be around 280 g/ha.

6. Collaborators

i) GLFRC-FIDS personnel have assisted us in locating suitable plots to conduct all the field trials.

ii) OMNR personnel at Hearst and Iron Bridge provided us with all the facilities for conducting the spray operation.

FPMI Report on Studies Carried Out by the
Use Strategies and Environmental Concerns Program
1981

J.A. Armstrong
Program Manager

The Use Strategies and Environmental Concerns Program is made up of projects studying aspects of spray application, efficacy testing, environmental assessment, chemical accountability and herbicide testing. During the 1981 field season field research programs were carried out in New Brunswick and Ontario to assess the efficacy of new formulations and increasing application rates of already registered insecticides. Other projects within the program were involved in studies on formulation changes, screening of new insecticides and herbicides, deposit assessment and chemical accountability. A summary report for each project is appended. It must be acknowledged that in some cases full data analysis has not been completed and only partial results are available.

FP-9 Spray Kinetics and Physics

A field program in the Bathurst area of New Brunswick was carried out to study the targetability of spray droplets and to compare the collection efficiency of foliage and ground sample units. These studies were all carried out under field conditions and showed the wide variation in deposit that occurs on artificial sample surfaces and which are attributed to the physical characteristics of the tree stand, micrometeorological factors and the actual placing of the sample units. In a joint project with Dr. C. Himel (U. of Georgia) an inflight encapsulation formula was used to study droplet deposition patterns on Kromekote cards and tree foliage. This project also assisted other studies by the provision of information on the physical nature of spray formulations and spread factor data.

FP-12 Toxicology and Screening of Chemical Insecticides

This project carries out the initial screening studies for the selection of insecticides for forest insect control. A total of 15 insecticides and their formulations were tested for contact, stomach, stomach-contact and residual toxicity. The results are summarized in the project report. A new fenitrothion formulation known as Sumithion Flowable was also studied. This formulation which had physical properties to hopefully reduce spray drift was introduced into the screening process in 1981. Unfortunately, the product is not efficaceous and further work is required on the formulation.

FP-13 Field Efficacy, Chemical and Biological Pesticides

A new aminocarb flowable formulation was compared with the standard aminocarb formulation in a series of small block trials carried out in cooperation with FPL and MFRC in the Bathurst area of New Brunswick. This formulation, which is air milled aminocarb suspended in oil, can be applied as either an oil or water suspension. The flowable formulation was applied as both water and oil suspensions at 70 g AI/ha in 1.87 ℓ/ha; two types of oil, ID585 and Sunspray 6N were used as carriers for the standard Matacil 1.8D (OSC) which was also applied at the same rate. A check block of Atlox and water was also treated. The results of the applications showed that the airmilled Matacil was slightly more effective than the standard Matacil 1.8D in ID585 in protecting both balsam fir and white spruce and the use of Sunspray 6N as a carrier enhanced the efficacy of Matacil 1.8D as compared to ID585 as a carrier.

FP-14 Biological Control Strategies

The major thrust of this project in 1981 was to assess the response of spruce budworm larvae to a range of dosages of B.t. The materials used were Thuricide 32B and Dipel 88 which were applied at 10, 20, 40 and 80 BIU/ha in single applications at 9.4ℓ/ha and 2x10 and 2x20 BIU each at 4.7ℓ/ha. Sprays were applied to test plots in the Atikokan area of Ontario. The tests showed that the optimum effect was achieved at rates between 20-30 BIU/ha and that a double application is no more effective than a single application. An assessment of the effect of the Dipel 88 (oil base) on the budworm parasitoid population showed no detrimental effect.

FP-15 Environmental Impact of Pest Management Strategies -

This project was involved in two major studies; the first was a series of laboratory and field programs to assess the effect of the Matacil flowable formulation on non-target organisms of the forest ecosystem. Terrestrial arthropod studies carried out in New Brunswick showed that the flowable formulation exerted a slightly greater knockdown effect than the standard Matacil formulation and that the presence of 6N oil resulted in a more pronounced and diversified knockdown. Studies in Ontario on honeybee and wild pollinator impact showed no more impact than the standard Matacil formulations. Aquatic studies indicated that the flowable formulation was 60 to 80 times less toxic to rainbow trout than the standard Matacil formulation.

The second project of this group was the Icewater Creek project. In this study a forest ecosystem is being studied to gain information on the aquatic and terrestrial populations and to determine the nature and degree of inherent risk, the level of actual exposure and the response to forest pest management strategies. This project is in its second year and in 1981 a significant portion of the program was aimed at studying the pollen flow.

FP-16 Chemical Accountability of Pest Control Products -

The chemical accountability project completed comparison studies on the fate of the new aminocarb formulation in the forest ecosystem. The new flowable formulation generally exhibited the same residual life as the standard Matacil, any differences being attributed to the presence of oil as a carrier. Chemical degradation studies on chlorpyrifos-methyl showed that this product became strongly adsorbed onto flooded soil particles when it was introduced to water. The parent compound and its breakdown products were readily degraded with only 0.1 ppb remaining in water and 10 ppb remaining in soil after 83 days. In a series of collaborative studies with FP-15 the fate of aminocarb formulations applied to a trout stream was studied, the product was found to disappear rapidly from the water and no significant metabolites were found in the tissue of exposed fish.

Other chemical studies on deposit assessment, dyes, and analytical support are reported.

FP-19 Toxicology and Screening of Herbicides

This project became operational in the spring of 1981 and is geared to the search for potentially useful new herbicides. The work reported has been primarily the development of a test protocol and the screening of new compounds. To date 19 new compounds have been tested. Baseline test data are presented in the report.

Major projects and identified problems for 1982

The success of the new airmilled aminocarb formulation as an efficaceous environmental product indicates that this material is ready for an operational application in 1982. It is proposed that this material be applied in cooperation with a provincial operator to an operational spray block at the standard rate 70 gm AI/ha and the operational volume delivery rate. During the course of the application and after FPMI will intensively monitor its effects on the non-target organisms of the forest ecosystem.

In a cooperative program with CANUSA, FPMI will be involved in what is hoped to be the final series of tests with *Bacillus thuringiensis*. These tests are aimed to provide more data on volume of material to be applied for most effective use.

In 1981, FPMI was asked to recommend possible insecticides and application rates for protection of trees attacked by the spruce bud moth. At the time, because there was no registered material, it was necessary to submit a request to Agriculture Canada for a modification to an existing label. The time lost in receiving this approval meant that an effective application could not be made. This problem has again surfaced in that concerned forest managers in New Brunswick have asked to have a material ready in case there is a repeat outbreak in 1982. A review of the situation by FPMI and GLFRC staff confirms the lack of available data and the need for registered insecticides. The Institute's recommendation with respect to possible insecticides and their proposed use pattern is as follows.

It must be acknowledged that control of the insect will be difficult since the later larva is found under the budcap thus sprays must be applied early when the young larvae are exposed. Spray timing and effective coverage will be critical.

The pesticides registered for forestry use and which should be considered are:

A. Aerial application (in order of priority)
   1. Matacil and Fenitrothion at the current spruce budworm rates
   2. B.t. and acephate - nominally at spruce budworm rate but experimental work will be required.

B. Mistblower application
   1. Acephate 0.841 kg AI/ha (12 oz/acre)
   2. Dimethoate 0.420-0.560 kg AI/ha (6-8 oz/acre)
   3. Methomyl 0.140-0.210 kg AI/ha (2-3 oz/acre)

All of these sprays should be applied to tree wetness.

The Institute also feels that for these situations when provinces such as New Brunswick are investing heavily to improve their forests it is essential that new pesticides be considered. These applications should not be considered as the routine forestry application and for that reason the Institute feels that pesticides such as permethrin would be the ideal material. New compounds which should be considered are, in order of priority:

1. Permethrin
2. Methomyl
3. Carbaryl
4. Guthion
   -(Note Guthion is presently used in the U.S.A. for control of cone insects).

STUDIES IN SPRAY KINETICS AND PHYSICS IN CANADIAN FOREST PEST CONTROL PROGRAMS IN 1981

(Study Ref. No. FP-9)

Report to the Annual Forest Pest Control Forum

by

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Studies in Spray Kinetics and Physics

in Canadian Forest Pest Control

in 1981

by

Alam Sundaram

During the 1981 summer field season, the Spray Kinetics and Physics Section of the Forest Pest Management Institute carried out research in the two problem areas targetability of aerial sprays and uniform coverage of the spray plot. This research was undertaken in two projects: the first one was carried out in Bathurst (N.B.) in collaboration with the Chemical Accountability Section (Study Ref. No. FP-16) and Field Efficacy Research Section (Study Ref. No. FP-13) during the field-testing of the three aminocarb formulations. The second study was done in Searchmont, Ontario, as a cooperative CANUSA effort between scientists in University of Georgia in U.S.A. and in the Province of New Brunswick.

I. *Bathurst Study with Aminocarb Flowable Formulations*

(a) Droplet targetability

(a.1) Physicochemical properties: Droplet targetability is a function of physicochemical properties of the formulation and therefore laboratory data were collected on the three aminocarb formulations described in Study Ref. FP-16. Table 1, lists viscosity, density and surface tension values for the three formulations at different temperatures. Table 2 present spread factor data, while Table 3 lists rates of evaporation for the three formulations at defined experimental conditions.

a.ii) Droplet Spectrum: The efficiency of droplet targetability is related to droplet spectrum. Each target has a defined range of droplets which would have a high impaction efficiency. Kromekote cards were used for droplet sizing to obtain an approximate picture of the spectrum obtained at the ground level. Although this droplet spectrum does not represent the one that would be found on the conifer needles, this technique has been found to be an excellent one to compare different formulations under field conditions. Tables 4 and 5 present data from droplet sizing for the three aminocarb formulations, following first application.

b) Uniformity of Spray Coverage: Screening of aerial sprays by tree canopy is an observed phenomenon that causes non-uniform spray deposition at the tree canopy and at ground level. However microturbulence at and beneath the canopy is common in a forest leading to an increased canopy penetration and foliar deposition. Such microturbulences, also tend to equalize spray deposition on Kromekote cards placed in a forest clearing and under the tree canopy.

In the Bathurst study, spray deposition was assessed to find the variation in droplet and deposit densities within and between sampling stations. Tables 6 to 11 represent data obtained to investigate the uniformity of spray coverage, following first application.

II. *Searchmont Study with In-Flight Encapsulated Formulation*

Under the cooperative Canusa project, Dr. Himel's in-flight encapsulated formulation (vegetable oil, Atlox, water-soluble polymer and a tracer dye) was sprayed over a ~15 ha plot in Searchmont, Ontario. Following impaction, foliage samples and Kromekote cards were counted for encapsulated droplets. A summary of results is presented in Tables 12 to 16.

III. *Results and Discussion*

a) Bathurst Study: Aminocarb formulations

Droplet spectrum was narrow for the two low viscous formulations 180 FE and 180 FO but for the highly viscous spray mix 180 D it was wide (Figs. 1, 2 and 3, respectively. It appears that viscosity plays an important role in size spectrum of aerially sprayed droplets. From Tables 4 and 5 it is evident that with all formulations *ca.* 75% of the number of droplets and the volume were due to drops less than 85 μm in diameter indicating the importance of drop size to efficacy.

Wide variations were observed in droplet and deposit densities between sampling stations (Tables 6 to 11) with all formulations indicating the need to take a closer look at the spray application techniques in order to obtain a uniform spray swath pattern and to avoid excessive overlap of swaths. Within a sampling station however, variations in droplet and deposit densities were minimal indicating the role of microturbulence in equalizing spray distribution under the tree and in adjacent clearing.

b) Searchmont Study: Encapsulated Formulation

From Table 12, it is clear that under the conditions of the spray trial, the number of droplets observed on the spruce needle were very low, and were only slightly higher on Kromekote cards. This difference however was statistically significant ($P < 0.01$). Tables 13 to 16 and Fig. 4 indicate the significant differences between the relevant size spectra observed on foliage and on Kromekote card.

Bathurst Spray Trial

Table 1: Physico-chemical Properties of Three Aminocarb Spray Mixes

Spray mix	Property	Application	5°C	10°C	15°C	20°C	25°C
180 FE	Viscosity (cp)	First	2.94	2.58	2.12	1.80	1.54
		Second	2.83	2.29	1.97	1.91	1.65
	Density (g/ml)	First	1.0133	1.0125	1.012	1.011	1.010
		Second	1.011	1.010	1.009	1.007	1.006
	Surface tension (dyne/cm)	First	31.65	31.63	30.34	30.31	29.01
		Second	31.58	31.56	30.25	28.95	26.39
180 FO	Viscosity (cp)	First	5.36	4.24	3.48	3.23	2.80
		Second	3.88	3.26	2.96	2.65	2.29
	Density (g/ml)	First	0.842	0.838	0.835	0.832	0.829
		Second	0.865	0.861	0.858	0.854	0.851
	Surface tension (dyne/cm)	First	30.11	29.17	29.04	28.53	26.01
		Second	30.92	30.37	29.84	29.30	28.76
180 D	Vicosity (cp)	First	66.5	49.1	38.4	28.5	21.0
		Second	61.9	40.5	29.4	22.5	17.0
	Density (g/ml)	First	0.893	0.889	0.887	0.883	0.879
		Second	0.864	0.858	0.855	0.852	0.848
	Surface tension (dyne/cm)	First	33.7	32.2	31.3	31.1	30.6
		Second	30.5	30.3	30.2	29.2	29.1

Bathurst Spray Trial

Table 2: Spread Factor on Kromekote Card

Spray mix	Application	Stain size: D (µm)	Drop size: d (µm)	Spread factor (D/d)
180 FE	First	55	19	2.9
		78	26	3.0
		135	42	3.2
		225	73	3.1
		259	84	3.1
	Second	65	21	3.2
		87	28	3.1
		139	45	3.1
		156	56	2.8
		225	75	3.0
		265	85	3.1
180 FO	First	85	17	5.0
		155	29	5.4
		270	48	5.6
		315	55	5.7
		405	71	5.7
		630	111	5.7
	Second	68	14	4.9
		142	27	5.3
		263	47	5.6
		355	62	5.7
		573	100	5.7
		650	112	5.8
180 D	First	55	14	3.9
		123	32	3.8
		180	38	4.7
		315	57	5.5
		360	65	5.5
		450	82	5.5
	Second	67	18	3.9
		145	30	4.8
		202	42	4.8
		320	58	5.5
		374	63	5.5
		485	88	5.5
		855	155	5.6

Bathurst Spray Trial

Table 3: Rates of Droplet

Evaporation* for Three

Aminocarb Spray Mixes

First Application

Spray mix	Initial drop diameter (µm)	Drop size at		Residual vol. % at	
		5 min (µm)	10 min (µm)	5 min (µm)	10 min (µm)
180 FE	52	47	47	74	74
	90	82	78	76	65
	124	117	116	84	82
	153	141	141	78	78
	183	164	164	72	72
180 FO	59	40	40	32	32
	82	61	61	48	48
	124	99	99	51	51
	130	100	96	46	40
	183	141	141	46	46
	243	182	182	42	42
180 D	47	47	47	100	100
	66	66	66	100	100
	82	82	82	100	100
	127	127	127	100	100
	141	141	141	100	100
	198	198	198	100	100

* Temperature = 22°C
Relative humidity = 50%

Bathurst Spray Trial

Table 4: Droplet Size Distribution on Card for Three Aminocarb Spray Mixes
First Application

Spray Mix	Stain size range (µm)	Spread factor	Drop size range (µm)	Average drop size (µm)	Drops per 100 cm²	Frequency %	Cumulative frequency %
180 FE	20 - 45	3.1 ± 0.1	7 - 15	11	6	1.0	1.0
	45 - 70	3.1 ± 0.1	15 - 22	18	126	21	22
	70 - 90	3.1 ± 0.1	22 - 29	25	108	18	40
	90 - 115	3.1 ± 0.1	29 - 36	33	178	30	70
	115 - 135	3.1 ± 0.1	36 - 44	40	102	17	87
	135 - 160	3.1 ± 0.1	44 - 51	47	72	12	99
	160 - 180	3.1 ± 0.1	51 - 58	55	2	0.3	99.3
	180 - 225	3.1 ± 0.1	58 - 73	65	6	1.0	100.3
180 FO	80 - 100	5.0	16 - 20	18	64	4.8	4.8
	101 - 125	5.4	20 - 24	22	56	4.3	9.1
	125 - 150	5.4	24 - 28	26	140	10.8	19.9
	150 - 190	5.4	28 - 34	30	160	12.3	32.2
	190 - 235	5.5	34 - 42	38	424	32.6	64.8
	235 - 285	5.6	42 - 50	46	292	22.5	87.3
	285 - 345	5.7	50 - 60	54	132	10.2	97.5
	345 - 485	5.7	60 - 85	72	32	2.5	100.0
180 D	15 - 35	3.8	4 - 9	6	135	8.4	8.4
	35 - 125	3.8	9 - 32	21	200	12.5	20.9
	125 - 220	4.7	32 - 47	45	355	22.2	43.1
	220 - 275	4.7	47 - 58	57	406	25.4	68.5
	275 - 410	5.5	58 - 73	65	255	16.0	84.5
	410 - 495	5.5	73 - 90	82	152	9.5	94.0
	495 - 580	5.5	90 - 105	98	97	6.0	100.0

N.M.D. from card data = 28 µm for 180 FE
35 µm for 180 FO
50 µm for 180 D

Bathurst Spray Trial

Table 5: Spray Volume Distribution on Card for Three Aminocarb Spray Mixes First Application

Spray mix	Average drop size (m)	Volume of one drop (10^{-8} cc)	Drops per cm^2	Volume distribution per cm^2 (10^{-8} cc)	Volume distribution %	Cumulative volume distribution %
180 FE	11	0.07	0.06	0.004	0.03	0.03
	18	0.31	1.26	0.39	2.94	2.97
	25	0.83	1.08	1.00	7.54	10.51
	33	1.91	1.78	3.40	25.62	36.13
	40	3.40	1.02	3.47	26.15	62.28
	47	5.50	0.72	3.96	29.84	92.12
	55	8.82	0.02	0.18	1.36	93.48
	65	14.56	0.06	0.87	6.56	100.04
180 FO	18	0.31	0.64	0.20	0.41	0.41
	22	0.56	0.56	0.31	0.63	1.04
	26	0.93	1.40	1.30	2.66	3.70
	30	1.43	1.60	2.29	4.69	8.39
	38	2.91	4.24	12.34	25.26	33.65
	46	5.16	2.92	15.07	30.84	64.49
	54	8.35	1.32	11.02	22.55	87.04
	72	19.78	0.32	6.33	12.96	100.00
	6	0.02	1.35	0.03	0.02	0.02
	21	0.50	2.00	1.00	0.53	0.55
	45	4.83	3.55	17.15	9.12	9.67
	57	9.82	4.06	39.87	21.20	30.87
	65	14.60	2.55	37.23	19.78	50.65
	82	29.20	1.52	44.38	23.58	74.23
	98	50.00	0.97	48.50	25.77	100.00

