REPORT OF THE ANNUAL FOREST PEST CONTROL FORUM

Place Vince Massey, Hull, P.Q.

November 14, 1973

In Attendance:

Newfoundland Forest Service

Mr. S.E. Holmes, St. John's

Nova Scotia Department of Lands and Forests

Mr. R.P. Michaud, Truro

New Brunswick Department of Natural Resources

Mr. H.H. Hoyt, Fredericton

Quebec Department of Lands and Forests

Mr. G. Paquet, Quebec
Mr. R. Desaulniers, Quebec

Ontario Ministry of Natural Resources

Mr. K.B. Turner, Toronto

Council of Forest Industries of British Columbia

Mr. H.A. Richmond, Nanaimo

Forest Protection Limited

Mr. B.W. Flieger, Fredericton
Mr. B.A. MacDougall, Fredericton

Canada Department of Agriculture

Mr. E.R. Houghton, Plant Products Division, Ottawa

Canada Department of Indian Affairs and Northern Development

Mr. J.P.G. de Lestard, Water, Forests and Land Division, Ottawa
Mr. R. Kroll, National and Historic Parks Branch, Ottawa

Canada Department of Health and Welfare

Dr. T.F. MacCarthy, Medical Services Branch, Ottawa

Canada Department of Environment

Canadian Wildlife Service

Mr. P.A. Pearce, Fredericton

Environmental Protection Service

Dr. H.S. Thompson, Ottawa
Dr. R.H. Cook, Halifax
Dr. P.B. Eaton, Halifax
Mr. R.H. Kussat, Vancouver

Dr. M.L. Prebble, Special Advisor, Renewable Resources
Mrs. M.K. Pearson, Executive Assistant

Canadian Forestry Service

R.M. Prentice, Ottawa (Chairman)
A.C. Molnar, Ottawa (Secretary)

D.R. Macdonald, Victoria
J.R. Carrow, Victoria
H.A. Tripp, Victoria
G.W. Green, Sault Ste. Marie
G.M. Howse, Sault Ste. Marie
J.M. Cameron, Sault Ste. Marie
T.A. Angus, Sault Ste. Marie
J.R. Blais, Quebec
L.J. Jobin, Quebec
W.A. Smirnoff, Quebec
M.M. Neilson, Fredericton
E.G. Kettela, Fredericton
G.P. Thomas, Ottawa
J.J. Fettes, Ottawa
C.H. Buckner, Ottawa
F.E. Webb, Ottawa

Dr. G.P. Thomas, Director General, Canadian Forestry Service welcomed the large turnout of delegates representing provincial and federal governments and private agencies. He noted that the Annual Forest Pest Control Forum replaces the long-standing Interdepartmental Committee on Forest Spraying Operations, (I.C.O.F.S.O.). The Forum, he said, will have the same general objectives as the former I.C.O.F.S.O., namely:

(i) To enable discussions of forest pest control operations recently undertaken in Canada;

(ii) to discuss current active, and planned future research and trials bearing on forest pest control in Canada, and

(iii) to review forest pest conditions that might require control action in the upcoming year and, where appropriate, to discuss operational plans.

The 16 years of mutually beneficial I.C.O.F.S.O. discussions, in particular the records of those discussions, provides a chronology of events that is an invaluable starting point for future meetings of this Forum. Dr. Thomas expressed the sincere hope that the Forum will prove to be as useful a medium for information exchanges as was the former I.C.O.F.S.O.

Like the I.C.O.F.S.O., he said, the Forum will function on the initiative of the Canadian Forestry Service. It will succeed in its purpose, however, only if it is supported fully and energetically by the principal private and public forest pest control agencies in Canada. It will succeed only if other federal agencies having an interest and concern for forest pest control operations join the Forestry Service, as in the past, to contribute their knowledge to pest control discussions. Again, the Forestry Service will sponsor and organize the Forum annually, but the success of the Forum will depend upon the regular participation of groups such as are represented today.

Dr. Thomas reminded the group that in his closing remarks to the 1972 I.C.O.F.S.O. meeting he predicted the creation of a formally constituted Canadian Forest Pest Control Control Committee arising from the anticipated pronouncement of a new federal policy of financial assistance to the provinces on pest control operations. Both events have materialized, and a pest control committee has been constituted and is now functioning. It meets to receive and process applications from provinces for partial reimbursements of the costs incurred by them in certain pest control operations.

Dr. Thomas emphasized that the Canadian Forest Pest Control Committee in no sense replaces the broader functions of the former I.C.O.F.S.O. and the present Forum. On the contrary, if the Forum functions properly, it will most certainly aid in the deliberations of the Pest Control Committee, but perhaps more importantly, it will serve as the instrument for the very necessary exchange of information between all parties that are concerned with forest pest control in Canada. He stated that a record will be kept of this and future meetings and that a report will be distributed to all persons attending.

The Chairman asked for and received approval of the detailed agenda distributed in advance of the meeting as follows:

1.0 <u>Spruce Budworm Aerial Spraying Operations</u>

1.1 New Brunswick:

1973 Program

- Operations - Mr. B.W. Flieger
  - Mr. H.H. Hoyt

- Surveys and Services - Mr. E.G. Kettela
- Environmental Monitoring - Mr. P. Pearce
  - Dr. H.S. Thompson
  - Dr. H.R. Cook
  - Dr. W.N. Yule

Prospects for 1974

- Insect and Forest Conditions - Mr. E.G. Kettela
- Proposed Aerial Spray Operations - Mr. B.W. Flieger
- Environmental Monitoring - Mr. P. Pearce
  - Dr. R.H. Cook

1.2 Quebec:

1973 Program

- Operations - Mr. G. Paquet
- Surveys and Services - Mr. R. Desaulniers
- Environmental Monitoring - Dr. C.H. Buckner

1.3 Ontario:

1973 Program

- Operations - Mr. K.B. Turner
- Surveys and Services - Dr. G.M. Howse
- Environmental Monitoring

Prospects for 1974

- Insect and Forest Conditions - Dr. G.M. Howse
- Proposed Spray Operations - Mr. K.B. Turner

1.4 Research 1973 and Proposed 1974:

New Brunswick
Quebec
Ontario
Other

2.0 <u>Hemlock Looper Aerial Spraying Operations in Quebec</u>

1973 Program

- Operations - Mr. R. Desaulniers
- Surveys and Services - Dr. L.J. Jobin
- Environmental Monitoring

Prospect for 1974

- Insect and Forest Conditions - Dr. L.J. Jobin
- Proposed Aerial Spray Operations - Mr. R. Desaulniers
- Environmental Monitoring

2.1 Research 1973 - Proposed 1974:

Dr. Cameron

3.0 Other Problems

3.1 Blackheaded Budworm - British Columbia:

1973 Program

- Operations - Mr. H.A. Richmond
- Surveys and Services - Dr. R. Carrow
- Environmental Monitoring - Mr. R. Kussat
  - Dr. C.H. Buckner

Prospects for 1974

- Insect and Forest Conditions - Dr. R. Carrow
- Proposed Aerial Spray Operations - Mr. H.A. Richmond
- Environmental Monitoring

3.2 White Pine Weevil - Ontario

1973 Program

- Operations - Mr. K.B. Turner
- Surveys and Services - Dr. G.M. Howse
- Environmental Monitoring

Prospects for 1974

- Insect and Forest Conditions - Dr. G.M. Howse
- Proposed Operations - Mr. K.B. Turner
- Environmental Monitoring

Research 1973 - Proposed 1974

3.3 Oak Leaf Shredder - Ontario

1973 Program

- Operations - Mr. K.B. Turner
- Surveys and Services - Dr. G.M. Howse
- Environmental Monitoring

Prospects for 1974

- Insect and Forest Conditions - Dr. G.M. Howse
- Proposed Operations - Mr. K.B. Turner
- Environmental Monitoring

3.4 False Hemlock Looper - British Columbia

3.5 Research 1973 - Proposed 1974

1. SPRUCE BUDWORM AERIAL SPRAYING OPERATIONS

1.1 New Brunswick

1973 Program:

Operations - Mr. Flieger in presenting his report (Appendix 1) noted that after his 21 years of association with this problem, there was more budworm in New Brunswick than when he started, albeit in different areas of the Province, but significantly, trees have been saved. He reviewed the areas treated during the larval spraying operation, some 4.2 million acres and reported a successful season. Of the total acreage treated, only 350,000 acres were sprayed twice, at the rate of 2 ozs. active fenitrothion in 0.15 gals. per acre. The remainder received 3 ozs. per acre of the same chemical in 0.15 gals. in a single application. All but 175,000 acres were treated with the water-based emulsion and the results bore out the previous year's observation that the more expensive oil solution was not justified. Mr. Flieger said the spray was applied a little earlier than previously with the apparently justified hope that more foliage would be protected. Spraying was frequently interrupted in the early part of the season but conditions later improved to allow completion of the operation by June 20th. Both T.B.M. and Stearman spray planes and Cessna (172) guidance aircraft were used.

Surveys and Services - Mr. Kettela reviewed the results of his monitoring program to assess the results of the operation, (Appendix 2). Weather conditions in spring and early summer favoured spruce budworm development, with emergence of larvae well underway by April 25 as compared to May 10 in 1972. Although considerable variation occurred, it was estimated that an average of 45 per cent of the foliage was saved in the treated areas. Best results in terms of both foliage protection and reduction in budworm survival were obtained in areas sprayed twice in the early instars of budworm development or sprayed once in the fourth and fifth instars. The aerial defoliation surveys were cancelled because of very poor weather conditions but defoliation maps were constructed from intensified ground surveys.

Environmental Monitoring - Mr. Pearce of the Canadian Wildlife Service stated that there had been no monitoring of the operational spray program because he was satisfied the present formulation posed no hazard (Appendix 3). However, there had been some reports of bird casualties, and carcasses submitted were being analyzed.

Dr. Cook reported on studies by the Environmental Protection Service on the influence of the aerial application of fenitrothion on stream dwelling invertebrates (Appendix 4).

Dr. MacCarthy, Department of National Health and Welfare, reported that the large scale operation and test sprays were again monitored and found to be up to safety standards. He noted that only one unsatisfactory situation had been encountered in 10 years.

Prospects for 1974:

Insect and Forest Conditions - Mr. Kettela, reviewed forest conditions and budworm population levels estimated from egg-mass surveys and indicated that the area of high infestation had more than doubled to 11 million acres (Appendix 2). The distribution of populations in relation to past damage, however, actually lead to a small reduction in areas of hazard. In Nova Scotia, hazard to trees by the budworm was generally low except for some areas of Cumberland County, where it was high. On Prince Edward Island, the hazard was generally moderate over the entire Island.

With reference to control operations in New Brunswick, Mr. Flieger said his recommendation for larval spraying will total something under 4 million acres with very little double spray, but a final decision must await further deliberations.

In answer to a question from Dr. Howse concerning budworm conditions in Maine, Mr. Flieger referred to a report by R.W. Nash and tabled it for the information of Forum participants. (Appendix 5).

Environmental Monitoring - Mr. Pearce speaking for the Canadian Wildlife Service, said that no formal monitoring is planned while present spray formulations and application procedures are in use. Dr. Cook indicated that the Environmental Protection Service will continue surveillance at present levels concentrating on aquatic invertebrates but will probably engage in some plot studies as well.

1.2 Quebec

1973 Program:

Operations - Mr. Paquet reported that the spruce budworm aerial spraying program carried out in Quebec in 1973 covered an area of 9.7 million acres. Of the total treated area, 7.4 million acres received two applications of 3 and 2 ozs. per acre, respectively, of oil-based fenitrothion applied by DC-6B and Constellation aircraft equipped with Decca guidance systems (Appendix 6). The remainder received two applications each of 2 ozs. per acre of water-based phosphamidon applied by TBM and CL-215 aircraft using the Litton LTN 51 guidance system and PV-2 aircraft using the Decca guidance system.

Surveys and Services - Mr. Desaulniers, reporting on pre- and post-spray surveys of pest populations and tree conditions stated that insect populations were reduced by 82.5 per cent and foliage protection averaged 63 per cent.

Environmental Monitoring - Pre-planned environmental monitoring was confined to limited special studies by the Chemical Control Research Institute (Appendix 7). Mr. Pearce, Canadian Wildlife Service, although not engaged in any planned studies, responded to local reports of intoxicated and dead birds. Mr. Paquet stressed that any bird and fish mortality was due to navigational and climatic problems. He reported with regret the crash of a large aircraft with a loss of three crew members. The resultant chemical spill fortunately did not create a significant hazard. He reported the planned formation by the Quebec Department of Lands and Forests of an Interdepartmental Committee to study the effects of aerial insecticide spraying on the fauna, flora and the environment in general. He invited the participation of federal agencies and indicated the committee would be asked to propose a monitoring program for next year. Mr. Prentice applauded the decision and assured him of full support by appropriate federal agencies.

Prospects for 1974:

Reviewing the situation for 1974, Mr. Desaulniers indicated (Appendix 6) the necessity of treating some 12 million acres. He indicated that *Bacillus thuringiensis* may be used over 100,000 acres.

1.3 Ontario

1973 Program:

Mr. Turner reported that the Ontario Ministry of Natural Resources sprayed 88,300 acres against the spruce budworm in 1973. Zectran was applied at a rate of 1.2 ozs. in 0.15 gals. (U.S.) of spray mixture per acre. Dr. Howse reported that the general results, based on aerial defoliation surveys and pupal and egg-mass counts, appeared good (Appendix 8). No environmental monitoring studies were undertaken.

Prospects for 1974:

Reviewing the outlook for 1974, Dr. Howse reported that on the basis of fall egg surveys, the total area of infestation in Ontario was somewhat smaller than in 1972 (Appendix 8), but counts indicate that budworm numbers will increase to all-time record highs in southern Ontario. Some 90,000 acres of susceptible forest have been delineated throughout the Province where protection from budworm would be desirable. The area to be sprayed, however, remains to be designated by the Province.

In answer to a question by Mr. Prentice, Mr. Turner replied that there were no plans to carry out environmental monitoring on programs using the present spray formulations.

1.4 Research for 1973 and Plans for 1974

New Brunswick:

Mr. Kettela reported on a number of experimental trials carried out in New Brunswick in cooperation with several agencies (Appendix 2). The Canadian Forestry Service monitored a 1,000 acre trial by Forest Protection Limited using an aircraft application of an U.L.V. formulation of Dylox. Two applications of 6 ozs. in 0.15 gals. per acre produced results which compared favourably with those obtained from fenitrothion. At the request of CIBA-GEIGY Canada Ltd., the Canadian Forestry Service monitored four 400-acre blocks treated with 2 dosages of two different insect growth regulators. While some interesting development responses were recorded for the insect, no foliage protection for the trees was achieved.

Studies on the chemical control of spruce budworm moths, started in 1972, were continued. Results with pyrethrum at the two dosage rates of 0.25 and 0.15 gal. per acre were poor, while with phosphamidon excellent results were obtained at 2 ozs. per acre and the double application of 2 ozs. per acre. Mr. Kettela suggested that chemical control of spruce budworm moths should be undertaken on an operational scale in 1974.

A number of additional points on the efficacy of budworm control through adulticides came out in discussions. In answer to a question from Mr. Pearce, Mr. Kettela expressed the opinion that moth control might be an alternative to larval control, if it proved out in large scale operations. Mr. Flieger did not feel that flying weather would put any more constraints on moth control operations than it does on larval spraying operations. In answer to Dr. Prebble, Mr. Kettela stated that the adulticide sprays affected both perching moths as well as those in flight. Mr. Prentice felt there were still gaps in our knowledge of adult behavior and advised caution in moving too quickly into large scale operational programs.

Mr. Pearce reported that the Canadian Wildlife Service monitored the large scale test of phosphamidon against spruce budworm moths in July with a census of pre- and post-spray bird populations and post-spray searches for casualties (Appendix 3). Due to inclement weather monitoring was at best superficial but results indicated some depression in bird populations in one block receiving two applications of phosphamidon. Interpretation of monitoring data was further complicated by the fact that some of the phosphamidon test areas had already been sprayed several times with fenitrothion by private operators. Mr. Pearce enquired if this problem might be dealt with by some form of regulation.

Dr. Fettes referred to the monitoring studies of Buckner and Ray (Appendix 9) which also reported serious damage to bird populations in such circumstances. These comments led to expressions of concern about unrestricted, unmonitored and unrecorded use of pesticides by some operators in the private sector, resulting in extremely high insecticide levels in some areas. Mr. Houghton drew the meeting's attention to the 1969 Pest Control Products Act which contains authority to classify pest control products in order that they may be directed or confined in their use to persons with the competence to ensure that such products are not used under unsafe conditions. After considerable discussion on the implications of and dangers inherent in this problem, Mr. Houghton agreed to provide an explanatory statement to Annual Forest Pest Control Forum participants which will help clarify this issue and point up the avenues open to ensure safe pesticide use practices within the revised Pest Control Products Act (Appendix 10).

As an expression of the seriousness with which the meeting viewed the hazards of careless pesticide use and in recognition of the goals and work of the Canadian Association of Pesticide Control Officials, Dr. Fettes proposed, and the meeting unanimously approved, that the following statement be included in the minutes:

"The members of the First Annual Forest Pest Control Forum agree with and endorse the intentions and goals of the Canadian Association of Pesticide Control Officials which, in the Forestry Sector, are the logical and safe use of forest pest control products consistent with the Pest Control Products Act and the regulatory restrictions thereof. It is understood that the restrictions are intended to bring to bear the various disciplinary and regulatory interests using provincial, industrial and federal expertise to establish the conditions under which pest control products may be used in any given project".

The Canadian Wildlife Service cooperated with the Canadian Forestry Service and CIBA-GEIGY Canada Ltd., in another test operation involving aerial sprays of two growth regulator analogs. There was no evidence that birds were adversely affected by the sprays.

Dr. Fettes reported improvements in the analytical facilities for pesticides at CCRI and noted that several studies had been initiated concerning further aspects of the distribution, persistance and fate of deposits and residues of fenitrothion and other agents in forest trees and soils (Appendix 11).

Quebec:

Dr. Smirnoff reported on cooperative studies with a new formulation of *Bacillus thuringiensis* involving the Canadian Forestry Service, Department of Lands and Forests, Quebec and Abbott Laboratories. The new, low volume formulation consisted of *B.t.* concentrate in a heavy, low-priced carrier plus a sticker and chitinase and was applied on a 300-acre, heavily infested stand using TBM and CL-215 aircraft (Appendix 12). Subsequent assessment showed that larval mortality had reached 83 per cent, and that 57 per cent of the current year's shoots remained on the trees for two weeks longer than on controls. Terminal bud survival was 22 per cent in treated stands as opposed to none in the controls. Observations carried out in areas treated in previous years with *B. t.* showed apparent prolonged beneficial effects of the treatments. Dr. Smirnoff recommended the commercial application of *B. t.* and suggested that the greater per acre cost ($2.50 for *B. t.* compared to $0.84 for fenitrothion) would be overcome in part by the carryover effect and probable saving in treating larger areas.

Ontario:

Four separate studies involving aerial spray trials with *Bacillus thuringiensis* were reported from Ontario. Mr. Tripp reported on trials with two commercial *B. t.* products, Thuricide[R] liquid concentrate and Dipel[R] wettable powder (Appendix 13). While some problems with unfavourable weather were encountered, it was concluded that a dosage of one B.I.U. was inadequate even when conditions were good and dosages of two and three B.I.U. gave moderate control and protection. Trials did not provide an estimate for 4 B.I.U. that produced 90 per cent control the previous year. Mr. Tripp recommended *B. t.* as a control agent for the spruce budworm but suggested that, because of difficulties in timing applications and unpredictable post-spray weather, dosages of not less than 5, and preferably 6 B.I.U. per acre be used.

Dr. Howse reported on operational *B. t.* trials involving several dosage rates carried out by the Ontario Ministry of Natural Resources. Satisfactory results were obtained at 4 B.I.U. per acre. He also reported on followup observations of 1971 virus spray trials and additional virus spray trials conducted in 1973 (Appendix 14). The Ontario Ministry of Natural Resources expressed interest in conducting further trials with biological control agents against the spruce budworm in 1974.

Dr. Fettes reported on studies conducted by Dr. O.N. Morris involving effective aerial applications of *Bacillus thuringiensis* and/or chitinase against the budworm in Algonquin Park (Appendix 15) and of *B. t.*-fenitrothion combinations at the Petawawa Forest Experiment Station (Appendix 16). In both these studies, careful observations were maintained on mortality and post-spray development of surviving target insects as well as non-target organisms. There was no indication of significant adverse effects on non-target organisms.

Dr. Fettes brought to the meeting's attention, studies at the Chemical Control Research Institute designed to evaluate commercial preparations of *Bacillus thuringiensis* for registered use in Canadian forestry (Appendix 17). He reported some preliminary conclusions and indicated detailed results would be available early in 1974. He also reported on studies on the efficacy for aerial application of chemicals of various large and small aircraft types, guidance systems and spray emission systems (Appendix 18).

Dr. Fettes cautioned the meeting against underestimating the problems with weather in connection with the aerial application of *B. t.*. With regard to the so called "carryover" effect of *Bacillus* observed by a number of workers, he felt this was merely the reflection of lowered populations.

Dr. Cameron reported on studies of the use of viruses to control spruce budworm by scientists of the Insect Pathology Research Institute. In 1973, 9 plots totalling 738 acres were sprayed with nuclear polyhedrosis virus. Observations on experiments carried out in previous years were continued (Appendix 19). Dr. Cameron stated that there is no foliage protection the first year but there will be a carryover for several years thereafter with considerable foliage protection. He said it appeared that the dosage should be approximately 10 grams of virus material dispersed in ½ gal. of water per acre. This would lead to 30 to 50 per cent infection carried over into subsequent years. Dr. Cameron observed further that studies have reached the point where large scale tests, up to 2,000 acres, would be warranted. A suitable test situation is required to avoid drift. He advocated similar tests with B. t. a chemical insecticide and a growth regulator, the whole to be repeated in five years.

Mr. Prentice enquired about the situation with respect to the registration of viruses for use in controlling forest insects. Dr. Cameron stated that certain data are required and that the Ontario Veterinary College is now ready to undertake research on mammalian toxicity. The necessary guarantees of efficacy against target insects will come from studies conducted by the Insect Pathology Research Institute.

A report of studies on the effect of forest spraying with fenitrothion on the pollination and subsequent fruit set and yield of lowbush blue blueberry carried out under contract by R.B. Scott was tabled for members information. (Appendix 20).

2.0 Eastern Hemlock Looper Aerial Spraying Operations in Quebec

1973 Program:

Dr. Jobin described the 1973 spray operations against the hemlock looper on Anticosti Island that covered some 25,000 acres. The operation had two aims: to prevent tree mortality in and to provide foliage protection for the infested balsam fir stands (Appendix 21). A CL-215 aircraft, modified for insecticide spraying, made two applications: the first by chance a fenitrothion-phosphamidon mixture at the rate of 2 ozs. per acre and the second 8 days later, fenitrothion alone at the rate of 2 ozs. per acre. Average larval mortality was estimated at 95.5 per cent and 75 per cent of the treated area showed no apparent defoliation. Epizootics of *Entomophthora* sp. were credited with the collapse of two localized infestations and with causing larval mortality throughout the remainder of the infested area. The infestation was now considered to have collapsed and no operations are planned for 1974.

Research 1973:

Cooperative research on the effectiveness of an aerial application of a juvenile hormone analog against the eastern hemlock looper was described by Dr. Cameron (Appendix 22). The Insect Pathology Research Institute, the Laurentian Forest Research Centre and the Chemical Control Research Institute participated in the studies. Characteristic deformities were recorded in samples taken following the spraying indicating that the hormone was acting on the insect and some population reduction was noted but, since the effect is manifested in the last larval stage, foliage protection was not expected in the year of treatment. Monitoring of birds and small mammals revealed no measurable impact on them by the hormone analog. Because effects can only take place in the last larval instar, a certain amount of developmental isolation of the pest species occurs and likelihood of effects on useful species was deemed to be small.

3.0 Other Problems

3.1 Western Blackheaded Budworm:

1973 Program:

Operations - Mr. Richmond reported on the blackheaded budworm control operation on northern Vancouver Island, involving the spraying of 28,800 acres. Fenitrothion at the rate of 2 ozs. of active ingredient in 20 ozs. of carrier per acre was applied twice with a 4 day interval (Appendix 23). Mr. Richmond reported extremely strong public opposition to the operation and stressed the importance of early and carefully planned liaison work. He added further that the problem emphasizes the need for the development of biological control alternatives, such as *B. t.*, under British Columbia conditions.

Surveys and Services - Dr. Carrow reported on surveys to assess tree condition and budworm population levels (Appendix 23). He noted that the spray area was reduced at the last minute eliminating a number of established test plots. Studies involved determining the biological effectiveness of the spray and its coverage and drift. On the basis of Abbott's formula, 83 per cent control of the budworm was achieved in young stands and 42 per cent in mature stands, the relatively low success in the latter being attributed to poor penetration of the insecticide into the large tree crowns. With respect to defoliation, young trees apparently benefited from the spray application while older trees did not.

Environmental Monitoring - Environmental monitoring studies in connection with the blackheaded budworm control operation were carried out by the Fisheries Service to assess the effects of the insecticide on fish fry and aquatic invertebrates (Appendix 24). It was concluded from the studies that a fenitrothion application of 2 ozs. per acre, even with a 600 foot buffer zone, may produce a measurable impact on aquatic invertebrates. The spray material was found to be highly mobile and present in measurable quantities in the buffer zone. Fenitrothion from contaminated insects was available to feeding coho but the threat posed by this contaminated food source was not ascertained. There was no apparent effect on coho fry in the test stream.

Mr. Kussat, Environmental Protection Service, Vancouver reported on the effects of fenitrothion on non-target arthropods (Appendix 25). Observations indicated a great variation in total numbers of arthropods between areas, a significant increase in their total numbers in the control plots and a significant decrease in their total numbers (mainly Diptera and Hemiptera) after spray application. The composition of arthropod population remained essentially the same. Dr. Buckner reported that no damage to aquatic insects and birds and mammals was detected during his observations in the blackheaded budworm control area.

Prospects for 1974:

Prospects for 1974 were assessed by the Pacific Forest Research Centre (Appendix 23). Mr. Macdonald reported that budworm populations had increased sharply on the northern mainland and Queen Charlotte Islands, causing moderate defoliation in 1973. While assessments have not been completed, continued defoliation is predicted for 1974. No consideration has been given to chemical control in these areas.

3.2 White Pine Weevil In Ontario

Dr. Howse reviewed the aerial spraying operations carried out by the Ontario Ministry of Natural Resources against the white pine weevil (Appendix 26). Methoxychlor was applied at the rate of 2.0 gals. (U.S.) per acre at a concentration of 2.4 lbs. of active ingredient with a Stearman and an Agcat aircraft equipped with micronairs. The population reduction attributed to the spraying was calculated to be 14 per cent. According to Dr. Howse, the results obtained were the poorest achieved during 5 years of spraying with methoxychlor in the Blind River and Sault Ste. Marie districts and suggested there was a need for better chemicals. Dr. Fettes felt that good results could be obtained with methoxychlor if it was properly used and referred to the studies of Deboo and Campbell (Appendix 27) involving a series of tests initiated in 1972. The 1973 trials corroborated the satisfactory results obtained with methoxychlor the previous year applied at a dosage of 2.5 lbs. of active ingredient in 4 gals. of fuel oil. Other dosages and chemicals produced less satisfactory results.

3.3 Oak Leaf Shredder in Ontario

Dr. Howse reported on control trials against the oak leaf shredder in May 1973 using 0.85 lbs. Sevin 4 oil in 0.78 qts. (Imperial) of spray mixture per acre (Appendix 28). Despite an apparently good deposit, no appreciable change was evident in pre- and post-spray larval counts or between treated and untreated stands. At least part of the difficulty was attributed to the protected feeding niche of early larval instars and it was suggested that better population control might be achieved by spraying the later, open feeding instars and accepting spray-year defoliation. No definite plans have been made for spray trials in 1974.

3.4 Western False Hemlock Looper in British Columbia

Mr. Macdonald described experimental control trials with Dipel (Bacillus thuringiensis Berliner) applied in a collaborative effort by the British Columbia Forest Service and Abbott Laboratories Inc., and monitored by the Canadian Forestry Service (Appendix 29). The treatments, applied to second and third instar larvae, were 0 (control) 0.25, 0.50 and 1.0 lb. B. t. per acre in a sticker-spreader containing a dye to aid monitoring. Analyses were incomplete but preliminary results showed that no insect mortality occurred until 21 days after spraying when 39 and 23 per cent of the loopers were killed in the 0.5 and 1.0 lb. per acre B. t. plots respectively. Analysis of variance may explain why greater mortality occurred at the lower dosage.

Tabled Reports:

A number of research reports were tabled for inclusion in this report. These deal with the development of an apparatus and a method for applying measured doses of simulated aerial spray to small trees (Appendix 30), effects of forest meteorological conditions on spray droplets and an analysis of the spray cloud (Appendix 31), a summary of analytical services for insecticide residues (Appendix 32), laboratory evaluations of insecticides against various species of forest pests during 1973 (Appendix 33), and aerial spray applications of fenitrothion and carbaryl for control of spruce budworm in Manitoba (Appendix 34).

Concluding Remarks

During the concluding discussions, Dr. Fettes reminded participants that pest control emergencies arise from time to time and appealed for as much lead time as possible for testing pesticides. He suggested that this could be obtained if insects were sent to the Chemical Control Research Institute for pesticide screening tests when outbreaks appeared to be developing. In reply to a question from Mr. Flieger, Dr. Fettes stated that at the present time, there is no better compromise chemical for the control of the spruce budworm than fenitrothion. As to adult spraying, Dr. Fettes felt that, in spite of the recent results reported by Mr. Kettela, the pyrethrins should be given further consideration.

Mr. Prentice adjourned the meeting after expressing his gratitude for the excellent turn-out and active participation by those present.

A.C. Molnar
Secretary

R.M. Prentice
Chairman

Hull, December 1973.

Berry grower foresees severe budworm losses

BANGOR DAILY NEWS, WED. AUGUST 15, 1973

By Peter Betts
NEWS Correspondent

ST. STEPHEN, N. B. — Cole Bridges Jr., vice-president of New Brunswick's largest blueberry growers, Bridges Brothers, predicts that the Pine Tree State is going to experience budworm damage "the likes of which Maine has never experienced."

Bridges Brothers Co., is currently conducting a 1.5 million dollar suit against a spraying firm, Forest Protection LTD., (F. P. L.) of Fredericton, N. B., for alleged damage to blueberry crops as a result of spraying insecticide deadly to bees.

The result of the spraying, the suit contends, has seriously affected the blueberry crop by preventing the bees from pollinating the blueberry fields.

The N. B. government contracted F. P. L. in 1970 to blanket spray nearly one half of N. B.'s land area with the chemical Fenitrithion (trade name sumithion). The highly toxic chemical is manufactured by a Japanese firm.

It was also during 1970 that Bridges began to notice an increase in the small bird population turning to the blueberry crop as a food source. This increase prompted Bridges to study the spraying program closely.

In 1967, because of large salmon kills related to the use of D D T, the Canadian government banned the use of D D T. Bridges stated that rather than banning D D T, the government should have banned the spraying program. He also [illegible] that the sprayers [illegible] D D T in [illegible] controlled

(Continued on [illegible] Col. 2)

THE 1973 SPRAYING OPERATIONS

OF FOREST PROTECTION LTD. AND RELATED MATTERS

NOVEMBER 1973

B.W. FLIEGER

Budworm outbreak forecast

(Continued from Page 1)

concentrations, thus killing the fish and giving the chemical a bad name.

Fenitrithion, two drops of which in a human's eye means death, is an organo phosphate. Organo phosphates were first developed by the Germans to be used as nerve gases. People in close proximity to the areas sprayed with the pesticide frequently complain of a tightening of the chest, nausea and or headaches. The pesticide specifically attacks enzymes which release the muscle. Thus contact with the poison causes death by contraction.

In the case of hymenopterous insects (bees, wasps and hornets) the insecticide is extremely toxic. The knockdown or toxicity to the insect world is far greater than that of D D T. Wasps and hornets are natural predators of the budworm larvae.

Exhibiting "spray area maps" for 1970, '71, and '72 for the N. B. spray program, Bridges showed this reporter that every year the area sprayed must be increased because of the spread of budworm infestation.

"The spray program is creating a 'super budworm'," Bridges declared. Budworms, by nature, prefer the crowns of old, dry trees in direct sunlight. Wet foggy weather is not to their liking. Now, however, the insects are not deterred by dampness. And they are turning their attack to healthy balsam firs. Clear cutting a stand of spruce and fir mixture, without replanting, results in only the susceptible balsam firs reseeding.

The insecticide kills the weak first and thus, only the strong survive. The result is that the spray program is creating, among other deleterious side effects, a budworm problem greater than before, Bridges said. "And the super insects are heading for the Maine border," Bridges stated. Inspection of the spraying map confirm this. "Maine residents probably are not aware of the fact that the state is currently paying F. P. L. $1.5 million annually for spraying already," Bridges said. "The worse is yet to come," he concluded.

In northern Maine, in addition to increasing the threat of budworms, the spray program appears to be increasing the population of insects that defoliate blueberry plants as well as increase the threat from the maple spanner (a moth which attacks hardwood.) Also scientists admit that long range ecological effects of the spray are still unknown.

LARVAL SPRAY PLAN 1973

Through the winter details of a spray plan for budworm larval spraying were worked out by the advisory spraying group of Forest Protection Ltd. in several meetings and the plan distributed to all sponsors. Minor changes were incorporated into the final edition as a result of spring checks by Environment Canada, in part initiated by members of the advisory group, and in part by Environment Canada in situations where additional checks seemed desirable.

In its final form the plan called for the spraying of approximately 4,200,000 acres of which some 350,000 acres were to receive two sprays. (For maps see Kettela)

TIMING OF SPRAYS

Although it is known that maximum knockdown of budworm populations results,as a rule, from sprays applied quite late in the larval development (4th & 5th instars) it was decided to continue the strategy of the last two years and push the starting time for first sprays forward to approximately May 10 because these early sprays seem to have given good results in saving foliage-of-the-year.

Accordingly all was made ready for an early opening and operations actually began at the Southern airstrips on May 10 and continued intermittently at a rather slow rate of production for the remainder of the month.

The weather, while not often suitable for spraying, was also not often favourable to the rapid growth and development of the pest. It was at first ideal for the rapid growth of twigs and needles and for some time the host trees were much ahead of insect development and so the rather slow progress in spraying in May did not jeopardize the project. However, the weather in the first part of June was almost wash-out for the sprayers and the insect began to move. Then after a week of no spraying action weather conditions finally improved and the project went on smoothly to a conclusion on June 20th.

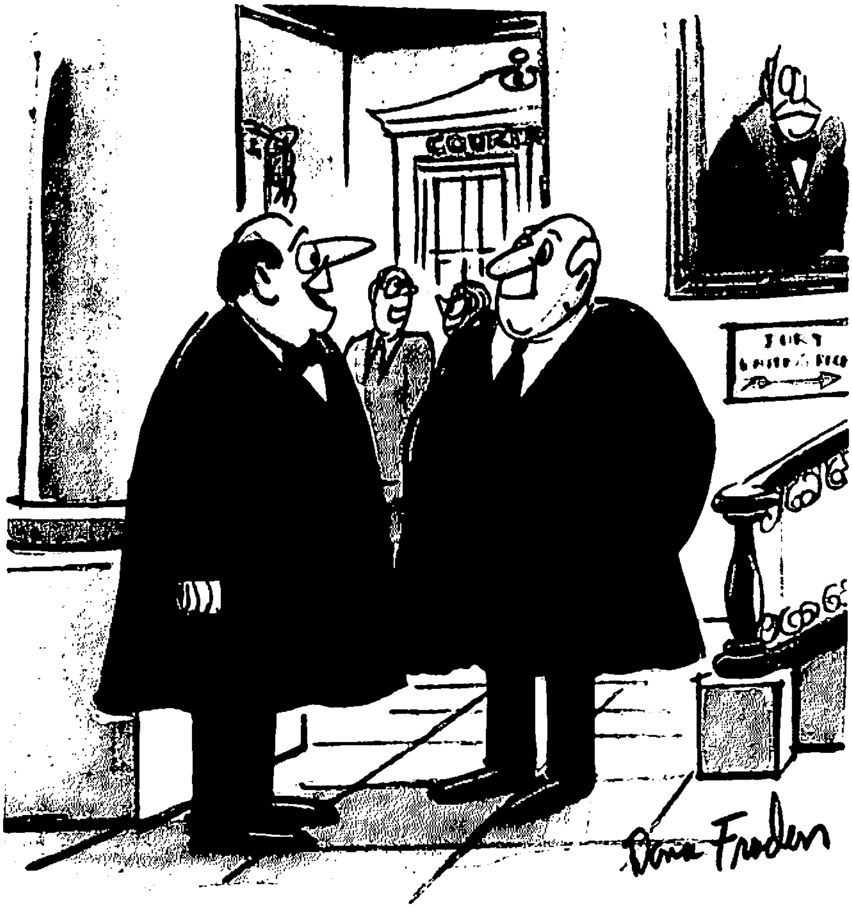
Overall the timing turned out to be good. Early active bases at Sussex and Blissville closed out at about the same time and the entire fleet was concentrated during the late good weather at Juniper and Sevogle strips. Even so there was some considerable feeding evident on the northern side of the spray plan.

DEFOLIATION 1973

Ordinarily the impact of insect feeding becomes clearly visible from the air in late June and may be accurately mapped by an aerial survey. This year for the second time in Company history it was decided to forego the aerial survey because of the erosion of dead needles caused by the combined effect of wind and rain. Much of the defoliation picture either failed to show or became so blurred as to provide observers with an erroneous impression. (See Kettela)

As in previous years it is known that most large solid areas of heavy feeding will be found to be in areas outside the spray plan.

COURT ACTION
BRIDGES BROS. VS. FOREST PROTECTION LTD.



"I'm happy to say that my final judgment of a case is almost always consistent with my prejudgment of the case."

The Company found itself in Court before larval sprays were complete. The action got underway in the Supreme Court of New Brunswick at Saint John on June 18 before Mr. Justice Stevenson. In the two court weeks June 18-22 incl. and June 25-29 incl. the plaintiff produced witnesses both "expert" and "ordinary" and had not finished on June 29 when Mr. Justice Stevenson announced a recess until Sept. 24, Moncton, 10:00 A.M.

Witnesses for the plaintiff were heard and these were followed by witnesses for the Defense, Sept. 24 - Oct. 19, when the case was further recessed until Dec. 3rd, Fredericton. Defense has several witnesses yet to be heard.