V.M.D. from card data = 36 µm for 180 FE; 41 µm for 180 FO; 65 µm for 180 D

Bathurst Spray Trial

Table 6: Aminocarb 180 FE

Plot PI: First Application

Variation in Droplet Density on Card Within and Between Sampling Stations

Sample No.	Sampling station	Drops/cm^2 at sample positions: Open upwind	Under tree upwind	Under tree downwind	Mean
1	Tree #1	14.5	19.4	16.9	16.9 → 17
2	Tree #2	20.8	20.8	18.9	20.2 → 20
3	Tree #3	14.1	9.3	11.7	11.7 → 12
4	Tree #4	4.7	3.5	3.5	3.9 → 4
5	Tree #5	2.3	2.4	2.2	2.3 → 2
6	Tree #6	2.1	2.0	1.9	2.0 → 2
7	Tree #7	2.0	1.7	1.8	1.8 → 2
8	Tree #8	2.4	1.9	2.3	2.2 → 2
9	Tree #9	1.8	1.7	1.5	1.7 → 2
10	Tree #10	1.7	1.9	1.9	1.8 → 2
11	Tree #11	1.8	1.5	1.3	1.5 → 2
12	Tree #12	9.2	8.2	7.5	8.3 → 8
13	Soil plot	4.9 E	4.6 S	3.7 W 4.7 N	4.5 → 5
14	Litter plot	5.8 E	4.3 S	4.8 W 7.1 N	5.5 → 6
					Mean ±SD 6 ± 6

Bathurst Spray Trial

Table 7: Aminocarb 180 FO

Plot PIII: First Application

Variation in Droplet Density on Card

Within and Between Sampling Stations

Sample No.	Sampling station	Drops/cm² at sample positions			Mean
		Open upwind	Under tree upwind	Under tree downwind	
1	Tree #1	9.3	9.8	10.0	9.7 → 10
2	Tree #2	7.5	8.3	8.2	8.0 → 8
3	Tree #3	11.5	13.0	10.1	11.5 → 12
4	Tree #4	18.6	14.7	14.3	15.9 → 16
5	Tree #5	11.7	14.2	14.1	13.3 → 13
6	Tree #6	23.2	30.7	23.6	25.8 → 26
7	Tree #7	15.0	11.2	10.8	12.3 → 12
8	Tree #8	25.0	26.3	24.2	25.2 → 25
9	Tree #9	11.0	8.8	8.0	9.3 → 9
10	Tree #10	6.3	7.5	7.2	7.0 → 7
11	Tree #11	10.2	8.1	9.1	9.1 → 9
12	Tree #12	6.0	6.1	8.4	6.8 → 7
13	Soil plot	10.1 E	12.2 S	7.8 W 10.0 N	10.0 → 10
14	Litter plot	14.4 E	15.0 S	15.1 W 14.2 N	14.7 → 15
					Mean ±SD 13 ± 6

Bathurst Spray Trial

Table 8: Aminocarb 180 D

Plot PV: First Application

Variation in Droplet Density on Card

Within and Between Sampling Stations

Sample No.	Sampling station	Drops/cm^2 at sample positions			Mean
		Open upwind	Under tree upwind	Under tree downwind	
1	Tree #1	Swath missed	Swath missed	Swath missed	-
2	Tree #2	Swath missed	Swath missed	Swath missed	-
3	Tree #3	Swath missed	Swath missed	Swath missed	-
4	Tree #4	7	7	5	6
5	Tree #5	10	12	13	12
6	Tree #6	14	16	15	15
7	Tree #7	24	27	26	26
8	Tree #8	11	11	10	11
9	Tree #9	18	19	19	19
10	Tree #10	15	18	18	17
11	Tree #11	12	12	12	12
12	Tree #12	22	19	22	21
13	Soil plot	14 E	12 S 14 W	12 N	13
14	Litter plot	20 E	17 S 21 W	16 N	19
					Mean ±SD 16 ± 6

Bathurst Spray Trial

Table 9: Aminocarb 180 FE

Plot PI: First Application

Variation in Deposit Density (g AI/ha)

on Glass Plate Within and Between Sampling Stations

Sample No.	Sampling station	g AI/ha at sample positions				Mean
		Open upwind	Under tree upwind	Under tree downwind		
1	Tree #1	3.42	4.27	3.42		3.70
2	Tree #2	5.55	6.83	4.27		5.55
3	Tree #3	3.42	3.42	4.27		3.70
4	Tree #4	3.42	2.56	2.56		2.85
5	Tree #5	2.14	1.71	1.71		1.85
6	Tree #6	1.28	1.28	2.14		1.57
7	Tree #7	1.71	1.71	1.28		1.57
8	Tree #8	1.71	1.71	2.14		1.85
9	Tree #9	0.854	1.71	1.71		1.42
10	Tree #10	1.28	0.854	1.71		1.28
11	Tree #11	1.71	1.28	0.854		1.28
12	Tree #12	2.56	2.56	3.42		2.85
13	Soil plot	3.42 E	1.28 S	2.56 W	3.42 N	2.67
14	Litter plot	2.56 E	2.14 S	1.28 W	2.99 N	2.24
						Mean 2.45 ± ±SD 1.22

Bathurst Spray Trial

Table 10: Aminocarb 180 FO

Plot PIII: First Application

Variation in Deposit Density on Glass Plate Within and Between Sampling Stations

Sample No.	Sampling station	g AI/ha at sample positions				Mean
		Open upwind	Under tree upwind	Under tree downwind		
1	Tree #1	4.27	4.70	4.27		4.41
2	Tree #2	3.42	3.84	2.99		3.42
3	Tree #3	4.27	5.12	5.55		4.98
4	Tree #4	10.7	11.1	9.82		10.5
5	Tree #5	7.69	6.83	8.54		7.69
6	Tree #6	19.2	18.8	17.1		18.4
7	Tree #7	6.83	7.69	6.83		7.12
8	Tree #8	19.2	17.1	19.2		18.5
9	Tree #9	4.27	5.12	5.12		4.84
10	Tree #10	3.84	3.42	4.27		3.84
11	Tree #11	3.84	3.42	3.84		3.70
12	Tree #12	3.84	4.70	4.27		4.27
13	Soil plot	4.27 E	4.70 S	5.12 W	4.27 N	4.59
14	Litter plot	8.97 E	9.39 S	9.39 W	9.39 N	9.29
						Mean 7.5 ± ±SD 5.1

Bathurst Spray Trial

Table 11: Aminocarb 180 D

Plot PV: First Application

Variation in Deposit Density on Glass Plate

Within and Between Sampling Stations

Sample No.	Sampling station	g AI/ha at sample positions			Mean
		Open upwind	Under tree upwind	Under tree downwind	
1	Tree #1	0.854	0.00	0.00	0.285
2	Tree #2	0.00	0.00	0.854	0.285
3	Tree #3	0.00	0.854	0.00	0.285
4	Tree #4	5.12	6.83	7.69	6.55
5	Tree #5	12.8	8.54	15.4	12.3
6	Tree #6	12.8	12.0	15.0	13.3
7	Tree #7	21.4	19.6	17.9	19.6
8	Tree #8	8.54	7.69	9.39	8.54
9	Tree #9	17.1	16.2	12.8	15.4
10	Tree #10	14.5	14.1	12.0	13.5
11	Tree #11	12.8	15.0	15.4	14.4
12	Tree #12	12.8	12.8	9.82	11.8
13	Soil plot	9.82 E	9.82 S	7.26 W 9.39 N	9.10
14	Litter plot	15.0 E	12.4 S	12.8 W 14.5 N	13.9
					Mean 9.95 ± ±SD 6.11

Searchmont Spray Trial

Table 12: Multiple Swath Trial

Summary of Droplet Data on Spruce Needles

In-flight Encapsulated Formulation

Sample No.	Tree No.	Foliar data: Drops/needle	Foliar data: Drops/cm^2 of needle	Kromekote card data (in a clearing adjacent to the sampling tree)
1	L100-T1	0.645	1.85	4
2	L100-T2	0.418	1.04	3
3	L200-T1	0.500	1.26	4
4	L200-T2	0.570	1.52	5
5	L300-T1	0.440	1.15	3
6	L300-T2	0.430	1.08	3
7	L400-T1	0.405	1.08	3
8	L400-T2	0.325	0.83	1.5
9	L500-T1	0.400	1.12	4
10	L500-T2	0.415	1.17	3
11	L300-T3	0.270	0.70	2.5
12	L300-T4	0.420	1.10	2
13	L400-T3	0.240	0.60	5.5
14	L400-T4	0.230	0.60	5
15	L500-T4	0.310	0.80	3.5
	Mean ± SD	0.40 ± 0.1	1.10 ± 0.6	3.3 ± 1.4

Searchmont Spray Trial

Table 13: Multiple Swath Trial

Droplet Number Distribution

Foliar Data (Spruce Needles)

Drop size range (µm)	Average drop size (µm)	Drops per 100 needles (µm)	Drops per 100 cm^2 (µm)	% Distribution	Cumulative % distribution
2 - 5	3.5	0.52	1.38	1.3	1.3
5 - 10	8.0	0.48	1.27	1.2	2.5
10 - 20	15.5	4.84	12.83	12.1	14.6
20 - 30	25.5	11.76	31.16	29.4	44.0
30 - 40	35.5	4.44	11.77	11.1	55.1
40 - 50	45.5	6.04	16.01	15.1	70.2
50 - 75	63.0	6.00	15.90	15.0	85.2
75 - 100	88.0	2.72	7.21	6.8	92.0
100 - 125	113.0	2.00	5.30	5.0	97.0
125 - 150	137.5	1.20	3.18	3.0	100.0

N.M.D. on the needle = 30 µm

Searchmont Spray Trial

Table 14: Multiple Swath Trial

Droplet Volume Distribution

Foliar Data (Spruce Needles)

Drop size range (µm)	Average drop size (µm)	Volume deposit on 100 needles (10^{-8} cc)	Volume deposit on 100 cm^2 area of needles (10^{-8} cc)	% Distribution of volume	Cumulative % distribution of volume
2 - 5	3.5	0.0011	0.003	0.0002	0.0002
5 - 10	8.0	0.0129	0.034	0.0024	0.0026
10 - 20	15.5	0.944	2.503	0.174	0.177
20 - 30	25.5	10.22	27.07	1.886	2.063
30 - 40	35.5	10.40	27.59	1.920	3.982
40 - 50	45.5	29.81	79.02	5.50	9.485
50 - 75	63.0	78.61	208.3	14.51	24.00
75 - 100	88.0	97.13	257.5	17.93	41.92
100 - 125	113.0	151.2	400.7	27.91	69.83
125 - 150	137.5	163.5	433.2	30.17	100.00

V.M.D. on the needle = 94 µm

Searchmont Spray Trial

Table 15: Multiple Swath Trial

Droplet Number Distribution

Card Data

Drop size range (µm)	Average drop size (µm)	Drops per 100 cm^2	% Distribution	Cumulative % distribution
5 - 10	7.5	0.066	0.02	0.02
10 - 25	18.0	4.22	1.28	1.30
25 - 45	35.5	20.33	6.16	7.46
45 - 70	58.0	81.44	24.7	32.1
70 - 90	80.5	87.35	26.5	58.6
90 - 110	100.5	49.96	15.1	73.8
110 - 130	120.5	35.41	10.7	84.5
130 - 150	140.5	23.53	7.13	91.6
150 - 170	160.5	8.45	2.56	94.2
170 - 190	180.5	5.05	1.53	95.7
190 - 220	205.5	7.46	2.26	98.0
220 - 250	235.5	4.36	1.32	99.3
250 - 315	283.0	2.18	0.66	99.9
315 - 380	348.0	0.264	0.08	100.0

N.M.D. on card = 75 µm

Searchmont Spray Trial

Table 16: Multiple Swath Trial

Droplet Volume Distribution

Card Data

Drop size range (µm)	Average drop size (µm)	Volume deposit on 100 cm^2 (10^{-8} cc)	% Distribution of volume	Cumulative % distribution of volume
5 - 10	7.5	0.001	0.000	0.000
10 - 25	18.0	1.29	0.005	0.005
25 - 45	35.5	47.67	0.187	0.192
45 - 70	58.0	832.7	3.26	3.455
70 - 90	80.5	2388	9.36	12.81
90 - 110	100.5	2657	10.41	23.22
110 - 130	120.5	3246	12.72	35.94
130 - 150	140.5	3420	13.40	49.34
150 - 170	160.5	1830	7.17	56.51
170 - 190	180.5	1556	6.10	62.61
190 - 220	205.5	3391	13.30	75.90
220 - 250	235.5	2981	11.68	87.6
250 - 315	283.0	2587	10.13	97.7
315 - 380	348.0	583	2.28	100.0

V.M.D. on card = 144 µm

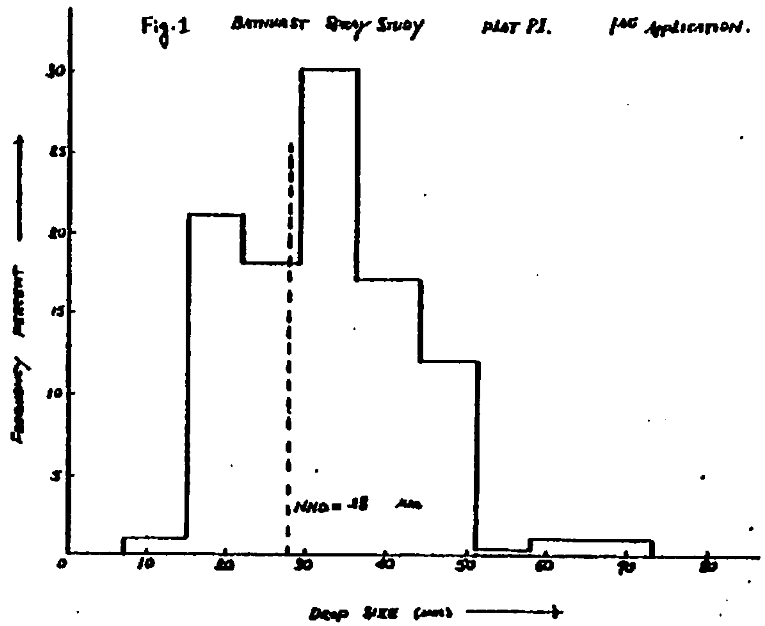
Fig. 1 BATHURST SPRAY STUDY PLOT P.I. 1st APPLICATION.
FREQUENCY PERCENT
DROP SIZE (µm)
NMD = 28 µm

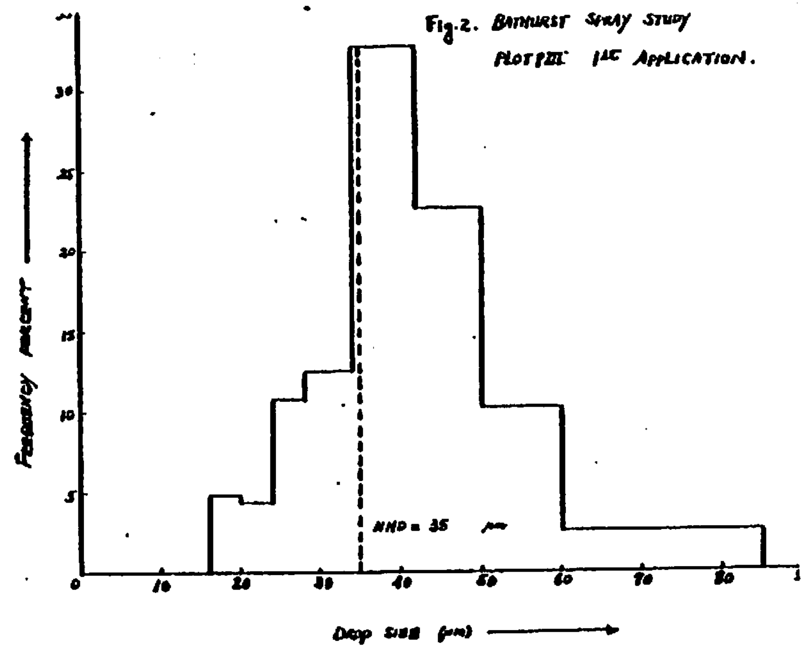
Fig. 2. BATHURST SPRAY STUDY
PLOT P.III 1st APPLICATION.
FREQUENCY PERCENT
DROP SIZE (µm)
NMD = 35 µm

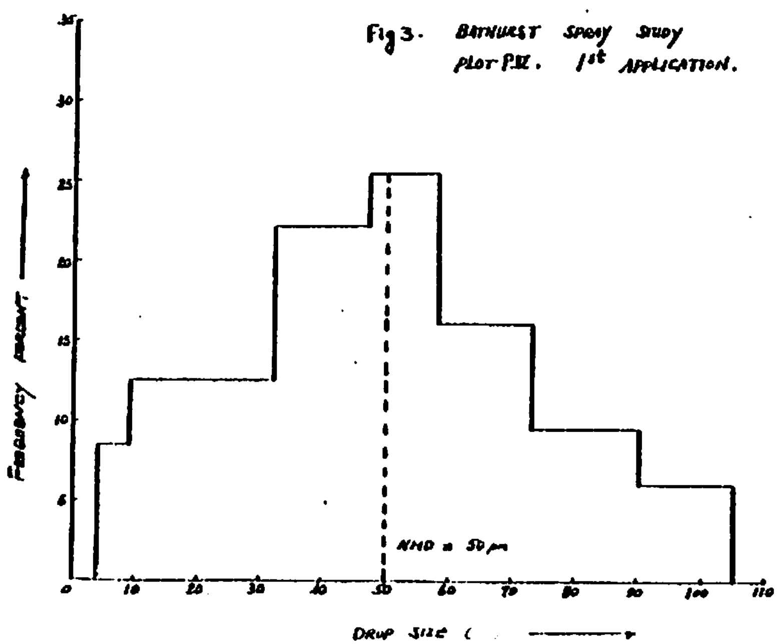
Fig 3. BATHURST SPRAY STUDY
PLOT P.II. 1st APPLICATION.
FREQUENCY PERCENT
DROP SIZE (
NMD = 50 µm

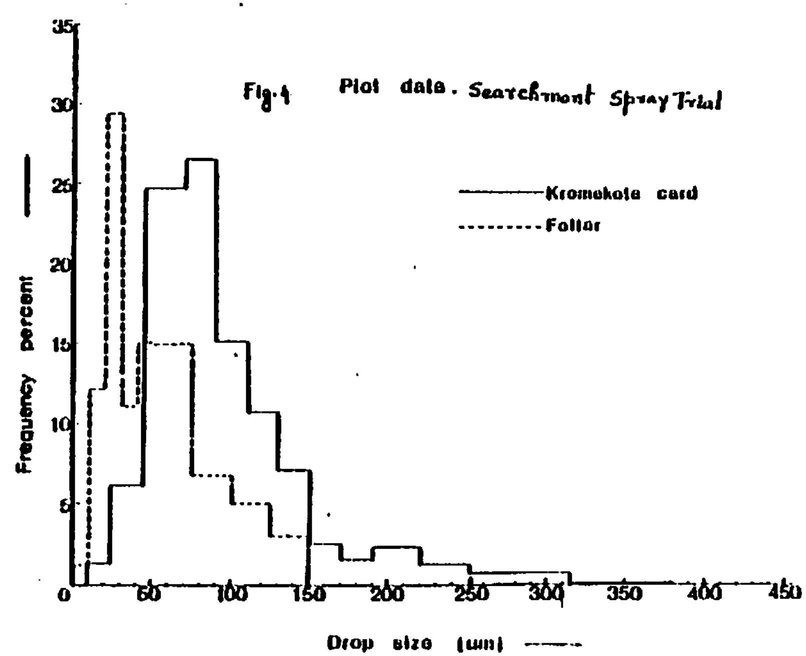
Fig. 4 Plot data. Searchmont Spray Trial
Kromekote card
Foliar
Frequency percent
Drop size (um)

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 198:

(Study Ref. FP-12)

Report to the Annual Forest Pest Control Forum

by

P.C. Nigam

J.W. McFarlane

and

D.R. Comba

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Canadian Forestry Service

Environment Canada

Sault Ste. Marie, Ontario

December 1981

Summary of Laboratory Evaluation of Insecticides Against Various Species of Forest Insect Pests During 1981

by

P.C. Nigam, J.W. McFarlane, D.R. Comba

Fifteen insecticides and their formulations were tested for contact, stomach, stomach-contact and residual toxicity using the Modified Potter's Towers. Four of these were new insecticides and/or formulations.

The results are summarized under contact, stomach, stomach-contact and residual toxicity studies. Unless otherwise specified, mortality data is given for a 72-hour observation period after treatment.

CONTACT TOXICITY

Twelve insecticides were tested for contact toxicity against insects from Ontario. The results are summarized by the area of origin and by species; insect collections were provided by personnel of the toxicology section, and the laboratory culture was received from the Insect Production Unit of FPMI (Table 1). Insecticides are arranged in descending order of toxicity on the basis of 100% mortality at the 72-hour observation period after treatment.

Spruce Budworm - *Choristoneura fumiferana* (Clemens) - Laboratory Reared

(a) Different insecticides

Ten insecticides and aminocarb samples of different AI level and formulation were tested using modified Potter's Towers against the fifth instar of the spruce budworm. The corrected percentage mortality ranged from 48% to 100%. Cypermethrin = AC 222-705 Permethrin = Fenvalerate Aminocarb (98% AI) = Aminocarb (99% AI) Aminocarb (97.1% AI) = Matacil 1.8D = Matacil 1.8F = Chlorpyrifos - methyl Azamethiphos = Fenitrothion = MV 770 = U56295.

(b) Field formulations of Fenitrothion and Aminocarb

Formulations of these two insecticides in oil and water formulations were tested for contact toxicity using the ultra-low volume (ULV) Potter's tower.

When the two formulations, Matacil Tech. and Fenitrothion Tech. were tested against fourth instar, the corrected percentage mortality ranged from 79% to 85%. Six formulations of aminocarb and fenitrothion were tested against fifth instar spruce budworm larvae; the corrected percentage mortality ranged from 0% to 88%. A summary of the results are as follows:

4th instar: Matacil Tech. (oil) > Fenitrothion Tech (oil)
5th instar: Matacil 1.8D (oil) > Matacil Tech (97.1% ai)(oil) > Matacil Tech. (99% ai)(oil) > Fenitrothion Tech. (oil) > Fenitrothion Flowable (water).

Note Preliminary testing of fenitrothion flowable was attempted, but is incomplete due to separation of the formulation and encapsulation during spraying. Modification in formulation and spraying equipment are suggested for further work.

Red-Headed Pine Sawfly - *Neodiprion lecontei* Field Collected

Three insecticides were tested against the 5th instar larvae of the red-headed pine sawfly. The corrected percentage mortality ranged from 30% to 67%.

AC 222-705 > MV 770 > U 56295

White Pine Weevil - *Pissodes strobi* - Field Collected

Seven insecticides were tested against the adult white pine weevil. The corrected percentage mortality ranged from 11% to 97%.

Cypermethrin > Permethrin > Fenvalerate > Dimethoate > Fenitrothion > Aminocarb > Lindane

STOMACH TOXICITY

Spruce Budworm Laboratory reared

Eight insecticides and their formulations were tested for stomach toxicity against laboratory-reared spruce budworm. The corrected percentage mortality ranged from 10% to 95%.

Chlorpyrofos-methyl > Cypermethrin > Fenitrothion > Permethrin > Matacil Technical = Matacil 1.8D = Matacil 1.5 F > Fenvalerate > Azamethiphos > Trichlorphon

STOMACH - CONTACT TOXICITY

Spruce Budworm Laboratory Reared

Nine insecticides were tested against laboratory-reared fifth instar larvae. The corrected percentage mortality ranged from 63% to 98%.

Cypermethrin > Permethrin = Chlorpyrofos-methyl > Fenvalerate > Aminocarb > Fenitrothion > RH 0994 > Trichlorfon > DDT

RESIDUAL TOXICITY

The residual program on each insecticide is carried out over a three year period. Nine insecticides were tested in 1981, with RH 0994 and Sumithion Flowable being the latest materials tested this year. The insecticides were tested for residual toxicity by spraying potted balsam fir and white spruce trees in a spraying chamber. The sprayed host trees were then exposed to natural weathering conditions from 0-10 days. The insects used for bioassay of residues were either reared in the laboratory or collected in the field to be maintained in the laboratory until their release onto the insecticide-treated foliage.

The insects were released onto clipped foliage obtained after a period of weathering (0-10 days) of the treated and check trees. The clipped foliage was placed, with the insects, in a clear plastic cup equipped with a perforated plastic lid to prevent moisture accumulation. These cups werre kept in an environmental chamber at 21°C, 70% relative humidity and a photo period of 16 hours. The residue of the insecticide bioassayed on the same day of spraying (i.e., 4 ± 2 hours after spraying) were referred to as 0-day and these host trees were not exposed to any weathering. The insecticides are arranged in descending order of residual toxicity from 0, 5 and 10 days of residual life. The corrected percentage mortality, 72 hours after the release of insects is given in brackets.

Spruce Budworm — *Choristoneura fumiferana* (Clem.)

(a) Standard Laboratory Formulation Testing

Residual toxicity of six insecticides were tested against field collected fifth instar larvae of the spruce budworm.

Sumithion (technical and flowable), Matacil (technical, 1.8D, 1.8F), NRDC 143 (Permethrin) and RH 0994 were all sprayed as a solution of 2% active ingredient; WL 43467 (Cypermethrin) as a solution of 0.25% active ingredient and Orthene (acephate) as a solution of 5.0% active ingredient, at the equivalent rate of 11.2 L/ha on white spruce and balsam fir for this bioassay.

Field Collected Fifth Instar Spruce Budworm on Balsam Fir

0 day - fenitrothion (technical = fenitrothion (Flowable) = aminocarb (Matacil technical) = aminocarb (Matacil 1.8F) = aminocarb (Matacil 1.8D) = permethrin (NRDC 143) = acephate (Orthene) = RH0994 = cypermethrin (WL 43467) (100)

5 day - aminocarb (Matacil 1.8F) = cypermethrin (WL 43467) (95) permethrin (NRDC 143) (93) > aminocarb (Matacil tech.) (90) > aminocarb (Matacil 1.8D) (88) > RH 0994 (63) > acephate (Orthene) (32) > fenitrothion (tech.) (5) > fenitrothion (Sumithion Flowable) (0)

10 day - aminocarb (Matacil 1.8F) (95) > cypermethrin (WL 43467) (92) > aminocarb (Matacil 1.8D) (90) > aminocarb (Matacil tech.) (85) > permethrin (NRDC 143) (65) > RH 0994 (10) > fenitrothion (tech.) (8) > fenitrothion (Sumithion Flowable) (5) > acephate (3)

Field Collected Fifth Instar Spruce Budworm on White Spruce

0 day - fenitrothion (technical) = aminocarb (Matacil technical) = aminocarb (Matacil 1.8F) = aminocarb (Matacil 1.8D) = permethrin (NRDC 143) = acephate (Orthene) = RH0994 (100) > cypermethrin (WL 43467) (98) > fenitrothion (Sumithion Flowable) (96)

5 day - Cypermethrin (WL 43467) (77) > permethrin (NRDC 143) (63) aminocarb (Matacil tech.) (59) > aminocarb (Matacil 1.8D) (58) > aminocarb (Matacil 1.8F) (49) > RH 0994 (8) > fenitrothion (tech.) (5) > acephate (Orthene) (3) > fenitrothion (Sumithion Flowable) (0)

10 day - aminocarb (Matacil 1.8F) (54) > cypermethrin (WL 43467) (38) > aminocarb (Matacil 1.8D) = aminocarb (Matacil tech.) (30) fenitrothion (Sumithion Flowable) = permethrin (NRDC 143) (8) fenitrothion (Tech.) (5) > RH 0994 (4) > acephate (Orthene) (3)

(b) Toxicity of Field Formulations of Aminocarb and Fenitrothion at Field Treatment Rates

Residual Toxicity of aminocarb and fenitrothion field formulations were tested against lab-reared third and fifth instar spruce budworm. The potted balsam fir and white spruce were treated at the rate of 1.5 L/ha, 14% concentration for the fenitrothion formulations and 4.7% concentration for the aminocarb formulations. The potted plants were weathered and clipped in the same manner as previously described in second treatment 5 days after the first and the 10 day weathered plants received their second treatment, 10 days after the first. Again, weathering, clipping and maintaining of test cups were carried out as previously described. The second treatment was to simulate a second application regime in the field.

Matacil 1.8D and Matacil 1.8F were used in oil and water formulations and Matacil tech. only with oil at 4.7% concentration of Matacil; fenitrothion technical was used in both oil and water formulations and Sumithion Flowable only with water at 15% concentration of fenitrothion. The fenitrothion blank, formulated with water, was also tested for toxicity at 1.5 L/ha, 14% concentration.

The data is arranged in descending order of residual toxicity of the 0, 5 and 10 day treatments for the 5th instar larvae and 0, 3 and 5 day for the 3rd instar larvae.

FIRST APPLICATION

Fifth Instar Spruce Budworm on Balsam Fir (lab. reared)

0 day - Matacil 1.8D (oil) = fenitrothion (oil) = Matacil 1.8D (water) = fenitrothion N.B. (formulation, water) (100) > Matacil tech. (oil) = Matacil 1.8F (oil) (96) > Sumithion Flowable (water) (92) > Matacil 1.8F (water) (55) > fenitrothion blank (0)

5 day - Matacil 1.8D (water) (65) > Matacil 1.8D (oil) (21) fenitrothion blank (4) > Matacil 1.8F (oil) = fenitrothion (N.B. formulation water) (2) > Matacil Tech. (oil) = fenitrothion (oil) = Matacil 1.8F (water) = Sumithion Flowable (water) (0)

10 day - Matacil 1.8D (water) (79) > Matacil 1.8D (oil) (66) Matacil 1.8F (oil) (33) > Matacil Tech. (oil) (15) > Matacil 1.8F (water) (11) > fenitrothion (oil) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) (0)

Fifth Instar Spruce Budworm on White Spruce (lab. reared)

0 day - Matacil tech. (oil) = fenitrothion (oil) = Matacil 1.8D (water) = fenitrothion (N.B. formulation water) (100) > Sumithion Flowable (water) (98) > Matacil 1.8D (oil) (90) > Matacil 1.8F (oil) (42) > Matacil 1.8F (water) (33) > fenitrothion blank (8)

5 day - Matacil 1.8D (water) (16) > Sumithion Flowable (water) (11) > Matacil 1.8F (water) = fenitrothion (N.B. formulation water) (2) > Matacil tech. (oil) = Matacil 1.8D (oil) = Matacil 1.8F (oil) = fenitrothion (oil) = fenitrothion blank (0)

10 day - Matacil 1.8D (water) (23) > Matacil 1.8D (oil) (10) > Matacil Tech. (oil) (7) > Matacil 1.8F (oil) = Matacil 1.8F (water) (2) > fenitrothion (oil) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) (0)

Third Instar Spruce Budworm on Balsam Fir (lab reared)

0 day - Matacil tech. (oil) = Matacil 1.8D (oil) = Matacil 1.8F (oil) = fenitrothion (oil) = Matacil 1.8D (water) = Sumithion Flowable (water) (100) > fenitrothion blank (10) > Matacil 1.8F (water) (0)

3 day - Matacil 1.8D (water) (89) > fenitrothion (oil) (67) Matacil 1.8D (oil) (40) > Sumithion Flowable (water) (12) fenitrothion (N.B. formulation water) (3) > Matacil tech. (oil) = Matacil 1.8F (oil) = Matacil 1.8F (water) = fenitrothion blank (0)

5 day - Matacil 1.8D (oil) (30) > Matacil 1.8D (water) (16) Matacil tech. (oil) (14) > fenitrothion blank (2) > Matacil 1.8F (oil) = fenitrothion (oil) = Matacil 1.8F (water) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) (0)

Third Instar Spruce Budworm on White Spruce (lab. reared)

0 day - Matacil tech. (oil) = Matacil 1.8D; (oil) = fenitrothion (oil) = Matacil 1.8D (water) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) (100) > Matacil 1.8F (water) (50) > Matacil 1.8F (oil) (24) > fenitrothion blank (10)

3 day 0 Matacil tech. (oil) = Matacil 1.8D (oil) = Matacil 1.8F (oil) = fenitrothion (oil) = Matacil 1.8D (water) = Matacil 1.8F (water) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) = fenitrothion blank (0)

5 day - Matacil tech. (oil) (57) > fenitrothion (oil) (25) Matacil 1.8F (oil) (22) > Matacil 1.8D (oil) = Matacil 1.8D (water) = Matacil 1.8F (water) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) = fenitrothion blank (0)

SECOND APPLICATION

Fifth Instar Spruce Budworm on Balsam Fir (lab reared)

0 day - Matacil 1.8D (water) = Matacil 1.8D (oil) = Matacil tech. (oil) = fenitrothion (N.B. formulation water) = fenitrothion (oil) = Sumithion Flowable (water 100) > Matacil 1.8F (oil) (84) Matacil 1.8F (water) (63) > fenitrothion blank (0)

5 day - Matacil 1.8D (water) (64) > fenitrothion (N.B. formulation water) (45) > Matacil 1.8D (oil) (26) > Matacil Tech. (oil) (19) > Matacil 1.8F (oil) (8) > Matacil 1.8F (water) = Sumithion Flowable (water) = fenitrothion blank (0)

10 day — Matacil 1.8D (water) (85) > Matacil 1.8D (oil) (66) Matacil Tech. (oil) (47) > Matacil 1.8F (oil) (43) > Matacil 1.8F (water) (18) > fenitrothion (N.B. formulation water) (13) > fenitrothion (oil) (5) > Sumithion Flowable (water) (5)

Fifth Instar Spruce Budworm on White Spruce (lab reared)

0 day - Matacil 1.8D (water) = Sumithion Flowable (water) = Matacil tech. (oil) = fenitrothion (oil) (100) > fenitrothion (N.B. formulation water) = Matacil 1.8D (oil) (98) > Matacil 1.8F (oil (56) > Matacil 1.8F (water) (21) > fenitrothion blank (0)

5 day - Matacil 1.8D (water) (19) > fenitrothion (N.B. formulation water) (17) > Matacil 1.8D (oil) (6) > Matacil 1.8F (water) = Matacil Tech. (oil) = Matacil 1.8F (oil) = Sumithion Flowable (water) = fenitrothion blank = fenitrothion (oil) (10)

10 day - Matacil 1.8D (water) (24) > Matacil 1.8D (oil) (9) Matacil Tech. (oil) (4) > Matacil 1.8F (water) = matacil 1.8F (oil) = fenitrothion (N.B. formulation water) = fenitrothion (oil) = Sumithion Flowable (water) = fenitrothion blank (0)

<u>Third Instar Spruce Budworm on Balsam Fir (lab reared)</u>

0 day - Matacil 1.8D (oil) = Matacil tech. (oil) = fenitrothion oil = Matacil 1.8D (water) = fenitrothion (N.B. formulation water) = Sumithion Flowable (water) (100) > Matacil 1.8F (water) (55) > Matacil 1.8F (oil) (50) > fenitrothion blank (0)

3 day - Sumithion Flowable (water) (100) > fenitrothion (N.B. formulation water) = Matacil 1.8D (water) (44) > fenitrothion (oil) (40) > Matacil 1.8D (oil) (22) > Matacil 1.8F (water) = Matacil 1.8F (oil) (11) > Matacil tech. (oil) (10) > fenitrothion blank (0)

5 day - Sumithion Flowable (water) (22) > Matacil 1.8D (oil) (20) > Matacil 1.8D (water (11) > Matacil 1.8F (oil) (10) fenitrothion (N.B. formulation water) = fenitrothion (oil) (1) Matacil 1.8F (water) = fenitrothion blank = Matacil tech. (oil) (0)

<u>Third Instar Spruce Budworm on White Spruce</u>

0 day - Matacil 1.8D (oil) = Matacil Tech. (oil) = fenitrothion (oil) = Sumithion Flowable (water) = fenitrothion (N.B. formulation water) (100) > Matacil 1.8D (water) = fenitrothion blank (37) > Matacil 1.8F (oil) (25) > Matacil 1.8F (water) (10)

3 day - Sumithion Flowable (water) (100) > Matacil 1.8D (water) (22) > fenitrothion (oil) = fenitrothion (N.B. formulation water) = Matacil 1.8F (oil) (13) > Matacil tech. (oil) (11) > Matacil 1.8D (oil) = Matacil 1.8F (water) = fenitrothion blank (0)

5 day - Sumithion Flowable (water) (100) > Matacil tech. (oil) (20) > fenitrothion (oil) (10) > fenitrothion blank (1) > Matacil 1.8D (oil) = Matacil 1.8F (oil) = fenitrothion (N.B. formulation water) = Matacil 1.8D (water) = matacil 1.8F (water) (0)

<u>NOTE</u>

Experiments fenitrothion and Matacil were conducted in late June and early July with overmature foliage; hence, these results are not an accurate representation of fenitrothion and aminocarb toxicities and therefore require repetition.

(c) <u>Residual Toxicity - Bioassay from Matacil Experimental Plots in New Brunswick</u>

Bioassay of residual toxicity of balsam fir and spruce foliage treated with Matacil formulations from experimental field plots in Bathurst was carried out to compare with the data produced by field simulated treatments in laboratory, so that a correlation can be established for future evaluation of residual toxicity of insecticides. The data is being processed and no conclusions can be drawn at this time.

Table 1

Insects Used in 1981

Insect	Area of Origin	Instar	No. Used
Contact, Stomach and Stomach/Contact Toxicity			
Spruce Budworm	Sault Ste. Marie, Ont. (lab-reared)	IV	840
Spruce Budworm	Sault Ste. Marie, Ont. (lab-reared)	V	25,620
White Pine Weevil	Massey, Ont.	Adult	2,520
Red Headed Pine Sawfly	Sault Ste. Marie, Ont. area	IV	420
Red Headed Pine Sawfly	Sault Ste. Marie, Ont. area	V	210
Residual Program			
Spruce Budworm	Sault Ste. Marie, Ont. (lab-reared)	V	16,200
Spruce Budworm	Sault Ste. Marie, Ont. (lab-reared)	III	8,000
Spruce Budworm	Sault Ste. Marie, Ont. (field collected)	V	3,000

Table 2.