Much time and effort was spent by Company persons before and during larval spraying in getting ready to defend. In anticipation of the need for continuity in data pertinent to pollination of blueberries in Southern New Brunswick and to the fate of the ripening crop the Company has continued to monitor native and honey bee pollinators in May-June, and to study population trends and behaviour of fruit eating birds.

Pollinating insects and fruit eating birds are so far the main items of concern to the plaintiff. It is alleged that operations of F.P.Ltd. adversely affect the crop and cause loss to the grower by preventing pollination and in some manner cause birds to increase in number and to concentrate in the fields and consume the ripening berries.

ADULT BUDWORM SPRAY

A highly significant reduction in adult budworms resulted from Experimental Sprays of two organo-phosphorous insecticides in 1972 (preliminary report given at fall meeting of IDCFSO in 1972). The reduction of moth numbers during the egg laying days gave a significantly lower than expected egg numbers in the sprayed plots.

In order to confirm results of the 1972 trials, and in order to get some measure or reinfestation from outside the treated plot (which cannot be estimated on small areas), it was decided to greatly enlarge the 1973 trial plot size. Also in the 1973 design included was more than one dosage in order to get some idea of the neat quantity of insecticide which would given an acceptable reduction in moth numbers.

Environment Canada and the Company jointly designed and carried out the experiment which took place from Boston Bk. airstrip. J.D. Irving Co. cooperated by making available a complete set of camps for the accommodation of ground and aerial personnel.

A small beginning on July 9 was followed by a large spray day July 10 when spraying of all blocks was complete. First reports are encouraging. The map area involved in the tests is approximately 340,000 acres (See Kettela)

ASSIST. TO ENVIRONMENT CANADA RESEARCH PROJECT

A sophisticated research effort took place June 15 - July 15 at Chipman Airstrip and from Fredericton Airport.

The study consisted of the observation of adult budworm behaviour and migration habits and the collection of weather and other related data during the time when adults are active. First reports are that this initial effort has been successful in unravelling some of the remaining budworm mystery and that in all probability this will be an important on-going field of research.

The Company had a modest, but necessary, input consisting, mainly, in the care and feeding of scientists.

During the larval and adult spraying days the Regional Laboratory of Environment Canada undertook, either on its own or in collaboration with others, several insecticide formulation field trials. In all cases the Company arranged for and carried out the application phase of the trial under the direction of the Regional Lab.

As has been the custom the Company cooperated with the Maritime Laboratory in the carrying out of defoliation and egg surveys.

Results - See Kettela

COST OF THE 1973 PROGRAMME

In the fall of 1972 when the cost of spraying in 1973 was first considered, it was clear that in the system which the Company had designed and was using costs could only go up over time.

"Off with his funding!"

What was not known was "how much"? Insecticide was purchased at a delivered price of less than in 1972. Application contracts were entered into at about the same rates as in 1972. Guidance system cost changes were not significant. Analysis of spray plan area distribution showed that the number of active fields could be cut from 5 to 4.

The manner in which the areas opened up for spraying allowed a high utilization of air power first in the South and later in the North.

All of these items helped to hold total cost down, food cost excepted.

It appears now that the cost will be less than 2,000,000 dollars when all bills are paid.

/jm

APPENDIX 2

AERIAL SPRAYING AGAINST THE SPRUCE BUDWORM IN 1973 AND A FORECAST OF CONDITIONS IN THE MARITIMES REGION IN 1974

E.G. Kettela

November 1974

INTRODUCTION

The 1973 aerial spraying operation in New Brunswick was the twenty-first conducted by Forest Protection Limited to prevent massive damage by the spruce budworm. The results of studies and surveys to assess the spray program and to forecast the situation for 1974 in the Maritimes are discussed. The report is divided into four parts; 1) Aerial spraying in New Brunswick and forecast for 1974; 2) Survey results in Nova Scotia; 3) Survey results in Prince Edward Island, and 4) Experimental spraying in 1973. In 1973 three compounds were tested against budworm larvae and two against the budworm moth.

1. NEW BRUNSWICK

Spraying in 1973

General-----Based on the results of surveys in 1972 which delineated 4.3 million acres of moderate and severe defoliation (Table 1), 7.5 million acres of moderate to high egg mass infestation (Table 2) and 4.8 million acres of high to extreme hazard (Table 3), Forest Protection Limited sprayed 4.2 million acres in 1973 (Fig. 1). Surveys for overwintering larvae in the winter of 1972-73 changed the hazard rating in some sectors of the province and approximately 150,000 acres were added to the plan and 150,000 acres removed from the plan.

The insecticide fenitrothion was used exclusively in the operational larval spray program. The number of acres sprayed with various formulations and dosages of fenitrothion is shown in Table 4. Except for 175,000 acres treated with an oil solution of fenitrothion, the rest was treated with a water based emulsion. Both T.B.M. and Stearman spray planes and Cessna (172) guidance aircraft were used. The area treated with the Stearman aircraft was small and was generally that area near blueberry fields. As in the past few years the T.B.M.'s were flown usually in teams of 3. Application rate was 0.15 U.S. gal/acre for all spray aircraft.

The spring of 1973 was wet, however, nights throughout April and May were warm and day-degree accumulation was uniform and fast. Although it did not seem so the spring and early summer weather favoured spruce budworm development. Emergence of larvae was well underway on 25 of April as compared to 10 May for 1972. Spray operation commenced on 10 May in Southern N.B. when most budworm larvae were in the second instar of development. This early start was necessitated by the injunction placed against F.P.L. An attempt was made to spray as much of the country as possible in which there were blueberry fields before the injunction came into effect. Larva spray operations were completed on 20 June.

Efficacy of spraying---The results of spraying in terms of effect on budworm survival and percentage of the foliage crop saved were determined from counts of budworms prior to and after spraying and from estimates of defoliation. An 18 inch branch tip was the standard size sample for budworm counts. In all, 19 spray blocks and 7 controls each consisting of 20 plots were sampled. An additional 320 random plots were also sampled. The data (Table 5) shows that the best results in terms of protection to foliage and reduction in budworm survival were obtained in areas sprayed twice in the early instars of budworm development and sprayed once in the fourth and fifth instars of larval development. Survival of budworms was much higher in areas sprayed during the second and third instar phase but the resulting foliage protection is still adequate. This is in keeping with results obtained last year. For the project as a whole the percentage reduction in survival (computed using Abbotts formula) is 81% on fir and 45% on spruce (Table 6) and compares closely with results obtained in the past

20 spray projects. During the course of the operation only one spray block treated with the oil solution of fenitrothion was monitored. The results obtained on this block are in line with those obtained in 1971 and 1972 in New Brunswick and indicate that the oil formulation does not perform as well as the emulsion.

Defoliation---The aerial survey for spruce budworm defoliation normally conducted in July was cancelled because of very poor weather conditions. However, a map depicting moderate and severe defoliation (Fig. 2) was constructed from information gathered during the egg-mass survey and from a defoliation survey conducted on the ground. This survey showed that there was a decrease in the amount of defoliation in southern N.B. (counties of Saint John, Albert, Westmorland, Kings, Queens and Charlotte) and a general increase in the northern counties of N.B. (Table 1). The largest increase was recorded in Madawaska County. In all 3.5 million acres of severe and 4.3 million acres of moderate defoliation were delineated.

Egg-mass Surveys---Over 1,000 locations in N.B. were sampled for spruce budworm egg masses. This survey shows that there was a dramatic increase in the budworm infestation both in area (Table 2, Fig. 3) and intensity (Table 7). This increase is due primarily to spring and early summer weather that enabled a very large portion of the larval population to survive (32%). The infestation now covers nearly all productive forest land in the province with the gross area affected by high infestations increasing from 4.8 to 11.0 million acres (Table 2). In terms of egg-mass density the largest increases were in northeast and northwest and eastern New Brunswick (Table 7). The lowest increases were in the sprayed areas and in southern N.B.

Hazard for 1974---Hazard to trees is computed from the results of egg-mass, defoliation and tree condition surveys. Weighted values are assigned to these measurements then the sum is taken. Hazard is divided into the categories, Extreme, High and Variable. The results are shown in Table 3 and Fig. 4. In spite of an increase in the amount of defoliation and egg-mass infestation there has been a decrease in the area of hazard. This decrease is due to spraying and the fact that a large proportion of the infestation is in new area. There are 1.9 million acres of extreme, 2.0 million acres of high and 1.8 million acres of variable hazard for 1974 as compared to 2.9, 1.9 and 3.0 respectively for 1973.

2. NOVA SCOTIA

Defoliation---Aerial and ground surveys detected patches of light, moderate and severe defoliation throughout Annapolis, Kings and Cumberland counties. In addition patches of light defoliation were noted at many locations in Hants and Colchester Counties in Antigonish County along the northwest coast, west of Antigonish and along the southwest coast of Inverness County. In Kings and Annapolis counties defoliation by the budworm was severe over 22,000 acres in 1973 as compared to 143,000 acres in 1972. However, in Cumberland County, 198,000 acres of severe defoliation were mapped in 1973 as compared to 132,000 acres in 1972. The bulk of this affected area is situated south of Joggins to Apple River, and north of Amherst.

Egg-mass Surveys---Counts of egg masses were generally high in Cumberland County where the egg mass density increased from 133 egg masses per 100 ft^2 of foliage in 1972 to 264 in 1973. Of note are: 1) that the infestation in Kings and Annapolis counties decreased to a low intensity, and 2) egg-mass counts rose sharply in Antigonish County from 16 in 1972 to 134 egg-masses per 100 ft^2 in

1973. Elsewhere in mainland Nova Scotia egg-mass densities are at a low level. No information is available from Cape Breton Island as the samples were lost by CN Express.

Hazard in 1974---Hazard was computed with the same formula used in New Brunswick. Hazard to trees by the budworm is generally low over most of the Province except in some areas of Cumberland County where it is high. These areas are located in the Cumberland peninsula from Joggins south to Sand River then inland to Shulie Lake, and north and west of Amherst.

3. PRINCE EDWARD ISLAND

Defoliation---An aerial survey was conducted in July. The results of this survey show that a major portion of the Islands softwood forest received at least light defoliation in 1973. Patches of moderate to severe defoliation were detected in all sectors of the Province, the largest being 180,000 acres situated east of Charlottetown. In 1971 and 1972 the infestation was largely situated in the western half of the Province.

Egg-mass Survey---Twenty seven locations were sampled for egg-masses. Except for three locations where low to moderate egg-mass densities were found the remaining locations have high to very high counts of egg-masses. The current infestation on P.E.I. has risen to an unprecedented level which is illustrated as follows:

	Mean egg masses per 100 ft^2 foliage	
County	1972	1973
Prince	211	477
Queens	39	587
Kings	103	564

Counts over 240 egg masses per 100 ft^2 are considered to be high.

Hazard in 1974---Computation of hazard shows that the level of hazard is generally moderate over the entire Island. Pockets of high hazard exist east of O'Leary, north of Alberton, and near North Enmore and Bedeque in Prince County, and south of Stanhope and near Vernon River in Queens County. This represents a significant increase in the amount of hazard forecast over 1973 when only moderate hazard was predicted for some locations.

4. EXPERIMENTAL SPRAYING

Larval spray trials---

a) Dylox - At F.P.L.'s request the C.F.S. monitored a 1,000 acre block that was treated with a new U.L.V. formulation of Dylox. Two applications of 6 oz. Dylox in 0.15 U.S. gal/acre were applied at the peak of the fifth instar of budworm development. The data show that about 80% reduction in survival was achieved and that 65% of the foliage crop was saved. These results compare favourably with those attained with fenitrothion.

b) Insect Growth Regulators (Juvenile Hormone Mimics) - At the request of CIBA-GEIGY Canada Ltd., the C.F.S. monitored four, 400 acre blocks treated with 2 dosages of 2 different Insect Growth Regulators. Each compound was tested at 2 + 2 ounces per acre and 1 + 1 ounce per acre. Each application was at a rate of 1/2 U.S. gal/acre. Of the two compounds the one called CG-13353 gave some results at the dosage of 2 + 2 ounces/acre. Approximately 41% of the budworms were affected to the adult stage. However, egg-mass populations in the block were much less than in the surrounding unsprayed area and in the other 3 blocks. It is of interest that budworm development was extended by as much as four days with both compounds. No foliage protection was afforded the trees in any of the plots.

Adult spray trials---

a) Pyrethrum - A 1,000 acre block east of Chipman, N.B. was treated with pyrethrum at the dosage of 0.25 oz/acre. One application at the rate of 0.15 gal/acre was emitted over the block. Results with this insecticide at the dosage used were poor with an estimated 20% of the adult population being killed. Mortality of budworm moths took place within 8 hours after spraying then no further mortality was recorded.

b) Dimecron - About 340,000 acres were treated with various dosages and numbers of applications of Dimecron (Table 4). Trials in 1972 showed that Dimecron was a superior moth killer compared to fenitrothion and that Dimecron at 2 + 2 ounces per acre would kill 90-95% of the population of moths. In 1973 it was hoped that 1) timing of spraying could be advanced early into the moth emergence stage to test the feasibility of stopping egg laying to a greater extent than in 1972 and 2) to determine the most satisfactory dosage.

T.B.M. spray aircraft were used in teams of 3. However, there were a number of changes made in the spray system over that used in the larva spray operation: the planes were calibrated to emit 0.09 U.S. gal/acre and when on the spray blocks the planes flew farther apart. These changes made it possible to spray 20,000 acre blocks very quickly.

The results are as follows:

1) The operation was late in starting and as a result many eggs were laid in the area prior to spraying. However, at spraying, at least in the large area treated with 2 ounces per acre, egg-mass deposition ceased primarily because of a large kill of moths. Therefore, it is possible to stop egg laying and dispersal of adults.

2) The best results in terms of moth mortality were attained at the 2 ounce rate and the double application of 2 ounces per acre (95%+).

3) The application rate of 0.09 U.S. gal/acre is just as effective as the application rate of 0.15 U.S. gal/acre.

It is my opinion that with the information at hand on the effect of spraying on budworm moths, and what is known of moth dispersal as determined in the summer of 1973 at Chipman on the radar project, that a very large area of budworm infested forest should be treated to kill as many moths as possible and to limit dispersal. This will be the only way to test the validity of this spraying technique.

Table 1 Areas (thousand acres) of moderate and severe defoliation caused by the spruce budworm by counties in New Brunswick, 1972 and 1973

County	1972		1973*		Ratio of Severe 73/72
	Moderate	Severe	Moderate	Severe	
Saint John	4.0	85.7	31.9	6.9	0.08
Albert	35.9	98.6	73.7	15.9	0.16
Westmorland	95.6	77.7	279.9	76.7	0.98
Kings	48.8	198.2	109.6	97.7	0.39
Queens	141.4	128.5	251.9	123.5	0.96
Charlotte	71.7	196.2	127.5	194.2	0.99
Sunbury	105.6	72.7	117.5	99.6	1.37
Kent	167.3	80.7	516.9	209.2	2.59
York	378.5	151.4	570.7	184.3	1.22
Northumberland	652.4	339.6	899.4	801.8	2.36
Carleton	81.7	78.7	63.7	89.6	1.14
Victoria	211.2	319.7	384.5	462.1	1.45
Madawaska	27.9	8.0	294.8	201.2	25.15
Restigouche	104.6	36.9	331.7	585.6	1.77
Gloucester	268.9	20.9	234.1	343.6	1.47
TOTALS	2395.5	1893.5	4287.8	3471.9	1.83

*1973- defoliation surveys were conducted on the ground because of no suitable weather for aerial surveys. Hence the areas noted here are gross areas inside which there is generally moderate or severe defoliation.

Table 2. Areas (million acres) by categories of spruce budworm egg-mass infestations in New Brunswick, 1960-1973

Year	Infestation category: Light	Moderate	High	Total
1973	2.5	1.5	11.0	15.0
1972	5.8	2.7	4.8	13.3
1971	4.9	.9	9.0	14.8
1970	4.2	.7	7.9	12.8
1969	3.0	2.0	5.0	10.0
1968	5.6	1.0	3.6	10.2
1967	4.3	.7	.8	5.8
1966	4.9	.5	1.4	6.8
1965	4.6	2.4	1.5	8.5
1964	4.4	.3	1.7	6.4
1963	3.2	.4	1.3	4.9
1962	2.7	.2	.2	3.1
1961	3.6	.8	.6	5.0
1960	3.1	.3	2.0	5.4

Table 3. Area (thousand acres) of forest in New Brunswick by hazard categories, 1971 to 1973

Hazard category[a]	Year 1971	1972	1973
High to extreme	575	2,856	1,886
High	4,120	1,857	2,038
Variable	4,000	3,000	1,764
Total	8,695	7,713	5,699

a. High to extreme - tree mortality and top-killing is expected.

High - tree vigor will be reduced and top-killing is expected.

Variable - trees more or less in fair condition; a high insect population is present; there will be reduction in tree vigor plus some scattered top-killing; areas of high and extreme hazard are too small to be delineated.

Table 4. Synopsis of the 1973 operational and experimental spray program in New Brunswick against the spruce budworm

Insecticide	Dosage (oz.) and application Rate (gal/acre)	Formulation	Applications	Acres sprayed
		Operational larval spray program		
Fenitrothion	3 oz. in 0.15 gal/acre	emulsion	1X	3,643,300
	3 oz. in 0.15 gal/acre	oil solution	1X	175,000
	2 oz. in 0.15 gal/acre	emulsion	2X	350,000
			Sub-total	4,168,300
		Experimental larval spray program		
Dylox (u.l.v.)	6 oz. in 0.15 gal/acre	organic solvent and water	2X	1,000
Insect growth regulators	2 oz. in 0.5 gal/acre	water solution	2X	800
Insect growth regulators	1 oz. in 0.5 gal/acre	water solution	2X	800
			Sub-total	2,600
		Experimental moth spray program		
Pyrethrum	0.25 oz. in 0.15 gal/acre	oil solution	1X	1,000
Dimecron	2 oz. in 0.09 gal/acre	water solution	1X	260,000
	2 oz. in 0.09 gal/acre	water solution	2X	20,000
	1 oz. in 0.09 gal/acre	water solution	1X	20,000
	0.5 oz. in 0.09 gal/acre	water solution	2X	20,000
			1X	20,000
			Sub-total	341,000
			Grand total	4,511,900

Table 5. Results of spraying with fenitrothion in New Brunswick in 1973 in terms of budworm survival and percentage balsam fir foliage saved

Budworm development (instar) at spraying	Pre-spray larvae/18" branch tip	Surviving pupae/18" branch tip	Survival % (P/L)	Defoliation (%)		% foliage saved
				Expected	Observed	
BALSAM FIR - 2 applications of 2 oz. each						
L2-L3	19.1	2.5	13	68	34	50
BALSAM FIR - 1 application of 3 oz.						
L2	26.9	4.8	18	95	58	39
L2-L3	18.2	3.5	19	65	40	39
L4-L5	13.5	0.9	6	51	29	43
L5+	15.9	1.2	8	55	25	55
Unsprayed controls	19.7	6.3	32	-	70	-
SPRUCE - 2 applications of 2 oz. each						
L2	29.9	1.3	4	-	-	-
SPRUCE - 1 application of 3 oz.						
L2	33.1	2.8	9	-	-	-
L3-L4	12.9	1.3	10	-	-	-
L4-L5	16.5	1.7	11	-	-	-
Unsprayed Controls	17.8	2.7	15	-	-	-

Table 6 Percentage reduction in survival of population, and percentage of balsam fir foliage saved by spraying, 1952-1973

Year	% reduction of survival of population		% balsam fir foliage saved
	Balsam fir	Spruce	
1952[a]	99	-[b]	7
1953	96	-	41
1954	-	-	52
1955	83	-	41
1956	89	-	25
1957	85	-	35
1958	80	-	34
1960[c]	81	42	-
1961	85	82	-
1962	82	70	-
1963	81	79	-
1964	83	65	-
1965	85	62	-
1966	88	73	-
1967	84	63	-
1968	79	70	-
1969	90	80	35
1970	76	72	65
1971	85	75	40
1972	78	65	35
1973	81	47	45

a. Data for 1952-58 (Webb *et al.* 1961).

b. - denotes no data.

c. Data for 1960-67 (Macdonald *et al.* 1963, 1968).

Table 7. Trends in spruce budworm populations by sector from 1970 to 1973 (Number of sample points in brackets)

	Egg masses per 100 ft^2 of foliage				Egg-mass ratios		
	1970	1971	1972	1973	71/70	72/71	73/72
Sprayed 1973							
Once	459(275)	561(282)	286(287)	367(297)	1.22	0.51	1.28
Twice	867(24)	592(24)	343(25)	285(25)	0.68	0.58	0.83
Unsprayed in 1973							
Northwest	17(111)	134(115)	83(122)	335(131)	7.88	0.62	4.04
Northeast	305(65)	325(66)	238(70)	775(71)	1.06	0.73	3.25
Central-west	270(156)	211(160)	152(160)	349(162)	0.78	0.72	2.30
Central	559(108)	458(111)	281(114)	631(116)	0.82	0.61	2.24
Southwest	369(51)	381(56)	149(57)	268(61)	1.03	0.39	1.80
Southeast	1108(26)	630(28)	212(30)	386(33)	0.57	0.34	1.87
East Coast	592(77)	434(80)	99(80)	456(85)	0.73	0.23	4.61

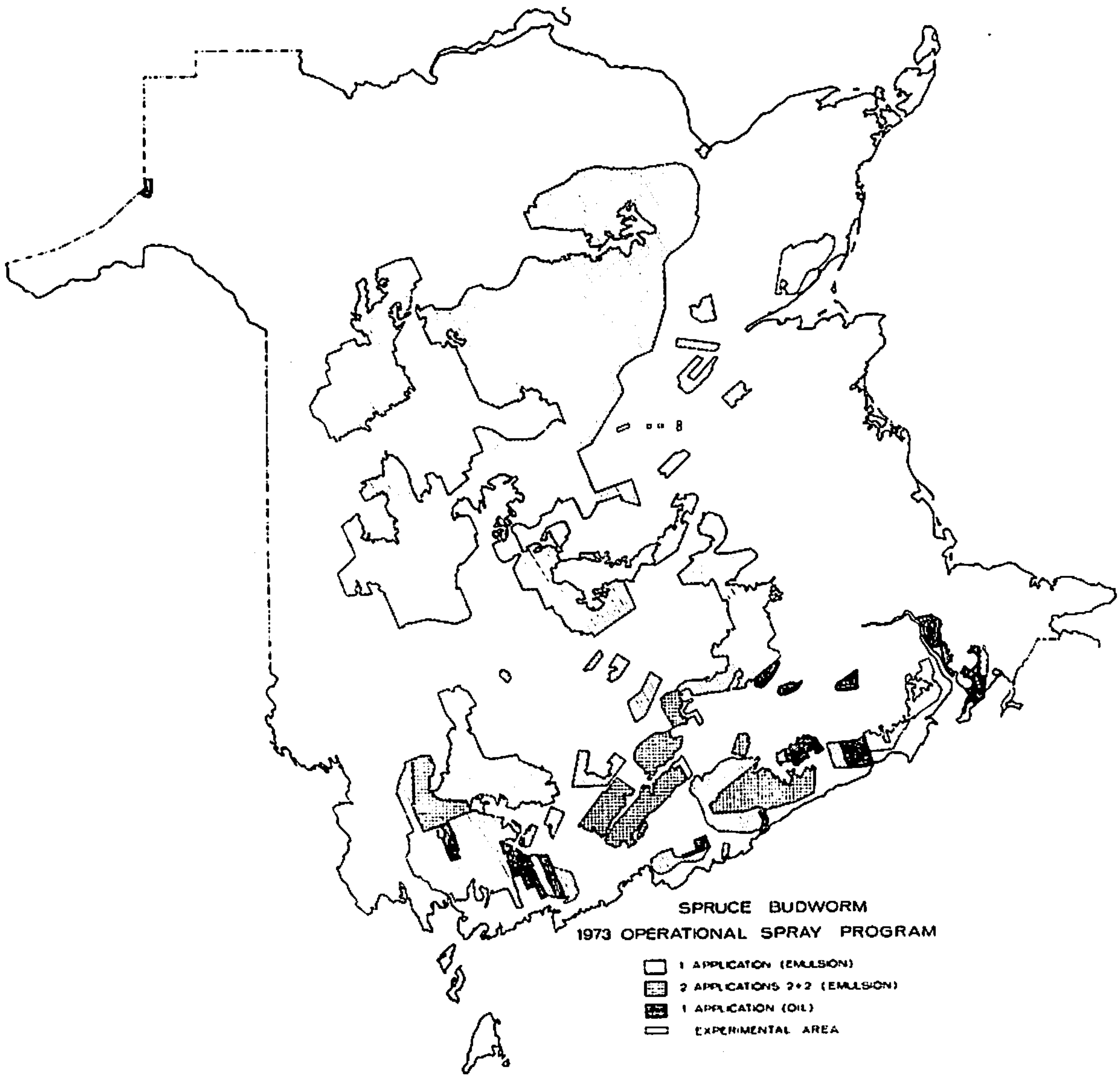

SPRUCE BUDWORM
1973 OPERATIONAL SPRAY PROGRAM
1 APPLICATION (EMULSION)
2 APPLICATIONS 2+2 (EMULSION)
1 APPLICATION (OIL)
EXPERIMENTAL AREA

Figure 1.

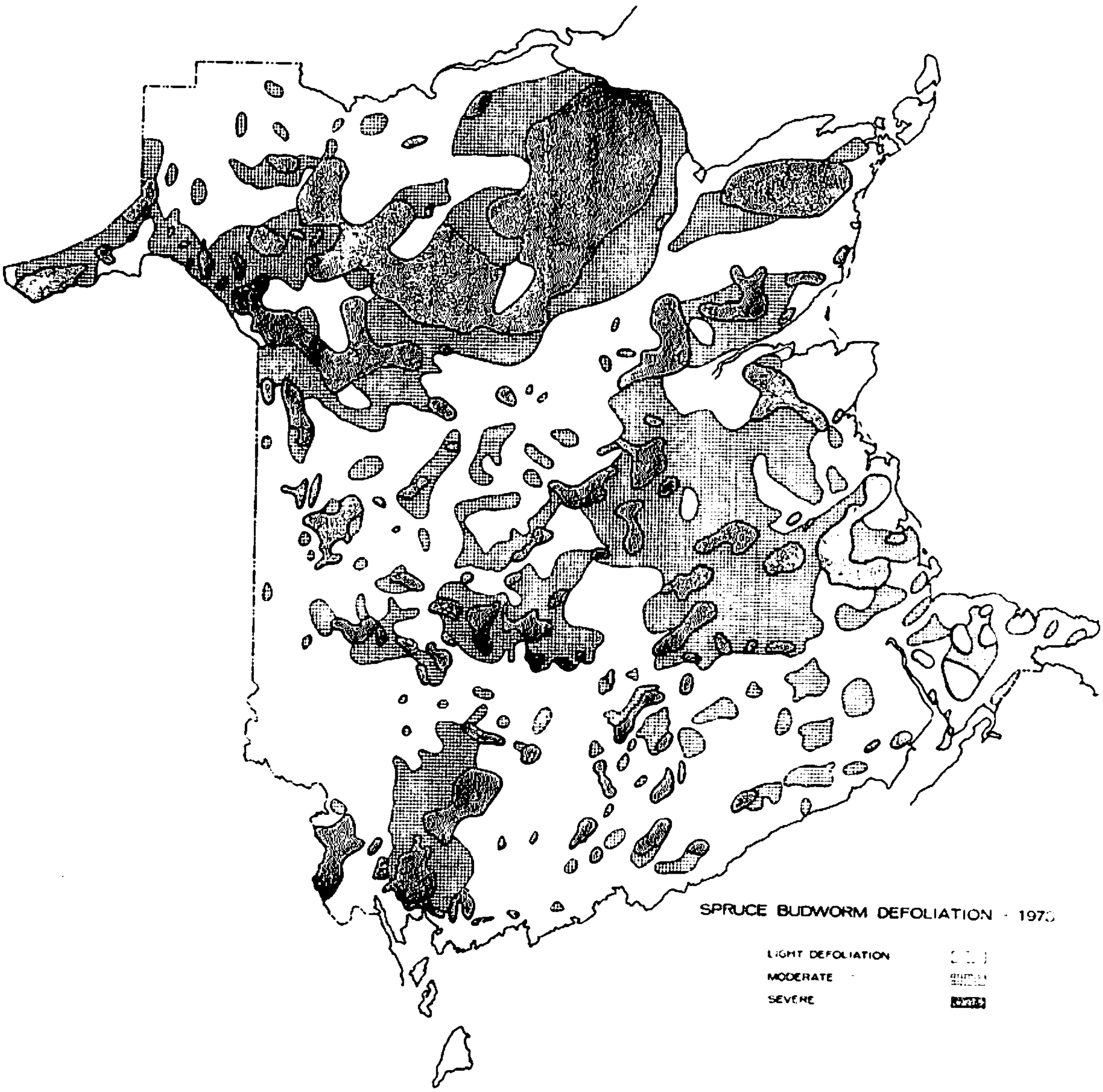

SPRUCE BUDWORM DEFOLIATION - 197
LIGHT DEFOLIATION
MODERATE
SEVERE

Figure 2.

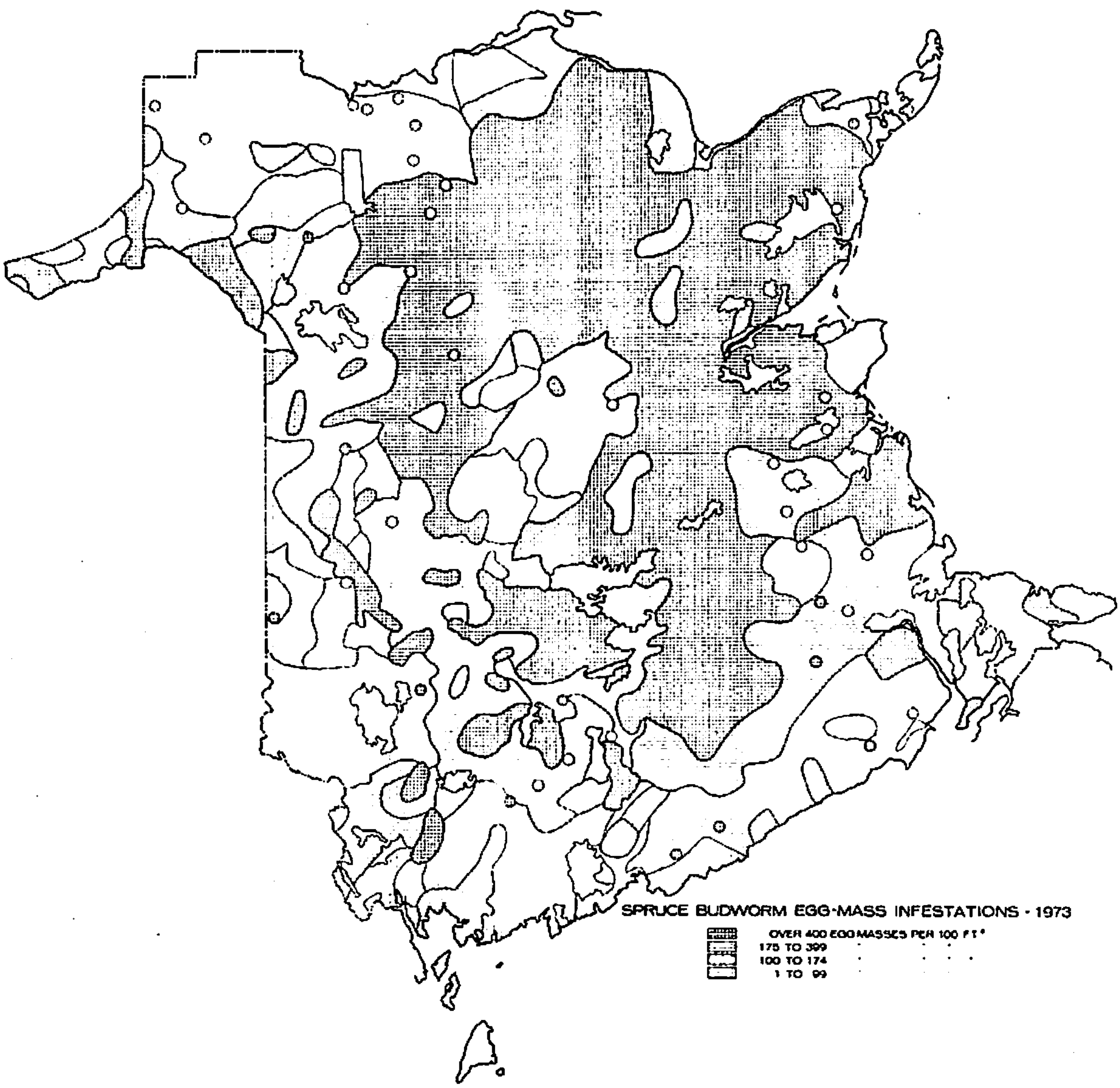

SPRUCE BUDWORM EGG-MASS INFESTATIONS - 1973
OVER 400 EGG MASSES PER 100 FT²
175 TO 399
100 TO 174
1 TO 99

Figure 3.

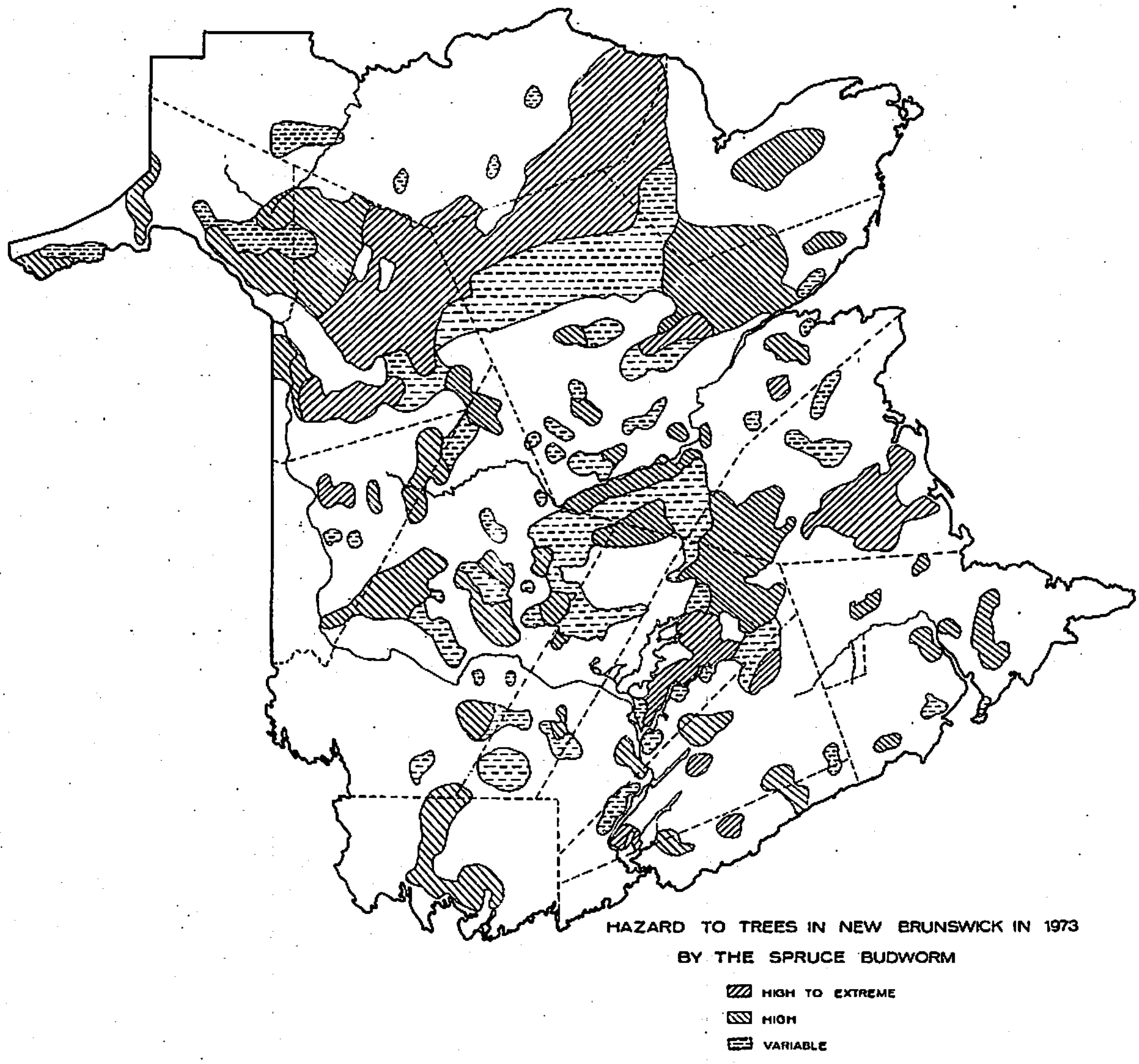

HAZARD TO TREES IN NEW BRUNSWICK IN 1973
BY THE SPRUCE BUDWORM
HIGH TO EXTREME
HIGH
VARIABLE

Figure 4.

APPENDIX 3

Summary of forest spray monitoring activities conducted by CWS in 1973

P.A. Pearce

Canadian Wildlife Service

Fredericton, N.B.

For Annual Forest Pest Control Forum, November 14, 1973. Hull.

Item 1.1 Regular fenitrothion spray operations against spruce budworm larvae were not monitored by CWS in New Brunswick in 1973. Reports of bird casualties were received from a few locations and some carcasses were obtained. Those localities were at North Pole Brook, at Fredericton, and at Fundy National Park where the forest was sprayed with fenitrothion at 3 oz a.i./acre. Some bird mortality was reported from Apohaqui but it remains unclear whether that could be attributed to forest spraying. Eye-witness evidence and past experience suggest that mortality in the spray zone may be mostly due to unintentional overdosing. Probably most such instances go unreported. Following customary procedure, the carcasses will be analysed for fenitrothion at the Ontario Research Foundation. Brain cholinesterase determinations may be conducted by the Environmental Health Directorate.

An attempt was made by CWS to monitor the large-scale use of phosphamidon (Dimecron) against spruce budworm moths in northwestern New Brunswick in July. Pre- and post-spray bird censuses, and post-spray searches for casualties, were conducted in spray blocks designated as E-14 and F-15. Block E-14 was sprayed twice with phosphamidon at the rate of 2 oz a.i./acre at an interval of one day, and block F-15 was treated once at the rate of 0.5 oz a.i./acre. No adverse effects on birds were noted in block F-15. Birds were not seen to be adversely influenced by the spray after the first application to block E-14. After the second phosphamidon application to that block there was apparently a depression of the bird population: the numbers of some warblers remained low, the numbers of others "recovered" after a few days. Several intoxicated birds, exhibiting the usual symptoms of organophosphate poisoning, were noted in that spray block. Due to insufficiency of adequate lead time and to prolonged poor census weather, monitoring was at best superficial. A further complexity arose from the fact that parts of the forest where phosphamidon was applied had already been sprayed several times with fenitrothion by the private sector. Bird censuses conducted elsewhere in the region suggested that avian populations were abnormally low, possibly due to the previous heavy spraying with fenitrothion.

Item 1.4 At the request of CFS, CWS co-operated with Ciba-Geigy Canada Ltd. in monitoring trial aerial sprays of two insect growth regulator analogues produced by that company. The two chemicals were designated by Ciba-Geigy as 42710 and 13353. Two applications of each compound were made at a five-day interval at the rate of 1 oz/acre. Each chemical was also applied twice, again with an interval of five days, at the rate of 2 oz/acre. On the suggestion of CWS, an additional single application of 42710 was made at the rate of 10 oz/acre. Bird censuses and post-spray searches for casualties were conducted over a period of one month. There was no evidence to suggest that birds were adversely affected by the sprays. No abnormal bird activity was detected and populations remained stable, small, apparent fluctuations reflecting the influence of weather on behaviour.

Item 1.2 Two incidents of bird mortality and one of fish mortality were investigated by Canadian Wildlife Service at Maniwaki and at Val Viger in Quebec. Samples of birds and fish from these two areas contained several times the quantity of fenitrothion generally associated with death (Appendix I).

The bird incident at Maniwaki appears to have been caused by a combination of navigation and climatic factors. The aircraft flew too low, into the wind and during an inversion. There appears to be no evidence of double swathing.

The incident at Val Viger, which included bird and fish kills, may have been due to similar causes and to repeated applications. There is at present a law suit for $6,000 damages in the Quebec Justice Department for losses due to that spray operation.

The economy of northern Quebec depends, to no small extent, on tourism and fishing. The long term effects of spraying tourists and recreational waters should be given serious economic consideration. The appropriateness of using four-engined aircraft for spraying environments with many lakes could stand some scrutiny.

Appendix I

Fenitrothion residues (in ppm) in Quebec Wildlife Samples, 1973.

Location	Species	Fenitrothion
Joseph Farm,Maniwaki	Myrtle warbler	10.3
	Red-winged blackbird	4.07
Val Viger, Mont Laurier	Robin	10.2
	Yellow shafted flicker	9.37
	Speckled trout	0.77
	Speckled trout	0.88

APPENDIX 4

SUMMARY REPORT ON THE EFFECTS OF THE 1973 FOREST SPRAY PROGRAM IN NEW BRUNSWICK ON AQUATIC INVERTEBRATES

PREPARED FOR

FOREST PEST CONTROL FORUM

OTTAWA

November 1973

by

H. A. Hall
Head/Ecological Effects Unit

and

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Surveillance & Analysis Division, EPS
Atlantic Region

November 12, 1973

INTRODUCTION

Aerial spraying of insecticides has been used to control the spruce budworm in New Brunswick since 1952. In 1969 the organophosphate, fenitrothion, became the major insecticide used with only minor experimental plots receiving other insecticides. In 1971 Banks began a two year program designed to examine the influence of the aerial application of fenitrothion on stream dwelling invertebrates. This program was initially under the auspices of the Fisheries Service but responsibility has since shifted to the Environmental Protection Service. This study, initiated by Banks, was continued during the 1973 season under the direction of H. Hall E.P.S. Halifax. This report deals with the 1973 results obtained from two areas in New Brunswick; one sprayed with Fenitrothion, the other, a small experimental plot of 20,000 acres, sprayed with Phosphamidon. The proceedure for collecting data followed very closely that of the 1972 study with main efforts concentrated on analysing the effect of the insecticides on Ephemeroptera, Plecoptera, Tricoptera, and Diptera, the major insect food organisms of juvenile Atlantic Salmon and Brook Trout.

STUDY AREAS

The fenitrothion study area was located on Cove Brook near Sussex, N. B. This same stream had been studied in 1971 and 1972 and was therefore a logical choice for the

1973 study since comparative data would be available (Fig. 1, 2).

The phosphamidon study area was determined by the location of the test blocks set up for the spruce budworm, a moth spraying trials. The trials were carried out on 20,000 acres Northeast of St. Leonard, N. B. Big Forks Brook (Fig. 3), a small stream within the trial block, was chosen for studying the effect of Phosphamidon on benthic stream invertebrates.

METHODS

The methods used in these studies were similar to those used by Banks in 1971 and 1972 at Cove Brook. Stream conditions such as temperature, water level, flow rate, and water chemistry were carefully monitored prior to, during and after spraying. Daily water samples were sent to the Water Quality Lab in Moncton, N. B. for analysis of pesticide residue, and some duplicate samples were analysed by the Pharmacology Dept. of Dalhousie Univeristy, Halifax, N. S. Insect larvae were also collected for analysis of pesticide residues to be carried out at Dalhousie University.

Two parameters were examined to study the effect of the insecticides on benthic insect larvae: fluctuation in the normal insect drift, and changes in the population. Insect drift was monitored by using drift nets designed to sample one foot cross sections of the stream. These nets were used in two ways: one to measure continuous 24 hr. drift, the other to measure drift for 15 minutes at intervals of 3 hours. At Cove Brook the period of prespray monitoring was seven days whereas the prespray monitoring at Big Forks was only 3 days.

Population densities were determined using two methods: the Surber Sampler and twenty-stone counts. The Surber sampler is designed to allow the investigator to determine the total population of invertabrates occupying a square foot of stream bottom. The boulders and gravel in the foot square area are stirred up and washed to release animals which are washed into a net. Nine samples were collected twice weekly during the study period. In the twenty-stone count method the investigator removes twenty stones from a selected area and counts the insects found on each stone. Two 10 ft. x 30 ft. plots were counted every three days using this method.

At Cove Brook sampling began on May 11 and continued nntil June 23. At Big Forks sampling was from July 7 to August 17.

RESULTS

Cove Brook:

The levels of fenitrothion in Cove Brook prior to the first spray was less than 0.020 ppb (Fig. 4). Due to bad weather, only half the block was sprayed on May 18, and three hours post-spray the fenitrothion level was 2.1 ppb. The level went up to 2.8 ppb 5 hrs. post spray but dropped to 0.88 ppb within 24 hrs. The other half of the block was sprayed on May 20 with a corresponding rise in insecticide levels in the stream up to 2.4 ppb. Levels were back down to less than 0.02 ppb within 48 hrs. Drift samples collected in Cove Brook (Fig. 5) show a gradual increase in numbers from May 11 to May 17. Following the first spray application on May 18 and 20 the drift numbers increased rapidly. Unfortunately heavy rainfall on May 22, 23, 24 made collecting impossible so that samples from these days are missing. Water levels were still high on May 25, 26 and 27 and this may account for very high drift numbers during this period. The whole block was sprayed on June 4 and insecticide levels in the stream went up to 11.2 ppb. An increase in the numbers of drifting insects on June 5 and 6 is probably a direct result of increased residues of fenitrothion in the stream.

The results of the twenty-stone counts do not indicate any significant decrease in the population of Ephemeroptera or Trichoptera following the application of fenitrothion in the Cove Brook area.

Surber sample results from Cove Brook show a small (approx. 10%) decrease in the numbers of Ephemeroptera following each of the two sprays, however, recovery appears to be rapid. Trichoptera show a similar response but continue to decrease after the final spray. Plecoptera appear to increase after the first spray but decrease after the 2nd spray, however, they have recovered by the end of sampling. Diptera show a decrease after each spray but recover within a few days.

Big Forks Brook:

The area of Big Forks Brook received only one application of Phosphamidon at 2 oz. per acre on July 10. One hour post-spray the level of phosphamidon in the stream was 12.8 ppb. Within 3 hours it had dropped to 3.63 ppb and after 24 hours insecticide levels were down to 2.28 ppb. Three days post-spray levels less than 0.05 ppb were measured and these low levels persisted for the remainder of the test period until August 11 (Fig. 6).

Information on insect drift during the test period from July 7 to 17 shows a definite increase in drift on July 11 and 12 immediately following the spray on July 10 (Fig. 7). Analysis for fenitrothion as well as phosphamidon was carried out on all water samples from Big Forks Brook. The first water sample, July 9, had a high level of fenitrothion, 12.0 ppb, which may account for the large drift count on July 8, prior to the phosphamidon spray. The peaks on July 15 and 16 do not correspond with any increase in insecticide residue and are unexplained.

Results from surber samples taken on July 9, 13 and 16 show no decrease in populations of Tricoptera, Plecoptera, Ephemeroptera or Diptera. This finding was confirmed by twenty-stone counts done on July 8, 12 and 16.

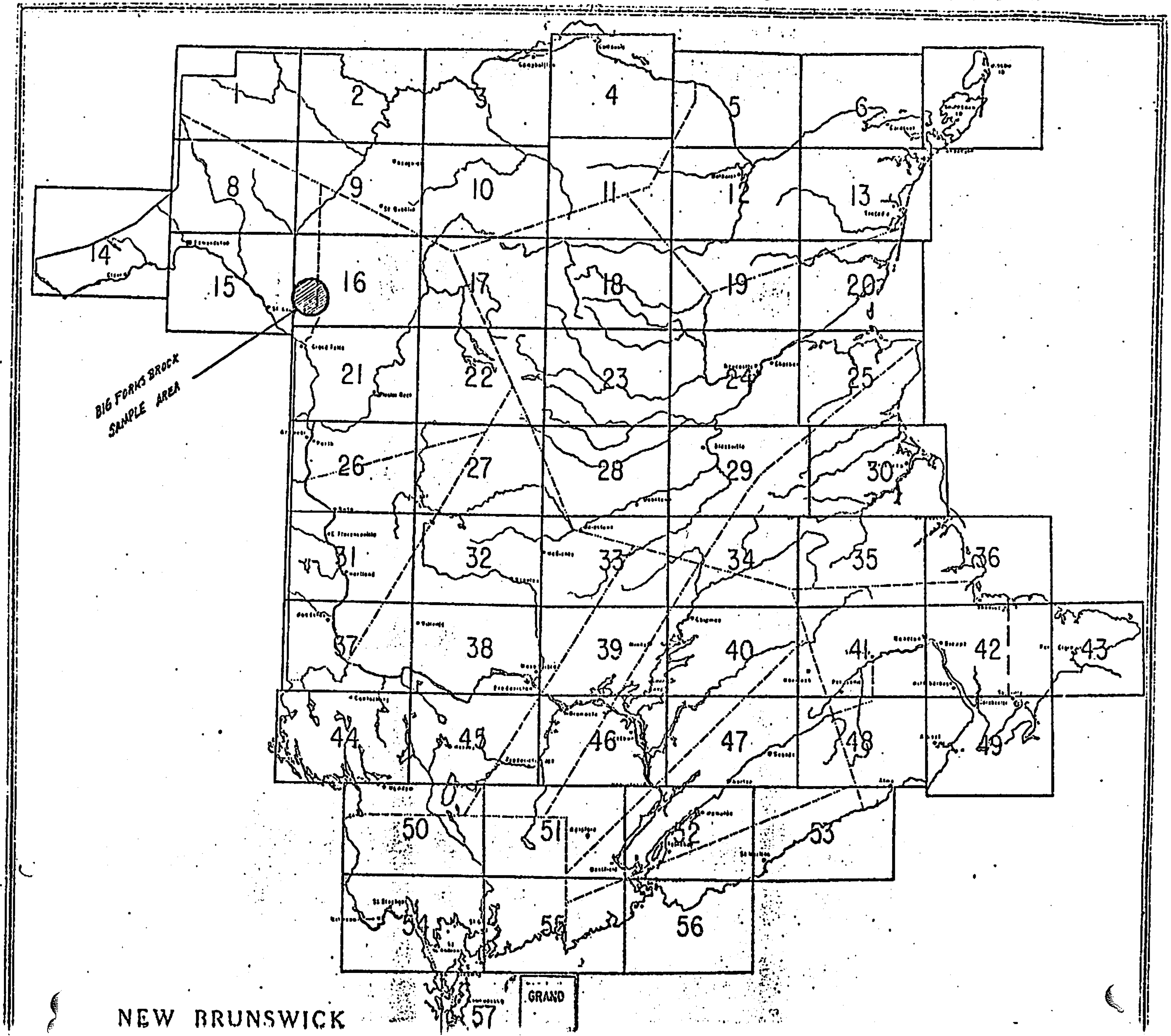
Bioassay of Phosphamidon:

Results from laboratory studies on the effect of phosphamidon on trout indicate a 96 hour LC50 of 8 ppm. A previous bioassay of fenitrothion on salmon showed a 96 hr. LC50 of 0.1 ppm.

ACKNOWLEDGEMENTS

We would like to express our thanks to Forest Protection Ltd., and to the Water Quality Laboratory of the Inland Waters Branch of D.O.E. for their cooperation and assistance during the 1973 field season.

Figure 1 Big Forks Brook Location



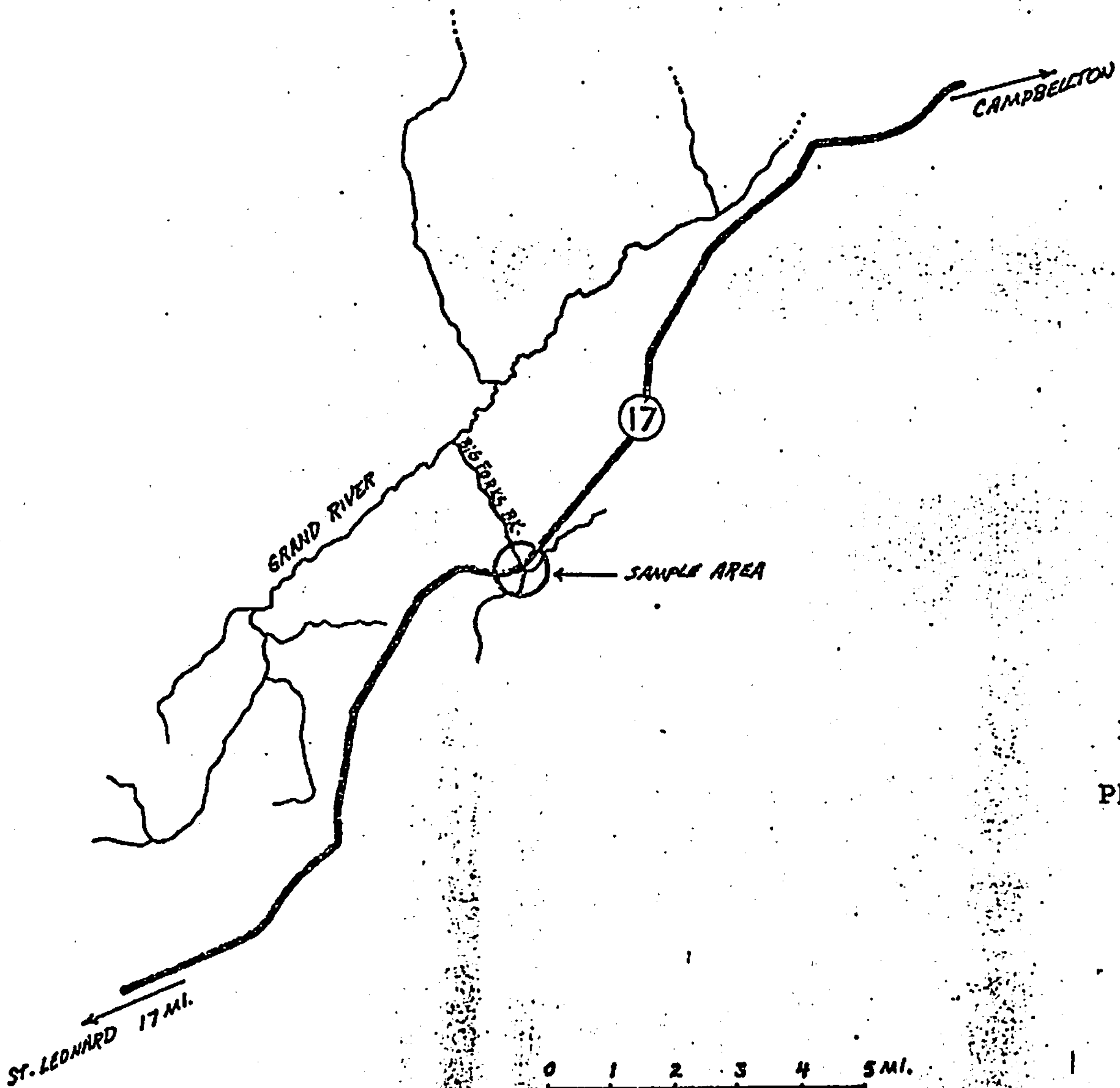


Figure 2

Phosphamidon study area

Big Forks Brook

Label

Phosphamidon Survey

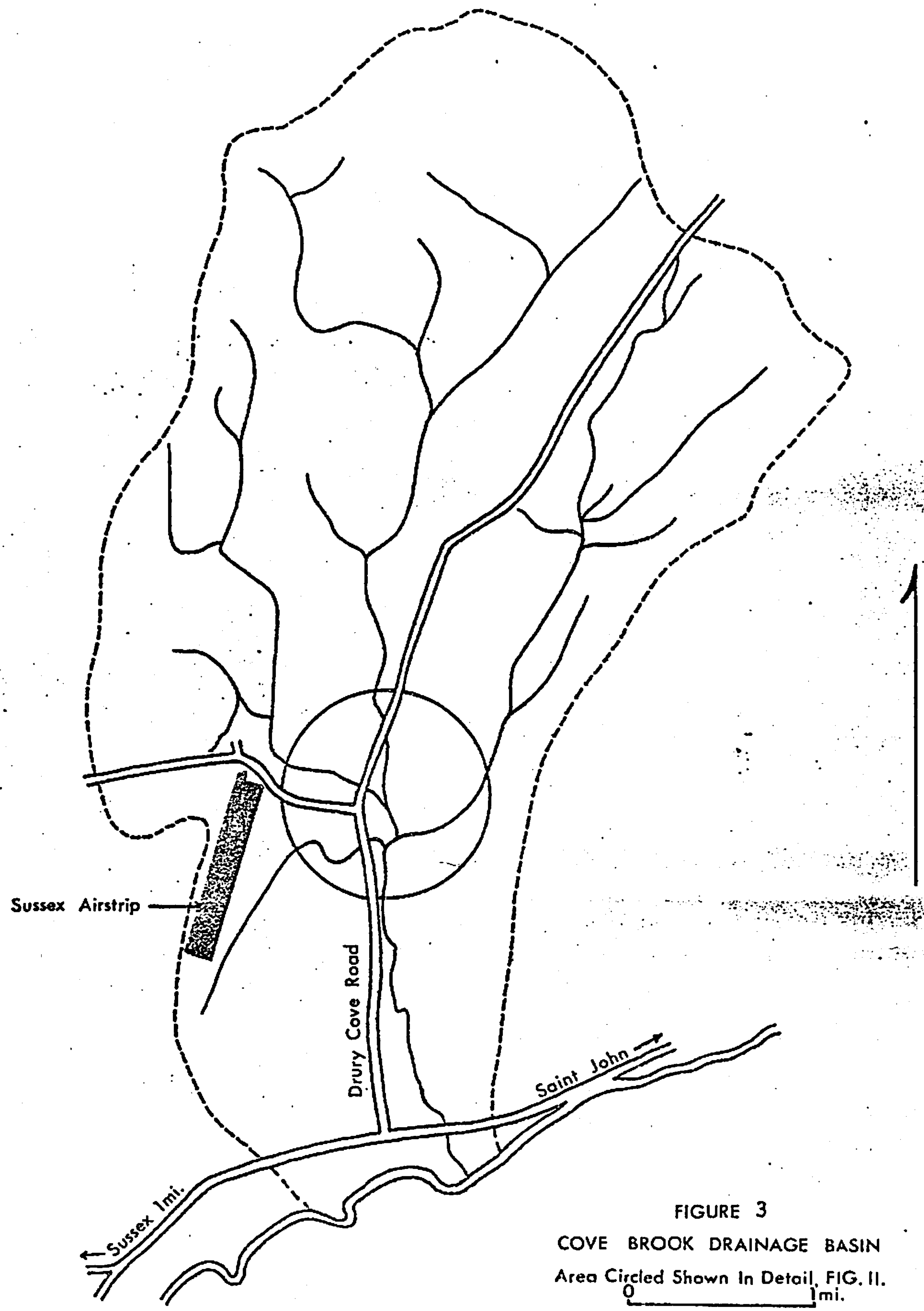


FIGURE 3
COVE BROOK DRAINAGE BASIN
Area Circled Shown In Detail, FIG. II.
0 1mi.

Figure 4 Fenitrothion Levels Cove Brook 1973

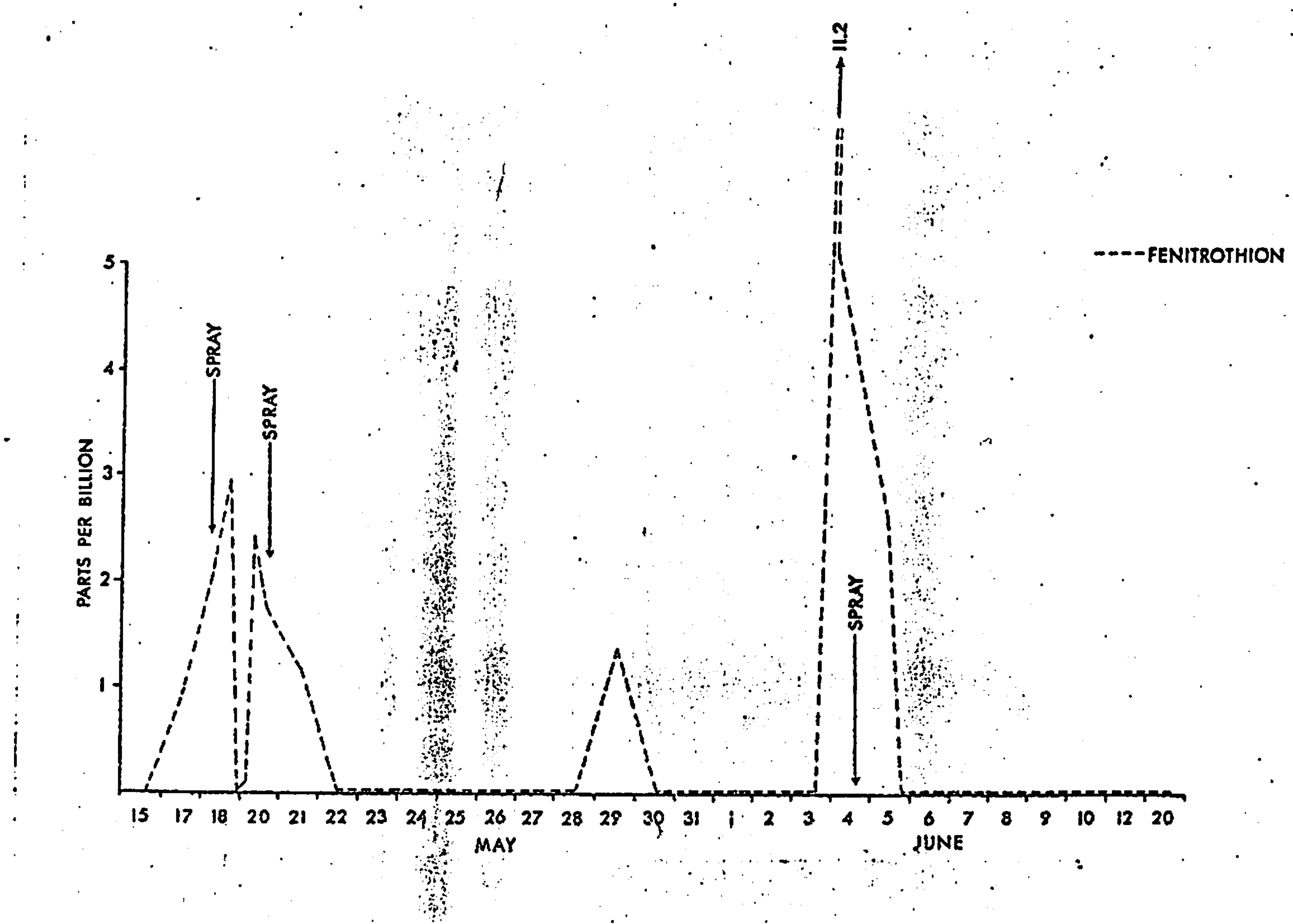


Figure 5 Total insect drift, Cove Brook 1973

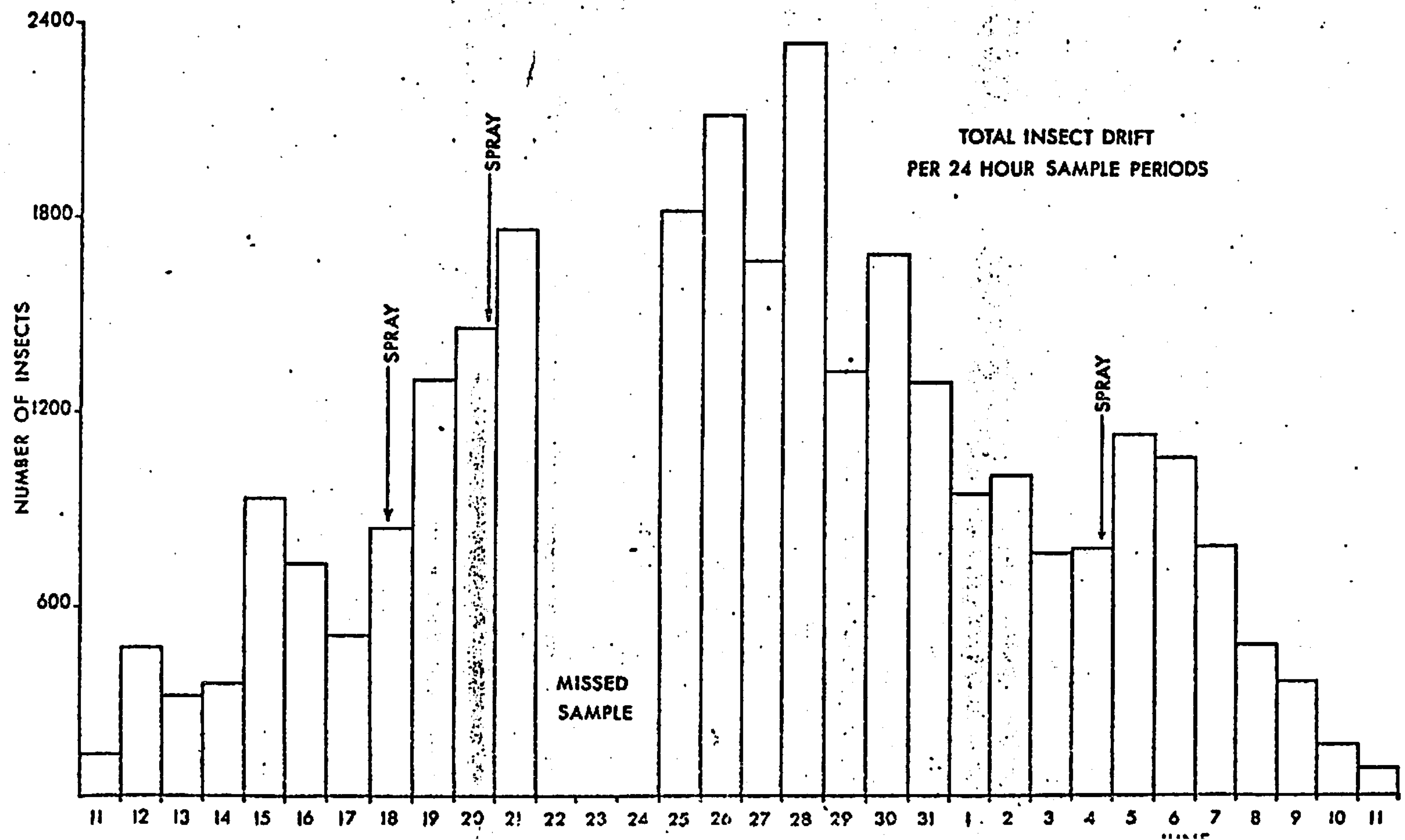
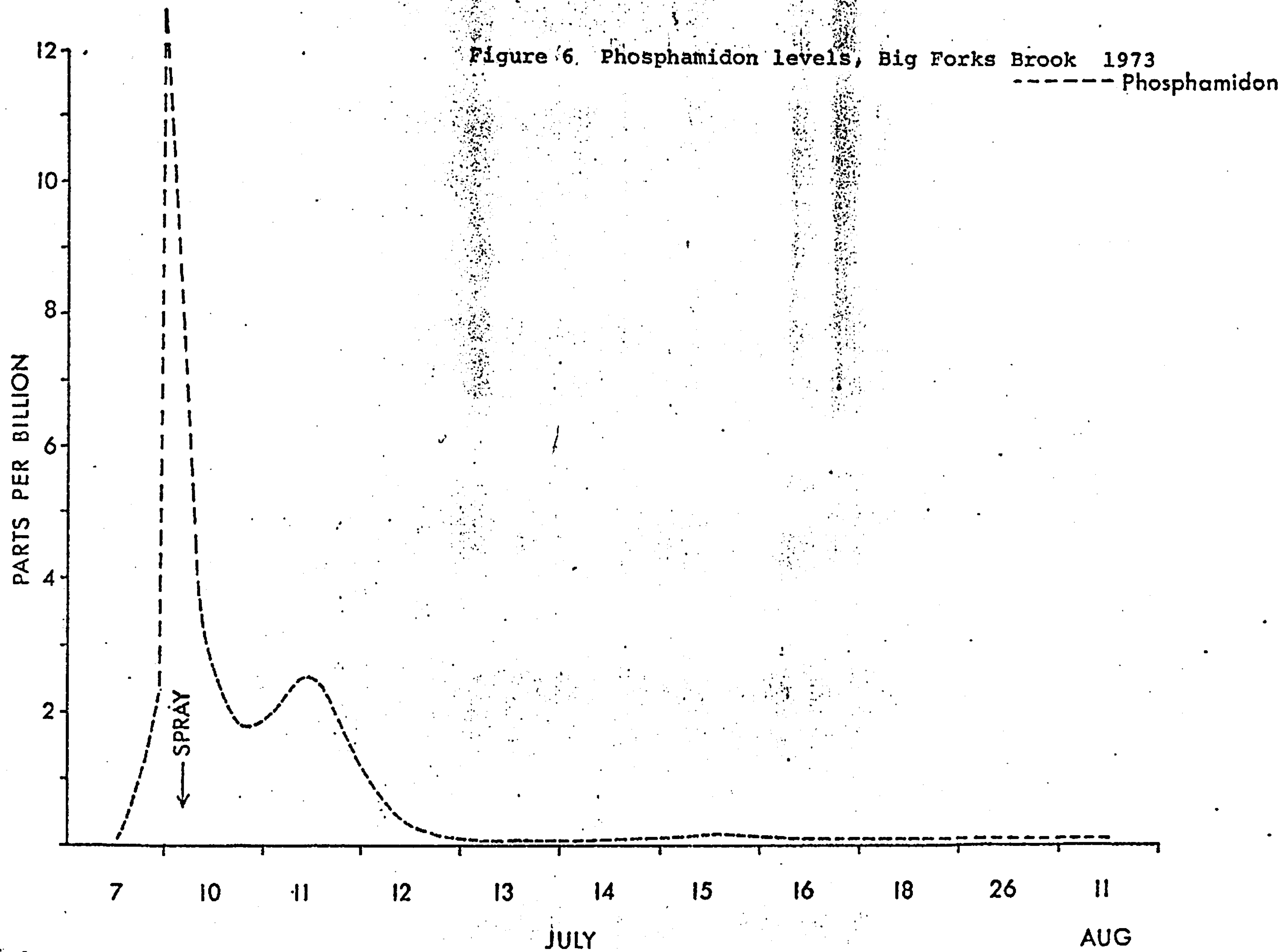


Figure 6. Phosphamidon levels, Big Forks Brook 1973



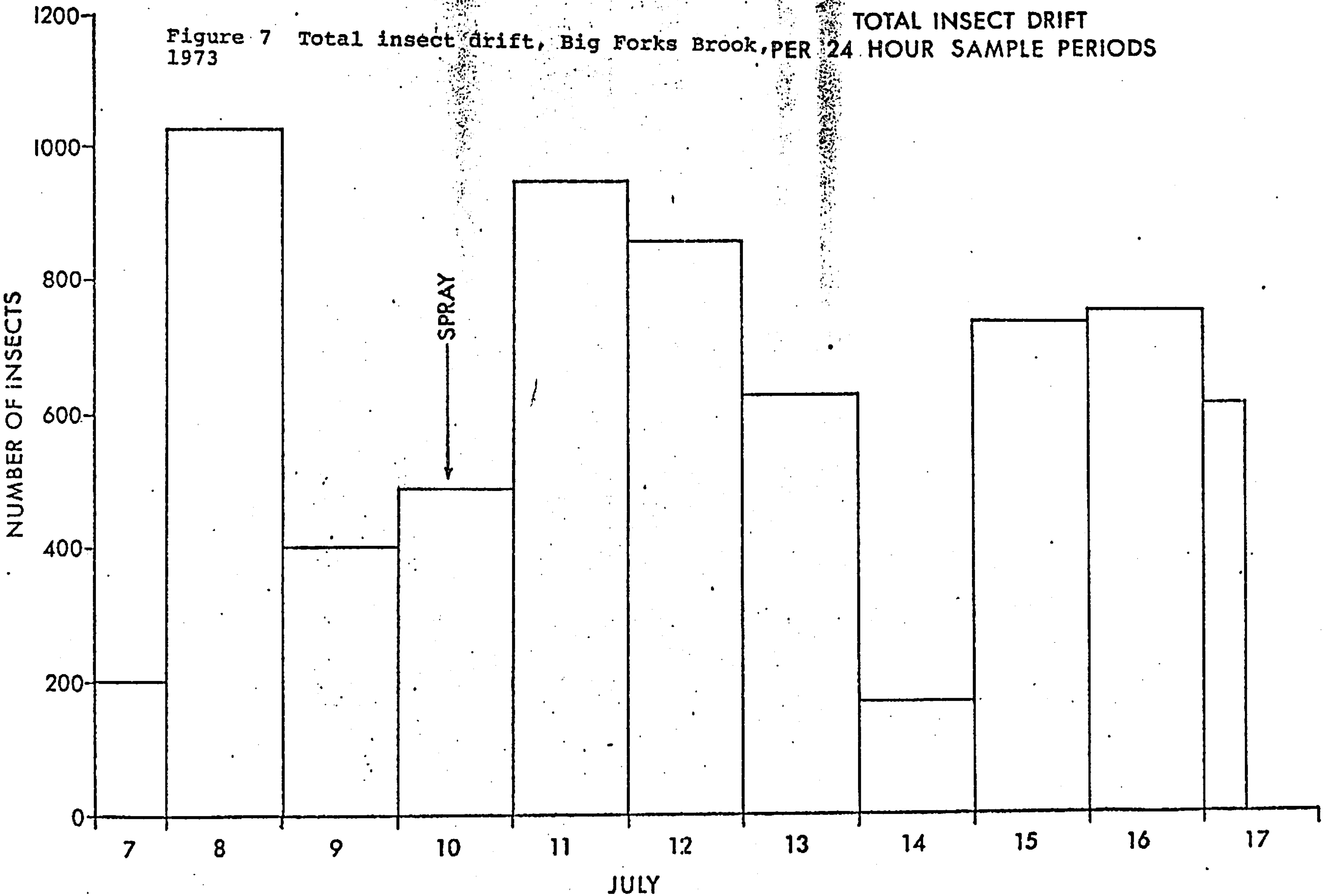


Figure 7 Total insect drift, Big Forks Brook, 1973

The 1973 protection project was completed in the period June 10-19 based at Presque Isle Airport. Treated were 470,000 acres. Results were appreciably better this year than in 1972, which involved the period June 8-25, and reflected better weather conditions of more stable air in consecutive days. There was better foliage protection and higher budworm reduction which amounted to 93%. Better foliage protection was due to getting the project done earlier to reduce the period of larval feeding.

Costs were $2.71 per acre of which $2.61 were direct costs; in essence the same as last year. This occurred although we had to reach out further from the base at Presque Isle, and had more spray and guide planes, than in 1972. Should we have to operate other than out of Presque Isle things would be appreciably different due to direct living costs and the intangible benefits of full supervision of a crew of 70-80 men under one roof.

Major part of the project was done by PV2 and TBM spray planes. 3500 acres of inhabited, wooded roadsides and lake shores were treated by helicopter.

The project insecticide was Zectran at the rate of 2.4 oz. in one gallon of solution per acre. Our desire has been to reduce the amount of carrier to cut costs of material and flying. For this reason some blocks of the total acreage were reserved for test applications of (1) 1.2 oz. Zectran in 1 quart solution/acre applied twice, (2) 2.4 oz. Zectran/1 quart/acre, and (3) 2.4 oz. Zectran/ 2 quarts/ acre, and (4) Bacillus thuringiensis. Results of the Zectran tests analyzed statistically were not significantly different between the regular operation and the 3 tests. A change in application is, therefore, in order. Data of the B.t. tests are not yet fully analyzed by Dr. John Dimond, U. of Maine, Orono.

Research on parasites by Dr. Dave Leonard and Gary Simmons (U. of Maine) was also funded. European species of parasites were released in Indian Twp. and T6 R7.

In the 1973 project, spray applications were as usual to those stands needing assistance in order to survive as determined by 1972 detailed surveys. A number of other areas were involved in rising budworm populations both in intensity and extent. Our detailed field surveys were continued in 1973 - aerial defoliation and stand condition surveys; ground, larval, pupal, and egg mass surveys - with analyses at the Portage and Cross Lake field laboratories. I will refer now to the display maps which will demonstrate the major conclusions and the increase in geographical extent of stands needing assistance. You will recall that the 1973 areas were around St. Francis. Long Lake, a small one at Square Lake, Squapan, and Telos. Previously we had been involved in some area in the region from Cut Lake (south of Oxbow to Van Buren). Explanation now of display maps.

It is our recommendation that the areas pointed out on the map and which total 400,000 acres be treated in 1974 by aerial spraying. We have additional areas becoming of concern to us and which warrant close analyses next year. For example, the Northwest area gives us concern southerly to St. Pamphile. The Musquacook area is only part of a much larger area with high and rising populations - extending easterly and south-southwest to the Telos area and to Chesuncook and Caucomgomac. Another area of concern occurs around Baker Lake.

Great credit for all the survey work and analyses must go to our entomologists/pathologists and forest insect rangers. With the problem expanding geographically in late years they have met the challenge without increase in personnel. The limit has been reached. We plan now to ask, of the Special Session of the Legislature, funds for additional personnel and trust you will appreciate the need.