INSECTICIDES TESTED IN 1981

Insecticide	Alternate Names	Formulation % A.I.	Type	Source
AC 222-705		30 Ec.	Pyrethroid	American Cyanamid
Acephate	(Orthene)	90	Organophosphate	Chevron
Azamethiphos	(CGA 18809)	10	Organophosphate	Ciba-Geigy
Chlorpyrifos-methyl	(Dowco 214, Reldan®)	30	Organophosphate	Dow Chemical
Cypermethrin	(WL 43467)	40 Ec.	Pyrethroid	Shell
DDT		100	Chlorinated Hydrocarbon	Ciba-Geigy
Dimethoate	(Cygon)	30	Organophosphate	American Cyanamid
Fenitrothion	(Sumithion®)	99.9 w/w	Organophosphate	Sumitomo
Sumithion Flowable		20 w/w	Organophosphate	Sumitomo
Fenvalerate	(S-5602)	20 Ec.	Pyrethroid	Sumitomo
Lindane	(-BHC)	95 Tech.	Chlorinated Hydrocarbon	Green Cross
Matacil Technical	(Aminocarb)	97.1 – 99 Tech.	Carbamate	Chemagro
Matacil 1.8D	(Aminocarb)	17.97 Sus.	Carbamate	Chemagro
Matacil 1.8F	(Aminocarb)	17.97 Sus.	Carbamate	Chemagro
HV 770		47.93	Organophosphate	Stauffer
Permethrin	(NRDC 143)	50 w/w	Pyrethroid	Chipman
RH 0994		48 Ec.	Organophosphate	Rohm & Haas
Trichlorfon	(Dylox 4.2)	41.9 Sol.	Organophosphate	Chemagro
U 56295		100 wp		Upjohn

Tech. = Technical, Ec – Emulsifiable Concentrate, Sus. = Suspension, Sol. = Solution, wp = wettable powder

PRELIMINARY RESULTS OF AN AMINOCARB AERIAL SPRAY TRIAL IN NEW BRUNSWICK: A SUMMARY

(Study Ref. No. FP-13)

Report to the Annual Forest Pest Control Forum

by

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P6A 5M7

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SUMMARY

Two formulations of the insecticide aminocarb[1], Matacil 1.8F, a flowable or suspension concentrate, and Matacil 1.5D an oil soluble concentrate were tested in New Brunswick to determine their comparative efficacies against the spruce budworm (Sbw) *Choristoneura fumiferana* (Clem.).

The research blocks measuring 1.0 x 0.5 km (50 ha) were located about 25 km south south-west of Bathurst and comprised mainly of Balsam fir *Abies balsamea* (L.) Mill., and spruce *Picea* sp. An untreated area was used as a check block to monitor Sbw populations unaffected by insecticides.

Matacil 1.8F (70 g AI/ha) was applied both in water and ID585[2]; Matacil 1.5D (70 g AI/ha) in ID585 and in Sunspray 6N oil, and Atlox an emulsifying component of the 'flowable' was also tested to investigate any insecticidal activity.

There were two applications of each insecticide using a Cessna Ag-truck[3], fitted with 4 micronair rotary atomisers, and the treatments were all dyed with either Automate "b" or Rhodamine red dye to facilitate deposit analysis.

Pertinent aircraft characteristics, weather and formulation data are summarized in Tables 1a, b.

RESULTS

Analysis of the droplet deposit data for this study was at writing still incomplete and therefore not included, thus these preliminary evaluations are based on Sbw population reduction and host-tree defoliation.

Sbw population reductions[4] >90% were recorded in all the blocks treated with aminocarb; however, the reductions varied according to species of host-tree. The Sbw population reduction and foliage defoliation in the block sprayed with Atlox alone were comparable to those in the untreated area thus inferring that the emulsifier possessed no discernible insecticidal activity. Good foliage protection resulted from all the aminocarb sprays with the aqueous treatment producing impressive results. Summaries of these biological data are presented in Tables 2 to 4.

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[1] 4-(dimethylamino)-3-methylphenyl methylcarbamate which was kindly supplied by Chemagro Ltd., Mississauga, Ontario, Canada.
[2] Shell insecticide filuent #585.
[3] Kindly supplied by Forest Protection Ltd., Fredericton, N.B.
[4] Corrected mortality using Abbott's formula (1925 - J. Econ. Entomol. 18: 265-267).

Note

These data are very preliminary and should not be cited as authority.

These preliminary results suggest that Matacil 'flowable' sprayed in water and in ID585, applied under particular regimes (Tables 1a,b) were equally as effective in controlling, *C. fumiferana* and protecting foliage of balsam fir and spruce, as Matacil 1.5D in ID585 or Sunspray 6N oil.

Table 1(a)

A Summary of Spray, Aircraft and Weather Data for Aminocarb Efficacy Trials (Bathurst N.B. 1981)

	Block 1 and 2		Block 3 and 4		Block 5 and 6	
	1st applic.	2nd applic.	1st applic.	2nd applic.	1st applic.	2nd applic.
Date	12-06-81	18-06-81	12-06-81	18-06-81	13-06-81	18-06-81
Time (hrs)	1940	0620	2100	0715	2010	2015
Insecticide	Aminocarb 180F		Aminocarb 180F		Aminocarb 1.5 OSC	
Volume active	70 g/ha		70 g/ha		70 g/ha	
Solvent	H_2O		*Shell I.D. 585 oil		Sunspray 6N oil	
Plot size	50 ha		50 ha		50 ha	
Aircraft data						
Type	Cessna 188 Ag Truck		Cessna 188 Ag Truck		Cessna 188 Ag Truck	
Speed kmph	160		160		160	
Applic. height	22-24 m	27 m	24 m	27-30 m	27-30 m	27-30 m
Applic. equipment	(4) Micronairs AU 3000		(4) Micronair AU 3000		(4) Micronair AU 3000	
Emission rate	23.5 l/min		23.5 l/min		23.5 l/min	
Applic. rate	1.5 l/ha		1.5 l/ha		1.5 l/ha	
Blade angle	25°		25°		25°	
Blade rpm	Maximum		Maximum		Maximum	

Weather data	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Temp. °C (mean)	13.00	10.25	13.00	10.75	10.00	13.75	10.00	13.75	16.50	22.25	17.25	20.75
RH % (mean)	80	100	83	96	96	73	96	73	73	58	69	56
Wind speed (mean)	.25	1.0	.25	2.0	0.0	5.0	0	5.0	0.0	1.5	0.0	1.0
Wind direction	E	W	E	SW-W	E	W	E	W	SE-SW	W	SE-S	W
Inversion**	↓	↓	↓	↓	↔	↓	↔	↓	↓	↓	↓	↓
Cloud cover	1/10	0/10	1/10	1/10	0/10	0/10	0/10	1/10	0/10	0/10	0/10	0/10

* I.D.--Insecticide diluent

** ↓--inversion

↑--lapse

↔--neutral (isothermic)

TABLE 1(b)

A Summary of Spray Aircraft and Weather Data for Aminocarb Efficacy Trials

(Bathurst, N.B. 1981)

	Block 8		Block 9	
	1st applic.	2nd applic.	1st applic.	2nd applic.
Date	16-06-81	19-06-81	15-06-81	19-06-81
Time (hrs)	0600	0715	2020	0600
Insecticide	Aminocarb 1.5 OSC		Atlox	
Volume active	70 g/ha			
Solvent	Shell I.D. 585*		H_2O	
Plot size	50 ha		50 ha	
Aircraft data				
Type	Cessna 188 Ag Truck		Cessna 188 Ag Truck	
Speed kmph	160		160	
Applic. height	27 m	24-27 m	27-30 m	24 m
Applic. equipment	(4) Micronair AU 3000		(4) Micronair AU 3000	
Emission rate	23.5 l/min	23.5 l/min	23.8 l/min	23.5 l/min
Applic. rate	1.5 l/ha		1.5 l/ha	
Blade angle	25°		25°	
Blade rpm	Maximum		Maximum	
Weather data				
Temp. °C (mean)	10.0	18.0	12.5	13.75
RH% (mean)	100	87	77	85
Wind speed (mean)	.50 kmph	1.0 kmph	.50 kmph	0.0 kmph
Wind direction	S-SW	W-NW	SE-S	SW
Inversion*	↑	↓	↑	↓
Cloud cover	10/10	0/10	10/10	0/10

* I.D.--insecticide diluent

** ↓--inversion

↑--lapse

↔--neutral (isothermic)

Table 2.

Summarized Data of Spruce Budworm Population Reduction and Host Tree Defoliation in Experimental Blocks.
Bathurst, N.B. 1981

Host Species: Balsam Fir

Spray Treatment	Spray Dates	Number Blocks	Number Samples	% Corrected Population Reduction				Defoliation %
				Count 1*	Count 2**	Count 3**	Count 4**	
Aminocarb 180F + Atlox + H_2O (70 g/ha AI)	12-06-81 18-06-81	2	200	49.0 2	88.7 2	90.8 6	94.8 10	12.4
Aminocarb 180F + ID585 (70 g/ha AI)	12-06-81 18-06-81	2	146	33.9 3	85.2 2	86.6 7	90.1 11	10.0
Aminocarb 1.5 OSC[1] Sunspray 6N (70 g/ha AI)	13-06-81 18-06-81	2	146	38.0 4	90.6 4	97.0 8	96.6 12	15.5
Aminocarb 1.5 OSC + ID585 (70 g/ha AI)	16-06-81 19-06-81	1	68	32.7 2	80.6 4	88.4 8	97.6 12	20.7
Atlox + H_2O	15-06-81 19-06-81	1	60	0.0 3	0.0 4	0.0 8	7.3 12	62.3
CHECK BLOCK (untreated)	N/A	1	60	N/A	N/A	N/A	N/A	75.5

1. OSC oil soluble concentrate
*denotes days after 1st application
**denotes days after 2nd application

Table 3.

Summarized Data of Spruce Budworm Population Reduction and Host Tree Defoliation in Experimental Blocks.
Bathurst, N.B. 1981

Host Species:White Spruce

Spray Treatment	Spray Dates	Number Blocks	Number Samples	% Corrected Population Reduction Count 1*	Count 2**	Count 3**	Count 4**	Defoliation %
Aminocarb 180F + Atlox + H_2O (70 g/ha AI)	12-06-81 18-06-81	1[2]	10	46.3 2	79.3 2	74.4 6	86.4 10	30.9
Aminocarb 180F + ID 585 (70 g/ha AI)	12-06-81 18-06-81	2	52	0.0 3	0.0 3	0.0 7	0.0 11	27.4
Aminocarb 1.5 OSC[1] + Sunspray 6N (70 g/ha AI)	13-06-81 18-06-81	2	30	0.0 4	42.9 4	30.6 8	18.5 12	19.4
Aminocarb 1.5 OSC + ID 585 (70 g/ha AI)	16-06-81 19-06-81	1	20	0.0 2	14.5 4	11.6 8	47.1 12	54.1
Atlox + H_2O	15-06-81 19-06-81	1	20	0.0 3	0.0 4	0.0 8	0.0 12	73.4
CHECK BLOCK (untreated)	N/A	1	30	N/A	N/A	N/A	N/A	76.3

[1]OSC - oil soluble concentrate
[2]block 2 contained no white spruce
*denotes days after 1st application
**denotes days after 2nd application

Table 4

Summarized Data of Spruce Budworm Population Reduction and Host Tree Defoliation in Experimental Blocks. Bathurst, N.B. 1981.

Host Species-Red Spruce

Spray Treatment	Spray Dates	Number Blocks	Number Samples	% Corrected Population Reduction Count 1*	Count 2**	Count 3**	Count 4**	Defoliation %
Aminocarb 180F + Atlox + H_2O (70 g/ha AI)	12-06-81 18-06-81	2	26	33.2 2	48.5 2	52.9 6	51.2 10	3.3
Aminocarb 180F + ID 585 (70 g/ha AI)	12-06-81 18-06-81	2	24	32.8 3	16.0 3	73.8 7	53.8 11	2.4
Aminocarb 1.5 OSC[1] + Sunspray 6N (70 g/ha AI)	13-06-81 18-06-81	2	32	15.6 4	29.5 4	29.1 8	74.9 12	3.8
Aminocarb 1.5 OSC + ID 585 (70 g/ha AI)	16-06-81 19-06-81	1	12	0.0 2	2.9 4	46.4 8	57.7 12	9.2
Atlox + H_2O	15-06-81 19-06-81	1	20	0.0 3	0.0 4	0.0 8	0.0 12	19.7
CHECK BLOCK (untreated)	N/A	1	30	N/A	N/A	N/A	N/A	26.5

[1]OSC - oil soluble concentrate
*denotes days after 1st application
**denotes days after 2nd application

FIELD RESPONSE OF THE SPRUCE BUDWORM
TO INCREASED DOSAGE RATES OF COMMERCIAL
BACILLUS THURINGEIENSIS

(Study Ref. No. FP-14)

Report to the Annual Forest Pest Control Forum

by

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SUMMARY

In 1981, the response of an hitherto untreated budworm population to graded doses of Thuricide 32B and Dipel 88® was investigated. This information was deemed basic to the making of cost-benefit decisions by pest control operators. The following conclusions were drawn from the data generated by this research and summarized below:

1. The atomization and ground deposit efficiency of highly concentrated *B.t.* tank mixes is far greater than the atomization and deposition efficiency of highly dilute mixes.
2. *B:t.* applied at 10 BIU/ha is significantly less effective than that applied at 20 BIU/ha. This latter dosage rate is suboptimal in terms of larval population reduction but acceptable in terms of foliage protection. Pending confirmation of these observations by other workers, it would appear that an increase of the dosage rate from 20 to 30 BIU/ha is justified.
3. *B.t.* treatments above 10 BIU/ha have a greatly detrimental effect of survivability and biomass of budworm populations. No detrimental effects on budworm parasitoid were detected with the Dipel 88 formulation.
4. Under the conditions of the present tests, double applications were no more effective against the budworm than single ones.
5. A repeat of this test in another geographical area is recommended.

INTRODUCTION

Agricultural and forest insect pests can be expected to respond differently to toxic agents under artificial laboratory conditions and under natural field conditions. Thus, in assessing the effectiveness of an insecticide or control agent for practical use, the dosage-response behavior of the pest species under natural conditions is an important requisite to its recommendation for use. Despite the considerable amount of field research on the use *Bacillus thuringiensis* against the spruce budworm, such a dosage-response has never been reported. This report addresses this specific question with a view to providing information on which cost benefit options can be based.

FIELD TRIALS

The field tests were conducted along Highway 11 between Atikokan and Mine Centre, Ontario, in balsam fir stands which had been infested with spruce budworm for the previous three years. An assessment of L_2 density the previous fall indicated that defoliation the following year would be moderate to severe on selected 12.5 hectare plot sites.

Dipel 88® and Thuricide 32B were applied at dosage rates of 10, 20, 40 and 80 BIU in 9.4 ℓ/ha by a Cessna 185 Skywagon equipped with 4 AU 3000 Micronairs. Uvitex ERN-P at 0.1% was used in the tank mixes as tracer dye. Application started on May 30 when budworm development was 73% L_2 and 26% L_3 and ended on June 7 when development was 18% L_3, 32% L_4, 39% L_5 and 11% L_6. Meteorological conditions were monitored within each spray plot at the time of spray. All balsam fir budcaps had been shed when spray started but only about 50% of the buds were fully flushed. Buds were fully flushed by the end of spray application. The aircraft which was calibrated for the desired delivery rate prior to application floew at about 5-10 meters above the tree tops. The Micronair setting was 11 for all applications.

The criteria studies during the test included: 1. Shoot density in treated and untreated spray blocks. 2. Larval development on May 22, 25 and 29, and June 1, 4 and 6. 3. Area weather conditions during the assessment period using a hygrothermograph, a rain gauge and a solar ultraviolet recorder. 4. Ground level deposit rates using Millipore filter membranes. The original plan was to study deposits on foliage but this had to be abandoned because the Uvitex dye was found to absorb very rapidly into the balsam fir foliage. 5. Budworm population reductions. 6. Defoliation (Fettes method). 7. Biomass of surviving budworm. 8. Larval parasitism at pre-spray and 14 and 21 days post-spray. 9. Pupal parasitism. 10. Pupal survival. 11. Budworm residual population density and 12. The effectiveness of single versus double applications. Table 1 summarizes the basic application criteria of the trials.

TABLE 1

Experimental *Bacillus thuringiensis* Applications Criteria, 1980 Dosage-response Field Tests

Formulations,* application date	Application rates	Plot Sizes (ha)	No. tests trees balsam fir**	Pre-spray shoot density per 45 cm branch	Pre-spray budworm density	
					per br.	per 100 shoots
Thuricide 32B, 5/31	10 BIU in 9.4 ℓ/ha	12.5	30	106	16	15
Thuricide 32B, 6/4	20 BIU in 9.4 ℓ/ha	12.5	30	87	12	24
Thuricide 32B, 6/6	40 BIU in 9.4 ℓ/ha	12.5	30	60	16	14
Thuricide 32B, 6/6	80 BIU in 9.4 ℓ/ha	12.5	30	100	36	21
Dipel 88 5/30	10 BIU in 9.4 ℓ/ha	12.5	30	86	19	22
Dipel 88 6/3	20 BIU in 9.4 ℓ/ha	12.5	30	73	16	24
Dipel 88 6/4	40 BIU in 9.4 ℓ/ha	12.5	30	77	25	32
Dipel 88 6/4	80 BIU in 9.4 ℓ/ha	12.5	30	91	17	19
Dipel 88	2 x 10 BIU in 4.7 ℓ/ha	12.5	30	76	78	23
Thuricide 32B	2 x 20 BIU in 4.7 ℓ/ha	12.5	30	85	20	23
Check - ML	-	12.5	30	69	12	17
Check - H	-	12.5	30	87	16	18

*0.1% Chevron Sticker and 0.1% Uvitex-ERN-P fluorescent tracer dye were added to all tank mixes. Diluent was tap water.

**Two 45 cm branches sampled at midcrown per tree for population assessment and 4/tree for defoliation.

Table 2

Summary of Main Responses of Spruce Budworm Populations to Increased Dosage Rates of *Bacillus Thuringiensis*.

Results & Responses	CK ML; CK-H	TREATMENTS IN BIU/ha: Thuricide 32B 10	20	40	80	Dipel 88 10	20	40	80
Ground Level									
Droplet Density (colonies/cm²)	-	31	28	77	80	40	43	25	23
Percent Larval									
Population Reduction per 100 shoots	24; 26	27	71	96	94	59	88	94	89
Percent Budworm Population Reduction									
per 100 shoots-corrected for pupal mortality	61; 73	57	92	97	99	80	98	99	96
Percent Defoliation*	71[d]; 89[e]	69[d]	45[bc]	36[ab]	61[d**]	71[d]	24[ab]	39[ab]	37[ab]
Percent Pupal Survival	49; 38	58	26	47	28	49	13	9	32
Budworm Survival									
Rate/45 cm br; corrected for pupal mortality	3.2; 3.2	2.5	0.7	0.3	0.2	2.3	0.2	0.1	0.4
Budworm Survival									
Rate/100 shoots, corrected for pupal mortality	5.9; 4.9	6.4	1.1	0.7	0.4	4.4	0.4	0.2	0.7
Mean Dry Wt. (Mg) of Emerged Female Moths	23; 22	23	12	20	19	22	18	NA***	14
Change in Larval Biomass (i.e. Mg Dry Wt./Current Shoot) between prespray and post spray I	6 ; 21	10	1.5	0.2	0.5	6.9	1.1	0.5	0.5
Percent Change In Incidence of Parasitism Pre-spray to Post-Spray I (Post-Spray I to II in Brackets) - Dipel Plots only	-10; -21	-	-	-	-	-7(+2)	-16(-5)	-2(-8)	-7(-17)
Percent Pupal Parasitism	3; 5	7	0	11	31	4	7	6	6

*Values followed by the same letter are not significantly different at 5% level.
**Mostly defoliation before spray, due to late application and advanced development of larvae.
***Only 1 moth emerged.