Of the men doing the detailed surveys, the entomologists are present here today and have wall maps. If you desire they can give you details of findings. These are Dave Struble, Hub Trefts, Henry Trial, George LaBonte, and the coordinator of budworm surveys, Doug Stark.

In addition, I give appreciation to our colleagues from the U.S. Forest Service; Paul Buffam, Vaughan McCowan, and Ken Lancaster and especially to our good cooperators over the years from New Brunswick and Forest Protection Ltd. - Barney Flieger and Bev McDougall

At the risk of over brevity, it seems best now to go to points which you may wish discussed further.

Robley W. Nash
November 2, 1973

AERIAL SPRAYING AGAINST THE SPRUCE BUDWORM IN QUEBEC IN 1973 AND PLANS FOR 1974

by

Real Desaulniers, F.Eng.

Department of Lands and Forests
Conservation Branch
Entomology and Pathology Service

Report presented at
the Annual Forest Pest Control Forum
held in Hull on November 14, 1973

AERIAL SPRAYING AGAINST THE SPRUCE BUDWORM IN QUEBEC IN 1973 AND PLANS FOR 1974

INTRODUCTION

An invasion of Quebec by the Spruce Budworm was discovered in 1967. Since 1970, the Quebec Department of Lands and Forests in collaboration with the interested limit holders and the Laurentian Forest Research Centre of the Federal Government Department of the Environment has carried out control measures, which have been intensified in 1973 because of the rapid spread of this epidemic.

1 - THE 1973 PROGRAM

The Spruce Budworm aerial spraying carried out in Quebec in 1973 covered an area of 9.7 millions acres, divided into five sectors according to the bases of operation.

In Western Quebec and in the Riviere-du-Loup sector, the objective of the spraying operations was to save the trees and the loss of increment. In the Bonaventure and Gaspe sectors, it was hoped to check the epidemic in its early stages or at least delay its progress.

2 - THE SPRAYING OPERATIONS

2.1 - Lac des Loups sector

2.11 - Area sprayed	2.7 million acres (figure 1)
2.12 - Type of treatment	Two applications of oil based Fenitrothion, one of 3 ounces and another of 2 ounces per acre
2.13 - Operator	Conair Aviation Ltd.
2.14 - Airfract used	4 DC-6B
2.15 - Aircraft characteristics	
Payload	3,600 USG
Swath width	3,000 feet
Speed	230 MPH

2.16 - Guidance system	Decca
2.17 - Beginning of operations	May 14
2.18 - Insect development at	15% L 3*
2.19 - End of operations	June 8
2.20 - Insect development at end of operations	L 4

2.2 - La Macaza sector

2.21 - Area sprayed	2.1 million acres (figure 1)
2.22 - Type of treatment	Two applications of oil based insecticide, one of 3 ounces of Fenitrothion per acre on the overall area, followed by a 2 ounces per acre application of Fenitrothion on 1.7 million acres and a 3/4 ounce per acre application of Matacil on 0.3 million acres
2.23 - Operator	Christler Flying Service
2.24 - Aircraft used	4 Constellations (L-749)
2.25 - Aircraft characteristics	
Payload	3,600 USG
Swath width	3,000 feet
Speed	230 MPH
2.26 - Guidance system	Decca
2.27 - Beginning of operations	May 13
2.28 - Insect development at beginning of operations	47% L 3

* L 3 : third larval instar

2.29 - End of operations	June 10
2.30 - Insect development at end of operations	L 4

2.3 - Casey sector

2.31 - Area sprayed	2.6 million acres (figure 1)
2.32 - Type of treatment	Two applications of oil based Fenitrothion, one of 3 ounces and another of 2 ounces per acre
2.33 - Operator	Aviation Specialties Inc.
2.34 - Aircraft used	4 Super Constellations (L-1049) 1 Constellation (L-749)
2.35 - Aircraft characteristics (L-1049)	
Payload	4,400 USG
Swath width	3,000 feet
Speed	230 MPH
2.36 - Guidance system	Decca
2.37 - Beginning of operations	May 20
2.38 - Insect development at beginning of operations	11% L 3
2.39 - End of operations	June 12
2.40 - Insect development at	L 4 et L 5

REMARK: We regret the crash of an L-1049 aircraft shortly after take-off on the morning of June 9. All three crew members lost their lives.

2.4 - Riviere-du-Loup sector

2.41 - Area sprayed	1.1 million acres (figure 2)
2.42 - Type of treatment	Two applications of 2 ounces per acre of water based Phosphamidon

2.43 - Operators	Aerial Service, Quebec Department of Transport (CL-215) Conair Aviation Ltd. (TBM Avenger)
2.44 - Aircraft used	2 CL-215 3 TBM Avengers
2.45 - Aircract characteristics	
2.451 - CL-215	
Payload	1,368 USG
Swath width	1,000 feet
Speed	150 MPH
2.452 - TBM Avenger	
Payload	806 USG
Swath width	880 feet
Speed	170 MPH
2.46 - Guidance system	
2.461 - CL-215	Litton LTN-51
2.462 - TBM Avenger	Visual
2.47 - Beginning of operations	May 30
2.48 - Insect development at beginning of operations	8% L 3
2.49 - End of operations	June 22
2.50 - Insect development at end of operations	L 5 and L 6

2.5 - <u>Bonaventure sector</u>

2.51 - Area aprayed	1.1 million acres (figure 2)
2.52 - Type of treatment	Two applications of 2 ounces per acre of water based Phorphamidon, except on 130,000 acres where only one application was made
2.53 - Operator	Aviation Specialties Inc.
2.54 - Aircraft used	4 PV-2

2.55 - Aircraft characteristics	
Payload	1,200 USG
Swath width	1,000 feet
Speed	170 MPH
2.56 - Guidance system	Decca
2.57 - Beginning of operations	June 1
2.58 - Insect development at beginning of operations	2% L 3
2.59 - End of operations	June 30
2.60 - Insect development at end of operations	L 6 and 10% pupa

3 - RESULTS OF THE SPRAYING OPERATIONS

The efficiency of the spraying was estimated from sample plots, composed of five co-cominant trees each and distributed throughout the treated area.

3.1 - Reduction of population

The original population of the insect, in the 455 sample plots established in Quebec, averaged 19.7 specimens per 18 inch branch and was reduced by 82.5 per cent to an average of 3.5 individuals after the treatment. Table 1 indicates the pertinent data for each sector.

3.2 - Protection of the foliage

Although the residual population of the insect amounted to 3.5 specimens per 18 inch branch, the foliage protected, in the 428 sample plots treated, amounted to an average of 63 per cent and varied from 52 to 76 per cent (table 1).

3.3 - Egg masses in the treated area

The egg masses, in the 267 sample plots treated in the Western part of the Province, amounted to 613 per hundred square feet of foliage, that is to say a slightly higher level than in 1972 (table 1). On the other hand, the egg masses in the two Eastern sectors amounted to only 74 per hundred square feet of foliage, that is to say a reduction of 61 per cent compared to 1972 (table 1).

3.4 - Effects of the operations on the environment

The Quebec Department of Lands and Forests did not systematically monitor the effects of the spraying operations on the environment. A biologist did, however, verify on the ground 19 complaints of damage supposedly caused to animal life by the insecticide.

As a result of the inquiries and analyses, there were only two cases in Western Quebec where damage to birds could be attributed to the insecticide. The particular locations, however, had been sprayed two or three times due to the defective aircraft guidance system. In other words, the concentration of the insecticide was doubled or tripled.

4 - THE 1973 DEFOLIATION OUTSIDE THE TREATED AREA

The aerial survey of some 150,000 square miles of woodland indicated that the Spruce Budworm had damaged an area of 15.8 million acres outside the 1973 treated area. The trees are dead on an area of 325,000 acres; the current year's defoliation is severe on 8.1 million acres, moderate on 4.0 million acres and light on 3.4 million acres (figures 3 and 4).

5 - EGG MASSES OUTSIDE THE 1973 TREATED AREA

In addition to the 445 sample plots established in the 1973 treated area, a total of 988 other sample plots (figures 5 and 6) were visited. In Western Quebec, the egg masses amounted to 520 per hundred square feet of foliage, that is to say 60 per cent higher than 1972. The egg population in 284 sample plots in Eastern Quebec is relatively low, since it only amounted to an average of 38 egg masses per hundred square feet of foliage, but the insect seems to be establishing itself in the Matapedia Valley.

6 - SPRAYING OPERATIONS PLANNED FOR 1974

In the light of the aerial and ground surveys, we presently anticipate the Spruce Budworm spray of some 12 million acres. This area would include in Western Quebec some 6 million acres already treated in 1973 and close to 5.7 million acres severely affected in 1973. Approximately 300,000 acres would also have to be sprayed in the Rivière-du-Loup sector to prevent tree mortality.

7 - PLANS FOR ENVIRONMENTAL CONTROL

The Quebec Department of Lands and Forests plans to form an interdepartmental committee to study the effects of aerial insecticide spraying on the fauna, the flora and the environment in general.

This committee would be composed of representatives of the provincial and federal agencies interested in ecological repercussions of spraying activity. The committee will be requested to examine the effects of the aerial spraying on the environment and propose a monitoring program for next year.

Table 1

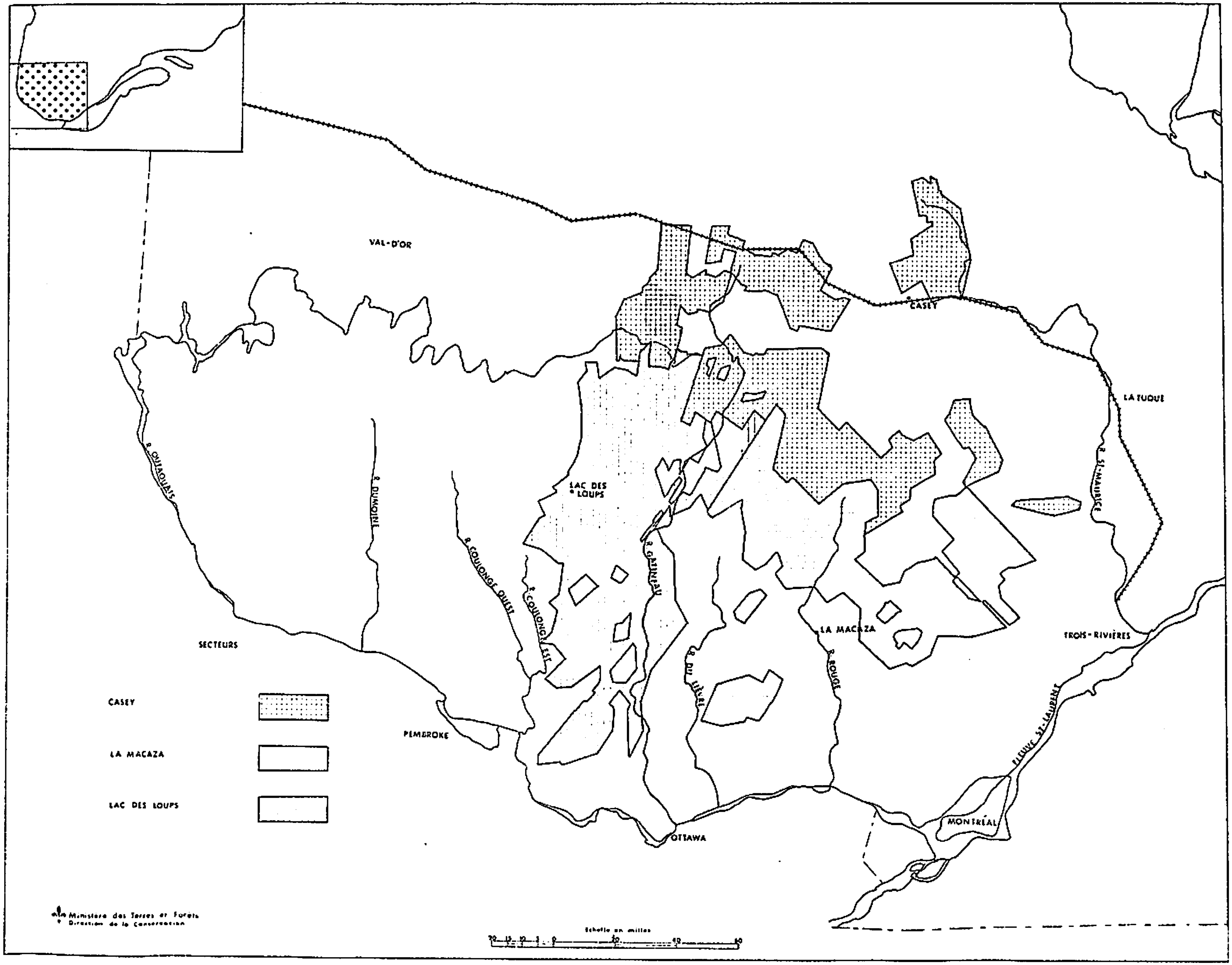
SUMMARY OF THE SPRUCE BUDWORM SPRAYING

IN QUEBEC IN 1973
(number of sample plots in parentheses)

Sector	Area (acres)	Population/18" branch		Mortality	Protected foliage	Egg masses per 100 square feet of foliage	
		Pre-spraying	Post-spraying			1973	1973/1972
Lac des Loups	2,700,000	16.5	4.2	74.0%(98)	68%(119)	512(119)	1.28
La Macaza	(300,000	44.1	3.3	92.5%(6)*	52%(68)	548(75)	1.03
	(1,800,000	31.2	3.1	90.0%(82)			
Casey	2,600,000	27.6	3.3	88.1%(100)	50%(73)	846(73)	0.88
Western Quebec		25.2	3.5	85.7(286)	59%(260)	613(267)	1.125
Rivière du Loup	1,100,000	7.3	2.0	71.3%(94)	76%(95)	73(97)	0.46
Bonaventure	(130,000	14.0	5.5	61.1%(22)#	54%(24)	75(81)	0.28
	(970,000	16.0	4.6	71.3%(53)	65%(59)		
Eastern Quebec		10.9	3.3	69.7%(169)	69%(178)	74(178)	0.39

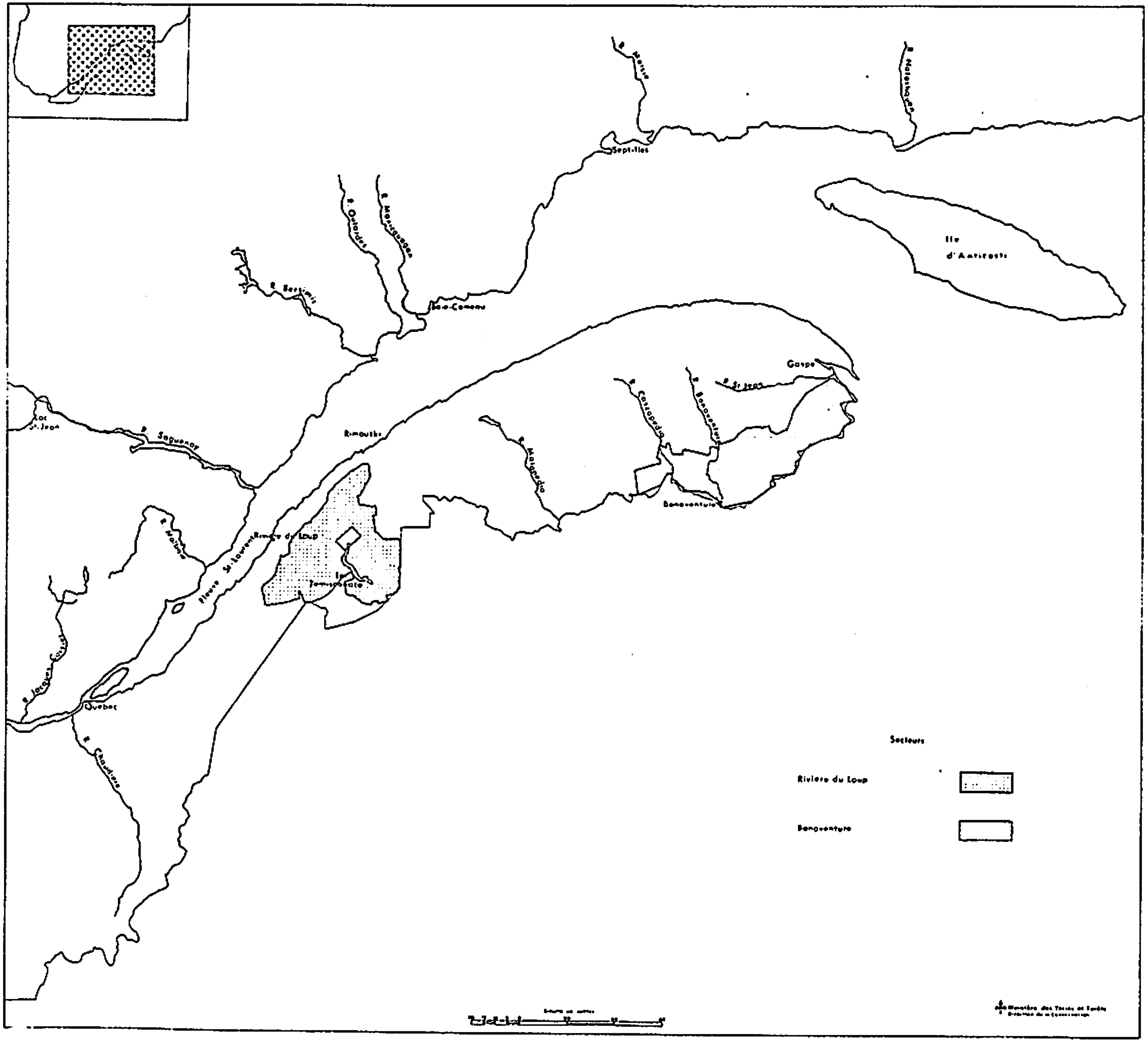
* Six sample plots were treated with Matacil in the second application

\# Twenty-two sample plots only received one application



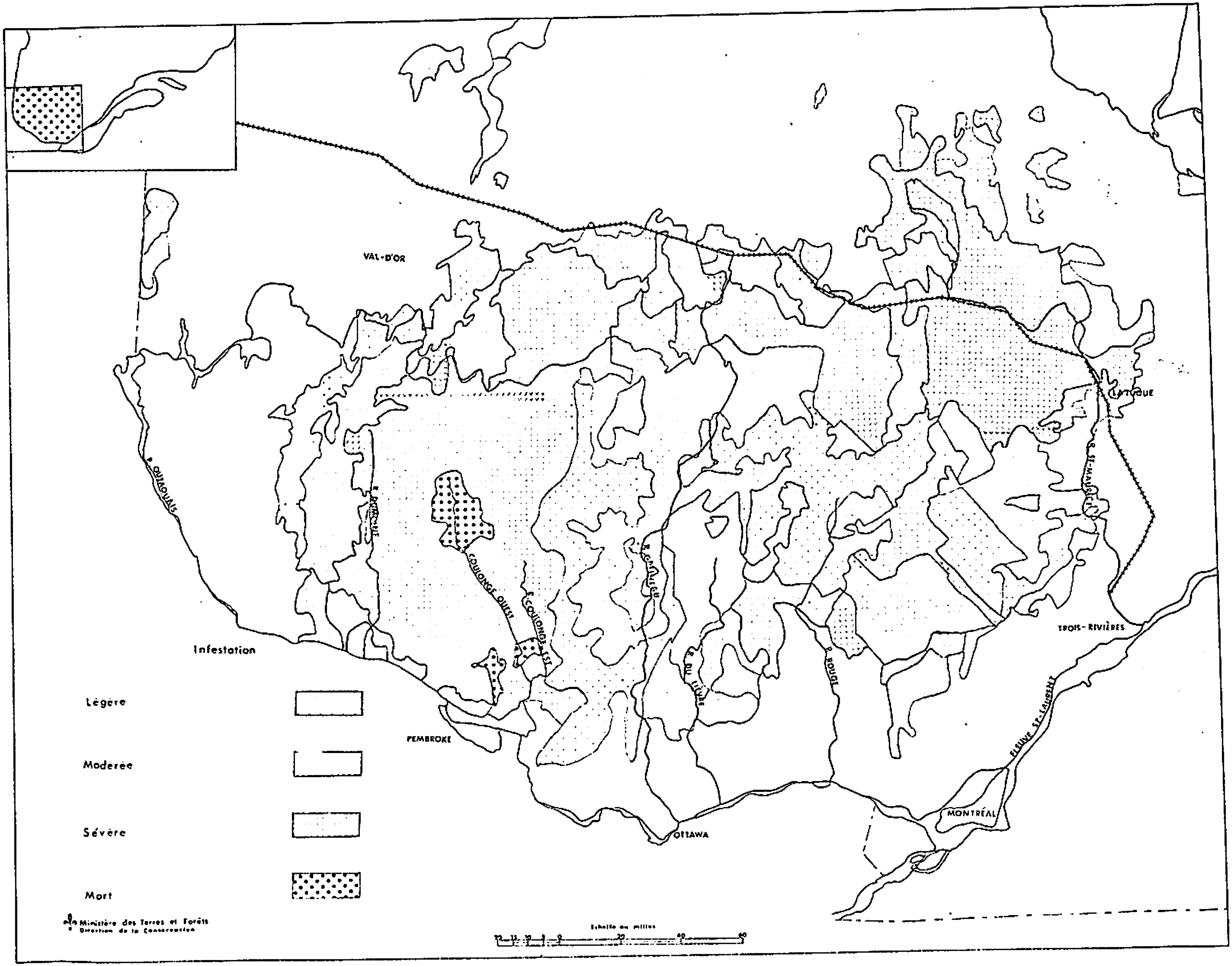
AIRES TRAITÉES CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'OUEST DU QUÉBEC EN 1973

figure 1



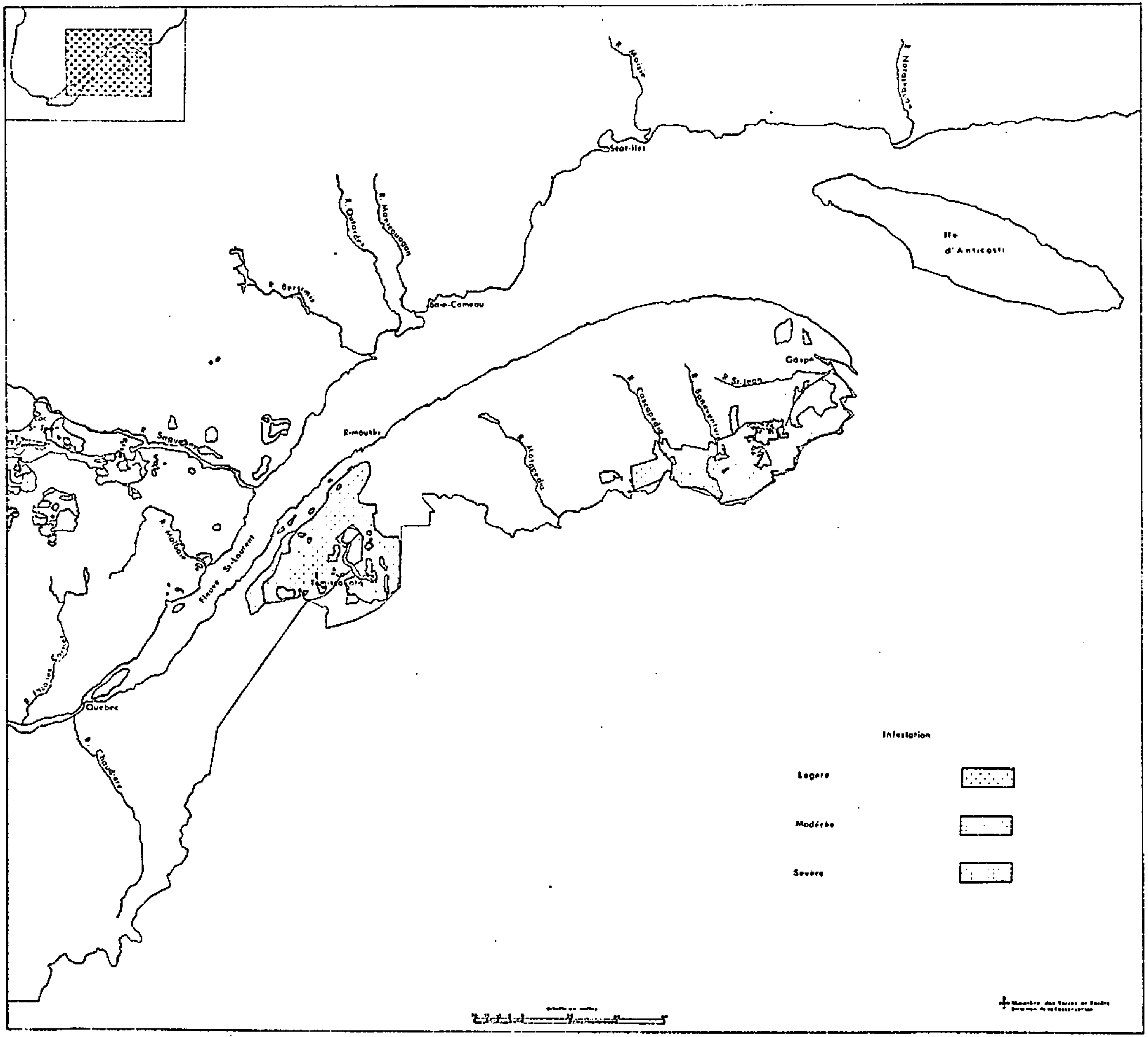
AIRES TRAITÉES CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'EST DU QUÉBEC EN 1973

figure 2



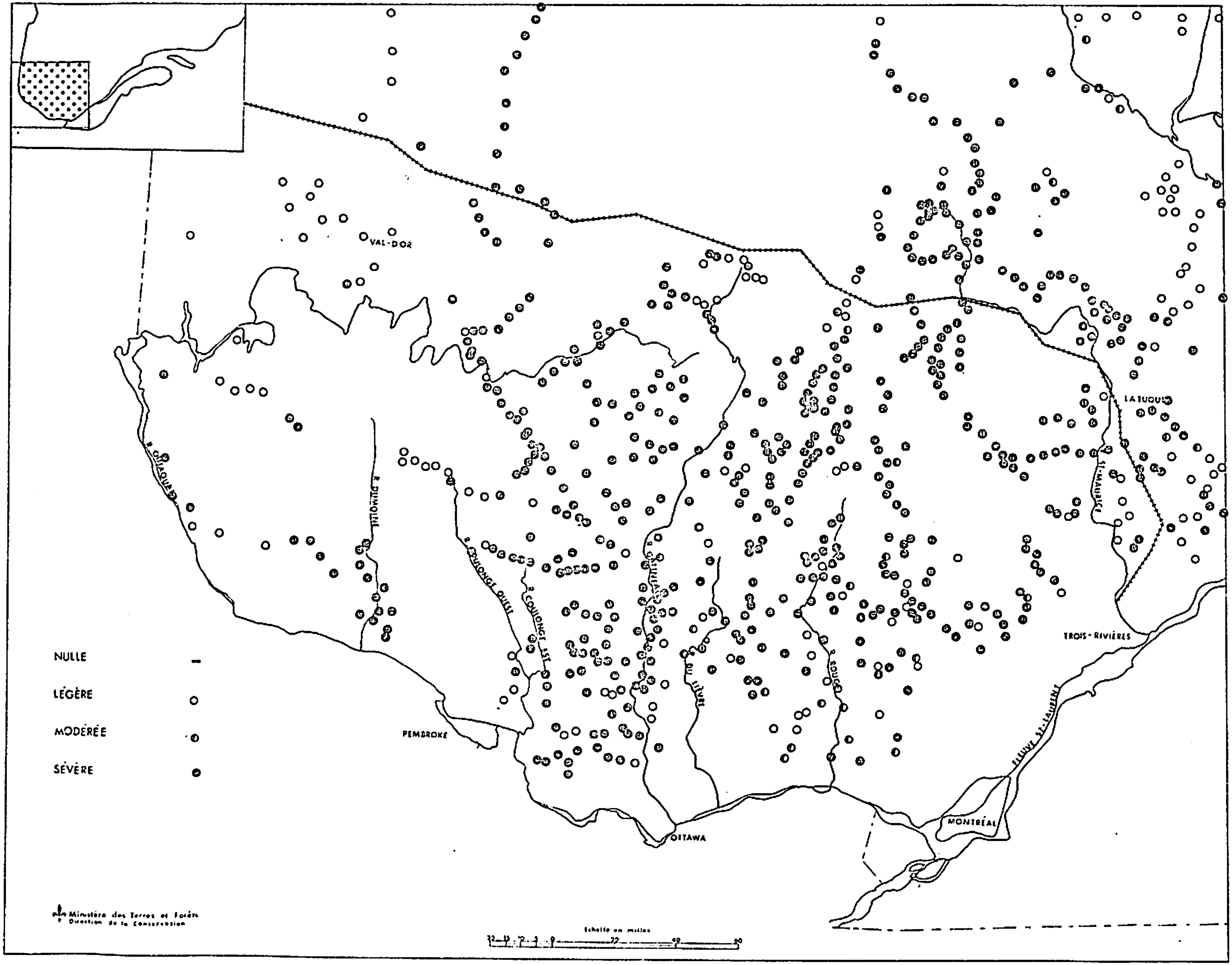
AIRES D'INFESTATION DE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'OUEST DU QUÉBEC EN 1973

figure 3



AIRES D'INFESTATION DE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'EST DU QUÉBEC EN 1973

figure 4



POPULATION DES OEUFS DE LA TORDEUSE DES BOURGEONS DE L'EPINETTE DANS L'OUEST DU QUEBEC EN 1973

figure 5

POPULATION DES OEUFS DE LA TORDEUSE DES BOURGEONS DE L'EPINETTE DANS L'EST DU QUÉBEC EN 1973

figure 6

ARROSAGES AÉRIENS
CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE
AU QUÉBEC EN 1973 ET PRÉVISIONS POUR 1974

par

Réal Desaulniers, ing.f.

Ministère des Terres et Forêts
Direction de la Conservation
Service d'Entomologie et de Pathologie

Rapport présenté au forum annuel
sur la répression des agents nuisibles de la forêt
tenu à Hull le 14 novembre 1973

ARROSAGES AÉRIENS

CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE

AU QUÉBEC EN 1973 ET PRÉVISIONS POUR 1974

INTRODUCTION

Une invasion de la tordeuse des bourgeons de l'épinette a été détectée au Québec en 1967. Depuis 1970, le ministère des Terres et Forêts du Québec en collaboration avec les concessionnaires intéressés et le centre de Recherche forestière des Laurentides du ministère fédéral de l'Environnement a élaboré des projets de répression qui se sont intensifiés en 1973 en raison de la progression rapide de cette épidémie.

1 - PROGRAMME DE 1973

Le programme d'arrosages aériens contre la tordeuse des bourgeons de l'épinette réalisé au Québec en 1973 couvrait une superficie globale de 9.7 millions d'acres répartie en cinq secteurs d'après les bases d'opération.

Dans l'ouest du Québec et dans le secteur de Rivière-du-Loup, la répression avait pour but de prévenir la mortalité des arbres et la perte de croissance des peuplements. Dans le secteur de Bonaventure, en Gaspésie, l'objectif était d'enrayer un début d'épidémie ou du moins d'en retarder la progression.

2 - OPÉRATIONS D'ARROSAGE

2.1 - <u>Secteur du Lac des Loups</u>

2.11 - Superficie traitée	2.7 millions d'acres (figure 1)
2.12 - Mode de traitement	Deux applications de Fénitrothion à base d'huile, l'une de 3 onces et l'autre de 2 onces l'acre
2.13 - Opérateur	Conair Aviation Ltd.
2.14 - Avions utilisés	4 appareils DC-6B

2.15 - Caractéristiques des avions	
Charge payante	3,600 USG
Largeur d'application	3,000 pieds
Vitesse	230 MPH
2.16 - Système de guidate	Decca
2.17 - Début des opérations	14 mai
2.18 - Développement de l'insecte au début des opérations	15% L 3*
2.19 - Fin des opérations	8 juin
2.20 - Développement de l'insecte à la fin des opérations	L 4

2.2 - <u>Secteur de La Macaza</u>

2.21 - Superficie traitée	2.1 millions d'acres (figure 1)
2.22 - Mode de traitement	Deux applications d'insecticide à base d'huile, une première de 3 onces de Fénitrothion l'acre sur tout le territoire, suivie d'une application de 2 onces de Fénitrothion l'acre sur 1.8 millions d'acres et 0.75 once de Matacil l'acre sur 0.3 millions d'acres
2.23 - Opérateur	Christler Flying Service
2.24 - Avions utilisés	4 appareils Constellation (L-749)
2.25 - Caractéristiques des avions	
Charge payante	3,600 USG
Largeur d'application	3,000 pieds
Vitesse	230 MPH
2.26 - Système de guidage	Decca

---

* L 3 : troisième âge larvaire

2.27 - Début des opérations	13 mai
2.28 - Développement de l'insecte au début des opérations	47% L 3
2.29 - Fin des opérations	10 juin
2.30 - Développement de l'insecte à la fin des opérations	L 4

2.3 - Secteur de Casey

2.31 - Superficie traitée	2.6 millions d'acres (figure 1)
2.32 - Mode de traitement	Deux applications de Fénitrothion à base d'huile, l'une de 3 onces et l'autre de 2 onces l'acre
2.33 - Opérateurs	Aviation Specialties Inc.
2.34 - Avions utilisés	4 appareils Super Constellation (L-1049) 1 appareil Constellation (L-749)
2.35 - Caractéristiques des avions (L-1049)	
Charge payante	4,400 USG
Largeur d'application	3,000 pieds
Vitesse	230 MPH
2.36 - Système de guidage	Decca
2.37 - Début des opérations	20 mai
2.38 - Développement de l'insecte au début des opérations	11% L 3
2.39 - Fin des opérations	12 juin
2.40 - Développement de l'insecte à la fin des opérations	L 4 et L 5

Remarque: Nous avons à déplorer l'écrasement d'un appareil L-1049 aussitôt après son décollage le matin du 9 juin, qui a entraîné la mort des trois membres d'équipage.

2.4 - Secteur de Rivière-du-Loup

2.41 - Superficie traitée	1.1 million d'acres (figure 2)
2.42 - Mode de traitement	Deux applications de 2 onces l'acre de Phosphamidon en solution dans l'eau
2.43 - Opérateurs	Service aérien, ministère des Transports du Québec (CL-215) Conair Aviation Ltd. (TBM Avenger)
2.44 - Avions utilisés	2 appareils CL-215 3 appareils TBM Avenger
2.45 - Caractéristiques des avions	
2.451 - CL-215	
Charge payante	1,368 USG
Largeur d'application	1,000 pieds
Vitesse	150 MPH
2.452 - TBM Avenger	
Charge payante	806 USG
Largeur d'application	880 pieds
Vitesse	170 MPH
2.46 - Système de guidage	
2.461 - CL-215	Litton LTN-51
2.462 - TBM Avenger	Visuel
2.47 - Début des opérations	30 mai
2.48 - Développement de l'insecte au début des opérations	8% L 3
2.49 - Fin des opérations	22 juin
2.50 - Développement de l'insecte à la fin des opérations	L 5 et L 6

2.5 - Secteur de Bonaventure

2.51 - Superficie traitée	1.1 million d'acres (figure 2)
2.52 - Mode de traitement	Deux applications de 2 onces l'acre de Phosphamidon en solution dans l'eau, sauf sur 130,000 acres où il n'y eut qu'une seule application
2.53 - Opérateur	Aviation Specialties Inc.
2.54 - Avions utilisés	4 appareils PV-2
2.55 - Caractéristiques des avions	
Charge payante	1,200 USG
Largeur d'application	1,000 pieds
Vitesse	170 MPH
2.56 - Système de guidage	Decca
2.57 - Début des opérations	1 juin
2.58 - Développement de l'insecte au début des opérations	2% L 3
2.59 - Fin des opérations	30 juin
2.60 - Développement de l'insecte à la fin des opérations	L 6 et 10% chrysalide

3 - RÉSULTATS DES OPÉRATIONS D'ARROSAGE

L'efficacité des arrosages a été estimée à partir de places d'étude, constituées chacune de cinq arbres co-dominants et distribuées sur tout le territoire traité.

3.1 - Réduction des populations

La population originale de l'insecte, dans les 455 places d'étude établies au Québec, s'élevait à une moyenne de 19.7 spécimens par branche de 18 pouces et elle a diminué de 82.5 pour cent pour s'établir à 3.5 individus après le traitement. Le tableau 1 montre les données pertinentes à chacun des secteurs.

3.2 - Protection du feuillage

Bien que la population résiduelle de l'insecte s'élève à 3.5 spécimens par branche de 18 pouces, le feuillage protégé, dans 438 places d'étude traitées, s'élève à 63 pour cent variant de 52 à 76 pour cent (tableau 1).

3.3 - Population des oeufs dans les aires traitées

La population des oeufs, dans 267 places d'étude traitées dans l'ouest de la Province, s'élève à 613 masses d'oeufs par cent pieds carrés de feuillage, soit un niveau légèrement supérieur à celui de 1972 (tableau 1). D'autre part, la population des oeufs dans les deux secteurs de l'est ne s'élève qu'à 74 masses d'oeufs par cent pieds carrés de feuillage, soit une réduction de 61 pour cent par rapport à la population de 1972 (tableau 1).

3.4 - Effets des opérations sur l'environnement

Le ministère des Terres et Forêts du Québec n'a pas conduit d'inventaires systématiques afin d'évaluer les effets des opérations sur l'environnement. Un biologiste a toutefois vérifié sur place 19 plaintes à l'effet que des dommages avaient été causés à la faune par les insecticides.

A la suite d'enquêtes et d'analyses, deux cas de dommages causés à des oiseaux dans l'ouest du Québec étaient attribuables au Fénitrothion. Chaque endroit a toutefois été survolé à deux ou trois reprises lorsque le système de guidage a été défectueux, ce qui a doublé ou triplé la concentration de l'insecticide.

4 - DÉFOLIATION CAUSÉE EN 1973 A L'EXTÉRIEUR DES AIRES TRAITÉES

L'inventaire aérien d'environ 150,000 milles carrés de forêts a permis d'enregistrer des dommages causés par la tordeuse des bourgeons de l'épinette sur une superficie de 15.8 millions d'acres à l'extérieur des aires traitées en 1973. Les arbres sont morts sur 325,000 acres; la défoliation de l'année courante est sévère sur 8.1 millions d'acres, modérée sur 4.0 millions d'acres et légère sur 3.4 millions d'acres (figures 3 et 4).

5 - POPULATION DES OEUFS A L'EXTÉRIEUR DES AIRES TRAITÉES EN 1973

En plus des 445 places d'étude établies dans les aires traitées en 1973, un total de 988 autres places d'étude (figures 5 et 6) ont été visitées. Dans l'ouest du Québec, la population s'élève à 520 masses d'oeufs par cent pieds carrés de feuillage, soit une population 60 pour cent supérieure à celle de 1972. La population dans 284 places d'étude de l'est du Québec est relativement faible, ne s'élevant qu'à une moyenne de 38 masses d'oeufs par cent pieds carrés de feuillage, mais l'insecte semble vouloir s'établir dans la vallée de la Matapédia.

6 - OPÉRATIONS D'ARROSAGE PRÉVUES POUR 1974

A la lumière des informations provenant des inventaires aériens et terrestres, nous prévoyons actuellement que le programme d'arrosage contre la tordeuse des bourgeons de l'épinette pourrait s'étendre à environ 12 millions d'acres. Cette superficie comprendrait dans l'ouest du Québec quelque 6 millions d'acres déjà traitées en 1973 et près de 5.7 millions d'acres sévèrement affectées en 1973. De plus, un territoire d'environ 300,000 acres dans le secteur de Rivière-du-Loup aurait besoin d'un traitement, afin de prévenir la mortalité des arbres.

7 - CONTRÔLE PROJETÉ DE L'ENVIRONNEMENT

Le ministère des Terres et Forêts du Québec envisage de constituer un comité interministériel chargé d'étudier les effets des pulvérisations aériennes d'insecticide sur la faune, la flore et l'environnement en général.

Feraient partie de ce comité des représentants des ministères tant provinciaux que fédéraux qui sont intéressés aux répercussions écologiques de ces travaux d'arrosage. Ce comité aurait pour mandat principal d'examiner les effets de ces pulvérisations sur l'environnement et d'élaborer à cette fin un système de contrôle biologique du programme projeté pour l'an prochain.

Tableau 1

RÉSULTATS SOMMAIRES DES ARROSAGES CONTRE

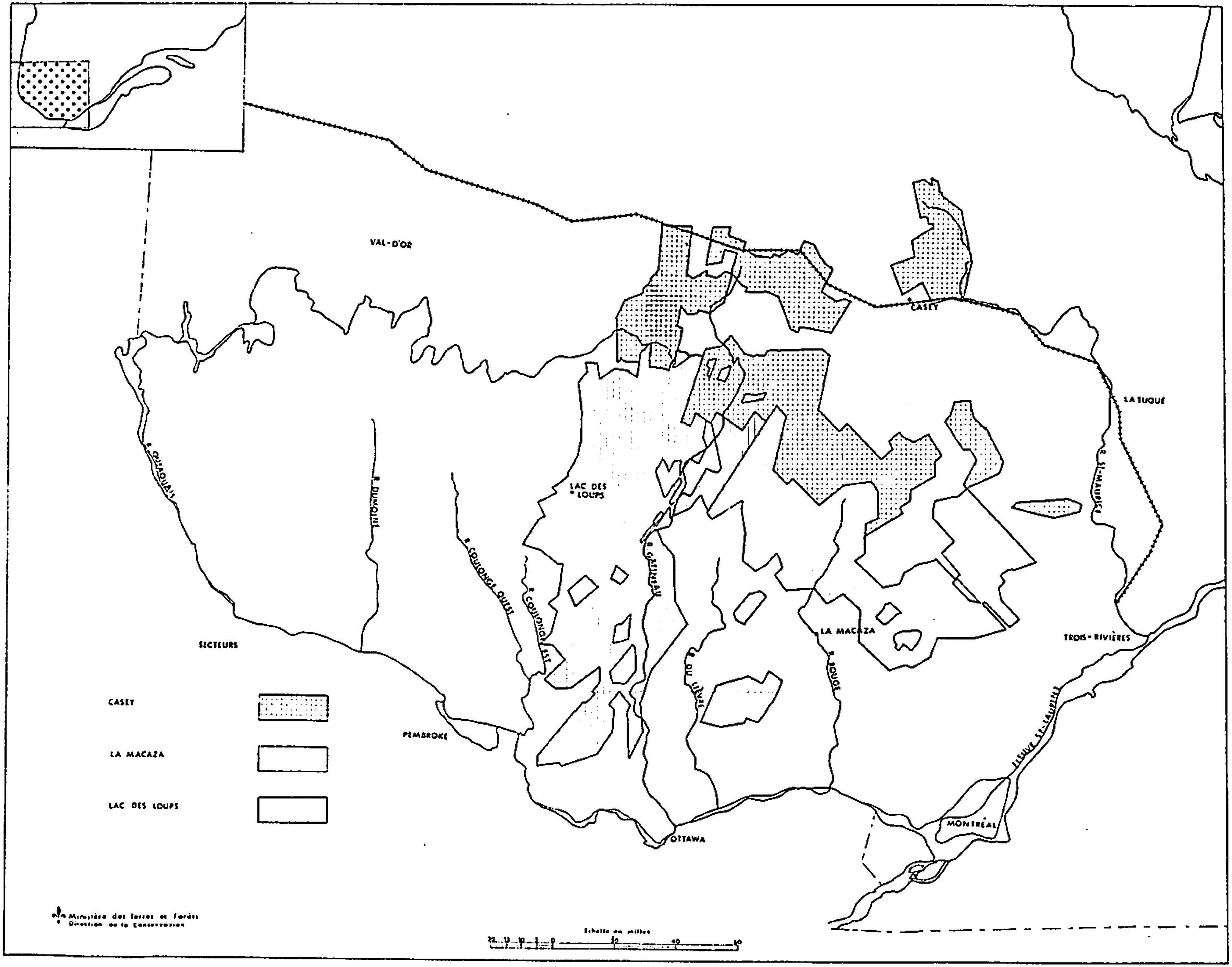
CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE AU QUÉBEC EN 1973

(nombre de places d'études entre parenthèses)

Secteur	Superficie (acres)	Population/branche de 18" pré-arrosage	Population/branche de 18" post-arrosage	Mortalité	Feuillage protégé	Masses d'oeufs/100 pieds carrés de feuillage 1973	Masses d'oeufs/100 pieds carrés de feuillage 1973/1972
Lac des Loups	2,700,000	16.5	4.2	74.0%(98)	68%(119)	512(119)	1.28
La Macaza	(300,000	44.1	3.3	92.5%(6)*	52%(68)	548(75)	1.03
	(1,800,000	31.2	3.1	90.0%(82)			
Casey	2,600,000	27.6	3.3	88.1%(100)	50%(73)	846(73)	0.88
Ouest du Québec		25.2	3.5	85.7%(286)	59%(260)	613(267)	1.125
Rivière du Loup	1,100,000	7.3	2.0	71.3%(94)	76%(95)	73(97)	0.46
Bonaventure	(130,000	14.0	5.5	61.1%(22)#	54%(24)	75(81)	0.28
	(970,000	16.0	4.6	71.3%(53)	65%(59)		
Est du Québec		10.9	3.3	69.7%(169)	69%(178)	74(178)	0.39

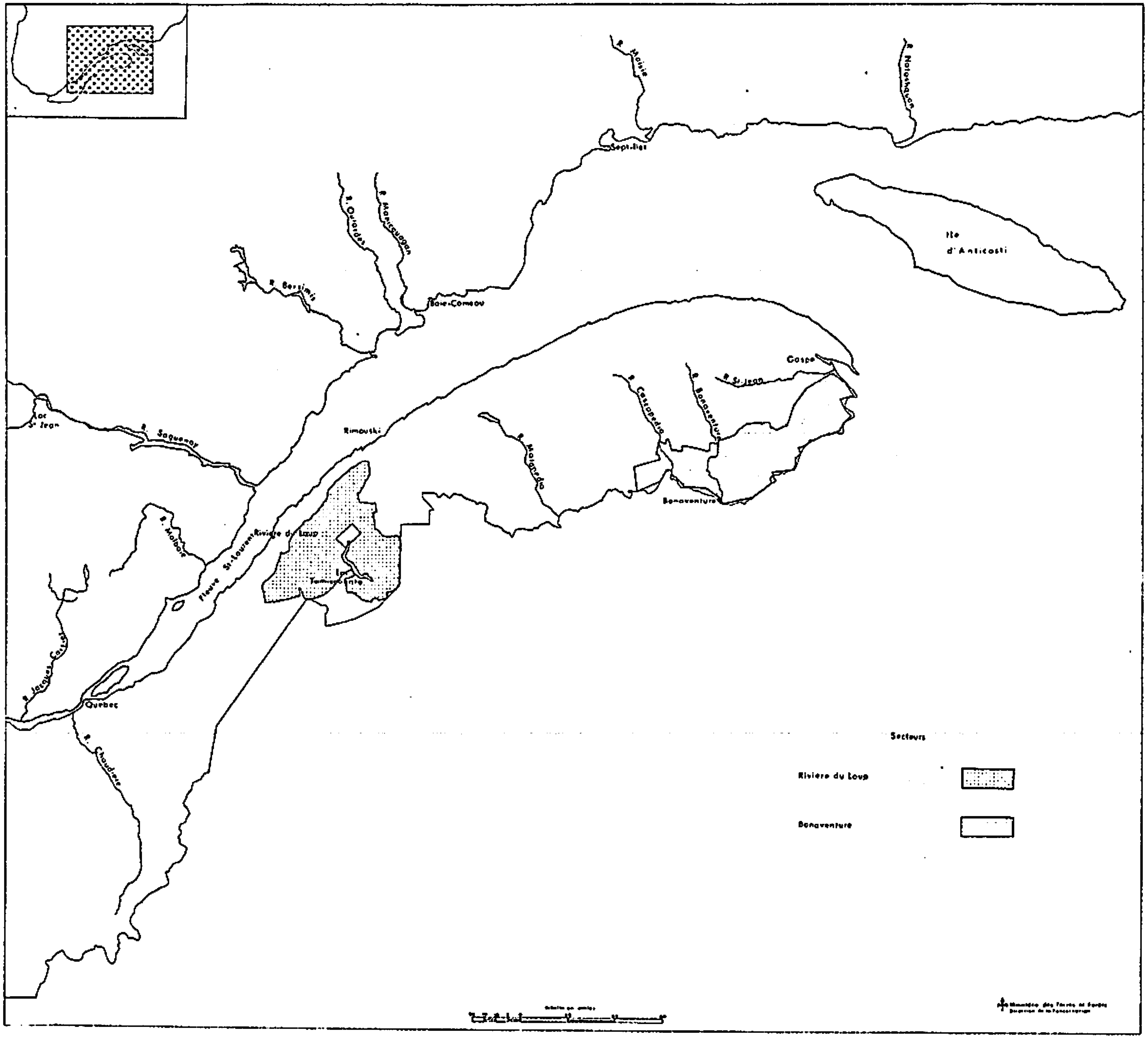
* Ces six places d'études ont été traitées au Matacil lors de la deuxième application

Ces vingt-deux places d'études n'ont reçu qu'une seule application



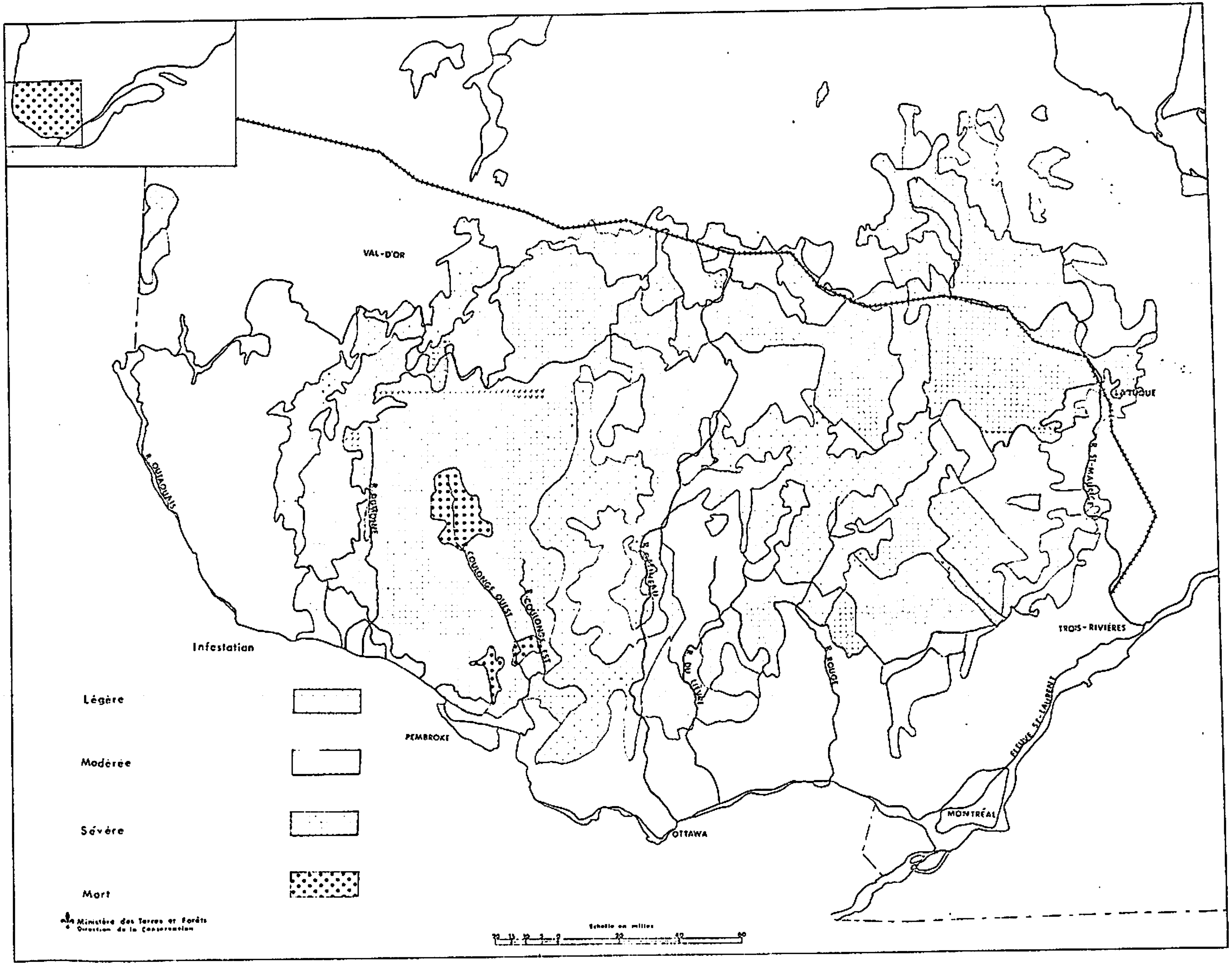
AIRES TRAITÉES CONTRE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'OUEST DU QUÉBEC EN 1973

figure 1



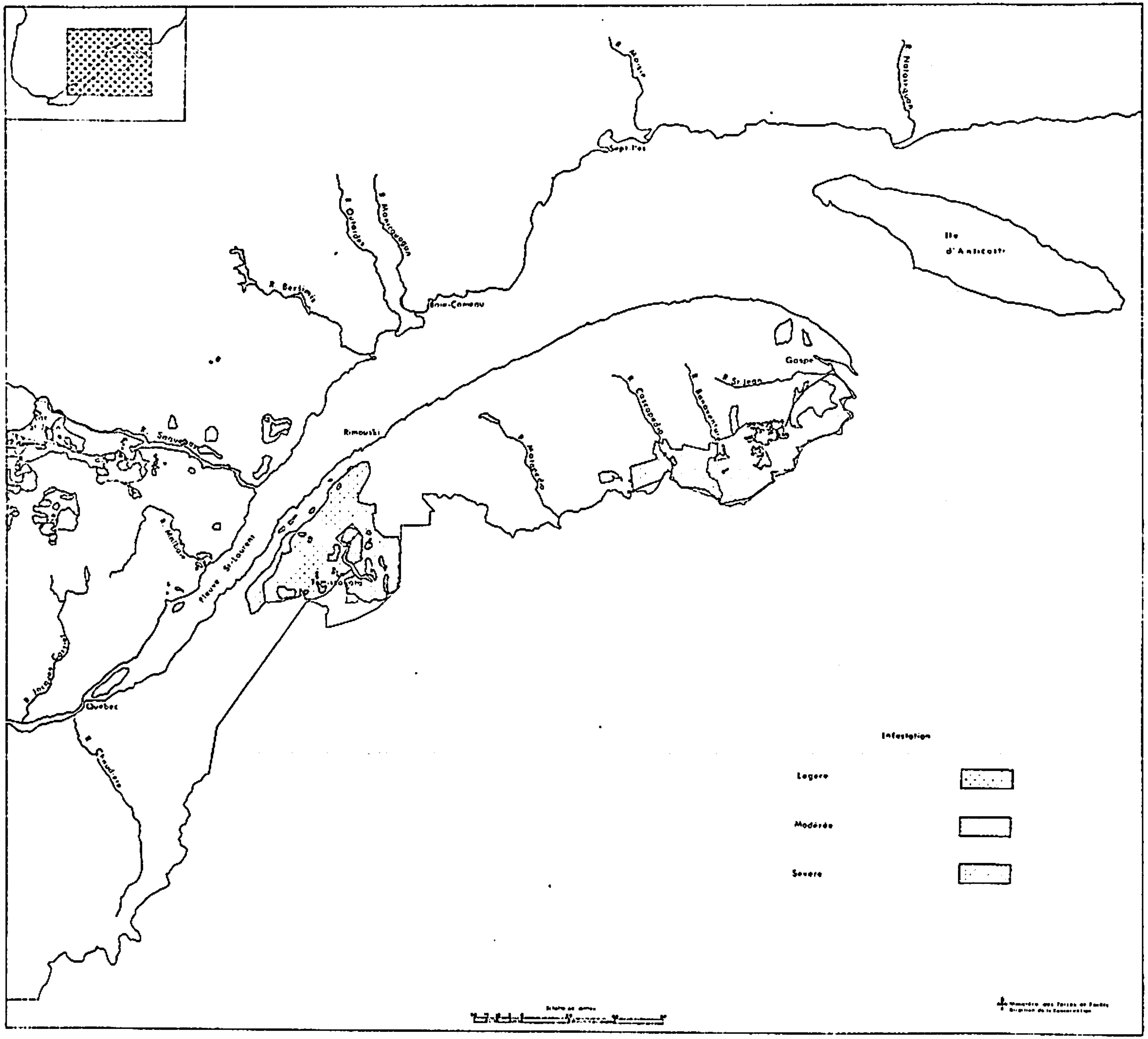
AIRES TRAITEES CONTRE LA TORDEUSE DES BOURGEONS DE L'EPINETTE DANS L'EST DU QUEBEC EN 1973

figure 2



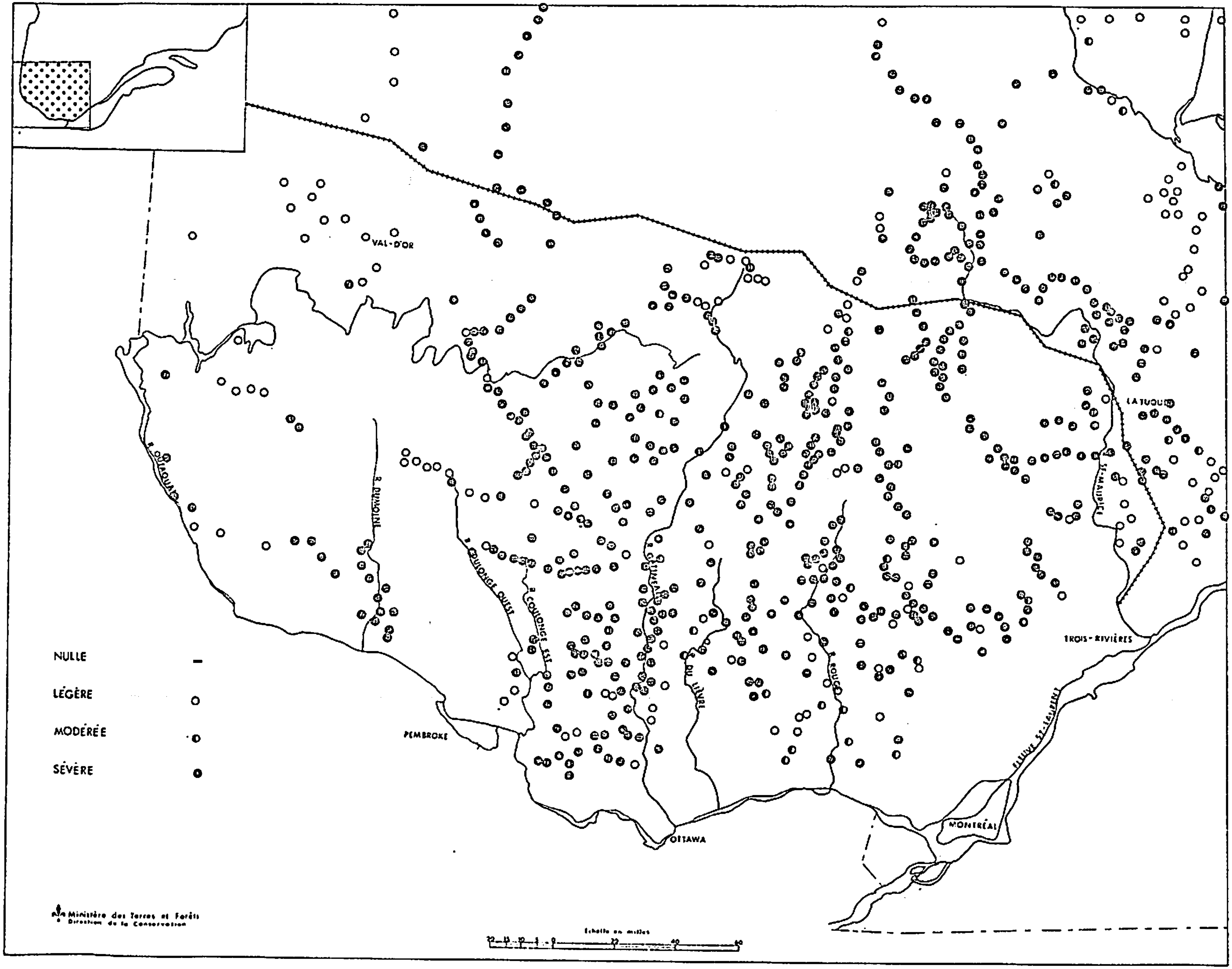
AIRES D'INFESTATION DE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'OUEST DU QUÉBEC EN 1973

figure 3



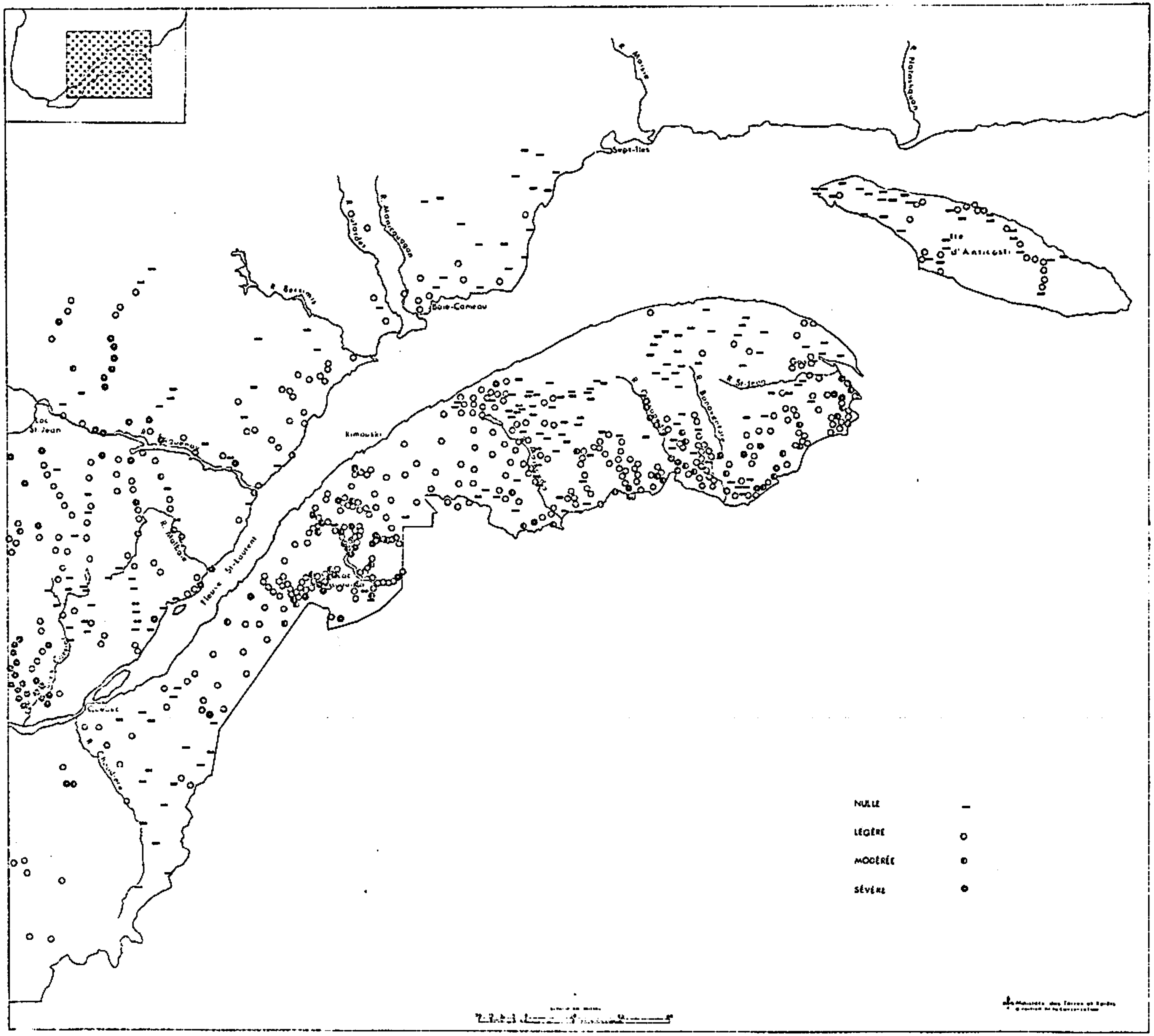
AIRES D'INFESTATION DE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'EST DU QUÉBEC EN 1973

figure 4



POPULATION DES OEUFS DE LA TORDEUSE DES BOURGEONS DE L'EPINETTE DANS L'OUEST DU QUEBEC EN 1973

figure 5



POPULATION DES OEUFS DE LA TORDEUSE DES BOURGEONS DE L'ÉPINETTE DANS L'EST DU QUÉBEC EN 1973

figure 6

APPENDIX 7

NOT FOR PUBLICATION

SUMMARY REPORT OF STUDIES ON THE IMPACT OF INSECTICIDES ON FOREST ECO-SYSTEMS

(Study Ref. No. CC-3-014)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

C.H. BUCKNER, B.B. McLEOD, and P. KINGSBURY

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario.

October, 1973

Report to the Annual Forest Pest Forum

of the Ecological Effects Team

by

C.H. Buckner, B.B. McLeod, and P. Kingsbury

The ecological effects team monitored operational treatments of insecticides in New Brunswick, Quebec, Ontario, Manitoba and British Columbia during the 1973 season. Extent of environmental monitoring and type of pesticide varied (Table I).

Table I

Monitoring operations of the ecological effects team

Area	Insecticide	Birds	Mammals	Bees	Aquatics
N. B.	Fenitrothion	X	X		
	Phosphamidon	X	X		
Quebec	Fenitrothion	X			X
	Matacil	X	X	X	
Ontario	Methoxychlor		X		
	Gardona		X		
Manitoba	Fenitrothion	X	X		
	Sevin	X	X		
	B. thuringiensis	X	X		
B. C.	Fenitrothion	X	X		

In addition, intensive studies provided intensive information on specified experimental areas (Table II).

Table II

Experimental investigations of the ecological effects team

Area	Insecticide	Birds	Mammals	Bees	Aquatics
LaRose Forest	Fenitrothion	X	X	X	X
Algonquin Park	Dipel	X	X	X	
	Dipel + Chitinase	X	X	X	
	Thuricide	X	X	X	X
	Thuricide + Chitinase	X	X	X	
Anticosti Island	Juvenile Hormone Analogue	X	X		X

Additional special studies were conducted on emergency situations involving accidents and insecticides.

Monitoring Control Operations

Monitoring in New Brunswick consisted of observations on the breeding bird and mammal populations in areas treated with fenitrothion for control of larval spruce budworm populations. The results were consistent with those of long term: no affect could be attributed to the treatment. Similar studies in an area treated with phosphamidon as an adulticide for spruce budworm suggested slight bird mortality. There is strong evidence however that this area had been treated repeatedly with a variety of insecticides and the residual bird populations were likely in a weakened condition by the time phosphamidon was applied.

In Quebec, an area previously treated with fenitrothion and then retreated with Matacil was monitored for side effects to breeding birds, small mammals and colonies of honey bees. The warbler group as a whole were slightly reduced in numbers as were evening Grosbeaks and Ruby-crowned kinglets. The small mammal complex was healthy and apparently suffered no adverse side-effects.

Colonies of honey bees suffered immediate knock-down and adult mortality continued for several more days. Pollen production picked up and there was no damage to brood. Mortality to the adult bee population was estimated at less than 10%.

In Ontario early spring applications of Methoxychlor and Gardona to weevil infested pine plantations were monitored for adverse side effects to the small mammal complex.

Methoxychlor was applied at the rates of 2.5 lbs (in 2 gals of fuel oil) per acre and 2.5 lb in 4 gals of fuel oil/acre, 2.5 lbs in 2 gals of water/acre and 2.5 lbs in 4 gals of water/acre. Gardona was used at the rates of 1 lb in 2 gals of water and 2 lbs in 2 gals of water/acre.

Animals taken from these plots were healthy and showed no interruption in breeding throughout the spring and early summer. Under the conditions of application (report by Dr. DeBoo) there was no adverse effect upon the small mammal populations of the area.

In Manitoba, bird and mammal populations were monitored on seven plots of three categories: 1) two plots were sprayed with Bacillus thuringiensis; 2) two plots were sprayed with Fenitrothion: 3) one plot was sprayed with Sevin. Two control plots were used. Preliminary analyses of data show no apparent effect of any of these insecticides on bird or mammal populations.

On the northern part of Vancouver Island fenitrothion (4 oz/acre active) was used to treat black headed budworm infested forests.

Mature and immature forests were selected for monitoring populations of birds and small mammals. There were no apparent changes in the population or ecology of either the avian or small mammal complex which could be attributed to the application of fenitrothion.

Experimental Studies

Studies on the impact of fenitrothion on the forest ecosystem continued in Larose Forest during 1973. The insecticide was applied to the two small plots established in previous years and to a new plot that was brought into the plan in 1973. The 2 mile square bee experimental plot was also treated at a time when the bees were actively foraging. No impact was observed on birds and mammals on any of the treatment areas, and the bees were not influenced significantly.

In Algonquin Park the effects of Dipel, Dipel and Chitinase, Thuricide, Thuricide and Chitinase, and Chitinase alone were studied relative to non-target terrestrial organisms. Thuricide was also examined in the aquatic environment. A slight reduction of non-target defoliating lepidoptera may have been attributable to *B. thuringiensis* treatment, but no other effects on the terrestrial system could be discovered. In the Thuricide treatment area aquatic bottom fauna populations showed no decrease in numbers after spraying except where similar decreases occurred in the control stream or where the changes were directly attributable to the emergence of adult aquatic insects. Visual surveys conducted after the spray by scuba divers revealed normal fish and bottom fauna populations. It is concluded that under the conditions of application there were no immediate adverse effects on the aquatic ecosystem attributable to this treatment.

In co-operation with Dr. A. Retnakaran of the Insect Pathology Research Institute and Dr. Luc Jobin of the Laurential Forest Research Station, bird and mammal populations were monitored in a series of Juvenile hormone analogue treatment plots on Anticosti Island, Quebec. Applications of 4oz, 2oz and 0.5 oz active ingredient per acre were monitored as well as a control. A stream in the treatment area was also sprayed and the aquatic fauna monitored for any adverse side effects.

No adverse effects upon the populations of small forest birds, small mammals or aquatic insect or fish fauna were recorded.

Special Investigations

Accidental bird mortality was reported from several isolated areas in western Quebec in association with applications of fenitrothion by means of large multiengined aircraft. Some bird mortality that could be attributed to the insecticide was identified in two of these cases and the cause was traced to overdose due to navigational errors. Reports on fish mortality attributable to fenitrothion poisoning proved unfounded.

Environmental contamination at the crash site of a Super Constelation near Casey Quebec proved to be very local in extent. Insecticide in the adjacent river was only slightly above background and was not considered hazardous. The incident points out the need for rapid decontamination capacity for operators of large pest control aircraft.

Spruce Budworm Aerial Spraying Operations
Ontario, 1973

by

G. M. Howse and W. L. Sippell
Canadian Forestry Service
Great Lakes Forest Research Centre, Sault Ste. Marie

and

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Introduction

In 1973, the Ministry of Natural Resources sprayed 88,300 acres against spruce budworm in Ontario. Four Stearman aircraft and one Agcat, contracted from General Airspray Ltd., St. Thomas, Ontario were employed to apply the sprays. Each aircraft was equipped with 4 micronair AU 3000 units for spray dispersal. Zectran was sprayed at a rate of 1.2 ounces in .15 gallons (U.S.) of spray mixture (Arotex) per acre.

The Canadian Forestry Service participated in planning the operation and took responsibility for timing the spray applications and assessing the results.

Northwestern Ontario

1973 Operations

As in previous years, the largest operation in the Province took place in northwestern Ontario, headquartered at Atikokan. A total of 77,300 acres were treated using 3 Stearman spray planes starting May 29 and finishing June 29. Budworm emergence occurred about mid-May. The sprayers were unable to operate for the first week of June due to poor weather.

Most of the spraying was done in Quetico Provincial Park where 69,000 acres lying between Poohbah Lake and the International Boundary, 1500 acres around Allan Lake and 4600 acres between Kawa Bay and Devine Creek were treated. Another 1500 acres at Northern Light Lake and 700 acres at Granite Lake, east of Quetico were also treated.

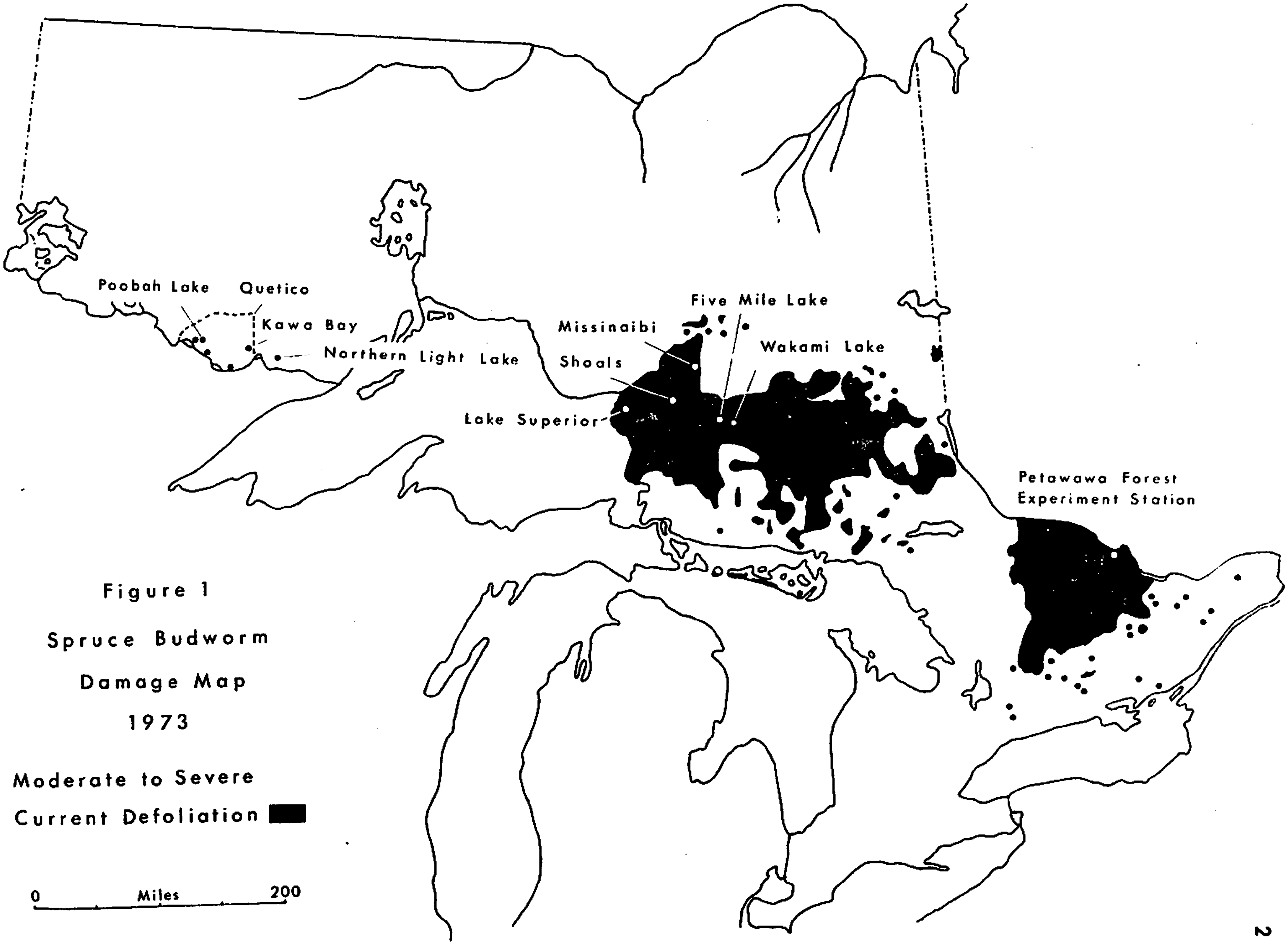


Figure 1

Spruce Budworm

Damage Map

1973

Based on aerial defoliation surveys, pupal counts and egg-mass counts, the results generally appear to be good. Several pockets of defoliation, totalling only about 5,000 acres were mapped in the largest spray block. Pupal counts and egg-mass counts from the sprayed areas show that budworm populations are reduced by an average of 70% compared to 1972.

Defoliation Forecasts for 1974

Defoliation in unsprayed areas in 1973 totalled about 5,000 acres and occurred mainly in small scattered pockets along the International Boundary. Egg-mass counts indicate medium infestation throughout an area of about 20,000 acres, primarily in the south-central part of Quetico Provincial Park. Persistent infestations at Northern Light Lake, Granite Lake, Kawa Bay and Allan Lake appear now to have been eliminated. Budworm populations are at extremely low levels elsewhere throughout northwestern Ontario.

Proposed Aerial Spraying Operations for 1974

The Province will likely spray the remnants of the main infestation in Quetico in the Poohbah and Tanner lakes area and possibly some of the small infestations remaining along the Border. Total acreage is not likely to exceed 20,000.