Table 3

Efficacy of Single vs Double Application of Similar Dose and Volume of *B.t.*

Treatment BIU/ha	Ground Deposit* (Colonies/cm^2)	Percent Budworm** Population Reduction	Percent Defoliation
Dipel 2 x 10	82	98	35^{ab}
Dipel 1 x 20	42	98	24^{ab}
Thuricide 2 x 20	71	94	37^{ab}
Thuricide 1 x 40	77	98	26^{ab}
CH-ML	-	62	71^{c}
CH-H	-	74	89^{d}

*Collected on Millipore filter membrane
**Corrected for pupal mortality.
Values under defoliation column followed by the same letter are not significantly different at 5% level.

RESULTS AND DISCUSSION

The pre-spray shoot density per 45 cm branch tip varied between 60 and 106 on Thuricide treatment plots, 73 and 91 in Dipel treatment plots and 69 and 87 in the untreated check plots (Table 1). This indicates that tree vigor was roughly similar between the test plots. Pre-spray larval densities were generally high (14-24/100 shoots for Thuricide treatments and 19 to 32/100 shoots for Dipel treatments) and high enough in all treatment plots to cause unacceptable defoliation if left untreated.

Budworm responses to increased dosage rates as observed in these tests are summarized in Table 2. Ground level deposit-rates increased tremendously with increased dosage of Thuricide. Theoretically, the amount of active ingredient in 28 droplets at 20 BIU/ha is twice that in 31 droplets at 10 BIU/ha. Thus the 28 droplets at the higher dosage is equivalent to 62 droplets at the lower dosage rate. Similarly, 77 droplets at 40 BIU/ha is equivalent to 56 droplets at 20 and 80 droplets at 80 BIU/ha is equivalent to 154 droplets at 40 BIU/ha. It is evident that with the Thuricide 32B formulation the atomization and deposit efficiency is greatly increased as concentration of the spray mixed is increased.

The behavior of Dipel was similar at the two lowest dosage rates (12.5% and 25% tank mixes) but different from Thuricide above the 25% concentration (40 BIU/ha). at 40 and 80 BIU/ha, the droplet densities were considerably lower than at the two lower Dipel concentration and only about 1/3 the densities of Thuricide at the same concentrations. The tank mix of Dipel at 40 BIU/ha is 50% in water with a viscosity of 1040 cps at 6°C. The viscosity of undiluted Dipel is 2300 compared with 64 cps of a 25% mix. These data would at least partly explain the lower than expected breakup and deposit efficiency of highly concentrated Dipel 88. Notwithstanding the lower droplet densities of 40 and 80 BIU/ha, the actual amount of active ingredient deposited per unit area at these rates were 2.5 to 4.6 times greater than that at 10 BIU/ha and from 1.2 to 2.1 times greater than at 20 BIU/ha.

It seems a reasonable assumption that the application of high concentrate *B.t.* produced better deposit efficient in terms of total active ingredient and, in the case of Thuricide, in terms of density of coverage as well.

Larval population reduction increase as dosage increased for both products. Dipel appeared to be more effective than Thuricide at the lowest dosage rate (10 BIU/ha). When the effect of the treatments on pupal survival was taken into account, it is evident that all treatments above 10 BIU/ha were highly effective in terms of budworm populations reduction. Based on the larval dosage-mortality response alone, 20 BIU/ha appears to be suboptimal.

Defoliation at dosage rates between 20 and 80 BIU/ha were generally not significantly different from each other but significantly different from the 10 BIU/ha treatments and the untreated checks. The 61% defoliation recorded for Thuricide at 80 BIU/ha was due to a combination of high budworm density and late application of that plot, i.e., the damage was done before application.

It is tentatively concluded that acceptable protection can be achieved at any dosage rate ranging from 20-80 BIU/ha.

Pupal survival was substantially reduced in plots treated with more than 10 BIU/ha of both *B.t.* products compared with survival in untreated plots. However, no direct relationship between dosage applied or deposit rate and pupal survival could be detected.

Residual populations of budworm were extremely low on plots treated with more than 10 BIU/ha compared with untreated checks. This was evident whether the data were based on budworm per 45 cm/branch or per 100 current shoots. The residual budworm in plots treated with 20 BIU/ha or greater ranged from 0.2 to 0.7/branch compared with 3.2/branch in the checks. Note that the survival rate at 80 BIU/ha was the lowest of the Thuricide treatment in spite of the high budworm density and late *B.t.* application on this plot. One residual budworm per 45 cm branch is considered to be the density which would not cause a significant budworm population in the succeeding year assuming no moth influx.

No direct relationship was detected between the mean dry weight of female moths from *B.t.* treated plots and the weight of those from untreated check plots. A gradual weight reduction is apparent among Dipel treated populations but because of the lack of female moths from the 40 BIU/ha treatment plot, such a reduction could not be demonstrated. Both *B.t.* graded treatments did, however, have a profound effect on larval biomass. On the average the change in biomass among larvae from untreated checks was 13.5 mg/current shoot. The change in biomass on the graded Thuricide plots were respectively, 74%, 11%, 1.5% and 3.7% of the untreated. Equivalent values for Dipel were 51%, 8.1%, 3.7% and 3.7%, respectively.

Larval and pupal parasitism were low among both treated and untreated test populations. There was no evidence that treatment with any of the graded level of Dipel had any detrimental effect on the non-target parasitoids.

The data comparing the efficacies of single and double applications (Table 3) show that under the conditions of the present test, double applications were not significantly more effective than single applications of the same dosage in a similar total volume. In fact, a single application of 20 BIU of Dipel in 9.4 ℓ/ha depositing at 42 colonies/cm^2 apparently caused 11% less defoliation than 2 x 10 BIU of Dipel in 4.7 ℓ/ha each depositing at 82 colonies/cm^2. The data suggest that, all things being equal, there is no advantage to double applications over a sample application in an unmixed balsam fir stand.

PLANS FOR 1981 - The relationship of graded volumes to *B.t.* effectiveness. The dosage of 30 BIU/ha is to remain constant in 2.35, 4.7, 9.4 and 18.8 ℓ/ha.

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

(Study Ref. FP-15)

Report to the 1981 Canadian 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 1981 dealt with evaluation of the effects of new formulations of aminocarb insecticide on terrestrial arthropods, honeybees, wild pollinators and aquatic organisms. Field sampling activities in the Icewater Creek watershed research area near Sault Ste. Marie initiated in 1980 were continued and expanded upon, in a continuing environmental impact research program focusing on terrestrial and aquatic organisms in a variety of forest habitats.

AMINOCARB FORMULATION STUDIES

New Brunswick

Terrestrial arthropod studies: A program was conducted to assess and compare the effects of different MATACIL® formulations applied to small efficacy plots in New Brunswick in 1981 by FPMI's Field Efficacy group on the native arthropod fauna of balsam fir. The formulations studied were: MATACIL 1.8D in Sunspray 6N, 1.8D in I.D. 585, 1.8F in I.D. 585, 1.8F and Atlox in water, and Atlox in water.

Preliminary results indicate that MATACIL 1.8D in 6N had a more pronounced and more diversified knockdown effect than the other formulations. When formulated with 585, MATACIL 1.8D had less of a knockown effect than either of the new flowable formulations, and was comparable in effect to Atlox in water. This suggests that the Sunspray 6N was either the more toxic element of the formulation, or greatly increased the deposit of active ingredient over water or 585 based treatments. The new flowable formulations appeared to exert a slightly greater knockdown effect than the original 1.8D formulation. No prominent differences were noted between the water and oil-based sprays of the flowable MATACIL, although the water-based treatment appeared to be more effective on Lepidoptera. Some of the effects of the water-based spray may be attributable to Atlox, as a short term knockdown effect was documented following the Atlox in water treatment. It should be noted that these conclusions may change after deposit assessment results become available.

Ontario

Honeybee and wild pollinator studies: MATACIL 1.8D and 1.8F were applied to small plots of native wildflowers near Searchmont, Ontario, to study effects on honeybees and wild pollinators. Sprays were applied using a Micron 'ULVA' Hand Sprayer, and both oil and water-based formulations of MATACIL 1.8F were tested. Knockdown effects were observed with all MATACIL sprays, but were usually limited to dipterans resting overnite on blossoms or foliage being knocked down due to direct exposure to spray. Wild pollinator activity was only slightly suppressed by the different treatments, with dipterans which normally forage early in the day the group most affected. Honeybee colonies held in cages in MATACIL 1.8F treated plots suffered higher mortality than control colonies, but an uncaged colony placed in the middle of an isolated patch of fireweed sprayed with MATACIL 1.8F was only slightly affected. The experiments carried out do not suggest that MATACIL 1.8F sprays will present any greater hazard to pollinators than MATACIL formulations previously used in Canadian forest insect control programs.

Aquatic Impact Studies: Field studies were conducted by the Environmental Impact Section and Toxic Chemicals Section of the Forest Pest Management Institute in 1981 to assess the effects on lotic ecosystems of exposure to MATACIL insecticide formulations either currently in use, or proposed for use, in spruce budworm control operations. Three solutions containing MATACIL insecticide (MATACIL 1.8D + Insecticide Diluent 585, MATACIL 1.8F + Insecticide Diluent 585 and MATACIL 1.8F + Atlox 3409F + water) and two containing no insecticide (Sunspray 7-N + Insecticide Diluent 585 and Sunspray 7-N + Atlox 3409F + water) were applied to a small, headwater trout stream near Sault Ste. Marie, Ontario using a Micron 'ULVA' Hand Sprayer. Studies included sampling of insecticide residues in water, sediment and fish tissue by the Toxic Chemicals Section, along with drift netting and Surber and artificial substrate sampling by the Environmental Impact Section. None of the 5 applications resulted in severe depletions of the benthos. Aquatic invertebrate drift increased significantly following the MATACIL 1.8D + Insecticide Diluent 585, MATACIL 1.8F + Atlox 3409F + water and Sunspray 7-N + Insecticide Diluent 585 applications, but not following the MATACIL 1.8F + Insecticide Diluent 585 and Sunspray 7-N + Atlox 3409F + water applications. The MATACIL 1.8F + Atlox 3409F + water application had both the greatest effect on drift and resulted in the highest measured residues of aminocarb in water.

A laboratory study was conducted at FPMI in 1981 to determine the relative toxicity to fish of 3 MATACIL field formulations. The results of this study indicate that the water-based and the oil-based field formulations of MATACIL 1.8F are about 60 to 80 times less toxic to rainbow trout than the field formulation of MATACIL 1.8D. The *in vitro* metabolism of aminocarb (MATACIL 1.8F formulation) was also investigated.

ICEWATER CREEK RESEARCH PROGRAM

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 program 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 tropohic 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.).

The field studies carried out in the Icewater Creek research area in 1981 represent the second year of data collection in the first phase of the program. A major effort of terrestrial studies was documenting season long pollen flow in the study area by collecting data on the phenology of wildflower blossoming and using introduced honeybee colonies equipped with pollen traps to determine pollen source utilization. Pollen collected is being prepared by acetolysis and identified with the assistance of specialists from the University of Guelph. In 1982 pollen utilization by wild pollinators will be focused on, with emphasis on bumblebees. Forest songbirds inhabiting three different forest habitats were censused in 1981 and over 130 resident birds were netted and banded in the preliminary year of studies to gather growth, reproduction and migration data. The mobility of the small mammal complex within the study area wasstudied by grid trapping, and mark and recapture methods. A season long census was carried out on ground arthropods using pitfall traps.

Major emphasis of aquatic studies in Icewater Creek were placed on a continuation of seasonal benthos and invertebrate drift studies, conduct of an intensive stream survey over the accessible watershed and initiation of native fish population and movement studies. Stream benthos throughout the watershed was surveyed by two different bottom sampling techniques over the entire year. Invertebrate drift was sampled at 2 h intervals over a 24 h period simultaneously at three sites on ten occasions between April and November. A contract was let to develop taxonomic keys to the major genera and species of aquatic invertebrates present in Icewater Creek, so that pesticide hazard and effects can be assessed at the lowest possible taxonomic level. Over 13 km of the Icewater Creek system were surveyed from the ground to determine stream gradient and character, bottom type, depth profiles, shoreline vegetation and overhead canopy, information essential to phase two studies on pesticide exposure to aquatic organisms. Upstream-downstream movements of the brook trout population native to Icewater Creek were studied using an instream trap, but were severely hampered by fluctuating water levels and beaver activities.

Icewater Creek research area studies will continue in 1982 with the initiation of the second phase of study on pesticide exposure utilizing available non-toxic tracer materials. The extent and scope of these studies will depend on the availability of suitable tracer materials and techniques for their analysis and section commitments to other institute programs.

ENVIRONMENTAL ACCOUNTABILITY OF THE CHEMICALS USED IN CANADIAN PEST CONTROL PROGRAMS

(Study Ref. FP-16)

Report to the Annual Forest Pest Control Forum

by

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Introduction

Large scale utilization of pest control chemicals although conferring significant benefits to forestry, can cause concern for their possible hazard to the environment. The primary objective of this project is to study and examine the fate and impact of pest control products and their metabolites on the environment. This report consists of a stock-taking of some of the major advances made in laboratory and field studies conducted during the year 1981.

(1) *The persistence and fate of three aminocarb (flowable and oil) formulations in a forest environment*

A collaborative program with studies FP9 and FP13 was undertaken to investigate the influence of additives on persistence, distribution and fate of aminocarb present in the three formulations *viz.*, 180 FE (flowable emulsion), 180 FO (flowable oil) and 180 D (oil). Each formulation of the insecticide was applied aerially twice at 70 g AI/ha to three separate 50 ha plots, PI, PIII and PV selected in a mixed coniferous forest in New Brunswick. Residue in balsam fir foliage varied according to the formulations sprayed. Usually higher values were found with the oil formulations 180 D and 180 FO compared to the water formulation 180 FE. In all the cases, the active material was lost rapidly and curvilinearly with time. Aminocarb residues were extremely low in soil compared to forest litter and persisted longer in the later. The additives in the formulation also played a significant role in droplet spectrum and deposition characteristics. Results are summarized in Tables 1 to 10.

(2) *The behaviour and degradation of chlorpyrifos-methyl in two aquatic systems*

Two aquatic models were set up separately in an environmental chamber at 15°C to investigate the movement, metabolism and persistence of 400 ppb chlorpyrifos-methyl in flooded soil and the behavior and degradation of 200 ppb of this chemical in natural water. Model I consisted of a 4.5 cm bottom layer of uncontaminated sandy loam, a 1.5 cm second layer containing 400 ppb of chlorpyrifos-methyl, and 80 l of lake water in a 100 L glass aquarium. Model II was similar, except all soils were uncontaminated and the water contained 200 ppb of chlorpyrifos-methyl. Both models and a control were held in an environmental chamber at 15°C for 90 days.

Chlorpyrifos-methyl was strongly adsorbed on the soil particles even when flooded; very little had desorbed and then dissolved in water. The maximum concentration in the water of Model I was 1 ppb, detected 0.7 days after incubation. Chlorpyrifos-methyl metabolized rapidly in the flooded soil; the major breakdown product was 3,5,6-trichloro-2-pyridinol. While the concentration of the parent compound in the flooded soil declined that of the pyridinol increased gradually and reached a maximum in about 27 days, then declined thereafter. The pyridinol was never detected in water. Both compounds were almost completely dissipated in 90 days.

In Model II chlorpyrifos-methyl moved rapidly from the water to the flooded soil. After incubation for 13 days, its concentration increased from nondetectable to a maximum of 560 ppb in the flooded soil, but decreased from 200 ppb to 40 ppb in the water. Both chlorpyrifos-methyl and its breakdown product, 3,5,6-trichloro-2-pyridinol, were readily degraded in soil and water; only 0.1 ppb and 10 ppb remained in the water and in the flooded soil respectively after incubation for 83 days.

(3) *Influence of formulation on foliar deposition and persistence of fenitrothion and aminocarb (collaborative research with Study No. FP9)*

Foliar deposition and persistence of fenitrothion and aminocarb was studied following simulated aerial application on to white spruce trees. Foliar concentrations were measured by gas-chromatography.

The additives in the formulation played a significant role in the degree of foliar deposition and persistence, thereby influencing the biological activity of the spray mixture. A volatile and low viscous solvent gave rise to low foliar deposition and persistence of the active ingredient. In this respect the presence of fuel oil resulted in a better tank mix than Arotex® alone in that more spray was deposited. With aminocarb, however, nonylphenol showed definite advantages over other additives, as it gave rise to the highest foliar deposits and persistence.

(3) *Translocation and dynamics of nonylphenol in an aquatic model ecosystem*

The dissipation of 1.0 ppm nonylphenol in stream and pond water, incubated in flasks at 16°C under simulated field conditions up to 44 days indicated that the half-life was 2.5 days if the flasks were open, and 16 days if they were closed. A transformed product was detected in the closed flasks.

Translocation and nonylphenol in water occurred when treated water samples were incubated in the presence of sediment. After 10 days, nonylphenol was detected only in the sediment, but not in water. About 80% of the nonylphenol was degraded in 71 days, but no degradation occurred if the water and the sediment were autoclaved prior to incubation

(4) *A preliminary study on the evaluation of analytical methods used in assessing aerial spray deposits (collaborative research with Study No. FP9)*

A study of spray deposit assessment was made under both laboratory and field operational conditions using the currently introduced Matacil 180 F emulsion formulation. Deposits were collected on balsam fir foliage and on the standard Kromekote card-glass plate collection units. Two different techniques were used for deposit assessment on foliage: gas-liquid chromatography (GLC) for the active ingredient (AI) and spectrofluorometry for the fluorescence of the tracer dye Rhodamine B. Two additional techniques were also used for the Kromekote card-glass plate units, *viz.* spot counting on Kromekote cards and use of the spread factor data, and spectrophotometry for Rhodamine B on glass plates. The measurement of aminocarb deposited on foliage using GLC gave consistently reproducible and reliable results whereas the spectrofluorometric technique following the eluation of the foliage with water (or H_2O/CH_3OH) gave erratic results partly due to the strong adsorption of the dye on to cuticular waxes and to interferences due to co-extractive impurities. Deposit assessment by spot counting yielded the lowest values among the four techniques used on the Kromekote card-glass plate collection system. Both spectrofluorometric and spectrophotometric techniques provided approximately similar results (inconsistent especially with field samples) with considerable standard deviation. The errors are partly due to solvent effects, interference due to coextractive impurities and adjuvants in the formulation and partly due to deviation from the Beer-Lambert law (absorbance is proportional to concentration) at extremely low dilutions (especially in the case with glass plates collected from the field) indicating that both techniques have considerable limitations. Although expensive and time consuming, GLC technique gave consistently reproduciable and reliable AI values in the foliage and on the glass plates collected from field and laboratory experiments.

Compared to sample units sprayed under laboratory conditions there was a wide variation in deposits on foliage and on the forest floor. Similarly, assessment of deposits on the forest floor using the above techniques, in random locations over the entire plot, indicated that only a fraction of the insecticide released over the canopy descended to the collection units kept on the forest floor. Various physical and environmental factors at the site of collection unit can prevent spray released over the canopy from reaching the ground.

(5) *Toxicity and metabolic fate of aminocarb formulations to fish (collaborative research with Study No. FP15)*

Fingerling rainbow trout (*Salmo gairdneri* Richardson) were used to determine the lethal toxicity of Matacil® 180 F and Matacil® 180 D ready-to-use formulations. The 96 h LC_{50}s were 21.3 mg/l for water-based Matacil® 180 F (180 FE), 29.1 mg/l for soil-based Matacil® 180 F (180 FO), and 0.36 mg/l for Matacil® 180 D.

Aminocarb (4-dimethylamino-m-tolyl N-methylcarbamate) and MA (4-methylamino-m-tolyl N-methylcarbamate) were detected in fish tissue 96 h after exposure. More than 50% of the total residue (aminocarb + MA) were the parent compound. The bioaccumulation ratio ranged from 1.70 to 3.32 at different concentrations of aminocarb. Both aminocarb and MA were rapidly eliminated after the fish had been transferred to clean water; the total residue declined by more than 90% in 72 hr and became nondetectable in 96 hr.

(6) *Fate and toxicity of three aminocarb formulations (180 D, 180 FO and 180 FE) added to a headwater trout stream in Searchmont, Ont. (collaborative research with Study No. FP-15)*

The three aminocarb spray formulations (180 D and 180 FO are oil formulations whereas 180 FE is an aqueous emulsion) were applied to different parts of a stream (down, middle and upstream) at three separate intervals of time *viz.*, 1 week apart using a "Micron ULVA" sprayer to yield a specific aminocarb concentration for a certain period of time. Aminocarb residues in water (4 sampling sites downstream from the point of application), sediment and fish were monitored for intervals of time following application of three formulations. The aminocarb concentration in water following the injection of oil formulations decreased extremely rapidly due to the hydrophobic nature of the additives. The emulsion formulation on the other hand, due to the presence of hydrophilic component (Atlox 3409F emulsifier) in it, showed a different picture. Similar trends were also observed in sediment and fish samples but the rate of disappearance in all the substrates was rapid. No fish mortality was noted and no significant amounts of the common aminocarb metabolite (MA is the one found in laboratory study) was found in them. Results are given in Tables 12 to 14.

(7) *Miscellaneous research studies*

In addition to these advances made in pesticide research, a number of other studies are either completed or in progress.

(a) *Use of Uvitex®, a fluorescent tracer, to assess B.t. spray deposits from conifer foliage*

Current studies carried out under laboratory conditions showed that Uvitex® is unsuitable as a tracer for assessing B.t. spray deposits because the tracer is strongly adsorbed to conifer needles giving poor recoveries and also it is highly photosensitive.

(b) Analytical testing of 1981 B.t. spray formulations for possible aminocarb contamination by GLC techniques.

(c) Provision of collaborative analytical support [also ref. 7(a) and (b)] to E.I. group on analysing various aminocarb formulations, fish tissues for aminocarb and its metabolites, analysis of glassware rinses and air samples for scientists involved in evaluation of vapour toxicity to target species (FP-12), analysis of tech. materials and tank mixes of formulations, and provision of advisory support to scientists within FPMI and other sister institutions (MFRC, PFRC, PNFI-carbofuran report, provinical agencies, universities and chemical companies).

(d) Coordination of the Forestry Substrate Program in FICP Check Sample Program organization, development, implementation and standardization of analytical techniques and sampling methods for forestry substrates.

TABLE 1

Composition of Tank Mix, Dosage and Application Rate

Formulation	Composition of tank mix (volume %)	Plot sprayed	Dosage AI/ha	Application rate (L/ha)
180 FE	Aminocarb 25.93%, Atlox 3409F[1] 1.27%, Water 72.27%, Rhodamine B[2] 0.53%	PI	70	1.5
180 FO	Aminocarb 25.93%, Shell I.D. 585[3] 72.07%, Automate B Red[4] 2%	PIII	70	1.5
180 D	Aminocarb 25.93% Sunspray 6N oil[5] 72.07%, Automate B Red 2%	PV	70	1.5

[1] Atlox® 3409F emulsifier supplied by Atlas Chemical Industries, Brantford, Ont., Canada

[2] Rhodamine B (dye tracer) supplied by Allied Chemicals, Morristown, New Jersey, U.S.A.

[3] Shell Insecticide diluent 585 supplied by Shell Canada Ltd., Toronto, Ont., Canada

[4] Automate B Red (dye tracer) supplied by Morton Williams Ltd., Ajax, Ont., Canada

[5] Sunspray 6N oil supplied by Sun Oil Co., Philadelphia, Pa., 19103, U.S.A.

TABLE 2

Deposit Data for Plots PI, PIII and PV

Studies	PI		PIII		PV	
	1st application	2nd application	1st application	2nd application	1st application	2nd application
Drops/cm^2	6 ± 6	0.5 ± 0.4	13 ± 6	3 ± 1	16 ± 6	13 ± 6
D min. (μm)	7	7	16	4	4	4
D max. (μm)	73	73	85	85	105	105
Number mode (μm)	30-40	15-35	35-45	10-40	50-60	50-80
N.M.D. (μm)	28 ± 3	23 ± 3	35 ± 6	21 ± 3	50 ± 7	58 ± 8
V.M.D. (μm)	36 ± 5	33 ± 5	41 ± 5	39 ± 6	65 ± 9	68 ± 9
S.F.	3.1 ± 0.1	3.1 ± 0.1	5.0±0.1 - 5.7±0.2	5.0±0.1 - 5.7±0.2	3.8±0.1 - 5.5±0.2	3.8±0.1 - 5.5±0.2
Spot counting (g/ha)*	0.57 (0.81%)	0.05 (0.07%)	2.2 (3.1%)	0.23 (0.32%)	8.5 (12%)	9.9 (14%)
GLC (g/ha)*	1.98 (2.8%)	0.26 (0.37%)	5.95 (8.5%)	0.87 (1.2%)	11.7 (17%)	13.5 (19%)
Colorimetry (g/ha)*	2.45 (3.5%)	0.91 (1.3%)	7.50 (11%)	1.03 (1.5%)	9.95 (14%)	12.5 (18%)
Dosage (g AI/ha)	70	70	70	70	70	70
Vol. sprayed (L/ha)	1.5	1.5	1.5	1.5	1.5	1.5
Conc. of AI in tank mix (GLC)(Wt/vol)%**	4.73	5.78	4.38	4.69	4.39	4.71

* Values in parenthesis represent the percent of AI reached the forest floor

** Spray formulation is supposed to contain 4.67 g AI/100 ml

TABLE 3

Aminocarb Residues in Balsam Fir Foliage from Plot PI

Time after spraying	Aminocarb concentration (ppm)					
	1st Application			2nd Application		
	As sampled	% Moisture content	Oven-dry*	As sampled	% Moisture content	Oven-dry*
0.5 h	2.41	60	6.03	0.75	66	2.21
1.0 h	1.86	61	4.77	0.96	65	2.74
4.0 h	1.54	62	4.05	0.85	63	2.30
12.0 h	1.37	66	4.03	0.70	64	1.94
15.0 h	1.12	64	3.11	0.66	58	1.57
1 d	0.88	58	2.10	0.68	59	1.66
2 d	0.48	63	1.30	0.63	61	1.62
3 d	0.35	69	1.13	0.58	60	1.45
4 d	0.27	66	0.79	0.55	58	1.31
5 d	0.20	65	0.57	0.51	60	1.28
6 d				0.45	62	1.18
8 d				0.35	64	0.97
10 d				0.29	60	0.73
12 d				0.24	57	0.56
21 d				0.14	59	0.34

* Moisture content was determined as per the A.O.A.C. Official Methods of Analysis, 8th Edn. 1955 by drying 2 x 10 g duplicates of each sample at 105°C for 16 hrs in a thermostatic oven

TABLE 4

Aminocarb Residues in Balsam Fir Foliage from Plot PIII

Time after spraying	Aminocarb concentration (ppm)					
	1st Application			2nd Application		
	As sampled	% Moisture content	Oven-dry	As sampled	% Moisture content	Oven-dry
0.5 h	2.27	61	5.82	0.85	56	1.93
1.0 h	1.98	61	5.08	1.79	57	4.16
4.0 h	1.67	62	4.40	1.44	59	3.51
12.0 h	1.45	66	4.26	1.16	62	3.05
15.0 h	1.36	62	3.58	1.12	62	2.95
1 d	1.31	57	3.05	1.06	63	2.86
2 d	1.14	59	2.78	1.02	64	2.83
3 d	0.79	62	2.08	0.98	66	2.83
4 d	0.57	60	1.43	0.88	64	2.44
5 d	0.38	64	1.06	0.69	65	1.97
6 d				0.58	64	1.61
8 d				0.51	58	1.21
10 d				0.48	60	1.20
12 d				0.44	61	1.13
21 d				0.32	59	0.78

TABLE 5

Aminocarb Residues in Balsam Fir Foliage from Plot PV

Time after spraying	Aminocarb concentration (ppm)					
	1st Application			2nd Application		
	As sampled	% Moisture content	Oven-dry	As sampled	% Moisture content	Oven-dry
0.5 h	0.77	58	1.83	2.35	56	5.34
1.0 h	1.30	60	3.25	2.76	58	6.57
4.0 h	1.15	61	2.95	2.69	58	6.41
12.0 h	1.01	63	2.73	2.04	62	5.37
15.0 h	0.96	62	2.53	1.92	64	5.33
1 d	0.87	62	2.29	1.68	64	4.67
2 d	0.72	63	1.95	1.59	63	4.30
3 d	0.68	64	1.89	1.43	61	3.67
4 d	0.61	63	1.65	1.36	60	3.40
5 d	0.52	62	1.37	1.23	63	3.32
6 d				1.19	59	2.90
8 d				0.97	63	2.62
10 d				0.92	59	2.24
12 d				0.84	60	2.10
21 d				0.64	61	1.64

TABLE 6

Aminocarb Residues in Forest Litter from Plot PI

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.018 (0.024)	0.016 (0.021)
0.50 h	0.023 (0.031)	0.018 (0.023)
1.0 h	0.022 (0.029)	0.015 (0.022)
3.0 h	0.023 (0.029)	0.016 (0.021)
5.0 h	0.018 (0.024)	0.016 (0.022)
12.0 h	0.015 (0.021)	0.014 (0.019)
1 d	0.018 (0.024)	0.012 (0.015)
2 d	0.015 (0.022)	0.012 (0.016)
3 d	0.017 (0.024)	0.010 (0.012)
4 d	0.014 (0.020)	0.007 (0.009)
5 d	0.015 (0.020)	0.006 (0.008)
6 d		0.007 (0.008)
8 d		0.005 (0.007)
10 d		0.006 (0.009)
12 d		T
21 d		N.D.

T = Trace, <0.005 ppm based on wet weight of litter

N.D. = Not detectable; detection limit 0.003 ppm based on wet weight in litter

Values in parentheses are for oven-dry litter samples

Percent moisture content of litter samples are not given since they can be calculated from the following expression:

Percent moisture content of litter =

$$\left[\frac{\left[\text{(Aminocarb in oven-dry litter sample)} - \text{(Aminocarb in wet litter sample)}\right] \times 100}{\text{(Aminocarb in oven-dry litter sample)}}\right]$$

TABLE 7

Aminocarb Residues in Forest Litter from Plot PIII

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.038 (0.052)	0.042 (0.052)
0.50 h	0.054 (0.072)	0.044 (0.049)
1.0 h	0.086 (0.146)	0.046 (0.060)
2.0 h	0.080 (0.106)	0.044 (0.056)
3.0 h	0.077 (0.100)	0.049 (0.066)
5.0 h	0.074 (0.099)	0.036 (0.044)
12.0 h	0.072 (0.096)	0.040 (0.049)
1 d	0.068 (0.088)	0.026 (0.032)
2 d	0.064 (0.079)	0.019 (0.028)
3 d	0.052 (0.069)	0.017 (0.026)
4 d	0.045 (0.060)	0.017 (0.024)
5 d	0.034 (0.046)	0.016 (0.021)
6 d		0.015 (0.022)
8 d		0.014 (0.019)
10 d		0.013 (0.018)
12 d		0.010 (0.014)
21 d		N.D.

See footnotes in Table 6

TABLE 8

Aminocarb Residues in Forest Litter from Plot PV

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.132 (0.175)	0.126 (0.172)
0.50 h	0.159 (0.211)	0.144 (0.188)
1.0 h	0.178 (0.227)	0.206 (0.269)
2.0 h	0.188 (0.240)	0.216 (0.269)
3.0 h	0.160 (0.199)	0.215 (0.263)
4.0 h	0.146 (0.181)	0.196 (0.246)
12.0 h	0.098 (0.128)	0.180 (0.245)
1 d	0.085 (0.108)	0.126 (0.157)
2 d	0.078 (0.098)	0.110 (0.141)
3 d	0.074 (0.094)	0.098 (0.138)
4 d	0.069 (0.086)	0.081 (0.108)
5 d	0.061 (0.077)	0.074 (0.101)
6 d		0.061 (0.084)
8 d		0.049 (0.068)
10 d		0.035 (0.046)
12 d		0.029 (0.037)
21 d		0.013 (0.017)

See footnotes in Table 6

TABLE 9

Aminocarb Residues in Forest Soil from Plot I

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.004 (0.007)	T
0.50 h	0.008 (0.013)	0.003 (0.005)
1.0 h	0.006 (0.011)	T
2.0 h	0.005 (0.008)	N.D.
3.0 h	0.006 (0.009)	N.D.
5.0 h	T	N.D.
12.0 h	N.D.	-
1 d	N.D.	-
2 d	-	-
3 d	N.D.	N.D.
4 d	-	-
5 d	N.D.	N.D.
6 d		
8 d		
10 d		
12 d		
21 d		

T = Trace < 0.003 ppm based on wet mass of soil

N.D. = Not detectable; detection limit 0.001 ppm based on wet mass of soil

Values in parentheses are for oven-dry soil samples

TABLE 10

Aminocarb Residues in Forest Soil from Plot III

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.008 (0.013)	0.004 (0.007)
0.50 h	0.014 (0.024)	0.005 (0.008)
1.0 h	0.018 (0.029)	0.010 (0.017)
2.0 h	0.016 (0.025)	0.005 (0.009)
3.0 h	0.010 (0.016)	0.004 (0.007)
5.0 h	0.011 (0.018)	T
12.0 h	0.007 (0.011)	N.D.
1 d	0.004 (0.006)	N.D.
2 d	N.D.	N.D.
3 d	N.D.	N.D.
4 d	-	-
5 d	N.D.	N.D.
6 d		
8 d		
10 d		
12 d		
21 d		

See footnotes in Table 9

TABLE 11

Aminocarb Residues in Forest Soil from Plot V

Time after spraying	Aminocarb concentration (ppm)	
	1st application	2nd application
0.25 h	0.024 (0.039)	0.008 (0.014)
0.50 h	0.032 (0.053)	0.016 (0.028)
1.0 h	0.050 (0.086)	0.034 (0.057)
2.0 h	0.051 (0.089)	0.044 (0.076)
3.0 h	0.046 (0.075)	0.038 (0.064)
5.0 h	0.037 (0.063)	0.030 (0.052)
12.0 h	0.024 (0.039)	0.022 (0.036)
1 d	0.011 (0.019)	0.017 (0.027)
2 d	0.007 (0.011)	0.011 (0.018)
3 d	0.004 (0.007)	0.006 (0.010)
4 d	T	0.004 (0.007)
5 d	T	T
6 d		T
8 d		N.D.
10 d		N.D.
12 d		N.D.
21 d		-

See footnotes in Table 9

TABLE 12

Aminocarb Concentration (ppb) in Stream Water at Different Stations

After Spraying the Stream with Three of its Formulations

Time after spraying	Formulation 180 FE				Formulation 180 FO				Formulation 180 D			
	Sampling station from application (m)				Sampling station from application (m)				Sampling station from application (m)			
	5	50	100	150	5	50	100	150	5	50	100	150
Prespray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1 min.	0.1	N.D.	N.D.	N.D.	301.9	N.D.	N.D.	N.D.	380.4	N.D.	N.D.	N.D.
3 min.	799.8	N.D.	N.D.	N.D.	3823.2	N.D.	N.D.	N.D.	1862.3	0.4	N.D.	N.D.
5 min.	1306.5	N.D.	N.D.	N.D.	15000.0	1.2	N.D.	N.D.	30.1	74.9	0.9	N.D.
10 min.	959.3	T	N.D.	N.D.	481.4	3.0	N.D.	N.D.	8.4	17.5	6.4	N.D.
15 min.	451.3	0.5	N.D.	N.D.	136.0	195.6	N.D.	N.D.	3.7	12.4	35.4	N.D.
20 min.	163.9	122.1	N.D.	N.D.	21.7	273.7	0.1	0.2	0.8	2.8	34.0	7.7
30 min.	28.5	363.0	N.D.	N.D.	3.3	13.8	127.2	0.2	0.1	0.3	2.4	25.0
1.0 h	2.2	15.9	256.1	0.3	0.6	3.9	29.1	109.5	N.D.	0.1	0.1	0.4
1.5 h	1.1	3.2	162.1	100.1	0.2	0.9	3.8	48.7	N.D.	N.D.	N.D.	0.1
2.0 h	0.5	1.0	33.5	109.7	0.2	0.3	1.5	15.9	N.D.	N.D.	N.D.	N.D.
3.0 h	0.3	0.4	3.6	38.6	T	0.2	0.1	0.4	N.D.	N.D.	N.D.	N.D.
4.0 h	0.2	0.2	1.3	4.7	N.D.	0.1	0.1	0.3	N.D.	N.D.	N.D.	N.D.
5.0 h	0.2	0.2	0.6	1.3	N.D.	N.D.	0.1	0.1	-	-	-	-
6.0 h	0.1	0.1	0.2	0.6	N.D.	N.D.	N.D.	0.1	-	-	-	-
9.0 h	N.D.	N.D.	0.1	0.1	N.D.	N.D.	N.D.	N.D.	-	-	-	-
25 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	-	-
50 h.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D	N.D.	N.D.	-	-	-	-

T - Trace <0.1 ppb. N.D. - Not detectable; detection limit 0.05 ppb.