Northeastern Ontario

1973 Operations

A total of 11,000 acres were sprayed in parts of five provincial parks in northeastern Ontario. The primary purpose of this spraying was again to minimize the intensity of damage caused by budworm within selected high value recreational areas. The following table lists the parks and acreages that were sprayed.

District	Park	Acreage sprayed
Wawa	Lake Superior	3,350
Chapleau	Shoals	1,600
	Missinaibi	5,250
	Five Mile	500
	Wakami	300
		11,000

Budworm emergence occurred about mid-May. Spraying was carried out June 9, 10, and 13 in Lake Superior Provincial Park and from June 14-21 in the parks in the Chapleau District. Two aircraft, a Stearman and an Agcat were available to expedite the operation but the weather was generally unsettled and the sprayers could not operate on several days.

As in 1972, a detailed assessment was made in a 550 acre block of Lake Superior Provincial Park to obtain detailed information on the effectiveness of Zectran when applied at the 1973 operational rate of 1.2 ounces in .15 gallons (U.S.) of Arotex per acre. The results showed population reductions of 90% on balsam fir and 74% on white spruce (corrected for natural mortality). Damage to current foliage showed defoliation to balsam fir of 16% in the Zectran plot compared to 85% in the untreated check. The corresponding figures for white spruce were 19% defoliation in the Zectran plot and 58% in the untreated check. Pupal counts and defoliation estimates for the areas sprayed in Chapleau District confirm that good protection was achieved. Lake Superior Provincial Park was also the location for operational spray trials using Bacillus thuringiensis carried out in cooperation with the Insect Pathology Research Institute. Results are reported under Research, 1973.

Infestation Forecasts for 1974

In 1973, about 12.5 million acres were moderately to severely damaged in northeastern Ontario. This represented a slight reduction from 1972 and resulted from a near collapse of the outbreak over 2.5 million acres north and east of Chapleau. Tree mortality caused by spruce budworm has occurred throughout an area of almost 200,000 acres in the Onaping Lake area in the Sudbury and Gogama districts.

Egg-mass densities in 1973 doubled over those of 1972 throughout the region. This signifies that populations have returned to the high levels recorded in 1971. Moderate to severe damage is expected next year throughout the area infested in 1973 and in much of the area north and east of Chapleau. New and enlarged infestations will likely occur in the North Bay District. Fortunately, no significant spread to the northwest or north of the main infestation has occurred.

Proposed Aerial Spraying Operations for 1974

It is planned that 16,500 acres will be sprayed in Lake Superior Provincial Park and 1,000 - 8,000 acres in various parks in the Chapleau District.

Southeastern Ontario

1973 Operations

There were no provincial spraying operations in southeastern Ontario. Spraying to protect stands on the Petawawa Forest Experiment Station was carried out by the Chemical Control Research Institute and PFES.

Results of this operation will be reported by CCRI.

Infestation Forecasts for 1974

The total area affected was reduced somewhat compared to 1972 to about 6,000,000 acres, with few changes in infestation boundaries. Pockets of tree mortality were found in several locations in Algonquin Park (Stratton, Preston, McLaughlin and Canisbay townships) and outside of the Park in Ross, Bromley, Galway and Bruton townships.

Budworm egg-mass numbers have increased to all-time record highs for the current outbreak in southern Ontario with a 5-fold increase in number compared to 1972. For example, counts from all locations sampled in Algonquin Provincial Park this year average more than 1,300 egg-masses per 100 ft^2 of foliage. At the Petawawa Forest Experiment Station, a relatively small increase was recorded but all samples indicated that severe infestations will occur throughout the station in 1974. It is expected that all major infestations in 1973 will persist in 1974 and that many susceptible stands on the periphery of these infestations will become infested.

Proposed Aerial Spraying Operations for 1974

Some 46,000 acres of susceptible forest has been delineated in Algonquin Provincial Park where protection against budworm damage would be desirable. The extent of area to be sprayed in 1974, if any, remains to be determined.

Report prepared for the Annual Forest Pest Control Forum

November 14, 1973

APPENDIX 9

CONFIDENTIAL

SONGBIRD POPULATIONS IN THE SPRUCE BUDWORM MOTH CONTROL AREA, NORTHWESTERN N.B., PRIOR TO TREATMENT WITH PHOSPHAMIDON

(Study Ref. No. CC-3-014)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

C.H. BUCKNER and D.G.H. RAY

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario.

October, 1973

Songbird Populations in the Spruce Budworm Moth
Control Area, Northwestern N.B., Prior to Treatment with Phosphamidon

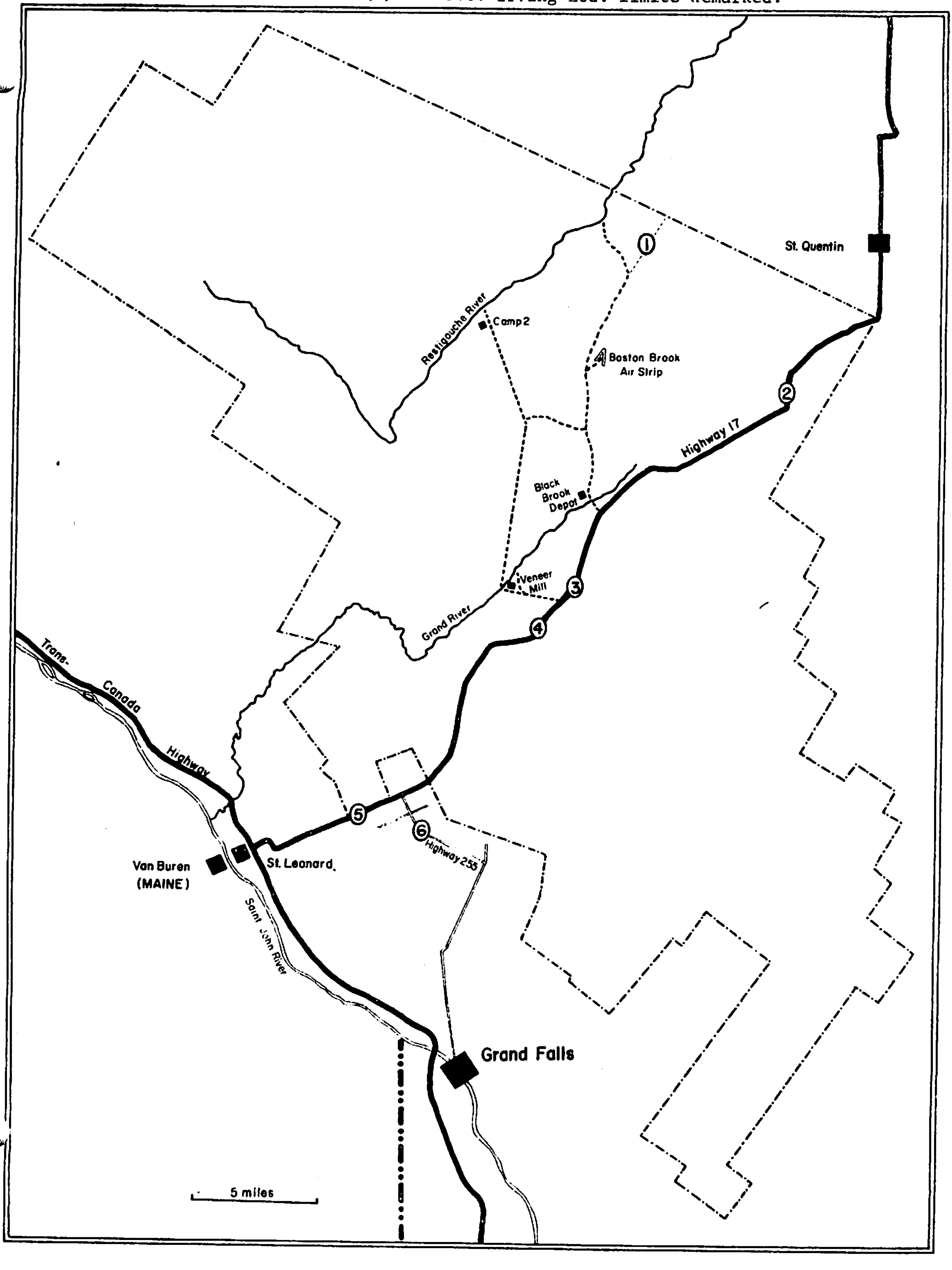
by

C.H. Buckner and D.G.H. Ray

In early July 1973, six study plots were established in Northern New Brunswick (Fig. 1) to assess the possible impact of the insecticide phosphamidon on populations of small forest birds. Plots 1-4 were within the proposed treatment area and Plots 5 and 6 were outside the boundary of intended application and were to be used as controls. All treatment plots were within the holdings of J.C. Irving Ltd., Woodlands Division. Plot 5 was partly within and partly outside this tract, and Plot 6 was entirely outside the Irving land (Fig. 1).

Breeding bird populations on all six plots were measured by the singing male technique (Kendeigh 1944, Buckner and Turnock 1965), which consisted of defining the territories of all singing males on a map by means of repeated transvering of predetermined lines. Populations on the plots intended for treatment appeared unusually low compared with populations in the control plots (Table I). There was an absence of yellow bellied sapsuckers, tyranid flycatchers, catbirds, Tennessee warblers, Nashville warblers, yellowthroats, and blackbirds, and a noticeably reduced population of nuthatches, kniglets, upper crown feeding warblers and certain fringillids. A summary of the data (Table II) suggested that total populations in Plots 1-4 were less than 60% of those in the control plots and the numbers of species on Plots 1-4 were less than 65% of those in the control plots. Parulid warblers and fringilids showed the greatest reduction in numbers.

Figure 1. Songbird census plots in Northeastern New Brunswick 1973. Plots are numbered (1) - (6) and J.C. Irving Ltd. limits demarked.



Populations, expressed as pairs per 100 acres, of small forest birds on the holdings of J.C. Irving Ltd., Woodland Division, Northwestern New Brunswick, 1973.

Family	Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5 (Control)	Plot 6 (Control)
Trochilidae	Ruby-Throated Hummingbird		5				
Picidae	Yellow-shafted Flicker	2					1
	Yellow-bellied Sapsucker					1	
Tyrannidae	Least Flycatcher						15
	Eastern Wood Peewee						5
	Olive-sided Flycatcher						5
Corvidae	Gray Jay	1					
	Blue Jay	1		2			
Paridae	Black-capped Chickadee	5	10		5	5	20
Sittidae	Red-breasted Nuthatch			5	5	5	
Troglodytidae	Winter Wren	10	5	10	10	5	10
Mimidae	Catbird						1
Turdidae	American Robin	5	15	10	5	5	10
	Wood Thrush		15				
	Hermit Thrush	10					15
	Swainson's Thrush	10	15	15	10	10	15
	Veery					5	20
Sylviidae	Golden-crowned Kinglet	10	20	15		10	5
	Ruby-crowned Kinglet	5				15	10
Bombycillidae	Cedar Waxwing						1
Vireonidae	Solitary Vireo		10	5	5		5
	Red-eyed Vireo		5		15	5	
Parulidae	Black-and-White Warbler		5		5		10
	Tennessee Warbler					25	35
	Nashville Warbler					10	35
	Parula Warbler	10	15		15	5	
	Magnolia Warbler	35	10	5		5	10
	Cape May Warbler		5		5		5
	Black-throated Blue Warbler						5
	Myrtle Warbler	15	5	5		10	15
	Black-throated Green Warbler	5	5	5	15	5	
	Blackburnian Warbler		5	5	10		
	Bay-breasted Warbler		20	5	10	10	
	Ovenbird		30	10	25	25	10
	Northern Waterthrush	5					
	Mourning Warbler						5
	Yellowthroat					5	10
	Canada Warbler	10		5			10
	American Redstart		15				10
Icteridae	Rusty Blackbird					1	
	Brown-headed Cowbird					12	2
Fringillidae	Rose-breasted Grosbeak	10	5	10		15	25
	Evening Grosbeak	1	6	1	1	9	3
	Purple Finch	1			1	5	1
	Pine Grosbeak						5
	Pine Siskin				2		1
	American Goldfinch					1	
	Slate-coloured Junco		5	10	5		
	Chipping Sparrow				5	5	10
	White-crowned Sparrow						5
	White-throated Sparrow	30	5	10	15	15	35

Table II

Population and species distribution of small forest birds in Northwestern New Brunswick, 1973

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5 (Control)	Plot 6 (Control)
Populations in Pairs per 100 Acres	181	236	133	169	229	385
No. of Species	20	23	18	20	27	36

The results of studies by P. Pearce and N. Garrity, Canadian Wildlife Service, were similar and indicated a drastic reduction of certain small forest song birds.

Spruce foliage samples collected in the Plots 1-4 were subjected to chemical analysis for fenitrothion through the courtesy of K.M.S. Sundaram and the results ranged from 0.04 to 0.19 ppm. No insecticide was detectable in samples taken from the control plots. Residues in samples from Plots 1-4 are unusually high considering that budworm control operations should have terminated about one month previously.

These studies indicate a sharply reduced songbird population as a result of excessive use of the insecticide fenitrothion.

References

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

Kendeigh, S.C. 1944. Measurement of bird populations. Ecol. Monogr. 14: 67-106.

Report to the Federal Interdepartmental Committee on Pesticides by the Working Party on

"The conditions under which pesticides should be used in forestry"

The revised Pest Control Products Act contains authority to classify pest control products in order that they may be directed or confined in their use to persons with the competence to ensure that such products are not used under unsafe conditions. In his concern for the safety of man and environmental quality the Minister may set forth additional conditions to be set forth on the label respecting the handling or use of the product.

The FICP expressed concern for the possible effects of disastrous spills or misapplication of pesticides used in large scale forestry operations. A Working Party was appointed to consider the conditions under which forestry applications of pesticide should be made and the means that could be used to assure compliance with those conditions. This was done and the matter discussed at the FICP meeting of September 12th. This paper is intended to represent the views of the committee and embody the proposals of the Working Party, expressed in a manner that is compatible with the provisions of the Pest Control Products Act, and taking into account provincial regulatory authority with which the requirements must be coordinated.

...2

Except for pesticides, for which abundant evidence on biological effects reveals no significant detrimental effect, uses of pest control products in forestry situations shall be classed as RESTRICTED. The nature of the restriction relative to such uses shall be that "no person may use the product for any purpose that is restricted except as authorized". That statement shall appear on labels of products that bear instructions for uses which are restricted. It is incumbent upon the user to seek the nature of the restriction in the province of the intended use. This is not an impractical imposition, since users of pesticides in forestry situations are professionals and should be aware of regulatory requirements. Any casual use of the product by other persons without regard to the restriction would be in violation and subject to the remedies of law under the P.C.P. Act and provincial legislation.

In practice the authorization of a restricted use will be accomplished under provincial legislation, and thus the purposes of the P.C.P. Act will be served in the assurance that conditions for safe use have been considered and imposed under local expertise and authority. In the absence of provincial legislation the authority of the P.C.P. Act may be invoked to accomplish the same ends.

The guidelines proposed to the FICP in the first report of the Working Party, set forth the conditions for the use of a pesticide in forestry which should be considered by the regulatory authority (federal or provincial) in the authorization of any restricted use. The conditions considered in respect to any given use or project, may be imposed to a greater or lesser extent, depending upon the site to which pesticides are to be applied and the inherent risks of the pesticide to be used. Once the conditions for authorization has been decided upon and documented the permit or authorization that is issued becomes a regulatory instrument that can be enforced by means of inspection if need be.

The elements of control proposed by the Working Party are as follows

(1) The responsible operator or agency should be required to make application to the regional regulatory authority to conduct the proposed pest control program and should include the following information

(a) a description, preferably maps, showing the area to be treated, and the purpose of the treatment

(b) the name of the control product to be used and the rates and volumes of application

(c) a description of the application equipment

(d) a description of the system to be used for guidance in the case of large areas to be covered by aircraft

...4

(e) safety precautions to be taken to protect personnel involved in the project, and avoidance of environmental damage

(f) qualifications of the key personnel involved in the project, and

(g) the proposed dates for the project.

The application should be viewed in light of the magnitude and location of the project, and the control product involved and consideration given to

(a) the need for a contingency plan in the event of a major spill and requiring that the means to decontaminate personnel and equipment be maintained on the site

(b) the adequacy of protective clothing and other measures for the safety of the crews involved

(c) the adequacy of the measures proposed to prevent significant contamination of waterways, crops and inhabited areas.

When needed the responsible agency or operator should be required to

(a) supply neutralizing or decontaminating agents together with the means to use them

(b) assure the availability of medical services and provide specific information respecting medical treatment in the event of intoxication of persons involved or in the vicinity.

The regulatory authority involved in the approval of the pest control project should satisfy itself that the conditions of approval are reasonably adequate to prevent an unsafe condition in the conduct of the program.

The restricted conditions referred to in this document do not apply to products for use in tree nurseries, rights of way or other uses not related to tree production management on forested land.

ERH/pm

November 22, 1973

APPENDIX 11

NOT FOR PUBLICATION

ENVIRONMENTAL CONTAMINATION - PESTICIDES

(Study Ref. No. CC-3-009)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

W.N. YULE

Chemical Control Research Institute
Canadian Forestry Service
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Ottawa, Ontario.

October, 1973

Environmental Contamination - Pesticides

(Study ref. no. CC-3-009)

A Report to the Annual Forest Pest Control Forum

by W. N. Yule

Progress has been made in 1973 with increasing and improving analytical facilities for pesticides at CCRI, and several studies were begun concerning further aspects of the distribution, persistence, and fate of deposits and residues of fenitrothion in forest trees and soils. A start has been made with methodology for studying matacil and phosphamidon in the forest environment, and routine checking of DDT residues was continued at Priceville.

A number of forest areas of New Brunswick that have been sprayed operationally with fenitrothion for up to six consecutive years for spruce budworm control were examined in the Spring of 1973 for fenitrothion residues. Relatively small amounts of fenitrothion were found to persist in coniferous foliage after a single application the previous Spring. (see also Yule, W.N. and J.R. Duffy, 1972. Bulletin of Environmental Contamination and Toxicology, 8, 10), and evidence was obtained that residues had accumulated in balsam fir foliage approximately in proportion to number of years sprayed and area-dosage. No persistent residues were found in forest soils (cf. DDT; Yule, W.N., 1973. ibid., 9, 57).

ANNUAL FOREST PEST CONTROL FORUM

OTTAWA, NOVEMBER 14-15, 1973

TEST OF A COMPACT AND ECONOMIC BACILLUS THURINGIENSIS FORMULATION AGAINST THE SPRUCE BUDWORM

Work conducted with the cooperation of:

Laurentian Forest Research Centre,
Canadian Forestry Service,
Department of the Environment,
Ste. Foy, Quebec.

Conservation Branch,
Department of Lands and Forests,
Quebec.

Abbott Laboratories,
North Chicago,
Illinois, U.S.A.

SUMMARY:

1) In 1972, the insect pathology unit of the Laurentian Forest Research Centre tested over 10,000 acres of forest with a Bacillus thuringiensis + chitinase formulation composed of Thuricide HPC, 7.8 billions B.I.U./acre, mixed in polyglycol with sticker and water. Spray rate was 2 gal/acre.

2) Following this experiment an effort was made to find a more compact and low-volume formulation. The formulation developed was first tested in the laboratory and was composed of B. thuringiensis concentrate of a heavy and low-priced carrier (gravity 1.4), of a sticker and of chitinase. Moreover, the formulation can be prepared in advance elimination mixing at the airfield.

3) The technology of production of the formulation was developed by Abbott Laboratories who also kindly supplied the material required to tread 300 acres of forest in 1973.

4) A 300 acre area, heavily infested by the spruce budworm (average population 34.0 larvae per 18" branch tip) was chosen to test the formulation in the Temiscouata region. This stand had been severely defoliated for four consecutive years, and the trees were in a critical condition.

5) Sprays were applied at the peak of third instar (first week of june) by two types of aircraft: TBM Avenger (capacity 625 gal.), and CL-215 (capacity 2000 gal.) aircraft.

6) The emitted volume was 0.5 gal/acre (6.8 billion B.I.U./acre), average deposit was 0.17 gal/acre, giving a 66% loss through evaporation. The number of droplets on check cards was 22.5 per sq. cm. and the number of B. thuringiensis colonies was 1400 per 68 sq. cm petri dish (20 colonies per sq. cm). Droplet size was in the range of 50 to 500 μm, average diameter 109 μm.

7) Fifty seven of the current year shoots were still present on trees in the B. thuringiensis treated area and none in controls on June 20, 15 days after treatment. Subsequently, however, most of the current year's foliage was destroyed by residual populations in the treated plot.

8) Larval mortality was 83%, and efficiency of the treatment, determined by the Abbott's formula, 70%

9) The number of the 1974 terminal buds present at the end of the growing season was 22% in the *B. thuringiensis* treated area and nil in the control area.

10) Determination of the number of egg masses revealed that infestation will be low in 1974 for one half of the sprayed area. The size of egg masses in the *B. thuringiensis* treated area was much smaller than in controls due to an effect of the metabolic perturbations provoked by the bacillus in the surviving individuals.

11) Conclusions for the 1973 experiment.

Larval mortality reached 83%, and 57% of the current year shoots were maintained on trees for two weeks longer, in the treated area than in controls. Also 22% of the 1974 terminal buds were preserved in the *B. thuringiensis* treated area while in the control, none were produced. Nevertheless, the *B. thuringiensis* treatment cannot be considered as suitable in stands having suffered four years of severe defoliation and where populations exceed 30 larvae per 18" branch tip. It must be admitted that this type of a situation is also somewhat hopeless for application of insecticides.

12) Observations were carried out in the 10,000 acres treated in 1972 (see interdepartmental committee report for 1972). In 18 of the 25 sampling plots in this area, the population averaged,

7.6 larvae per branch tip lower than before treatment in 1972. Also, at the end of the season in 1973, there was 68% of the 1974 buds and 74% of the current year shoots present on trees in over 70% of the territory.

13) Observations carried out in the two 100 acre plots treated in 1971 revealed that population level at the end of 1973 was still lower by 5 individuals than before treatment, per 18" branch tip. The number of 1974 buds present on trees was 38.8% but defoliation of current year's shoots was severe this year.

14) Recommendations:

The field experiments carried out during the last three years with various; dosages of bacillus, formulations, density of population and degree of defoliation indicates that _B. thuringiensis_ is an efficient weapon in the control of the spruce budworm. The Quebec Department of Lands and Forests estimates the cost of two applications with Fenitrothion at 0.84 per acre; the cost of one application of _B. thuringiensis_ is estimated at $2.50 per acre. It is recommended that chemical insecticides be applied during two consecutive years, while with bacillus it may not be necessary to repeat treatment the following year because of an apparent prolonged beneficial effect, and under certain forest conditions this may possibly be prolonged two years. Although the cost of _B. thuringiensis_ treatment was reduced 4 times with development of the new formulation, the present cost could still be reduced by treating larger areas. An even better way to reduce the cost of B. thuringiensis formulation would be the installation in Canada of a B. thuringiensis manufacturing plant. Also, this would permit a wider spectrum of activity for the bacillus such as the control of agricultural insects and of forest insects other than the spruce budworm. The most important and unquestionable property of B. thuringiensis is that it does not affect in any way the quality of the environment.

For this reason, I ask this meeting adopt a resolution for promoting the production and use of B. thuringiensis in Canada.

Dr. W.A. Smirnoff,
Laurentian Forest Research Centre,
Canadian Forestry Service,
Department of the Environment,
Ste. Foy, Quebec.

October 22, 1973

Aerial Spraying of *Bacillus thuringiensis* Berliner to Control Spruce Budworm, Mashagama, Ontario, 1973

by

H. A. Tripp

The objective of these trials was to determine the minimum dosages of commercial *B. t.* preparations applied from the air which would effectively control spruce budworm.

Experimental Area

The site selected was a heavily infested balsam fir stand near Mashagama Lake in townships 3F and 4F, District of Algoma, about 65 miles north of Thessalon, Ontario. Observations and pre-emergence sampling in 1973 revealed that although 1972 populations were high there had been no visible back-feeding. Early spring laboratory rearing revealed very high populations for 1973. In effect, 1973 was only the second year of severe defoliation so the infestation was considered to be relatively new.

Seven 50-acre plots were utilized; each measured 1000 x 2178 ft., and all were located within one linear mile.

Temperature, relative humidity and precipitation were recorded at the 4-foot level in a central location within the experimental area.

Formulations

Two commercial *B. t.* products were employed. Thuricide^R liquid concentrate was supplied by International Minerals Corp., and Dipel^R wettable powder by Abbott Chemical Co.

The Thuricide was supplied in concentrations of 16, 8, and 4 Billion International Units per U.S. gallon but with equal proportions of additives to maintain more or less similar viscosity. By combining equal proportions of 16B and 8B a mixture containing 12 B.I.U. per gal. was obtained. When these four mixtures were diluted with equal parts water, spray mixtures containing 8, 6, 4, and 2 B.I.U.'s per gal. were obtained which were applied at the rate of one-half gallon per acre resulting in spray emissions of 4, 3, 2 and 1 B.I.U. per acre.

The Dipel wettable powder had a rating of 7.2 B.I.U. per lb. This was prepared with water and additives to provide 8 and 2 B.I.U. per U.S. gallon which were applied at one-half gallon per acre resulting in spray emissions of 4 and 1 B.I.U. per acre. The Dipel 4 B.I.U./acre mixture contained 20% Cargill Insecticide Base (C.I.B. - molasses) and one percent Biofilm® supplied by Colloidal Products Corp. The Dipel 1 B.I.U./acre mixture contained only the 20% C.I.B.

No colour markers other than the natural colour of the additives were used.

Application

Vertical air movement was monitored by means of thermistor probes at 4-foot, tree-top, and 18 ft. above the canopy. Horizontal air movement was estimated by direct observation of a helium-filled balloon, while relative humidity was measured by a hygrothermograph. Spraying commenced only when horizontal air movement was estimated at less than 5 MPH and when vertical air movement was nil or downward (inversion).

Spray deposit cards were placed across the plot to be sprayed and other nearby test plots at 25-foot intervals.

The spray was applied by a Grumman AgCat aircraft guided in 100-foot swaths by means of helium-filled balloons. The aircraft was equipped with four AU 3000 Micronair units with orifice eleven, prop pitch at 30 degrees, 35 lbs. tank pressure, and it flew at 90 MPH.

Assessment

Fifty co-dominant balsam fir were selected and tagged, across the breadth of each plot. One or two 18-inch branch samples were taken from mid crowns from each sample tree before spray and at the 2nd, 4th, and 6th week after spraying. A few trees, however, were eliminated or substituted from each plot because of lost tags or lack of spray deposit.

Foliage protection was determined using entire 18-inch branch samples. Standard defoliated branches were established by carefully measuring and counting needles on branches until a wide range with approximately 10 percent differences were obtained. Subsequent samples were then compared with the standards and defoliation estimated to the nearest one percent. Such defoliation estimates include the back-feeding on previous year's foliage.

Results and Discussion

The results of these trials are presented in Table 1 and the relevant environmental data in Table 2.

The failure of the Thuricide 4 B.I.U. application may be explained by a torrential rain which occurred almost immediately following application. Even though the Thuricide formulation carried a good sticker it had not time to "set". Cards picked up during the beginning of the rain were washed clean of any visible deposit. Also it is doubtful if budworms fed during or immediately after application in view of the low temperature and rainfall.

Although the Dipel 4 B.I.U. was applied earlier the same morning a small measure of control (28%) was estimated from the samples taken 6 weeks later. This formulation had no better sticking qualities but since it was applied about one hour before rainfall it probably "set" sufficiently to have some residual action. No estimate of foliage protection was taken, however, as visible signs were not encouraging.

The most favourable spray conditions with respect to timing of budworm development (3rd and 4th instars), post spray temperature (mean 60°F), and lack of rain for about 70 hours following application, occurred with the Thuricide 1 B.I.U. treatment. From this treatment a control of 26% two weeks after spraying, increasing to 41% at six weeks, was recorded. Foliage protection, however, was virtually non-existent (4% recorded).

The treatment with Thuricide at 2 B.I.U./acre gave surprisingly good results in consideration of the adverse post spray weather (0.2" rain 22 hours after application); an estimated 47% control after two weeks increasing to 59% at six weeks. This was the only treatment which resulted in pronounced visible signs of foliage protection, estimated at 55 percent. This foliage protection with only moderate control of larvae may be credited to application before budworm had reached the 5th instar.

Thuricide at 3 B.I.U./acre resulted in budworm control estimated at 70% two weeks following application but remained virtually unchanged at six weeks. This treatment was followed by 0.2" rain about 18 hours later and 1.3" the next day. This probably accounts for the lack of delayed mortality in that all mortality recorded probably resulted from feeding during the initial 18 hours after application. Foliage protection was estimated at 29%. A plausible explanation for the relatively low protection as compared to the 2 B.I.U. treatment is the timing of treatment with respect to budworm development; about 20% of the population had already reached the 5th instar and the older larvae are known to be more difficult to kill with B. t.

Dipel at the rate of 1 B.I.U./acre was applied during the same evening as the Thuricide 3 B.I.U. and was therefore subjected to the same adverse conditions. This formulation did not contain a sticker, other than the 20% C.I.B. No control was evident from sampling nor was there any significant foliage protection. This should not be construed as evidence of superiority of the

Thuricide 1 B.I.U., as the latter was applied when conditions were close to ideal and it carried a superior sticker.

Conclusions

These results indicate that a dosage of one B.I.U. per acre was inadequate even when conditions were good. Dosages of two and three B.I.U. gave moderate control and protection under somewhat unfavourable environmental conditions. Unfortunately, these results do not provide an estimate for 4 B.I.U. However, results at Chapleau during 1972 with both Thuricide and Dipel at 4 B.I.U./acre gave over 90% control, and the very apparent visible foliage protection achieved this year in Lake Superior Provincial Park with Thuricide 4 B.I.U. suggests that given good conditions during and after spraying, a dosage of 4 B.I.U./acre will provide acceptable protection to balsam fir.

These tests also show that adequate coverage may be achieved using an aqueous mixture of B. t. at two quarts per acre when applied with the equipment and calibrations specified in this report.

In conclusion, I do not hesitate to recommend Bacillus thuringiensis as a control agent against eastern spruce budworm. However, in view of the difficulties involved in timing of applications and the unpredictable post spray weather it is suggested that the dosage be not less than 5, and preferably 6 B.I.U./acre. Increased dosages alone cannot ensure success as demonstrated by the complete failure of 4 B.I.U./acre during these trials. Unlike a contact insecticide, B. t. must be ingested, preferably by early instar larvae. To achieve this phenomenon the material must be deposited when the larvae are relatively young (certainly before 5th instar), when the foliage is open to allow for penetration, when the larvae are feeding (above 55°F and dry), and when the danger of post spray cleansing-type of precipitation is at a minimum. Of these, the latter two are by far the most important and most difficult to predict. Nevertheless, the spray captain should pay greater heed to local weather forecasts and wait for a period that allows for 48 hours of warm and dry post-spray weather.

TABLE 1. Estimated control* of spruce budworm and foliage protection by *Bacillus thuringiensis* on balsam fir, Mashagama, Ontario, in 1973.

Treatments B.I.U. per 2 qts./acre	Pre Spray Budworm per 18" Branch	First Post Spray Spray + 2 weeks			Third Post Spray Spray + 6 weeks			Percent Defoliation - (All Foliage)		
		Budworm	% Reduction	Control	Budworm	% Reduction	Control	Observed	Expected no treatment	Protection
Untreated	36.8	17.3	53	-	14.2	61	-	34	34	-
Thuricide 1 B.I.U.	27.5	9.5	65	26%	6.3	77	41%	24	25	4
Thuricide 2 B.I.U.	33.2	8.3	75	47%	5.3	84	59%	14	31	55
Thuricide 3 B.I.U.	36.7	5.2	86	70%	4.6	87	67%	24	34	29
Thuricide 4 B.I.U.	23.8	18.8	21	0%	9.4	61	0%	not estimated	-	-
Dipel 1 B.I.U.	29.1	14.3	51	0%	11.5	60	0%	25	27	7
Dipel 4 B.I.U.	25.7	12.2	53	0%	7.2	72	28%	not estimated	-	-

*Adjusted for natural mortality by Abbott's Formula.

TABLE 2. Spray data relative to control of spruce budworm by *Bacillus thuringiensis* at Mashagama, Ontario, in 1973.

Treatments B.I.U./acre	Date and Time of Application	Larval Development	Temperature and Air Stability	Spray Deposit per cm on Ground			Post Spray Weather	
				No. drops	Mean diam.	% cover	Mean temp. 48 hrs.	Precipitation
Thuricide 1 B.I.U.	June 2 9:30 PM	3rd & 4th instar	56°F inversion	27	165 μ	0.6	60°F	.2" after 70 hrs.
Thuricide 2 B.I.U.	June 4 9:30 PM	Peak of 4th instar	62°F inversion	29	195 μ	1.0	60°F	.2" after 22 hrs.
Thuricide 3 B.I.U.	June 6 9:15 PM	4th & 5th instar	63°F neutral to inversion	25	135 μ	0.4	55°F	.2" after 18 hrs. 1.3" after 40 hrs.
Thuricide 4 B.I.U.	May 31 7:15 AM	Peak of 3rd instar	45°F inversion	21	125 μ	0.3	50°F	.65" immediately
Dipel 1 B.I.U.	June 6 8:30 PM	4th & 5th instar	63° F neutral	49	135 μ	0.8	55°F	.2" after 18 hrs. 1.3" after 40 hrs.
Dipel 4 B.I.U.	May 31 6:30 AM	Peak of 3rd instar	42°F inversion	16	155 μ	0.6	50°F	.65" after 1 hr.

Spruce Budworm Aerial Spraying, Ontario

Research 1973 and Proposed 1974

by

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Canadian Forestry Service
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Introduction

During 1973, the Great Lakes Forest Research Centre engaged in several cooperative studies that involved the aerial application and assessment of biological insecticides against the spruce budworm. Basically, the Great Lakes Forest Research Centre involvement was to carry out population reduction and damage assessments similar to those used to evaluate operational trials and operational spraying as carried out in Ontario over the 5 previous years. Some of the studies were also assessed by other individuals using different evaluation techniques. Our results are summarized below.

A. Operational Trial of B. t. Sprays, 1973 - Lake Superior Provincial Park

In 1973, the Ontario Ministry of Natural Resources tested Bacillus thuringiensis (Thuricide formulation) at an operational level in Lake Superior Provincial Park. The Canadian Forestry Service (the Insect Pathology Research Institute and the Great Lakes Forest Research Centre) provided technical advice and evaluated the effectiveness of the B.t. sprays. Ontario Ministry of Natural Resources provided financial support for entomological evaluation work.

Using a Stearman spray plane equipped with micronairs AU3000, a 160 acre area was sprayed with B.t. Thuricide at a rate of 4 Billion International Units per .5 gal. (U.S.) per acre on the evening of June 11. A second 160 acre area was sprayed on the evening of June 12 at a rate of 2 B.I.U. per .5 gal. (U.S.) per acre. Budworm development was third and fourth instar. The 2 B.I.U. plot was sprayed a second time at a rate of 2 B.I.U. per .5 gal. (U.S.) per acre on the evening of June 20. Budworm development was then primarily fifth and sixth instar.

All spray applications were made under satisfactory weather conditions and spray deposit was generally good, although somewhat variable. Droplet counts in excess of 100 per $cm.^2$ were recorded in some cases.

Results of population reduction (corrected for natural mortality) and defoliation studies carried out by GLFRC are summarized in Table 1.

Table 1. Population reduction and foliage protection attributable to B.t. sprays, Lake Superior Provincial Park, 1973

Treatment	Host	Spray + 8 days	Spray + 24 days	% Current B.t.	Defoliation Control
B.t.-4 B.I.U.	bF	61	61	36	85
	wS	34	42	41	64
B.t.-2 B.I.U.x2	bF	57	59	40	85
	wS	3	18	59	64

These results are supported by diagnostic studies of H. A. Tripp, IPRI, (personal communication) who determined the proportions of larvae infected with B.t. in the different sprayed areas. His work showed that budworm in the sprayed plots were infected with B.t. in proportions ranging from 22% to 46% one to two weeks after the sprays were applied. Higher proportions of budworm were infected on balsam fir than on white spruce.

Data in Table 1 show that B.t. at 4 B.I.U.'s per acre is capable of causing significant infection and mortality of budworm resulting in foliage protection. B.t. applied twice, 8 days apart, at 2 B.I.U.'s per acre each time provided similar results on balsam fir. In both plots, better results were obtained on balsam fir than on white spruce. The double application approach appeared to make little difference in the end results except perhaps for the poor results on white spruce. A single application of 2 B.I.U.'s per acre is as effective as 4 B.I.U.'s per acre on balsam fir when both applications are made during third and fourth instars. The poor results on white spruce (2 B.I.U.x2) may have been due to advanced age of larvae at the time of the second application.

B. Virus Carry-over - Follow-up of 1971 Virus Spray Trials

Areas sprayed with NPV and entomopoxvirus in 1971 were re-examined in 1973 in a cooperative study between IPRI and GLFRC. Population reduction and foliage protection attributable to virus carry-over were assessed by GLFRC.

In 1971, 6 plots were sprayed with entomopoxvirus at Achray in Algonquin Provincial Park. In 1972, it was discovered that virus had carried over, probably as a foliage contaminant, in sufficient quantity on both balsam fir and white spruce to cause considerable infection, larval mortality and foliage protection. The virus that carried over however, was NPV, which had been present in the original entomopoxvirus sprays as a contaminant. Also in 1971, two white spruce plantations on Deluthier Road were sprayed with heavy concentrations of NPV. In 1972, NPV was found in budworm populations in both of these plantations and one plantation had excellent foliage protection.

All of these areas were re-examined in 1973. IPRI determined that NPV was again present in appreciable quantities in budworm populations in all areas sampled. GLFRC studies showed that population reduction and foliage protection occurred in all plots sampled. At Achray, the 4 plots sampled showed an overall population reduction of approximately 50% on wS and 25% on bF. Defoliation averaged about 65% for the four plots for wS compared to 80% in check plots and 65% compared to 95% for bF.

On Deluthier Road, there was a population reduction of about 65% in plot G (early 1971 spray) and 45% in plot H (late 1971 spray). Defoliation was approximately 60% in plot G, 70% in plot H and 80% in check plots.

C. Virus Trials, 1973 - Massey and Mashagama

In 1973, IPRI conducted a series of NPV spray trials in the Massey and Mashagama areas of northern Ontario. GLFRC carried out population reduction and defoliation studies in conjunction with some of the trials.

Data for four plots at Massey showed only slight population reduction and no foliage protection on balsam fir. However, a population reduction of about 30% and some foliage protection were determined for white spruce in the two plots receiving the highest dosages of NPV.