TABLE 13

Aminocarb Concentration (ppb) in Stream Sediments

Time after spraying	Formulation 180 FE		Formulation 180 FO		Formulation 180 D	
	Sampling station from spray site		Sampling station from spray site		Sampling station from spray site	
	5 m	50 m	5 m	50 m	5 m	50 m
Prespray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1 min.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3 min.	3.5 (3.9)	N.D.	3.2 (4.0)	N.D.	T	N.D.
5 min.	20.2 (23.8)	N.D.	7.6 (8.6)	N.D.	T	N.D.
10 min.	9.4 (10.9)	N.D.	T	N.D.	N.D.	N.D.
15 min.	6.8 (7.9)	T	N.D.	N.D.	N.D.	N.D.
20 min.	3.5 (4.1)	T	N.D.	N.D.	N.D.	–
30 min.	T	T	N.D.	N.D.	N.D.	–
1.0 h	T	T	N.D.	–	–	–
1.5 h	N.D.	N.D.	N.D.	–	–	–
2.0 h	N.D.	N.D.	–	–	–	–
3.0 h	N.D.	N.D.	–	–	–	–

Residues in parenthesis were based on dry weight of sediment

T - Trace, <3 ppb based on wet weight of sediment

N.D. - Not detectable; detection limit 1.5 ppb based on wet weight of sediment

TABLE 14

Residues of Aminocarb (ppb)* in Rainbow Trout Fingerlings** Kept in Cages on Stream-bed at Different Stations From Site of Application of the Aminocarb Formulations

Time after spraying (hr)	Formulation and sampling station		
	180 FE (150 m)	180 FO (100 m)	180 D (100 m)
Prespray	N.D.	N.D.	N.D.
0.5	N.D.	T	17.1 ± 6.1
1.0	4.4 ± 3.2	4.6 ± 2.9	3.8 ± 2.8
1.5	85.1 ± 7.9	18.0 ± 4.9	T
2.0	106.6 ± 7.4	31.6 ± 6.7	N.D.
3.0	127.4 ± 8.8	T	N.D.
6.0	T	N.D.	N.D.

* Values are the mean of four determinations

** Average number of fish per cage (61 x 61 x 41 cm) = 25

Average mass of fish = 23.2 ± 6.4 g

Average length of fish = 13.3 ± 1.3 cm

T = Trace, <3.0 ppb based on wet weight of fish

N.D. = Not detectable; detection limit 1.5 ppb based on wet weight of fish

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

(Study Ref. FP-19)

Report to the Annual Forest Pest Control Forum

by

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Sault Ste. Marie, Ontario
P6A 5M7

December 1981

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 screening of newer products for this purpose was initiated about six months ago.

Evaluation of Herbicides for Forestry Use

It is difficult to make any significant advance in a short time but 19 herbicides were obtained from various chemical companies (see attached list) and are being tested against 8 major weed species (raspberry, salmonberry, eastern and western alders, birches, pincherry, poplars and maples). Because prechilling, stratification and nutritional requirements of some of these pest species are not clearly understood, some difficulty has been experienced in cultivating them under the greenhouse conditions. In addition, before a large-scale evaluation trial is undertaken, it is necessary to establish a screening protocol and baseline reference point using a currently registered product Esteron-600 (2,4-D) and then testing candidate materials against this. Generally the response to herbicide treatment is sigmoid and so the data is processed on a computer with probit analyses and the effective dose halving the rate of response (ED_{50}) is calculated for each species. From a series of curves, the ED_{50} are computed and thus the relative efficiency of the candidate material is thus evaluated. Table 1 shows the results of such a preliminary trial using 2,4-D as a reference point.

Herbicide Samples Received for Screening Trials

Common Name	Trade Name	Source	Potential for Use
1. Blazer	Acifluorfen	Rohm & Haas	Broadleaf weeds
2. Banvel	Dicamba	Velsicol	" "
3. Caparol	Prometryne	Ciba-Geigy	Grass-annual weeds
4. Devrinol	Napromide	Stauffer	"
5. Antor 4 ES	Diethatyl	Hercules	"
6. Dowpon	Dalapon	Dow	"
7. Esteron 600	2,4-D	Dow	Brush-conifer release
8. Esteron T-6E	2,4,5-T	Dow	" " "
9. Goal	Oxyfluorfen	Rohm & Haas	Grass
10. Herbec 20	Tebuthiuron	Elanco	Brush-conifer release
11. Kerb	Pronamide	Rohm & Haas	Grass & broadleaf
12. Primatol A	Atrazine	Ciba-Geigy	" "
13. Princep	Simazine	Ciba-Geigy	" "
14. Roundup	Glyphosate	Monsanto	Grass & brush
15. Spike 5% G	Tebuthiuron	Elanco	Total vegetative control
16. Spike 80W	Tebuthiuron	Elanco	" " "
17. BAS 9052	Poast	BASF	Grass
18. Dycleer 10)	Diacamba	Velsicol	Grass & brush
19. Garlon 4	Trichlopyr	Dow	Brush-conifer release

TABLE I

Evaluation of Esteron-600 on radical growth and seed germination of coniferous and deciduous species.

Species	Radical growth (ED_{50}-ppm)	Seed germination (ED_{50} in ppm)
White birch	0.0301	159.40
Yellow birch	0.020	136.10
Green ash	0.400	0.080
Eastern alder	0.030	1.90
Jackpine	163.20	1,526.6
White spruce	60.20	8,473.0
Black spruce	50.60	23,313.6

Thus these data amply demonstrate that conifers are resistant and the pest species are far more sensitive to Esteron-600 treatment. Further experiments were carried out with about 6-month old seedlings in the greenhouse. Plants were sprayed with Esteron-600 and the response was measured after 4 weeks. The results showed a similar trend.

TABLE II

Evaluation of Esteron-600 on survival of 6-month-old seedlings of coniferous and deciduous species

Species	ED_{50}
Eastern alder	3,192.2 ppm
Jack pine	74,309.4 ppm

Clearly, there is about a 25-fold difference between the sensitive (alder) and resistant (jack pine) species. Having established a reference baseline with 2,4-D, it is hoped to evaluate the rest of the newer compounds by this method. The ED_{50} values do provide a basis for relative performance and selection of a promising compound.

Current Status of Existing Forest Herbicides

Four promising herbicides (Krenite, Roundup, Garlon and Velpar) are being considered for registration and their current status is as follows:

Krenite is a promising herbicide suited for conifer release and site preparation in B.C. It seems quite effective against western alder and salmonberry. Owing to lack of adequate toxicological data its registration has not been complete. Unless registration is accomplished there is very little chance of its being used on a commercial scale in forestry.

Roundup is another very efficacious herbicide for forestry use and its widespread application in a forestry situation is hampered due to lack of registration. Monsanto Chemical Company is actively pursuing this matter and hopefully glyphosate would soon be registered for site preparation, conifer release and plantation use.

Garlon has a high potential for commercial use in forestry and seems to be a powerful selective plant killer like phenoxy herbicides but its registration is not yet complete again because of deficiencies in toxicological and field efficacy data.

Velpar has shown considerable promise for forestry use both for site preparation and conifer release and attempts are being made to get it fully registered for widespread use in forestry practices. It was on the I.B.T. list but was cleared on the 15th of October 1981 and hopefully it would be soon available for commercial applications.

NINTH ANNUAL FOREST PEST CONTROL FORUM MEETING
December 1 - 3, 1981, Ottawa
Prepared by H. Cerezke, NoFRC

8. Report on the Status and Control of Other Pests: Prairie Provinces and Northwest Territories

Mountain Pine Beetle (*Dendroctonus ponderosae* Hopk.)

The area of mountain pine beetle infestation in forested areas of southwestern Alberta did not expand beyond that reported in 1980. However, it did intensify within this zone (map 1). In southwestern Alberta, patches of infested pine are scattered over some 240 000 ha of forest land, of which about 180 000 ha are on provincial lands, the remainder are in National Parks and Indian Reserves. In addition, the Cypress Hills area on the Alberta-Saskatchewan border includes 35 - 40 000 ha which also have scattered infestations. Increases in beetle-killed trees were also reported in Kootenay and Yoho National Parks, but the beetle has not thus far been found in Banff or Jasper National Parks. Infestations intensified in Waterton Lakes National Park where the outbreak was first reported in 1977. Tree mortality is particularly high throughout the park.

In southwestern Alberta, two zones of the outbreak on provincial lands were delineated by the Alberta Forest Service for beetle management purposes. The southern most portion extending between Highway 3 and Waterton Lakes N.P. was considered beyond control because of the rapid invasion and spread of the beetle, and was designated for salvage. This zone was estimated to have 283 000 m^3 of lodgepole pine killed by the beetle, of which about 106 000 m^3 have been salvaged to date. A portion of the remaining 177 000 m^3 will be salvaged but a large proportion is unsalvagable because of deterioration, steep slope conditions and scattered small pockets. The salvaged areas are clearcut and most areas have received immediate rehabilitation treatment in the form of scarification and/or planting.

In addition, because of depressed lumber market conditions and the fact that the extensive residual dead stands increase the fire hazard, the provincial government is offering an incentive to companies to encourage early removal of the dead timber. This amounts to $34.00 per 1000 FBM (or per 2.35 m^3) and applies to beetle-killed as well as fire-killed trees.

The northern most part of the outbreak extending north of Highway 3 was considered controlable even though numerous small infestations were widely scattered throughout a forested area about 60 km long. In this zone, a control program was launched in April 1980, to remove all beetle-attacked trees. Approximately 16 000 trees were removed in 1980, and since October 1980, an additional 24 000 trees were removed, at a total cost of about $2.5 million. The 1980 attacked trees were located by aerial and ground cruises and were distributed in over 3000 individual infestation patches, with an average of about 8 infested trees per patch. About 70% of the total trees removed were subsequently utilized for wood products, while the remainder were burnt or peeled on site.

Because of time constraints and the location of some infestations in steep unaccessible terrain, the Alberta Forest Service experimented with tree removal by helicopter using a 206 load capacity. This added to costs of the control program but speeded up the process of sanitation cuttings. Overall costs were about $60.00 per tree.

Provincial Parks staff in both Saskatchewan and Alberta portions of the Cypress Hills were also involved in control programs. To date, on the Saskatchewan side, approximately 400 beetle-killed trees have been removed while about 700 have been removed and burnt on the Alberta side. Both programs will continue during the winter and should result in near total destruction of all beetle broods.

Low level aerial photography has been undertaken by the provinces over the Cypress Hills and the forested area in southwestern Alberta to assist in mapping infestations and for estimating volume losses.

A survey was conducted in the prairie zone of southern Alberta to establish the range and intensity of mountain pine beetle dispersal from the main population sources to the west and southwest. Locations examined included planted farm shelterbelts, park areas and urban areas. The presence of the beetle was found at some 35 locations, (see map 1) some as far as 300 km from the nearest beetle source. The main host tree affected was the exotic Scotch pine, a species widely planted throughout the prairies.

During 1981 two committees were structured with representation of CFS (PFRC and NoFRC), Alberta Forest Service, B.C. Ministry of Forests and Parks Canada. The two committees have worked closely at assessing infestations in the Rocky Mountain region along the B.C.-Alta. border, and in preparing a control action plan for forested areas within and adjacent to the border.

The general outbreak is expected to continue in 1982, although there is an indication the main outbreak reached a peak in 1981 in southwestern Alberta.

<u>Forest Tent Caterpillar</u> (*Malacosoma disstria* Hbn.)

The outbreak of the forest tent caterpillar continued throughout central and northern Alberta and Saskatcehwan with some reduction in defoliated areas in the latter province in 1981 (see map 2). An estimated 121 000 km^2 of continuous and scattered aspen forests were moderately to severely defoliated in Alberta, about the same as that reported in 1980. In Saskatchewan, some 82 000 km^2 sustained moderate to severe defoliation, a considerable reduction over that in 1980. A splitting up of the infestation was apparent in Saskatchewan with extension eastward into western Manitoba between Flin Flon and The Pas. Defoliation was rated moderate-severe in this area. In addition, scattered moderate defoliation occurred in the Turtle Mountains of southwestern Manitoba where it was reported in 1980.

Other defoliator species commonly associated with the forest tent caterpillar included the large aspen tortrix (*Choristoneura conflictana* (Wlk.)), Bruce spanworm (*Operophtera bruceata* Hlst.), early aspen leaf curler (*Pseudexentera oregonana* Wlshm.), a green fruitworm (*Orthosia hibisci* Guen.) and the linden looper (*Erranis tiliaria* Harr.). Some 7000 km^2 of aspen defoliated area in Wood Buffalo National Park was attributed to the large aspen tortrix.

Egg band surveys to predict 1982 population levels have been largely completed in all three prairie provinces. In both Alberta and Saskatchewan, similar high populations are again expected throughout most of the outbreak area. However, virus disease and incidence of natural parasites appeared to be common throughout the outbreak area and may contribute to further caterpillar declines in 1982.

In Manitoba, scattered light defoliation is predicted in the Turtle Mountains and moderate-severe defoliation in the area between The Pas and Flin Flon, including Grass River Provincial Park, Cormorant Provincial Forest and Clearwater Provincial Park.

Various municipalities in central and northwestern Alberta attempted control in high-use areas to combat the nuisance aspect of tent caterpillar larvae and to protect foliage. Some 6070 ha in the vicinity of Edmonton were aerially sprayed, 1200 ha with Bt and the remainder with malathion. Results with Bt were indicated to be generally poor but can be accounted for by improper timing, maturity of larvae and early defoliation. Further control spraying is anticipated in 1982 where populations are expected to be high on privately-owned land as well as on provincial campground areas.

Dutch Elm Disease

Dutch elm disease continued to increase and spread in Manitoba in 1981 as indicated in the following table.

Year	No. trees sampled	No. trees DED Infected	% DED Infected
1979	2542	793	31
1980	3115	1217	39
1981	4726	2744	58

Similar increases were recorded in the cities of Winnipeg and Brandon as indicated below.

	No. DED infected trees	
Winnipeg:	313 (1980)	757 (1981)
Brandon :	106 (1980)	298 (1981)

In addition, new infections were found at 13 locations in Manitoba and for the first time on one tree in the city of Regina, Saskatchewan.

The province of Manitoba has developed a cost-shared program of assistance to help the various municipalities control DED. The program gives assistance for pruning, sanitation, removal of DED killed trees, to carrying out elm tree inventories, assisting with a base tree spraying program, providing elm replacement and in helping establish tree disposal sites.

A Dutch Elm Disease Symposium held in Winnipeg during early October 1981, was considered highly successful. Some 247 delegates were present with representation from Canada, the United States and several European countries.

Other Pest Problems

Larch sawfly - during aerial surveys in 1981, defoliation of tamarack stands was noted in northern Alberta and the Northwest Territories.

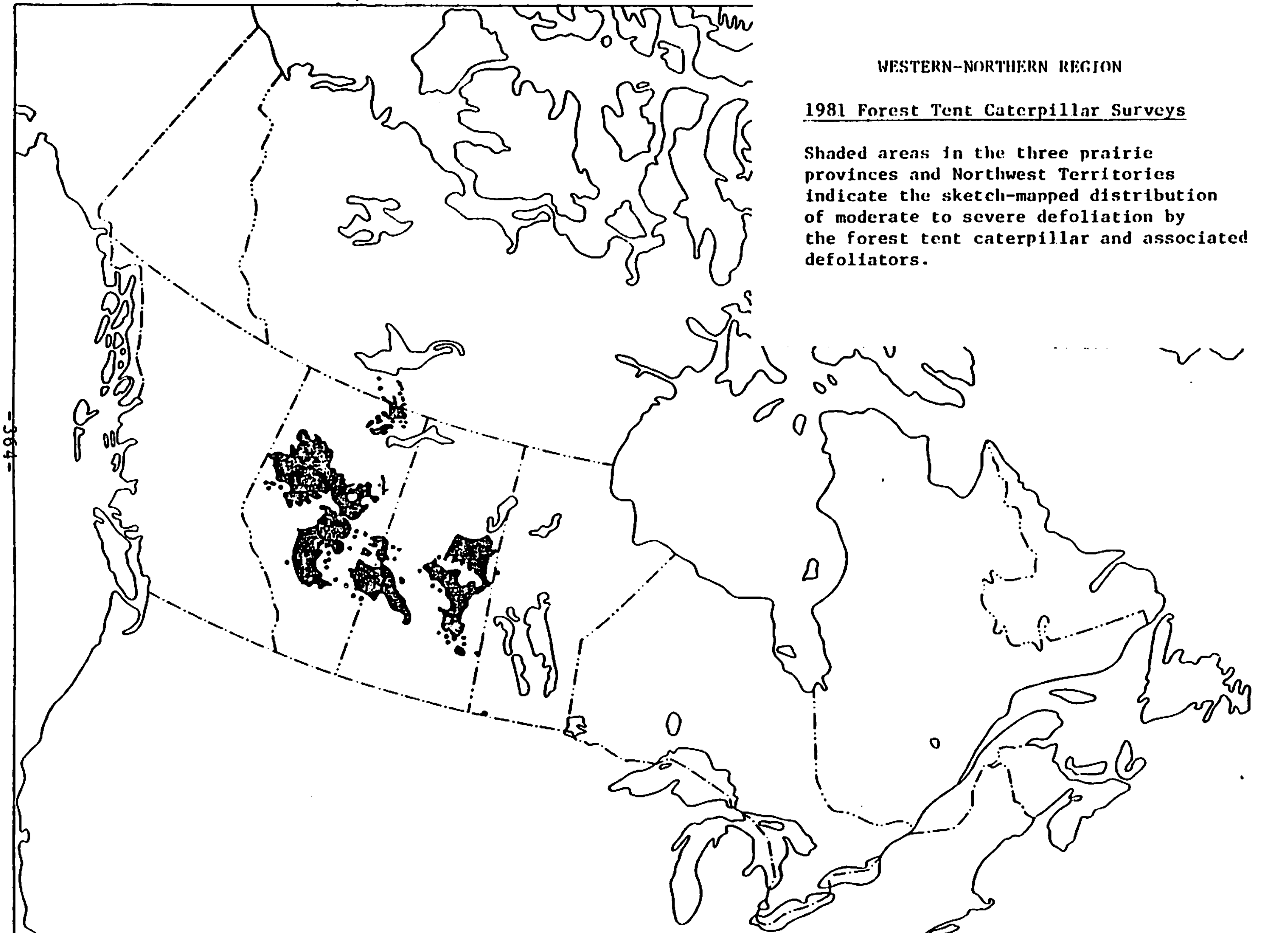
Dwarf Mistletoe - a perennial problem, especially in jack pine stands in northeastern Alberta, northern and central Saskatchewan and central and southeastern Manitoba. Some control programs are being considered in Manitoba and Alberta.