Data for two plots at Mashagama, show population reductions of 20% and 45% on balsam fir for plots sprayed respectively with 5 and 10 gm NPV per acre. No foliage protection is evident. On white spruce, there was no population reduction attributable to virus detected in the 5 gm per acre plot but a mortality of 43% was measured in the 10 gm per acre plot. Again, no white spruce foliage protection was discernible in either plot.

Proposed - 1974

1. The areas sprayed with virus in 1971 (Achray & Deluthier) and in 1973 (Massey and Mashagama) should be examined in 1974 for presence and effects of virus (GLFRC & IPRI).

2. Provincial authorities in Ontario have expressed an interest in further investigating the feasibility of using biological agents to control spruce budworm on a typical Ontario operational basis in 1974. Should such an opportunity materialize, we would recommend that full-strength mixtures of Zectran-NPV and B.t.-NPV be sprayed under operational conditions. The compatability of these mixtures would have to be tested before field trials of this kind could be attempted and trials would involve participation by OMNR, GLFRC and IPRI.

Report prepared for the Annual
Forest Pest Control Forum

November 14, 1973

APPENDIX 15

NOT FOR PUBLICATION

AERIAL APPLICATIONS OF BACILLUS THURINGIENSIS AND/OR CHITINASE AGAINST THE SPRUCE BUDWORM

(Study Ref. No. CC-1-019)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

O.N. MORRIS

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario

October, 1973

Aerial Applications of Bacillus Thuringiensis

And/or Chitinase Against the Spruce Budworm

Project #CC-1-019

A Report to the Annual Forest Pest Control Forum

by O.N. Morris

In 1973, spruce budworm infested balsam fir and white spruce in Algonquin Park were aerially sprayed with Thuricide 16B® (International Minerals and Chemicals Corp., Libertyville, Illinois) or Dipel® Wettable Powder (Abbott Laboratories, Chicago, Illinois). The sprays were formulated with and without Chitinase, an enzyme, which, when ingested by insects, renders the pest more susceptible to bacterial infection. Test plots were 100 acres in area, except for the Thuricide alone plot which was 2500 acres.

Applications were made May 29 - 31 when the budworm were mostly in the 3rd instar at the rate of 4 billion International Units (in 0.5 gallons of liquid suspension) per acre. A Cessna Agtruck and a Piper Pawnee, both fitted with Micronair emission units, were used for all applications. Meteorological equipment was used to determine the best conditions for time of spray and for recording weather conditions during the entire test period.

The percentages of emitted spray which reached sampling units at ground surface were 34, 81, 33, 27, and 18 for Thuricide alone, Thuricide + chitinase, Dipel alone, Dipel + chitinase, and chitinase alone, respectively. The high deposit recovery of the Thuricide + chitinase application was likely due to ideal meteorological conditions at the time of spray of this plot. The number of viable spores deposited per acre was also highest with this formulation. Budworm population reduction was highest in plots treated with Dipel alone and Dipel + chitinase (76% and 94%, respectively) but these two plots had extremely high pre-spray populations (52 to 69 larvae per 18" branch), and starvation may well have contributed to the drastic reduction. The thuricide treatments, chitinase alone, and fenitrothion (4 oz. ai/A produced 24-29%, 0%, and 55% population reduction respectively.

Data on larval development and frass collected on mats placed under sample trees indicate that Thuricide + chitinase and Dipel + chitinase were the most effective in slowing down larval development and reducing feeding activity. Chitinase alone did not affect these criteria, but the Bt formulations without chitinase were also highly effective.

Mortality of non-target organisms (collected on mats) in control plots were only slightly lower than in treated plots indicating that Bt is relatively safe for beneficial organisms.

The plot treated with Thuricide + Chitinase showed 41% current growth defoliation as against 90% in the untreated check. The difference was highly significant at 99% level of confidence. Defoliation on trees treated with Thuricide alone was the same as that in untreated check plots.

Probit analyses of the data showed a direct relationship between ground level deposit rates and defoliation in Thuricide-treated plots and between ground deposit rate and population reduction in Dipel treated plots. There were no substantial differences in deposit rates, or droplet densities, at 10', 15' and 25' levels of the tree crowns, indicating good break-up and distribution of the sprays.

The incidence of B. thuringiensis septicemica in dead larvae collected in the plots was highest in the Dipel alone plot followed by Thuricide alone, Thuricide + chitinase, and Dipel + chitinase in that order. All plots showed very low natural incidences of nuclear polyhedrosis virus or microsporidea. Residual activity of the sprayed bacteria decreased with time but viability of some spores lasted up to 42 days post-spray.

Studies on post larval effect of the treatments showed that (1) moth emergence was drastically reduced among insects treated with Thuricide + chitinase, (2) the pupal weight among Dipel alone treated insects was considerably lower than in other treatments or untreated check, (3) B. thuringiensis apparently has no effect on moth emergence sex ratio, (4) the Dipel treatment caused a substantial reduction in oviposition as well as the viability of deposited egg masses.

APPENDIX 16

NOT FOR PUBLICATION

AERIAL APPLICATIONS OF BACILLUS THURINGIENSIS (BT) FENITROTHION COMBINATIONS AGAINST THE SPRUCE BUDWORM

(Study Ref. No. CC-1-019)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

O.N. MORRIS

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada,
Ottawa, Ontario.

October, 1973

Aerial Applications of *Bacillus thuringiensis* (Bt)

Fenitrothion Combinations Against the Spruce Budworm

Project #CC-1-019

A Report to the Annual Forest Pest Control Forum

by O.N. Morris

White spruce and balsam fir trees carrying high populations of spruce budworm were sprayed with mixtures of Thuricide[R] 16B (International Minerals and Chemicals Corp., Libertyville, Illinois) or Dipel[R] Wettable Powder (Abbott Laboratories, Chicago, Illinois) and fenitrothion.

Plots located on the Petawawa Forest Experiment Station, Chalk River, were sprayed at the rate of 4 billion International Units of bacteria (in 0.5 gallon U.S. liquid suspension) plus 0.25 oz ai. fenitrothion per acre. Plot sizes varied from 65 - 100 acres. Eighteen-inch branch samples were taken from white spruce and balsam fir sample trees at intervals of 0, 8, 17, and 30 days post-spray and data were collected throughout the field season to supply information on deposit and distribution of sprays, spruce budworm population reduction, larval development, mortality of non-target organisms, effect of treatments on feeding activity and larval growth, larval mortality, incidence of naturally occurring and introduced pathogens, defoliation on white spruce and balsam fir, oviposition and post-larval effects.

Analysis of the data so far has shown that:

1. Plots were sprayed while larvae were mostly in the 4th instar on both tree species,

2. Meteorological conditions at the times of spray were generally unsatisfactory with stability ratios varying from unstable to marginally stable conditions,

3. Only 16%, 27%, 14, and ?% of emitted sub-lethal fenitrothion (0.25 oz ai/acre) Dipel & Fenitrothion, Thuricide & Fenitrothion and Operational fenitrothion, respectively, reached grown surface. This may be compared with 81% deposit of Thuricide & Chitinase at Algonquin Park under more ideal meteorological conditions,

4. Dipel & fenitrothion reduced spruce budworm population by 87% and 6% on balsam fir and white spruce, respectively. The sub-lethal and operational doses of fenitrothion reduced populations by 60 and 55%, respectively.

5. None of the treatment adversely affected non-target organisms from either tree species,

6. Larval development was slower and feeding activity lower in Bt-fenitrothion treated plots than in insecticide treated plots or untreated checks,

7. Larvae from both white spruce and balsam fir on Thuricide & fenitrothion treated plot showed the highest incidence of bacterial septicemia. The natural incidences of nuclear and cytoplasmic polyhedrosis viruses and of microsporidia were low in treated and untreated plots,

8. The sub-lethal dose of fenitrothion showed the largest reduction in moth emergence. The population treated with Thuricide & fenitrothion deposited fewest viable eggs per female,

9. Percentages defoliation on the Thuricide & fenitrothion plots were 26 and 59 and on operational fenitrothion plot (4 oz ai per acre) were 31 and 58 for balsam fir and white spruce, respectively. Defoliation estimates for the other plots will soon be availbble.

APPENDIX 17

Evaluation of Insecticides For Registered Use in Canadian Forestry: Applications of Commercial Preparations of Bacillus thuringiensis for Control of Spruce Budworm

(Study Reference No. CC-1-025)

By

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November, 1973

I. INTRODUCTION

Commercial formulations of *Bacillus thuringiensis* (Bt) contain spores, which are the hardy forms of the bacteria, and a toxic protein crystal. The value of this crystal protein to the bacteria is uncertain but it is known that the crystal is extremely important in the pathogenicity of the bacteria since it does affect the gut of the insect thereby allowing the bacteria (which germinates from the ingested spores) to pass more easily from the gut of the insect to its blood stream. Here greatest damage is done and the insect dies after a few days. Bt is now widely used on agricultural crops and has considerable potential for forestry crops as well. The spruce budworm is highly susceptible to Bt.

A field study was designed in 1973 to evaluate Bt for operational application after consultation with staff from regional laboratories of the Canadian Forestry Service and from industry. The major objectives of the study were to:

(1) Assess and compare the efficacy of various Bt spray formulations as developed by the C.F.S. and other agencies against the spruce budworm.

(2) Monitor Bt aerial spray applications for impact on representative non-target organisms.

(3) Report the results of the inter-disciplinary study to management with reference to product registration and recommendation for control of this insect.

Results of C.C.R.I. Bt Spray Experiments

I Laboratory Toxicological Experiments, 1973.

Five concentrations of Thuricide[R] and Dipel[R] were tested against fifth instar laboratory reared spruce budworm larvae, in order to compare the stomach toxicity of Bt formulations with and without chitinase. The formulations were sprayed on larch foliage @ .5, 1 and 2 gpa and given to larvae as food. The observations were taken three, five and seven days after treatment. The final observations after seven days are arragged in descending order of toxicity.

Dipel = Dipel + Chitinase > Thuricide + Chitinase > Thuricide

II Simulated Aerial Spray Applications of Bt to Small White Spruce, Shawville Quebec, 1973.

The apparatus and technique were successfully field tested on plantation grown spruce, 8-10 ft high, with a natural infestation of spruce budworm. The opportunity was taken to run a series of tests on the Bt formulations being investigated by C.C.R.I. in aerial application trials in Algonquin Park. Eight different formulations were applied to 50 trees. A portable tower was placed around each tree and a measured volume of the test mix emitted (66 fl. oz/acre, nominal) by a spinning disc device being moved systematically over the area within the tower. Samples of deposit showed good distribution of drops, with size ranges similar to that obtained in aerial spray deposits. Observations of budworm populations on treated and control trees before and after treatment were made.

The effect of the various treatments on budworm control were judged by comparison of treated tree budworm levels with that on control trees. There are two parameters here; (1) the number of budworm at final count related to the number of mined needles. There was good correlation between these two counts and most emphasis was placed on this criterion when judging effectiveness. (2) The average infestation level as measured by number of budworm per 100 buds. Infestation levels between trees on this basis varied widely but was also taken into account in judging effectiveness.

The indications are:

1. Dipel alone gave a small reduction in population compared with control; Thuricide alone resulted in an "increased" population over control.

2. Addition of chitinase did not change effectiveness of Dipel: chitinase added to Thuricide improved it significantly to make it more effective than Dipel with or without chitinase.

3. Chitinase alone gave a slight reduction from control, the same as Dipel with and without chitinase.

4. The addition of a very small amount of fenitrothion (0.4%) to Thuricide activated this formulation and reversed population change from 35% "increase" (Thuricide alone) to 13% decrease. Fenitrothion added to Dipel in the same amount, again showed Dipel to be more active than Thuricide with 43% reduction.

5. Fenitrothion at 6 oz. a.i./acre (average measured deposit) gave better control than any other treatment (50% reduction) and at 2.2 oz. a.i./acre was not as effective as Thuricide + chitinase or Dipel + 0.4% fenitrothion.

As a check for other possible activity of the various mixes the percent of budworm in each stage of development at time of final count was determined. In the cases of Dipel, Dipel + chitinase, Dipel + fenitrothion and Thuricide, budworm development seems to have been slowed as indicated by a small percent in the pupal stage as compared with control. Thuricide + chitinase however had normal distribution as did chitinase alone. In the case of heavy fenitrothion (5.9 oz. a.i./acre) there is a much higher percent in pupal stage, probably as a result of smaller larvae being more susceptible to the insecticide and eliminated from sample.

III Aerial Applications of Bacillus thuringiensis and/or Chitinase Against the Spruce Budworm, Algonquin Park, 1973

In 1973, spruce budworm infested balsam fir and white spruce in Algonquin Park were aerially sprayed with Thuricide 16B^{R} (International Minerals and Chemicals Corp., Libertyville, Illinois) or Dipel^{R} Wettable Powder (Abbott Laboratories, Chicago, Illinois). The sprays were formulated with and without Chitinase, an enzyme, which, when ingested by insects, renders the pest more susceptible to bacterial infection. Test plots were 100 acres in area, except for the Thuricide alone plot which was 2500 acres.

Applications were made May 29 - 31 when the budworm were mostly in the 3rd instar at the rate of 4 billion International Units (in 0.5 gallons of liquid suspension) per acre. A Cessna agtruck and a Piper Pawnee, both fitted with Micronair emission units, were used for all applications.

The meteorological tower and instruments to record wind speed and direction, turbulence, temperature and relative humidity was set up adjacent to the 2500 acre block. The tower operator was in radio contact with the ground crews in the spray plots and with the support personnel at the airstrip. Prior to spray application the limits of desirable spray conditions were set as being a wind speed of less than 8 mph and inversion temperature conditions. At the time of each spray period, observations of meteorological conditions were made starting one to two hours before the expected time of spray and continuing for one to two hours after the spray. With the exception of the Dipel + chitinase application made under neutral conditions which shifted to lapse by the end of spray application all sprays were made under the desired weather conditions. A complete analysis of the meteorological conditions at the time of spray applications is being made and will be reported at a later date.

The percentages of emitted spray which reached sampling units at ground surface were 34, 81, 33, 27, and 18 for Thuricide alone, Thuricide + chitinase, Dipel alone, Dipel + chitinase, and chitinase alone, respectively. The high deposit recovery of the Thuricide + chitinase application was likely due to ideal meteorological conditions at the time of spray of this plot. The number of viable spores deposited per acre was also highest with this formulation. Budworm population reduction was highest in plots treated with Dipel alone and Dipel + chitinase (76% and 94% respectively) but these two plots had extremely high pre-spray populations (52 to 69 larvae per 18" branch), and starvation may well have contributed to the drastic reduction. The thuricide treatments, chitinase alone, and fenitrothion (4 oz. ai/A produced 24-29%, 0%, and 55% population reduction respectively.

Data on larval development and frass collected on mats placed under sample trees indicate that Thuricide + chitinase and Dipel + chitinase were the most effective in slowing down larval development and reducing feeding activity. Chitinase alone did not affect these criteria, but the Bt formulations without chitinase were also highly effective.

Mortality of non-target organisms (collected on mats) in control plots were only slightly lower than in treated plots indicating that Bt is relatively safe for beneficial organisms.

The plot treated with Thuricide + chitinase showed 41% current growth defoliation as against 90% in the untreated check. The difference was highly significant at 99% level of confidence. Defoliation on trees treated with Thuricide alone was the same as that in untreated check plots.

Probit analyses of the data showed a direct relationship between ground level deposit rates and defoliation in thuricide-treated plots and between ground deposit rate and population reduction in Dipel treated plots. There were no substantial differences in deposit rates, or droplet densities, at 10', 15', and 25' levels of the tree crowns, indicating good break-up and distribution of the sprays.

The incidence of B. thuringiensis septicemica in dead larvae collected in the plots was highest in the Dipel alone plot followed by thuricide alone, thuricide + chitinase, and Dipel + chitinase in that order. All plots showed very low natural incidences of nuclear polyhedrosis virus or microsporidea. Residual activity of the sprayed bacteria decreased with time but viability of some spores lasted up to 42 days post-spray.

Studies on post larval effect of the treatments showed that (1) moth emergence was drastically reduced among insects treated with thuricide + chitinase, (2) the pupal weight among Dipel alone treated insects was considerably lower than in other treatments or untreated check,

(3) B. thuringiensis apparently has no effect on moth emergence sex ratio, (4) the Dipel treatment caused a substantial reduction in oviposition as well as the viability of deposited egg masses.

IV Environmental Impact Studies, Algonquin Park, 1973.

The following components of the environment were monitored for side effects produced by the aerial application of a bacterial spray in Algonquin Park; small mammals, small forest songbirds, the aquatic fauna in Opeongo River, non-target insects, parasites of the spruce budworm and colonies of domestic honeybees.

Breeding Birds:

Populations and territories of breeding songbirds were monitored before and after application. Census plots covered an area of 20 acres and were located on each of the 5 spray plots and a control. The most common families censused were Parulidae (the warblers) and the Fringillidae (Sparrows, Finches, Grosbeaks). Examination of the data to date indicates that the breeding bird fauna did not suffer measurable side effects due to the spray. Specimens of birds were collected by mist nets and preserved for later examination for any possible infection by the bacterium.

Small Mammals:

Standard snap-back trapping methods were employed on all plots to obtain small mammal specimens. Three consecutive trap nights produced a total of 53 animals including deer mice, red-backed mice, jumping mice, chipmunks and shrews. Breeding adults and sub adults were collected from all plots except # 2 where only a single specimen of Blarina brevicavda was taken.

Adult female specimens were dissected and the genital tract examined for embryos and placental scars. Preliminary results indicate that no detrimental side effects were suffered by the small mammal complex in the areas sprayed.

Aquatic Environment:

The Opeongo River, which flows through the 2500 acre Thuricide treated plot was monitored for side effects upon the fish and benthic fauna. Pre and post spray; qualitative and quantitative samples of the river bottom were collected, direct observation records of fish and aquatic insects were taken as well as drift net samples. Preliminary analysis of field data and examination of some of the bottom samples indicate that the Bt. application had little or no impact upon the river fauna. The drift net samples show a light knockdown of adult midges during the spray. This is likely related to mechanics and formulation rather than toxicity. The apparent persistence of viable Bt spores in river water and in fresh water clams for periods up to one month is indicated and is now being studied further.

Honey Bees:

42 colonies of honey bees were used in the five spray and 1 control plot (7 on each). Each colony was equipped with an activity counter and pollen trap. Brood was examined throughout the test period and hive weights were taken at regular intervals. The bees were placed on the plots 2 days prior to spraying and left for 11 days after application and then removed to the H.Q. bee yard for further observations. Examination of data processed to date indicates no impact upon the adult bee population or brood. Pollen production does not appear to be affected and colonies did not suffer a weight reduction as a result of the spray.

Non-Target Insects:

Non-target insects were sampled by three techniques:

(1) Pitfall traps for forest floor invertebrates.

(2) 18" branch samples for foliage feeding insects.

(3) Sweep net samples of insects from ground flora.

The pre-spray sampling was conducted just prior to the applications of the bacterium and the post spray collections taken immediately after the spray and again in one and four weeks. Results available at this date indicate a reduction of leaf rollers and insects infesting foliage collected from 18-inch branches but populations of insects inhabitating the forest floor or low plants and shrubs did not sustain any measurable side-effects which can be attributed to the spray program.

Spruce Budworm Parasites:

Spruce budworm were collected from the plots as pre-spray and 2nd-3rd instar larvae, 5-6th instar post spray larvae (spray day + 14) and as post spray pupae. Rearing took place in the rearing rooms of C.C.R.I. Data are in preliminary stages of analysis, but to this point there appears to be no significant differences in parasitism, as a result of the treatment.

V Bt Spray Experiments at Spruce-Woods Provincial Park, 1973.

Both aerial and groundspray treatments of Bt for control of spruce budworm (on white spruce) were applied in June at the Spruce Woods Provincial Park, Manitoba. The experimental sprays were made as a research contribution in conjunction with operational applications of the insecticide fenitrothion by the Manitoba Government.

Two 100-acre blocks were selected for airspray (Cessna Agwagon, 4 Micronair AU2000 units) with Dipel[R] at the same dosage used in Algonquin Park (i.e. 4 billion International Units) but at higher spray emission rates (2 and 4 gal. water/molasses mix) per acre. Airsprays were made June 8-10 against mostly 4th-and-5th-instar larvae, about one week late due to inclement weather (e.g., winds to 60 m.p.h.).

Groundsprays by mistblower (John Bean Model 51) were made on June 9 and 10, utilizing replicated groups of 25 trees. Treatments included Dipel[R] and Thuricide[R] formulated as per aerial spray specifications, but diluted and applied at approximately 100 gal. spray mixture/ac.

Larval mortality (reduction) in airspray blocks five days after treatment was approximately 70%, about 85% after 10 days, and 95% after 15 days.

Corrections for extremely high natural population decline (due to competition for food) indicated that actual mortality due to treatment at the 2 gpa rate was only 43.2% ten days after application and 60.8% at the 4 gpa rate. Foliage protection analyses have not been completed to date. Cessation of feeding was documented on many sample trees, however, and it is expected that up to 90% of the foliage was preserved on some trees which obtained optimum deposits.

Similarly, groundsprays of both Bt preparations induced variable mortality (and protection of foliage) within treatment plots. Superior reductions of budworm populations were attained by the Thuricide[R] sprays (73.3% reduction), but rainfall which occurred after the Dipel[R] (20% reduction) sprays could have, in part, accounted for this difference.

Preliminary analysis of results indicate that the Bt sprays were effective in inducing high mortality of infected larvae and good protection of some, but not all, treated trees. It is suspected that higher concentrations of spray mixtures might have provided more effective control. The excessively high budworm populations (70-90 larvae/18 in. branch tip) and the inclement weather which prevented optimum timing of sprays were the two most important factors influencing efficacy of the Manitoba Bt sprays.

SUMMARY AND CONCLUSIONS

A confidential and preliminary report on this study was distributed to collaborators on August 24, 1973. Complete details will be available by means of a C.F.S. Information Report planned for early 1974. Although data analyses are incomplete at this time, the authors believe the following general statements to be true:

(1) Laboratory toxicological studies indicated that Dipel^{R} is more infectious than Thuricide^{R} at equivalent dosages.

(2) Field applications of Thuricide^{R} plus chitinase indicated that good protection of foliage can be obtained with this combination.

(3) No measurable detrimental effects on non-target organisms were detected after application of any of the prescribed Bt treatments.

(4) In view of the urgency of registration requirements, the authors feel that the current dosages as recommended by the manufacturers will provide some protection of infested stands. The degree of control (or protection) is highly dependent on population densities, host condition, spray coverage, etc., although the addition of chitinase will enhance efficacy of all sprays.

(5) Additional evaluations of spray formulations, dosages and adjuvants are definitely required for recommendation against spruce budworm.

(6) It is concluded, therefore, that registration procedures for commercial Bt preparations may be initiated immediately with the expectation that use at this time may be practical only in limited areas within the distribution of the current budworm outbreak.

APPENDIX I 8 NOT FOR PUBLICATION

STUDIES ON THE CONTROL OF THE SPRUCE BUDWORM BY AERIAL APPLICATION OF CHEMICALS

(Study Reference No. CC-001)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

A. P. RANDALL

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario.

November, 1974

Studies on the Control of the Spruce Budworm
By Aerial Application of Chemicals

Study Projects for 1973 (Ref. No. CC-001)

A. Research and Development of ULV spray equipment on the following type aircraft used for aerial application of insecticides:

1. Multi-engine aircraft. (DC-6, Constellation 1049, constellation 749.
2. Twin-engine aircraft.
   Canadian CL-215
   Lockeed Ventura (PV-2)
3. Single engine aircraft
   Grumman Avenger TBM.

B. Calibration of Multi-engine Aircraft:

1. DC-6 - (Barstow California USA - Feb 1973)
   (Williams Lake, B.C. - Oct 1973)
2. Constellation 1049. (Barstow Calif. Feb, Mar 1973)
3. Constellation 749. (Barstow Calif. Mar, 1973)

Calibration of Twin engine aircraft:

1. CL-215 (Canadair)(Barstow, Calif. U.S.A. Jan/Feb 1973)
2. Lockeed PV-2 (Barstow, Calif. U.S.A. Feb, 1973)

Calibration of Single engine aircraft:

1. TBM (Abbotsford, B.C.) Mar, 1973.

C. Assessment of ULV spray equipment of the above aircraft under operational spraying conditions:

1. DC-6 Field trials (Lac du Loup)
2. Constellation 749 Field trials (La Ma Coza)

3. Canadair CL-215 - Field trials (Riviere du Loups)

4. TBM Avenger - Field Trials (Riviere du Loups)

D. Field Development and assessment of the electronic guidance system for incremental spraying of pesticides for spruce budworm control.

1. DC-6 Decca field trials (Lac du Loup, Quebec)

2. CL-215 Litton LTN-51 field trials (Riviere du Loups, Que).

Results of the 1972 - DC-7 trials using the Litton LTN-51 inertial guidance system for aircraft/spray block positioning and swath track alignment indicated that accurate guidance was essential for the proper location and placement of large aircraft over the desired target site. Without a type of electronic guidance system the aircraft could not operate satisfactorily as a spray aircraft due to their higher speeds and hence increased magnitude of error. This fact was well illustrated in 1973 when early spray flights were attempted using the DC-6 on a visual spray block identification basis. The human error in swath positioning was also shown during Decca trials when the Decca signals from one of the slave stations was too weak to record the pairs of Decca lanes required for coordinate positioning of the aircraft during spraying.

Data from the aerial and ground monitoring of the Decca guidance system and the Litton Intertial guidance system trials are currently under analysis and will be presented at a later date.

E. Research and development of insecticide formulations for aerial application:

1. ULV fenitrothion formulations.

2. ULV Zectran formulations.

3. ULV Matacil formulations.

Research and development of insecticide formulations for aerial application using multi engine aircraft.

This phase of the program was initiated during the early days of the DC-7 trials, when it became imperative to maintain a wide swath width in order to reduce the basic operating cost per acre of sprayed forest. Data from the ULV - high concentrate sprays formed the basis for the development of a suitable formulation for use in the larger aircraft. The present low cost oil formulation recommended for the DC-7, and used successfully in 1973 is currently being investigated for the night spray trials, scheduled for 1974.

resultant improvement in both droplet spectrum and spray cloud formation. This is a continuing project with modification and developments being currently undertaken.

B. Calibration of single, twin and multi-engine type spray aircraft.

Because of the magnitude of the Quebec Spray project in 1973 and their decision to go directly to the large multi-engine spray aircraft it became imperative not only to develop new spray systems in these machines but also to undertake a series of calibration trials on each type to establish swath width, rate of flow and froplet spectrum performances on each type equipment. Preliminary assessment of the various machines established the following parameters for each group.

Multi-engine aircraft - swath width - 3000 feet interval for a deposit emission of 20 oz/ac. using oil formulations of insecticides

Single and twin-engine aircraft - 1500 foot interval for oil formulations.

- 1000 feet interval for oil/water formulations.

C. Assessment of ULV spray equipment of type aircraft under operational spraying condition.

To confirm the results of the calibration trials, experimental blocks were established within the operational spray area at Lac du Loup airport and La Macoza to assess the deposit characteristic of the DC-6 and Constellation 749 aircraft. Results were in very close agreement with those found and recommended from the earlier calibration trials.

Similar studies were undertaken with the Canadair CL-215 and the Grumman Avenger (TBM) aircraft at Riviere du Loup; eastern Quebec, using water and oil based formulations.

D. Field Development and assessment of electronic guidance systems for incremental spraying of pesticides for spruce budworm control.

Experimental use of viruses to control spruce budworm, *Choristoneura fumiferana*

Spray trials in 1973

1973 was the third year of virus spray trials and 9 plots (total of 738 acres) in 2 areas were sprayed with nuclear polyhedrosis virus. The first area, about 10 miles north of Massey, Ontario, covered 385 acres and was divided into 4 plots; the second, near Mashagama Lake, Ontario, covered 353 acres divided into 5 plots. A Grumman Agcat fitted with Micronair spray equipment was used for all the applications and the emission rate for the aqueous suspensions was 1 U.S. gal./acre. The size of the plots, formulation, the stage of development of the larvae, and the percentage virus infection which resulted, are given in Table I. A satisfactory deposit, recorded on spray cards, was obtained on all plots except No. 5 and No. 9 which had to be sprayed during sub-optimal conditions in order to maintain the desired relativity in timing of applications. Population reduction studies were made by Dr. G. M. Howse of G.L.F.R.C. and are presently being analyzed.

There was no significant foliage protection in the sprayed areas, which is as expected in the year of introduction of this kind of virus. The infection obtained on plot 3, using 100×10^9 inclusion bodies/acre, indicates that this is an adequate dosage to initiate an epizootic when applied during the second instar. This dosage also causes a reasonably good level of infection when applied during the fifth instar as shown in results for plots 6, 7 and 8. The higher level of infection found in plot 7 indicates that the use of Chevron sticker enhances the formulation.

Follow-up studies on previous years' applications

To have a significant impact on an insect population, viruses should persist in the population following application. Virus was recovered in 1973 from 6 plots sprayed near Pembroke, Ontario in 1971 and the level of virus infection varied from 4% to 17% in these plots. These levels are down from the 1972 levels but are still quite significant. Some population reduction due to virus, and foliage protection, were recorded by Dr. G. M. Howse.

No virus was recovered from an area of 3 square miles near Chapleau, Ontario which was sprayed in 1972. This was not unexpected since the spruce budworm population was decimated by frost soon after the application; the population level throughout the entire area in 1973 was very low.

J. C. Cunningham

Insect Pathology Research Institute,
Sault Ste. Marie, Ontario,
October 25, 1973.

Table I

Plot number	Locality	Acreage	Dominant instar when sprayed	Virus inclusion bodies/acre	Additives	Percent Virus Infection* Balsam fir	White spruce
1	Massey	100	II	20×10^9	2.5% IMC sunlight protectant	2	9
2	"	70	"	50×10^9	"	5	17
3	"	140	"	100×10^9	"	12	37
4	"	75	"	40×10^9 (double application)	"	3	10
5	Mashagama	110	V	50×10^9	"	2	10
6	"	80	"	100×10^9	"	10	13
7	"	80	"	100×10^9	2.5% IMC sunlight protectant, 0.13% Chevron sticker	17	26
8	"	50	"	100×10^9	2.5% IMC sunlight protectant, 0.2% Biofilm	7	13
9	"	33	"	100×10^9	None	6	7

*Highest percentage observed in post spray random samples

THE EFFECT OF FOREST SPRAYING WITH FENITROTHION ON POLLINATION AND SUBSEQUENT FRUIT SET AND YIELD OF LOWBUSH BLUEBERRY

The following report summarizes the activities and findings of the study (MC-73C-4) contracted with Mr. R.B. Scott of Charlotte County, N.B. during the past year. Although field activities concluded in July, some analyses have yet to be made and a full report will not be prepared until a later date. However, some of the data available at this time should be helpful in discussions pertaining to the broader aspects of the forest spraying operation in New Brunswick, particularly where they might relate to future planning.

The 1973 study included two aspects: the first part was to deliberately apply a direct spray to a blueberry field at the peak of the bloom period with fenitrothion, and to determine the effect of this insecticide application on pollinator activity and subsequent fruit set and yield; the second part was to measure the same effects but in commercial fields exposed to the insecticide only as it might occur as a result of drift from the operational forest spray carried out by Forest Protection Ltd.

The first part of the study was carried out in the vicinity of Lynnfield, Charlotte County, N.B. and was approximately ten miles west of the nearest block of forest spraying. A private air service was hired to carry out the spraying, and this was done on June 8 with a Piper Pawnee aircraft outfitted with proper equipment for crop spraying. The insecticide was obtained from the regular stock stored at the Juniper airstrip and provided by Forest Protection Ltd. The sprayed blueberry field was in the centre of a five acre block sprayed with fenitrothion at the rate of 4 ounces/acre.

Because of heavy fog during the morning of the spray date, the application was not made until 12:30 p.m. At the time of application, the temperature had reached 78°F and the air was calm with occasional gusts of wind between 3 and 5 m.p.h. Three panes of glass each measuring 20 in. x 12 in. and previously washed with benzene were placed in the field before spraying. One-half hour after spraying the glass panes were washed with benzene and the washings refrigerated until they were analysed at the Kentville Research Station. Using a gas chromatographic method of analysis, fenitrothion residues expressed as 15.8, 9.2, and 16.4 grams/acre were obtained. Counts of native bees and honeybees were made in the sprayed field and four nearby unsprayed fields during three days previous to spraying and three days after spraying. There was no measurable decrease in bee activity in any of the fields and no indication of honeybee mortality in the hives. Fruit set in the sprayed field was similar to that recorded in the unsprayed fields. There was no evidence that the spraying with fenitrothion had in any way affected the pollinating insects or the blueberry crop.

The second part of the study consisted of a comparison of pollinator densities, fruit set, and yield in fourteen commercial blueberry fields in Charlotte County, N.B. Five fields were within designated blocks for forest spraying, five were outside of the designated spray blocks but no greater than five miles away, and four were ten miles away from the nearest sprayed block (they were, in fact, the four control fields used in the first part of the study). Data were obtained on native bee activity, fruit set, and yield in all fields. Glass panes were also placed in each field, and within two hours after nearby forested areas had been sprayed with fenitrothion by F.P.L aircraft, the panes were washed with benzene, the washings refrigerated and

.../3

later sent to Kentville for residue analyses. There was no detectable fenitrothion residue in the fields ten miles from the spray operation, there were at least trace amounts in all fields located within five miles of the spray operation, and samples from four of the five fields located within the spray blocks contained significant amounts of residue (one field contained as much as 7.3 grams of fenitrothion per acre, two contained an average of 2.7 grams/acre, one contained an average of 0.5 grams/acre). Because all commercial fields are marked on maps provided for the spray applicators, it is assumed that the residues obtained were the result of drift. Statistical analyses of the data showed significant negative correlation between amount of fenitrothion residue found in the field and all of the parameters measured. The interaction between spray residue and yield showed an R value of -.7021 with the probability of $R \neq 0$ was 0.98 - 0.99.

The two aspects of this study appear to present contradictory findings. In the direct spray test there was no measurable effect of fenitrothion on pollinator activity or crop production. On the other hand when the effects of the operational spray were monitored there was significant correlation between relatively small amounts of fenitrothion residue, bee activity, fruit set, and yield. This apparent contradiction cannot be explained at this time. However, it is known that the spraying operation carried out with the Pawnee aircraft was done at midday at very high temperature, while the operational sprays carried out with T.B.M. (Avenger) aircraft were done early in the morning at much lower temperatures. In fact there has been a court injunction prohibiting F.P.L. from spraying near blueberry fields (in bloom) when the temperature is above 45°F. I would suggest that we need to know more about the effect of temperature on spray deposition and fenitrothion toxicity before we can make further comment at this time.

George Wood

G.W. Wood, Research Scientist,
Fruit Insects, Research Station,
Fredericton, N.B.

EASTERN HEMLOCK LOOPER SPRAYING OPERATIONS

ON ANTICOSTI ISLAND IN 1973.

by

L.J. Jobin, Laurentian Forest Research Centre,
Canadian Forestry Service, Quebec.

and

R. Desaulniers, Direction Générale de la Conservation,
Department of Lands and Forests, Quebec.

INTRODUCTION

Aerial spraying operations to protect valuable forest stands against the eastern hemlock looper, *Lambdina fiscellaria fiscellaria* (Guen.), were conducted on Anticosti Island for the past two years by the Quebec Department of Lands and Forests. The Laurentian Forest Research Centre participated in planning the operations and was responsible for timing of spray application and assessing results.

In 1973, the aim of the operation was twofold: to prevent tree mortality and to insure foliage protection of the affected balsam fir stands. Cost of the operation was shared between the Department of Lands and Forests and the Consolidated-Bathurst Company.

Defining areas requiring protection

In 1972, a total of 425,000 acres of mature balsam fir stands were treated with fenitrothion. A residual outbreak remained in some 50,000 acres of the treated area located mainly in the Jupiter and Brick watersheds. The 1973 pre-spray surveys of eggs and young larvae indicated that populations had collapsed in most areas where high moth counts and defoliation was reported in 1972, but that some 10,328 acres near Port-Menier still remained infested and would require treatment to prevent further tree mortality.

Spraying operation

A CL-215 water-bomber of the Quebec Department of Transport modified for insecticide spraying was used. The aircraft operated from the base at Bonaventure, Gaspé Peninsula. As for the 1972 spray operation, two applications of fenitrothion at the rate of 2 ounces per acre were recommended; the first application was to be made when twenty percent of the larvae had reached the second instar.

The first sprays, through fortiutous circumstances, consisted of a mixture of phosphamidon and fenitrothion and was applied at the rate of 2 ounces per acre June 29, 1973 on approximately 6,274 acres. Because of fast looper development, due to warm and dry weather conditions, it was recommended that the second application take place 5 days after the first spray. This optimum timing could not be achieved because of unfavorable weather conditions and the second application took place 8 days after the first one. Fenitrothion alone was used at the rate of 2 ounces per acre. For uncontrollable reasons the remaining 4,054 acres received only one application of fenitrothion on July 9.

Effectiveness of operation

High larval mortality was observed in areas having received one and two applications; average total mortality was 95.5 percent. Surveys indicated that epizootics caused by Entomophthora fungi occurred and were responsible for the collapse of localized infestations in the Jupiter and Brick watersheds; these entomogenous fungi are also believed to have reduced looper numbers in the areas sprayed in 1973. The old foliage suffered light defoliation and new foliage was severely damaged on 2,528 acres. Seventy five percent of treated areas showed no apparent defoliation.

In the sprayed area of 1973, there was no measurable increase of tree mortality in comparison with that of last year. Moth, pupae, and egg surveys indicated a complete collapse of the insect populations. No further damage is expected in 1974.

The 1972 and 1973 aerial spraying operations played an important part in bringing the eastern hemlock looper outbreak on Anticosti Island to an end.

Report prepared for the
Interdepartmental Committee
on Forest Spraying Operations.

November 1, 1973.

Effectiveness of an aerial application of a Juvenile Hormone Analog against the Eastern Hemlock Looper, *Lambdina fiscellaria fiscellaria*

Arthur Retnakaran[1], Luc Jobin[2], and Charles Buckner[3]

Canadian Forestry Service, Department of the Environment

1. Insect Pathology Research Institute, Sault Ste. Marie, Ontario.

2. Laurentian Forest Research Centre, Ste. Foy, Quebec.

3. Chemical Control Research Institute, Ottawa, Ontario.

One of the functions of juvenile hormone is to regulate larval differentiation in insects. During the last larval instar, juvenile hormone titer diminishes progressively concomitant with development towards the pupal stage. If at this time the hormone is applied topically, the larva is adversely affected and becomes a larval-pupal mosaic. This morphogenetic effect is the rationale behind the use of juvenile hormone as a pest control agent in this test.