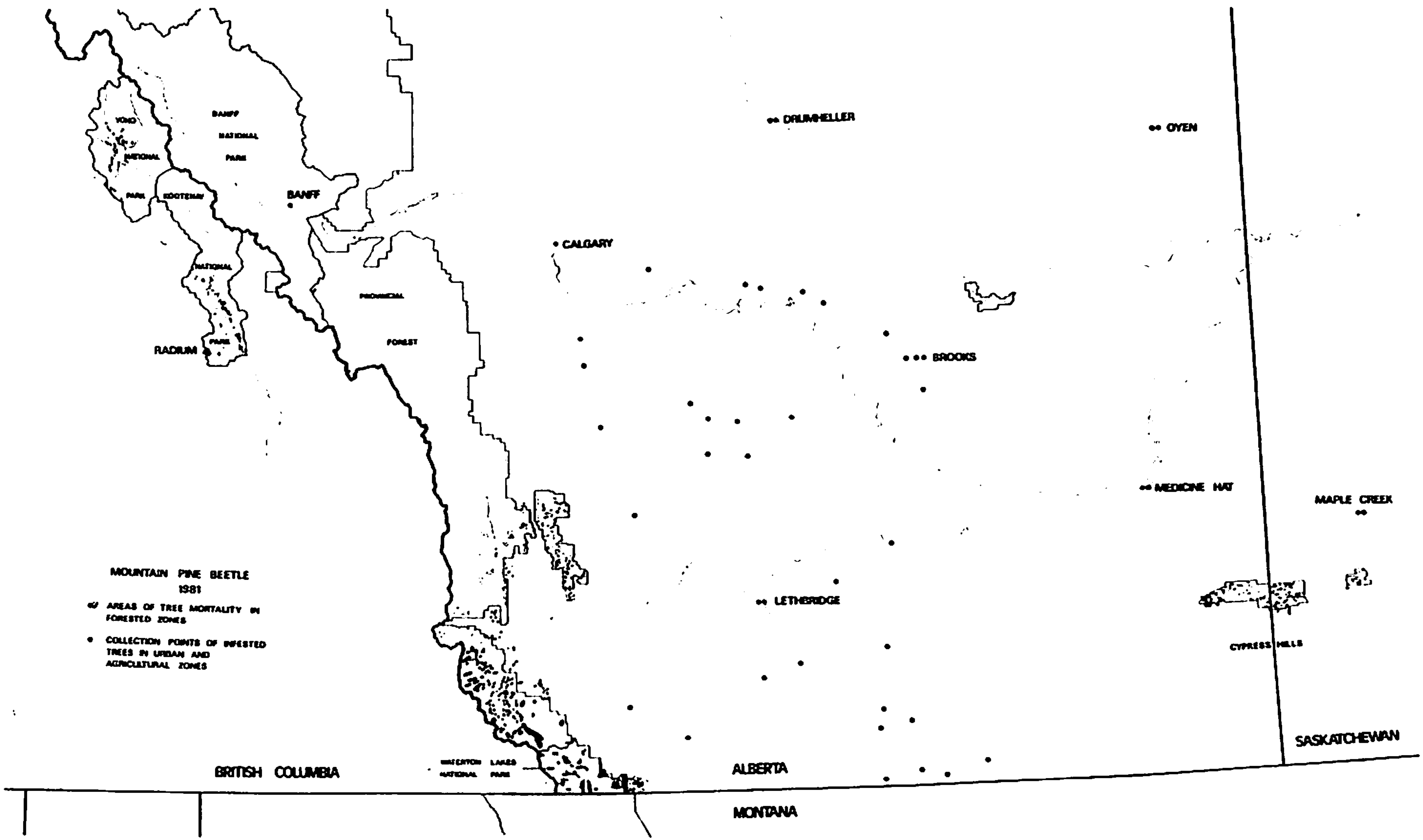
American (snowshoe) hare - populations have generally been high over wide areas of the Boreal Forest region during the past 2-3 years, coinciding with peak 9-10 year intervals of the cycle. Reports of conifer regeneration mortality from girdling are common, widespread, and severe in some cases.

WESTERN-NORTHERN REGION

1981 Forest Tent Caterpillar Surveys

Shaded areas in the three prairie provinces and Northwest Territories indicate the sketch-mapped distribution of moderate to severe defoliation by the forest tent caterpillar and associated defoliators.





DRUMHELLER
OYEN
BANFF NATIONAL PARK
YOHO NATIONAL PARK
KOOTENAY NATIONAL PARK
BANFF
CALGARY
PROVINCIAL FOREST
RADIUM
BROOKS
MEDICINE HAT
MAPLE CREEK
MOUNTAIN PINE BEETLE
1981
AREAS OF TREE MORTALITY IN FORESTED ZONES
COLLECTION POINTS OF INFESTED TREES IN URBAN AND AGRICULTURAL ZONES
LETHBRIDGE
CYPRESS HILLS
WATERTON LAKES NATIONAL PARK
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MONTANA

Experimental Control of the Birch Leaf Miner, *Profenusa thomsoni*

Prepared for the Ninth Annual Pest Control Forum

by

K. Knowles, Y. Beaubien

Province of Manitoba
Department of Natural Resources
Forestry Branch
Forest Pest Management

INTRODUCTION

An infestation of the birch leaf miner, Profenusa thomsoni, has persisted in northwestern Manitoba for approximately 10 years. Being a late season feeder, there has been no appreciable detrimental effects to the white birch. The majority of the damage is done in August. Due to leaf browning and early leaf drop, the birch leaf miner is objectionable to local residents. The Big Island Lake Cottage Owner's Association requested the Department of Natural Resources to investigate control measures which could be implemented by the home owner.

METHODS

Three methods, trunk injections, Acecap implant and Cygon banding were compared. Five trees were tested for each treatment. An additional five trees were selected for a control. The study trees were approximately 70 years old and ranged in height from 15.9 to 20.7 metres. The range in D.B.H. was 13.7 to 29.0 cm.

Pre-Treatment Analysis (July 24-26)

Extension pole pruners were used to randomly collect 100 leaves from each of the 20 sample trees. The total number of eggs and/or feeding larvae were tallied on each leaf.

Trunk Injections (July 24-25)

Orthene (15.8% active ingredient) was injected directly into the water conducting tissue of 5 trees. The application rate was 1 ml per cm of D.B.H. in a total volume of 1 litre per 5 cm of D.B.H. Water was the carrier. The injections were made under a pressure of 12 psi. Injector heads were spaced approximately 12 cm apart at 30 cm above ground level. The drill bit size was 7/32". The uptake time ranged from 45 minutes to 1 hour and 50 minutes.

Acecap Implants (July 24)

Acecaps are small plastic implants (2.7 cm in length x 1.1 cm diameter) containing a single gelatin capsule of orthene (0.875 gram active ingredient). The implants were placed 12 cm apart in a spiral formation around the tree, beginning at approximately 30 cm above ground. Drill bit size was 7/16".

Cygon Banding (July 25)

Undiluted Cygon 2E was painted in a band on the trunk of each tree at breast height. The band width was equal to D.B.H. up to a maximum of 15 cm.

Post-Treatment Analysis (August 7 and Sept 1)

Two post-treatment analyses were made, 2 weeks and 5 weeks following treatment. One hundred leaves were randomly collected from each of the 20 trees. The number of eggs, live feeding larvae and dead larvae were tallied for each leaf. Larval reduction was calculated by the formula:

$$\text{Larval reduction} = \frac{\text{Unhatched Eggs + Dead Larvae}}{\text{Total Number}} \times 100\%$$

Leaves were assessed for degree of leaf mining using 6 categories: 0%, 1-25%, 26-50%, 51-75%, 76-99%, and 100%.

RESULTS

Pre-Treatment Analysis

Approximately 4 to 6 larvae will cause complete mining of a leaf. The pre-treatment counts indicated a population capable of severe mining damage. See Table I.

TABLE I - PRE-TREATMENT ANALYSIS

Treatment	Average Number of Larvae per Leaf
Orthene injection	5.3
Acecap implant	7.7
Cygon band	5.3
Control	7.0

Pre-Treatment Analysis

There was a discrepancy in larval reduction between 1st and 2nd post-treatment analysis with the Cygon band treatment. This discrepancy can be attributed to an incomplete hatch at the time of the post-treatment analysis. The results of both post-treatment counts were consistent for the orthene injection and Acecap treatments. Good control achieved by both these treatments prevented additonal hatching after the 1st post-treatment count. There was little variation in larval reduction between individual sample trees for both these treatments. The control had higher larval reduction (44.0% vs. 22.6%) in the 2nd post-treatment count. Many larvae had vacated the leaf by September 1, making this count difficult. See Table II.

The greatest foliage protection was achieved with the orthene injection method. See Table III.

TABLE II - POST-TREATMENT ANALYSIS

Larval Reduction

Treatment	1st Count	2nd Count
Orthene injection	99.8%	99.3%
Acecap implant	97.2%	96.1%
Cygon band	82.9%	69.9%
Control	22.6%	44.0%

TABLE III - LEAF MINING ASSESSMENT

Mean Percentage of Leaf Mined

Treatment	1st Post-Treatment	2nd Post-Treatment
Orthene injection	7.5%	7.6%
Acecap implant	20.9%	16.3%
Cygon band	33.0%	47.0%
Control	48.0%	53.3%

DISCUSSION

Larval reduction with Acecaps and orthene injection were comparable. Less foliage protection was achieved with Acecaps due to a delay in activity as the gelatin capsule disolved. Implanting Acecaps earlier in the season would likely give protection comparable to trunk injection. Both these methods gave satisfactory control of *P. thomsoni*. An assessment of wound healing will be done for the Acecap and trunk injection methods.

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A PRELIMINARY REPORT ON THE SPRUCE BUD MOTH (ZEIRAPHERA SPP.)

Spruce bud moth populations (*Zeiraphera* spp.) have increased sharply in white spruce plantations throughout north-western New Brunswick. The insect is present at lower population densities throughout the rest of the province but the indications are that infestations of these insects will increase in 1982.

Although *Zeiraphera* has been found occasionally on red and black spruce, it feeds primarily on white spruce. Historically, the insect's population builds up rapidly, followed by a sudden collapse. Damage caused by *Zeiraphera* spp. is generally considered to be of little consequence. However, because of the high value of commercial plantations of white spruce, damage such as that caused by *Zeiraphera* spp. can be of consequence and closely parallels similar pest problems associated with agricultural crops.

The objectives of the 1981 research program were three-fold;

(1) Study the ecology and behaviour of the spruce bud moth;

(2) Assess insect damage to white spruce plantations;

(3) Measure the impact of the insecticides fenitrothion and Dylox on *Zeiraphera* populations.

METHODS

Thirty-three White Spruce plantations representing a wide range of age classes were selected in north-western New Brunswick. Most of the plantations studied were managed by J. D. Irving Ltd. Ground surveys established base-line data on pre-spray population levels of *Zeiraphera* and spruce budworm. Additional surveys were made following first and second applications of fenitrothion and after one application of Dylox.

Tree damage by insect feeding was assessed by measuring four parameters. These are:

(1) percent tree defoliation;

(2) proportion of shoots attacked per tree;

(3) proportion of trees with leaders damaged;

(4) tree leader growth pattern.

Drop trays were placed under trees in both insecticide treated and untreated plantations. They provided a measure of spray-induced larval mortality. Since most Zeiraphera larvae drop to the soil to pupate the trays also were used to establish the precise time of pupation.

RESULTS AND DISCUSSION

Larval populations of Zeiraphera were several times higher than budworm in most plantations. Pre-Spray Zeiraphera populations averaged 16 to 40 larvae per 100 shoots.

Statistical analyses of data established that the first application of fenitrothion did not contribute significantly to mortality of Zeiraphera or budworm. Both species remained insulated from the spray by feeding under budcaps held in place by the larvae's silk. The second application of fenitrothion coincided with Zeiraphera pupation. Larval counts taken on branches following the second spray were significantly lower than the pre-spray counts. However, preliminary data analyses were unable to separate the effect of insecticide-induced mortality from that of larvae dropping from the foliage to pupate. A subsequent application of Dylox was sprayed too late to have any effect on Zeiraphera. Larvae had advanced to the pupae stage and lay protected in the soil. However, the insecticide was responsible for knock-down of budworm.

Studies showed that care must be exercised when estimating defoliation on white spruce. Budcaps are retained on attacked shoots and this tends to exaggerate one's impression of the amount of defoliation. Actual defoliation rarely exceeded 10% of the current foliage (range of 1 to 25%).

Although defoliation was generally light, several other aspects of Zeiraphera feeding behaviour cause some call for alarm.

(1) Larvae fed on a significantly higher proportion of terminal shoots than lateral shoots.

(2) The chance of larvae feeding on a tree leader was greater (generally over 75%) than the chance of feeding on any other shoot (11 to 48%).

(3) Zeiraphera often team-fed with as many as 8 larvae on a single shoot. There was therefore, frequent loss of terminal shoots and leaders on trees attacked in high numbers. Tree injury was similar in many respects to white pine weevil damage. The trend after several years of severe Zeiraphera infestation is to limit vertical tree growth by producing "cabbage-like" tops and a bushy crown like that of white spruce growing in open fields.

CONCLUSIONS AND RECOMMENDATIONS

(1) The 1981 study established that *Zeiraphera* is a serious pest of white spruce plantations in north-western New Brunswick.

(2) White spruce cannot be protected by simply spraying for spruce budworm and hoping to kill *Zeiraphera* in the process. The spruce bud moth must be treated as a separate pest that brings with it its own unique control problems.

(3) Current timing of insecticide application and/or use of fenitrothion is an unacceptable method for reducing *Zeiraphera* populations.

(4) It is recommended that future control efforts incorporate *Zeiraphera* larval development surveys to provide appropriate timing of insecticide application.

(5) It is recommended that research continue in 1982 to determine the optimal time of spray application and to find an appropriate insecticide. The plantations used in the 1981 program are ideally suited for establishing discrete blocks in which to test multiple combinations of the two variables under investigation.

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RELEVANCE OF TREE IMPROVEMENT TO FOREST PEST MANAGEMENT

Report to the Canadian Forest Pest Control Forum

by

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RELEVANCE OF TREE IMPROVEMENT TO FOREST PEST MANAGEMENT

by

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INTRODUCTION

How can tree improvement programs contribute to Forest pest management? To answer this question we first need a reasonably clear perception of what we mean by pest management. It stands on its own as a field of knowledge and of advanced technology applied to pest identification, detection, evaluation, prediction and control. Control strategies include the use of chemical pesticides; in forestry this generally involves aerial application of insecticides, fungicides and herbicides over large forested areas. Use of biological control agents is another strategy involving aerial applications of entomopathogenic microorganisms and release of parasites to exercise long-term regulation of pest populations. Practicing good silviculture and stand management is another strategy. This involves, inter alia, use of high quality seed in forest regeneration; seed which is genetically superior and capable of producing planting stock well-adapted to site conditions and tolerant or resistant to insects and diseases. This is where tree improvement can make a significant contribution to pest management. Pest problems will not be eliminated but intelligent forest pest management does not aim to eliminate pests; its principal aim is to reduce losses to acceptable levels.

SEED PRODUCTION AREAS AND PLUS TREE SELECTION

Establishment of seed production areas (Lamontagne, 1978) and selection of plus trees for seed orchard development (Morgenstern et. al., 1975) are first steps in a tree improvement program. The susceptibility of growing stock can be influenced by applying basic principals of genetics, ecology, and pest biology during selection of stands for seed production, stand roguing and plus-tree selection. How can development of seed production areas and selection of plus trees, contribute to forest pest management?

Stands selected, should be relatively free of diseased and insect damaged trees and some effort should be made to determine if it has had a history of repeated insect outbreaks or disease epidemics. If the stand is growing vigorously in spite of repeated attacks it may be an excellent candidate because it contains genotypes well-adapted to or tolerant of pest outbreaks.

When a decision has been made to use a particular stand as a candidate SPA it should be rogued to remove insect- and disease-damaged trees. Such trees are probably genetically inferior and in addition they serve as infection centres for renewed outbreaks or epidemics when conditions become favorable.

In addition to form, growth and wood quality as a basis for plus-tree selection, consideration should be given to health of the tree. Only trees free of disease and damage due to insects should be selected. Intense outbreaks or epidemics should be used to select survivors which may be genetically superior and adapted to withstand or resist attacks or infection.

VARIATIONS IN SUSCEPTIBILITY

Variation in susceptibility among species, among related species, and within species does exist and serves as a base for producing vigorous trees which can withstand or resist insect outbreaks or disease epidemics. What evidence suggests that such variations in susceptibility of trees can contribute to forest pest management?

Variation in susceptibility among related species and natural hybridization between species provide us with important clues about the possibility for genetic manipulation of trees. For example the spruce budworm has a fairly wide host range including balsam fir, white spruce, red spruce, black spruce and other conifers. Red spruce is highly susceptible and black spruce is relatively resistant. These two species produce hybrids where their ranges overlap (Morgenstern and Farrar, 1964) and progeny of these natural crosses show a high degree of variation in susceptibility to damage by spruce budworm (Manley and Fowler, 1969). Some of the progeny retain many of the characteristics of red spruce but display a high degree of resistance to budworm typical of black spruce. This suggests that trees can be manipulated by hybridization to produce types which are tolerant or resistant.

Provenance studies on geographic variation and adaptability to site within native species provide us with important information which can be used in pest management. For example, studies in jack pine indicate that there are definite limits for the transfer of seed from one part of the range of the species to another. Certain seed sources are highly susceptible to late frost and to infection by scleroderris canker; infection and mortality is greatest for sources from latitudes south of planting sites (Yeatman, 1976). Seed can be moved over fairly wide distances east to west or vice versa but transfer from south to north over a short distance of only 80 miles is questionable. Similar studies with lodgepole pine have demonstrated that it is highly susceptible to sweet fern blister rust when planted in Ontario (Yeatman, 1974).

Provenance studies of exotic trees point to possibilities for replacing native species which are very susceptible to introduced pests. For example exotic larches may be utilized in the place of tamarack to take advantage of their high growth rate and ability of some seed sources to tolerate or resist attack by larch sawfly. Experiments established at Petawawa in 1960 and 1961 to compare silvicultural potential of exotic larches for selection of superior phenotypes provide such information. A severe outbreak of sawfly in 1977 in these plantations provided an opportunity to rate seed sources for defoliation. There were significant differences in defoliation, height and volume among seed sources; combinations of low susceptibility and high yield are rare but can be found.

Studies on intensive selection of Norway spruce for hardiness and weevil resistance indicate that it is feasible to produce exotic trees which are tolerant to our native pests and harsh conditions. In 1924, sixteen hundred Norway spruce, produced from seed, from a plantation of unknown origin in Quebec, were planted at Petawawa. Trees were subjected to intensive selection for weevil resistance and frost hardiness by Dr. Carl Heimburger so that only thirty trees remained. Progeny from these trees were planted at Petawawa along with several other seed sources from the International Norway Spruce Trial of 1938. Observations on weeviling were made from 1963 to 1972 in this plantation. Four provenances from Northern Europe confirmed Holst's (1955) observation that narrow-crowned phenotypes are less prone than others to weevil attack and have a higher recovery rate; the best seed source was the selected population from Petawawa.

CONCLUSIONS

Awareness of pest problems and consideration of variations in susceptibility have been an integral part of the tree improvement program at Petawawa since its inception in 1924. Studies to date indicate that breeding for resistance is possible because there are significant variations in susceptibility to insects and diseases among related host species, geographic strains of a particular host species and among interspecific hybrids. In addition, trees can be selected for resistance to pests and for hardiness. Breeding for resistance is possible but it takes time; for example, progeny from a plus-tree selection program need to be assessed for the period of time required for a plantation to reach maturity. In the meantime, small improvements can be made by careful selection and roguing of seed production areas and by selection of resistant or tolerant plus-trees as parents for seed orchards. Use of resistant trees and information from tree improvement programs should be part of long-range pest management strategies, especially when chemical control, biological control or other silvicultural prescriptions fail or are not appropriate.

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