Very many analogs of juvenile hormone have been synthesized, by commercial and non-commercial laboratories, that are more active and less labile than the authentic hormone. One such compound, Isopropryl 11-methoxy-3,7,11-trimethyldodeca-2,4-dienoate (Altosid or ZR-515) manufactured by Zoecon Corporation in California was found to be very active against the eastern hemlock looper (Fig. 1). Greenhouse tests showed that the chemical when sprayed on potted balsam-fir trees remained active for >21 days, was not decomposed by exposure to short-wave UV-radiation, and not washed-off from the needles when the tree was heavily sprayed with water at 24 hr intervals for 2 weeks. However when the material was suspended in water it lost its activity within 24 hr. The compound is quickly degraded by microorganisms but perhaps remains protected when adsorbed by the cuticular lipids in the needle.

A small area of a hemlock looper infestation on Anticosti Island was made available to us for our spray work and included four test blocks of 10 acres each, one of which served as a control plot. A Bell helicopter with boom and nozzle equipment was used for spraying the compound. Rhodamine-B was dissolved in the spray mixture to enable detection of deposition of spray droplets on cards. A telethermometer to detect the onset of inversion was used on the site. Possible drift of Fenitrothion being sprayed by the Quebec Government in adjacent areas was assayed from foliage in the juvenile hormone test blocks. GLC-analyses by Dr. Yule at CCRI indicated extremely low amounts (<10 ppm) and was considered as residue from previous year's drift. Bioassays confirmed that the population was not affected by the insecticide. Plots A,B,C were sprayed at a concentration of 3 oz, 1 oz, and 0.25 oz of active ingredient per 2 gallons per acre. The control plot was located approximately 5 miles from the hormone-blocks.

Pre-sampling was done at three times. The first sampling (first and second instar larvae) indicated a very heavy infestation. Since these larvae feed on new foliage, the pole clipping samples gave an accurate estimate of the population.

Ten days of hot and humid weather resulted in an Entomophthora outbreak. This fungus frequently attacks hemlock looper when the weather is favourable. Therefore a second sampling was necessary. The larvae (Third and fourth instars) had now dispersed and so the pole-clipping samples did not truly reflect the population. Therefore a beating sample was taken which showed that the population was still quite heavy (Table 1).

Following spraying, samples were collected from the test blocks and reared in the laboratory. Characteristic deformities were apparent indicating that the hormone was indeed acting on the insects. Population reduction was estimated from sampling pupae with burlap traps (Table 2). To ensure that the insects had not pupated on the upper crown, several trees were cut down and the pupae counted. Very few were found on the crown indicating that the hormone had not altered the normal pupation behavior of the insect (Table 3). In order to ensure that the larvae had not dropped from the trees and pupated in the ground, a moth survey using pherotraps was undertaken. The results showed a similar population reduction pattern (Table 4).

The possible effect of the hormone analog on small mammals, birds, and aquatic fauna was studied. The results indicate no measurable impact.

Since the hormone must be applied when the insect is in the last larval stage, it is apparent that the foliage protection afforded will not be realized until the succeeding year. Although the hormone is not species specific, it acts only at a particular developmental stage. Only those insects that are in the last larval instar will be affected. This affords a certain amount of developmental isolation of the pest species and hence the likelihood of effects on useful species such as predators and pollinators is minimal.

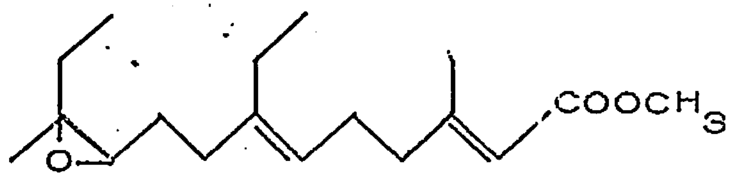
Arthur Retnakaran

Arthur Retnakaran

cc. Dr. J. M. Cameron,
Dr. L. Jobin,
Dr. C. H. Buckner

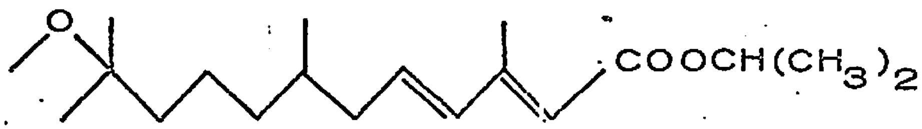
November 5, 1973.

CECROPIA JUVENILE HORMONE



Methyl rac-10,11-epoxy-7-ethyl, 3,11-cis-dimethyl-2-trans, 6-trans-tridecadienoate

ZR-515



Isopropyl 11-methoxy-3,7,11-trimethyldodeca-2,4-dienoate

Fig. 1. A comparison of Altosid (2R-515) with the Cecropia juvenile hormone.

Table 1

PRE-SPRAY BEATING SAMPLES

	Number of larvae/tree	
Sample No.	Plots A,B,C	Control Plot
1	540	132
2	304	288
3	1089	180
4	396	207
5	873	216
6	208	225
7	1224	-
$\bar{x}$	662	208
% Instars		
1:2:	0:4.1:66.6:	1.3:2.4:
3:4	29.3	85.4:10.9

Table 2

POST-SPRAY PUPAL SAMPLING

Plot	Pupae/Burlap Trap	Entomo-phthora	Parasite	Total Healthy Pupae	Healthy Pupae/ tree	%
Control	1984/10	226	139	1619	161.9	100
A (3 oz/2 gal/acre)	86/15	10	4	72	4.8	3.0
B (1 oz/2 gal/acre)	156/15	18	3	135	9.0	6.0
C (0.25 oz/2 gal/acre	593/15	72	30	491	32.7	20.2

Table 3

PUPAL POPULATION IN TREES CUT DOWN

Plot	Trees cut	Pupae	Entomo-phthora	Parasite	Healthy	Healthy/tree
Control	5	94	21	28	45	9.0
A	5	54	2	9	43	8.6
B	5	23	1	0	22	4.4
C	5	27	1	2	24	4.8

Table 4

MOTH SURVEY - PHEROTRAPS

Plot	Traps	Moths	Moths/Trap	* Beating: Moths/ tree
Control	5	182	36.4	4.8
A	5	27	5.4	0.55
B	5	23	4.6	0.65
C	5	21	4.2	0.85

*Axe-beating of tree trunk and counting moths that fly

APPENDIX 23

AERIAL SPRAYING AGAINST THE BLACKHEADED BUDWORM ON VANCOUVER ISLAND IN 1973 AND A FORECAST OF CONDITIONS FOR 1974

H.A. Richmond, J.R. Carrow, and R.L. Fiddick

Prepared For

ANNUAL FOREST PEST CONTROL FORUM

November 14, 1973

OTTAWA, ONTARIO

INTRODUCTION

The aerial spraying operation against the western black-headed budworm (*Acleris gloverana* Wals.) on northern Vancouver Island in 1973 was the first forest pest control operation in British Columbia since 1964 and the first against this insect pest since 1960. The project was conducted by the Council of Forest Industries of British Columbia and was the first operational test of fenitrothion against a forest insect in this province. The cost of the operation ($39,345.78) was shared equally by the Council and the Province of British Columbia. Mr. H.A. Richmond acted as Project Manager for the Council, and the Department of the Environment provided advice and services as follows:

Canadian Forestry Service

Pacific Forest Research Centre, Victoria

Dr. J.R. Carrow-entomological advice and assessment

Chemical Control Research Institute, Ottawa

Dr. C.H. Buckner-assessment of effects on birds and small mammals
Mr. W. Haliburton-analysis of spray deposits
Dr. K.M.S. Sundaram

Environmental Protection Service, Vancouver

Mr. M. Wan-assessment of effects on non-target arthropods

Fisheries Service, Vancouver

Mr. R. Taylor-assessment of effects on fish

Reports on the conduct of the operation and the entomological assessment follow.

OPERATIONS - H.A. Richmond[1/]

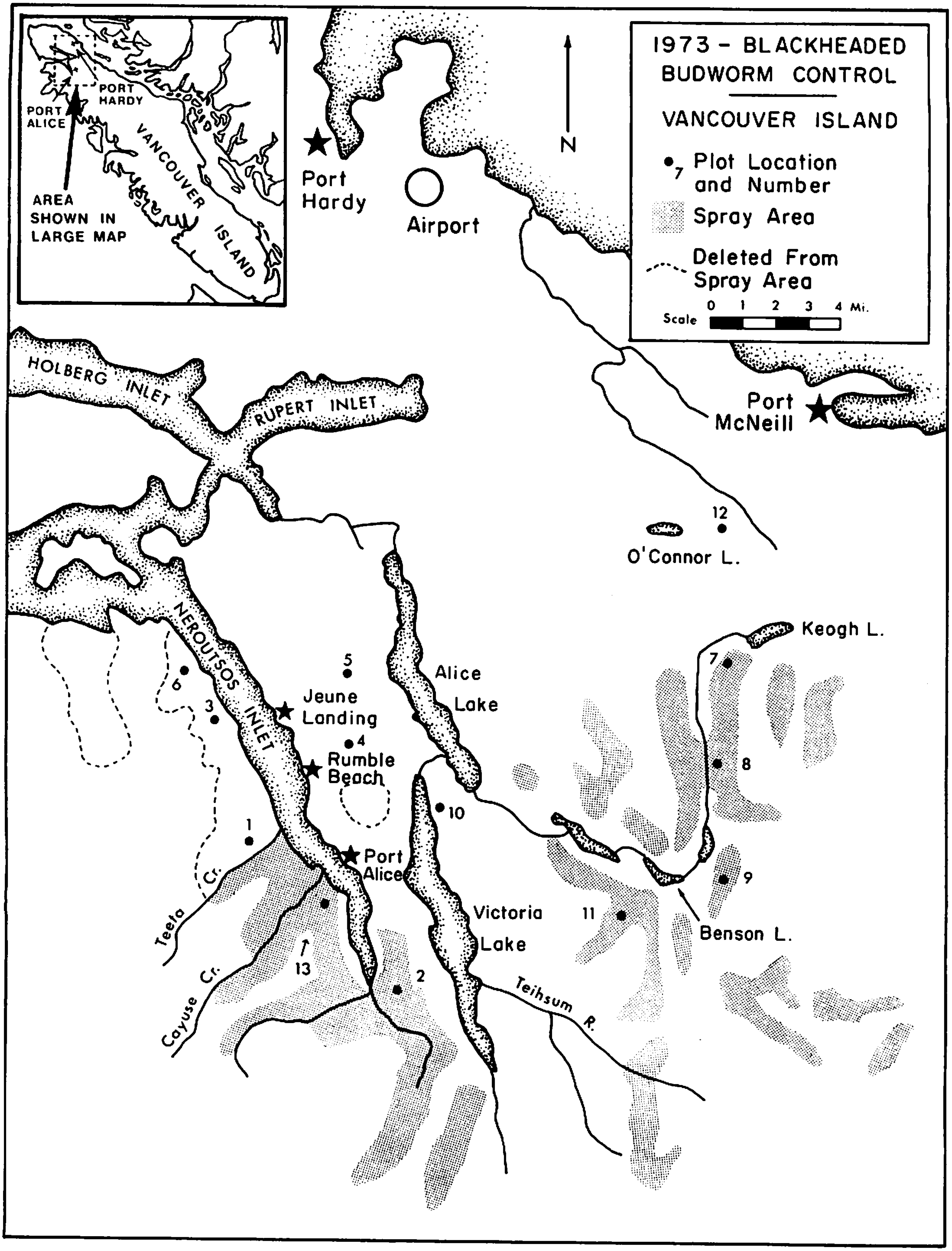
Control of the blackheaded budworm was undertaken in the Port Alice region of Vancouver Island in June, 1973. Some 28,800 acres were sprayed with fenitrothion (Sumithion) at a rate of 2 oz. active ingredient in 20 oz. carrier per acre, applied twice at an interval of 4 days. The total application therefore, was 4 oz. a.i./acre. The selection of areas for spraying was based on high populations of overwintering eggs and severe defoliation sustained during 1972 feeding. The western part of the area around Neroutsos Inlet (see map) consisted of stands ranging from 20-30 year-old regeneration (ca. 50 ft.) to 50 year-old second growth (ca. 125 ft.). In the eastern part around Benson Lake, the forest was mature-over-mature and ranged from 150 to 250 feet in height. Since most of this forest was inaccessible for immediate salvage, the control operation was undertaken to protect the hemlock from further damage.

The initial plan provided for spraying of 32,000 acres, but due to public opposition to the proposal, some of the area around Neroutsos Inlet was deleted from the spray area by the provincial Minister of Health (see map). Leave strips of 600 feet were left around water bodies to reduce the risk of damage to fresh water and inter-tidal organisms.

Insecticide Formulation

The formulation of chemical was that currently used in

[1/] Council of Forest Industries of British Columbia


1973 - BLACKHEADED BUDWORM CONTROL
VANCOUVER ISLAND
Plot Location and Number
Spray Area
Deleted From Spray Area
Scale 0 1 2 3 4 Mi.
N
PORT HARDY
PORT ALICE
VANCOUVER ISLAND
AREA SHOWN IN LARGE MAP
Port Hardy
Airport
Port McNeill
HOLBERG INLET
RUPERT INLET
NEROUTSOS INLET
O'Connor L.
Keogh L.
Alice Lake
Jeune Landing
Rumble Beach
Port Alice
Victoria Lake
Benson L.
Teeta Cr.
Cayuse Cr.
Teihsum R.
1
2
3
4
5
6
7
8
9
10
11
12
13

eastern Canada.

Sumithion (fenitrothion 97%) .... 76.5% by volume

Atlox (Atlos Chemical, Brantford, Ont.) ... 11.9%

Aerotex 3470 (Texaco Co.) 11.6%

Atlox was the emulsifier and Aerotex the solvent; specific gravity Sumithion 1.32. All chemicals were delivered to Port Hardy airport, the operations base, which was located about 20 miles from the spray area. Formulation was done with equipment provided by the contractor, Conair Aviation Ltd., Abbotsford, B.C. Mixing of the emulsifiable concentrate was done the day before application. This concentrate was pumped into the plane with water and final mixing was achieved within the aircraft during flight.

Aircraft

One TBM (Grumman Avenger) aircraft was used for spraying; it was calibrated by A.P. Randall (CFS, Ottawa) at Abbotsford. The plane carried 500 gallons formulated spray which was applied in a strip 880 feet wide and covered about 4,000 acres; boom time for each load was 17 minutes. The bird dog plane was a Cessna Skymaster.

Application Dates

Spraying was done on the following dates:

22 June - Neroutsos Inlet (Rayonier) - first application

26 June - " " " - second application

25-26 June - Benson Lake area (MacMillan Bloedel) - first application

29-30 June - " " " " " - second application

SURVEYS AND SERVICES - J.R. Carrow[2]

The biological effectiveness of the spray, and coverage and drift of the spray were assessed by the Pacific Forest Research Centre, using 13 plots established in April, 1973 (see map). Each plot (4.8 acres) consisted of 16 trees on two lines oriented perpendicular to the anticipated flight path.

Spray Assessment

a) Coverage of Plots. Kromekote cards and glass plates were placed in the plots during spray operations and later sent to the Chemical Control Research Institute, Ottawa, for analysis. The cards indicated that "spray distribution was non-uniform and deposit levels were far from adequate". In sprayed plots, deposits of fenitrothion on glass plates were extremely low; the highest concentration detected was 0.0027 oz. a.i./acre. The reason for such a low deposit is unknown but two factors undoubtedly were influential:

(a) the very rough terrain and steep slopes prevented the pilot from flying close to the canopy; during most of the operation, the plane flew several hundred feet above the trees.

(b) although spray cards and plates were placed in openings, the very dense canopy and long tree crowns (50-75 feet) probably intercepted almost all the spray.

Two of the 7 control plots received a trace of spray ($<$ 0.0002 oz.

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[2] Canadian Forestry Service, Pacific Forest Research Centre, Victoria, B.C.

a.i./acre). Within the spray area, no spray deposit was detected on two plots (7 and 11).

b) Drift of Spray onto Rumble Beach. Even after deletion of part of the spray area from the operation (see map), some residents of Rumble Beach continued to express concern about the possibility of spray drift onto the community. As a result, 10 stations were established throughout the town to detect drift. Examination of Kromekote cards showed no deposit of fenitrothion up to 3 days after spraying (Table 1). Samples of hemlock foliage collected from each station were also analysed by the Chemical Control Research Institute, using gas liquid chromatography. The results showed that small amounts of fenitrothion (0.01-0.02 ppm) were deposited on and retained by the foliage within two days of application, indicating that northward drift of the spray must have occurred. Again this may have resulted partly from the flying height of the aircraft above the canopy.

Table 1. Analysis of Kromekote Cards and Hemlock Foliage for Presence of Fenitrothion in Rumble Beach Following Operational Spraying.

Date of Collection	Amount of Fenitrothion	
	Foliage Samples	Kromekote Cards
June 21 - pre-spray	ND	-
22 - spray applied	-	NVD
23	-	NVD
24	0.01 ppm	-
25	-	NVD
26 - spray applied	T	-
28	0.02 ppm	-
30	0.01 ppm	-

T = < 0.01 ppm ND = not detected NVD = no visible deposit

Analysis by Chemical Control Research Institute, Ottawa.

Larval Development and Timing of Spray

Egg hatch was first detected June 4th and thereafter larval development was monitored continually at 8 locations. Development was expressed as a Development Index (DI)[3] which was used as a guide to the timing of applications. In the Neroutsos Inlet area, the first application was made when the mean DI for the area was 35; at this point, the population was about 50% first instar, 42% second instar, and 8% third instar. The second application took place when the DI was 38. In the Benson Lake area, the DI was about 31 when both applications were made.

This timing of application was earlier than in the previous control operation in 1957 in which case a DI of 40 was used as the threshold for application. Several factors contributed to the decision to spray at an earlier point in larval development this year: well advanced 1973 bud flush; the desire to protect trees from bud damage and defoliation; highly unstable weather and resulting difficulties in completing two applications of spray; and the residual systemic action of fenitrothion.

Biological Effectiveness of the Spray

The effectiveness of the control operation was assessed by

3/ Development Index (DI) = $\frac{\text{SUM (\% of population in stage x stage value)}}{100}$

stage values: egg - 16; first instar - 28; second instar- 40; third instar - 52; fourth instar - 64; fifth instar - 76.

studying population survival, crown defoliation and bud development.

a) Population Survival. Egg counts made in April, 1973 indicated that the potential for serious defoliation was present, the mean population being 21 eggs per branch[4] (Table 2). Larval populations in the plots 1 to 3 days prior to the first application averaged 7 per branch, although larger populations (25-30 per branch) were found outside the plots in overmature hemlock near Benson Lake. The size of most study trees (> 150 feet) made accurate sampling of third and fourth instar larvae impossible and so no attempt was made to assess larval mortality immediately following spraying. Nevertheless, development sampling after the first application revealed high mortality of young larvae. Pupal counts made in August showed that the population had experienced a natural collapse during the summer; survival of the unsprayed larval population to the pupal stage was only 3.9% (Table 2). The available evidence indicates that the collapse occurred during the third instar stage prior to heavy feeding activity. Immediately following spraying there was a week of continuous heavy rainfall. Since the third to fifth instar larvae are very sensitive to physical disturbance, this rain may have resulted in extensive larval dropping from the trees.

Nevertheless survival in sprayed plots was lower in both young and old stands. Using Abbott's formula, 83% control was achieved

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[4] The standard sample unit throughout the study was one 18-inch branch per tree selected from the mid-third of the crown.

Table 2. Blackheaded Budworm Control Operation: Summary of Data on Population Survival, Control and Defoliation During 1973 in Regeneration and Mature Hemlock (mean values).

	No. Budworm/Branch[5]				Per cent control[6]	Improvement in Crown Defoliation (%) During 1973	
	Eggs (April)	Larvae (June)	Pupae (Aug.)	Eggs (Oct.)		Upper crown	Lower crown
Regeneration							
Control (3)[7]	19.3	9.4	0.17	1.2	-	0	-2.2
Sprayed (2)	36.0	8.1	0.06	0.6	83	13.1	2.0
Mature							
Control (4)	17.3	5.6	0.33	1.1	-	11.5	5.1
Sprayed (4)	18.3	5.2	0.22	0.7	42	11.2	3.8
All Plots							
Control (7)	18.1	7.9	0.25	1.1	-	5.8	1.5
Sprayed (6)	24.2	6.1	0.14	0.7	64	12.2	2.9

5/ 18 inch branch

6/ by Abbott's formula, using survival from egg to pupa

7/ No. of plots in brackets.

in regeneration stands and 42% in mature stands. The low control in older stands was probably related to the poor penetration of spray into the crowns mentioned earlier.

b) Defoliation. The crown condition of each study tree was examined in April and again in August to determine the effects of 1972 and 1973 feeding respectively. Young trees apparently benefited from the spray in that the crown condition of sprayed trees improved much more during 1973 than on unsprayed trees (Table 2). On sprayed trees, upper crown defoliation decreased 13.1% from April to August, whereas on unsprayed trees there was no improvement in upper crown condition during the summer. In mature stands, however, spraying resulted in little improvement. An aerial survey at the end of August revealed that some budworm populations in the region had not collapsed this year. Current year's feeding was moderate to heavy in some areas (Mahatta River, northeastern end of Neroutsos Inlet, east of Jeune Landing) and light in other areas (Yreka Mine, Port Alice, Teihsum River), all of which were outside the sprayed zone.

c) Bud Development. Trees were sampled in August for assessment of bud and shoot development during 1973. Spraying had no significant effect on the frequency of normal shoot development. In regeneration stands, about 80% of the buds flushed normally this year whereas in mature stands, normal development was 54% (Table 2). However, this examination indicated that formation of new buds during 1973 may have been seriously inhibited by feeding, but this cannot be confirmed before next year.

The results of the biological assessment suggest that:

1) regeneration stands benefitted most from the control operation;
2) the larval population experienced natural, severe mortality during the third instar stage.

PROSPECTS FOR 1974 - R.L. Fiddick[8/]

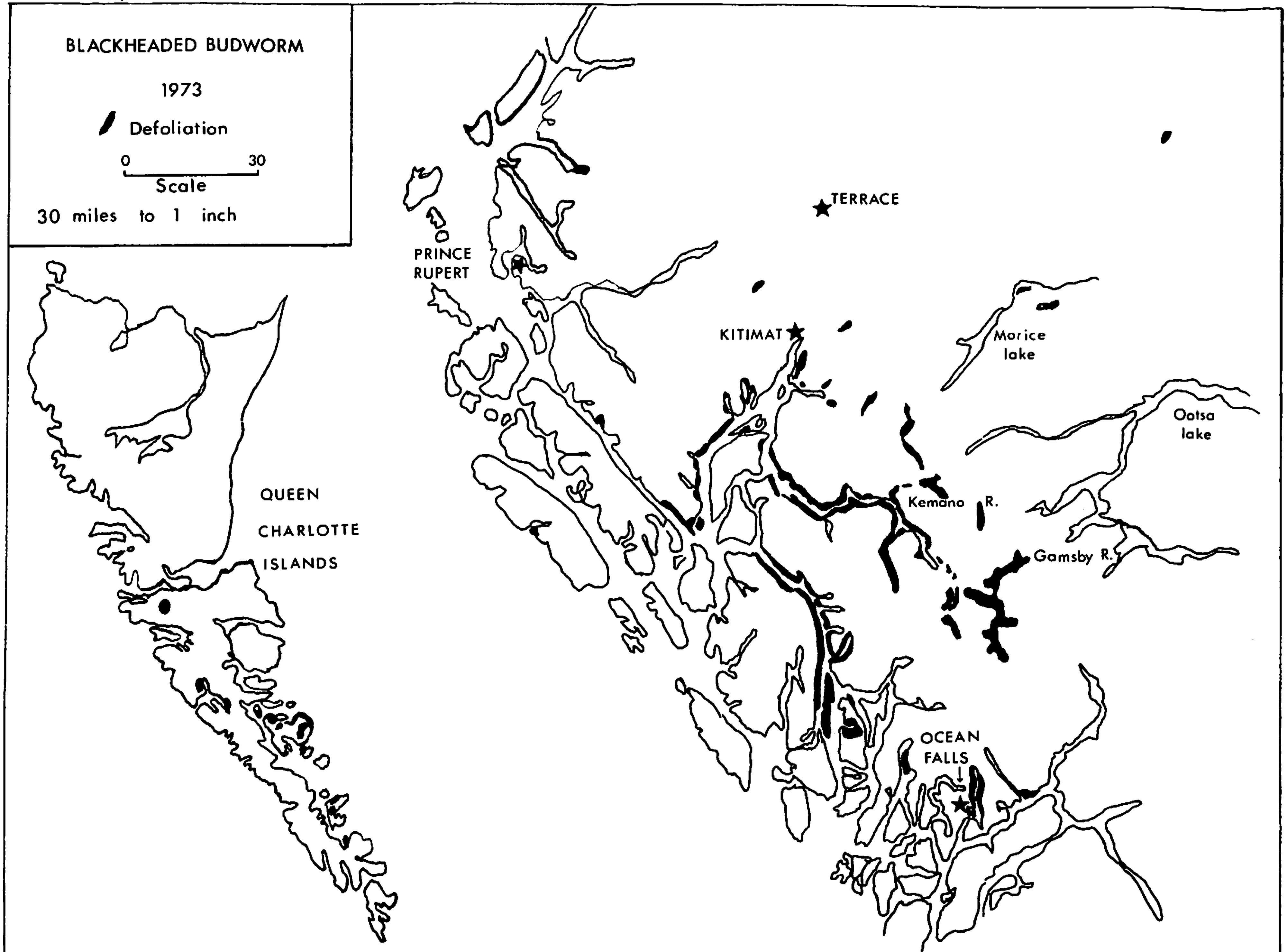
In 1973 light to moderate defoliation of western hemlock was observed from Kitimat to Ocean Falls and at several locations on the Queen Charlotte Islands (see map). In the eastern part of the Prince Rupert Forest District, larval populations were heavy in several locations. The new growth on alpine fir and white spruce was severely attacked near Morice River, Ootsa Lake, and the Nilkitkwa River Road.

Egg samples taken at 20 locations from Terrace to Ocean Falls indicated that there will be light to moderate defoliation in the same areas in 1974 with some areas of heavy defoliation, notably: along Kemano River, Chief Mathiews Bay, Klekane Inlet, Link Lake and Gamsby River. On the Queen Charlottes, there was moderate defoliation at Deena River, and egg counts indicate similar defoliation in 1974. Egg sampling for the southern Queen Charlottes is not yet completed.

Budworm populations on Vancouver Island declined sharply during 1972 and 1973, and little defoliation is predicted for 1974.

At present, no decision has been made as to whether to undertake control action against this insect in 1974.

[8/] Canadian Forestry Service, Pacific Forest Research Centre, Victoria, B.C.


BLACKHEADED BUDWORM
1973
Defoliation
0
30
Scale
30 miles to 1 inch
PRINCE
RUPERT
TERRACE
KITIMAT
Morice
lake
Ootsa
lake
Kemano R.
Gamsby R.
QUEEN
CHARLOTTE
ISLANDS
OCEAN
FALLS

FISHERIES SERVICE MONITORING PROGRAM
BLACK- HEADED BUDWORM CONTROL
NORTHERN VANCOUVER ISLAND - June 1973

Several important salmon streams are located in the area of the 1973 fenitrothion control program for the black-headed budworm. In order to protect the rearing fish and their invertebrates food supply, Fisheries Service proposed the following guidelines:

1) That two applications of 2 oz. fenitrothion per acre (ie. active ingredient) be used instead of one more concentrated application (ie. 4 oz./acre). These applications were to be timed a minimum of five days apart.

2) That a 600' buffer zone be maintained on each side of the designated salmon streams. This buffer zone was to also include estuarine areas and the marine foreshore.

The Fisheries Service monitoring program attempted to assess the effects of the first 2 oz. spray on fry and aquatic invertebrate populations. The effectiveness of the buffer strip was also examined. The methods employed, as well as the results are briefly noted below:

1) Aquatic invertebrate drift collections.

Both pre and post spray aquatic invertebrate collections were made with one foot square fyke nets.

A temporary increase in the numbers of drift aquatic insects was observed in the experimental stream following treatment of the upper watershed with 2 oz. of fenitrothion. In addition, approximately five hours after the spray large numbers of downed aerial insects were observed drifting on the stream surface. Coho fry were actively feeding on these insects which were found to contain 0.2 ppm. fenitrothion.

2) Benthic invertebrate collections.

Pre and post Surber collections were taken from the experimental stream.

Fewer numbers of invertebrates were obtained in the post spray collections; however, sample sizes were not adequate for a statistical analysis.

3) In-situ salmon fry bioassay.

Coho fry were held in the experimental stream for 96 hours following spray application.

Neither fry mortality nor loss of vigour was observed. The wild populations of coho fry seemed unaffected during the period of observation.

4) Static laboratory bioassay.

A sample of chemical obtained from the spray project (fenitrothion, Aerotex (a solvent) plus Atlox (an emulsifying agent)) was used for laboratory bioassay purposes.

....................3

The threshold of toxicity was 1.0 parts per million, the TLM_{96}* was 2.4 ppm.

5) Spray Plates.

One foot square glass plates were placed within the 600 foot buffer zones of the experimental creek. After the fenitrothion application, the plates were rinsed with pestiquality benzene. The rinseate was subjected to gas-chromatographic analysis.

Levels of up to 3.44 micrograms per square foot fenitrothion were observed within the buffer zone. It is estimated that the nearest spray flight path was at least one quarter mile downwind from the glass plate set up. This quantity of fenitrothion in 6 inches of water (approximately $2.2x10^{-4}$ ppm fenitrothion) is below the established toxicity to coho fry.

From this project it is concluded that:

1) Fenitrothion application at 2 oz. per acre even with a 600 foot buffer zone may produce a measureable impact on aquatic invertebrates.

2) The spray material is highly mobile and was found in measureable quantities within the buffer zone.

3) Fenitrothion, from contaminated insects, was available to feeding coho. The threat posed by this contaminated food source was not ascertained.

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* TLM_{96} - concentration at which 50% of test animals die in 96 hours.

The Effects of Fenitrothion on Non-Target Arthropods

(Environmental Protection Service)

During the Blackheaded Budworm Control Operation of Northern Vancouver Island E.P.S. conducted a monitoring program to investigate the effects of fenitrothion on non-target arthropods.

The basic aim was to determine any drastic or significant change in (1) the numbers, and (2) the composition of non-target arthropods following insecticide application.

Five locations of broadly similar habitat types were selected within the Treated area, and five Control sites outside the Treated area. Considerable difficulty was experienced in selecting accessible sampling sites of similar habitat. Samples of arthropods were taken at all locations before and shortly after spray application. Additionally, a close surveillance was also maintained on some of the more accessible streams for moribund arthropods.

Two methods of sampling were employed, net sweeping and light trapping. The sweep-net consisted of a muslin bag with circular opening of approximately 14 inches in diameter. The light traps were the Rothamsted type, and were slightly modified using marine batteries and automobile seal beams as the light emitting source.

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Three classes of arthropods were found in our samples -- Arachnida (spiders, ticks and mites), Diplopoda (millipedes), and Insecta (insects). Some Mollusca (slugs and snails) were also collected. The majority of the arthropods belonged to ten insect Orders.

The results of our analyses on arthropod numbers indicate the following:

1) Great variation of total numbers between areas;
2) A significant increase in total numbers in the Control Plots after spray application (90% CL);
3) A significant decrease in total numbers in the Treated Plots after spray application (80% CL).

The great variation of arthropod numbers between areas was expected because of habitat differences.

The total numbers of arthropods in the Control Plots doubled between sampling time. This was mainly due to a significiant increase in numbers of Arachnida (17 fold) and Diptera (3 fold). The reason for the population increase in the Arachnida is not clear at present. In the Diptera, however, the change was possibly due to adult emergence from pupae. The composition of arthropods remained essentially the same.

In the Treated plots, the number of post-spray arthropods was one-third of the prespray estimation. The most significant decrease was in the Dipterean and Hemipterean insects (both were reduced 3 fold). However, an increase in numbers of Arachnida was noted. There was no change in the composition of the arthropod populations.

At Cayeghle Creek (a large part of its watershed was within the spray plots) some moribund adult Dipterean and Hymenopterean species were collected. Analyses carried out on samples of these insects by the Chemical Control Research Institute, Ottawa, yielded a residue of 0.20 ppm fenitrothion in the insect tissues.

The reduction in numbers and mortality of some non-target insects following spray application of treated plots could be taken as an indication that fenitrothion had immediate short term effects on some groups of non-target arthropods. However weather changes, habitat variation, sampling techniques, natural mortality, emergence and migration of arthropods also cause fluctuation in numbers. The possibility of long term effects of the chemical was not investigated.

In summary, our studies indicated that while the composition of the arthropod population remained essentially unchanged, there was a significant decrease in numbers of some non-target arthropods (i.e. Diptera, Hemiptera) in the treated forest plots following fenitrothion application.

White Pine Weevil Aerial Spraying Operations
Ontario, 1973

by

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Great Lakes Forest Research Centre
Sault Ste. Marie

and

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Introduction

Approximately 2500 acres of white pine plantations in the Peshu Management Unit of the Blind River District were sprayed by the Ontario Ministry of Natural Resources in 1973 to reduce damage by the white pine weevil. The Canadian Forestry Service (GLFRC) assisted the province by conducting weevil incidence surveys to select areas requiring treatment and assessed the effectiveness of the operation.

The 1973 Operation

Spray applications were made on May 5, 6 and 9 using two aircraft, an Agcat and a Stearman, both equipped with micronairs and contracted from General Airspray Ltd., St. Thomas, Ontario. Sprays were applied at the rate of 2.0 gallons (U.S.) per acre at a concentration of 2.4 lbs of Methoxychlor per acre. The chemical was mixed with water, with Target E (molasses) added as an adjuvant at a rate of 2 gallons per 100 gallons of spray mixture. Spray deposit was not monitored.

Results

The results of the spraying are shown in the following table.

Table 1. Incidence of weevilling in sprayed and unsprayed areas in the Peshu M.U. before and after spraying

	Per cent of trees weevilled	
	Pre-spray (1972)	Post-spray (1973)
Sprayed Area		
Peshu M.U. - Twp. V and W (2500 acres)	15.6	9.1
Unsprayed Area		
Peshu M.U. - Twp. 2A (adjacent to V & W)	10.5	7.1

The incidence of weevilling in the unsprayed check area declined from 10.5% in 1972 to 7.1% in 1973, a reduction of 32% due to natural causes. The incidence of weevilling in the sprayed areas declined from 15.6% in 1972 to 9.1% in 1973 after treatment or a reduction of 42% due to both natural causes and treatment effects. Using the formula,

$$\% \text{ reduction} = \frac{\text{Expected population} - \text{Observed population}}{\text{Expected population}} \times 100$$

it was calculated that a population reduction of 14% owing to spraying was achieved.

Discussion

These data represent the poorest results achieved over the past five years of aerial spraying Methoxychlor against white pine weevil in the Blind River and Sault Ste. Marie districts. One could speculate that these evaluation results may be faulty owing to sample error or atypical check plots. However, the sampling was done in the same fashion as in previous years and by the same people. Weevilling incidence in other untreated areas showed an overall decrease of 23%, thus there is no reason to believe that the Peshu check (Township 2A) is atypical.

Dye and spray cards were not used to check spray deposit owing largely to accessibility problems. However, OMNR personnel and the pilots on the operation were experienced and would not likely spray under unsatisfactory conditions. But, weather probably was a major factor affecting the results. The start of spraying was preceded by five days with showers and heavy rains and the interruption in spraying from May 6 to May 9 was caused by rain, fog and drizzle. Daily weather records from Sault Ste. Marie and Sudbury airports, show that there was no rain on May 5 or 6 but that there was precipitation for seven consecutive days starting May 7. Thus it seems likely that any insecticide deposited on white pine leaders was washed off by the almost continuous rainfall and would present very little protection against adult weevils when they resumed activity after the cool, wet period.

Conclusions

There is obviously an urgent need for more suitable chemicals or formulations in white pine weevil spraying operations in Ontario since the risk of poor results remains high relative to the cost involved.

Forecasts for 1974

It is expected that 2500-3000 acres of white pine plantation will be sprayed for white pine weevil in 1974 in the Blind River District (formerly in the Sault Ste. Marie District).

Report prepared for the Annual
Forest Pest Control Forum

November 14, 1973

PLANTATION PEST CONTROL RESEARCH, 1973: AERIAL APPLICATIONS OF METHOXYCHLOR AND GARDONA® FOR CONTROL OF WHITE PINE WEEVIL

(Study Reference No. CC-1-012)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

R.F. DeBoo and L.M. Campbell

Chemical Control Research Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario.

November, 1973

Plantation Pest Control Research, 1973: Aerial Application of Methoxychlor and Gardona® for Control of White Pine Weevil

by

R.F. DeBoo and L.M. Campbell

Experimental aerial applications of methoxychlor to pine plantations infested by white pine weevil (Pissodes strobi) were initiated in southern Ontario during 1972. Results indicated that dosages of 2.5 lb. active ingredient applied in 4 gal. fuel oil/acre provided satisfactory protection of leaders (i.e. less than 1% weeviling) and that oil-base sprays were superior to water sprays containing equal amounts of the insecticide.

During 1973, the study was continued to (1) further evaluate the importance of spray volumes, formulations and adjuvants, (2) to determine the efficacy of Gardona® as well as methoxychlor by aerial application, and (3) to evaluate spray deposition by Micronair emission equipment (vs. boom and nozzle equipment used in 1972). The study was conducted at the Kirkwood Forest Management Unit north of Thessalon, Ontario, in conjunction with the operation spray program of the Ontario Ministry of Natural Resources.

Results of the 1973 study (Table I) basically corroborated those results obtained in 1972: (1) Methoxychlor at 2.5 lb. a.i. in 4 gal. fuel oil/ac. reduced leader infestation by 93% (only 1% leader mortality after treatment), (2) oil-base sprays were superior to water-base sprays at the 2-and 4-gal/ac. emission rates, (3) the addition of a molasses adjuvant (Target E) to all water sprays did not improve spray efficacy to the levels attained with the oil sprays, however, leader protection generally was superior to results obtained during 1972 with methoxychlor in water sprays without the adjuvant, (4) applications of Gardona® at rates of 1 and 2 lb.

a.i./ac. gave inferior control, due possibly to its short residual activity (as compared with methoxychlor) and the occurrence of adverse weather conditions after treatment, (5) the Micronair AU2000 emission system provided droplet densities of up to 120/cm^2 and MMD of about 125 μ under ideal weather conditions. The system was considered more suitable than boom and nozzle equipment as greater disposal of fine droplets to weevils resting on leaders or on the ground during time of application was obtained.

In summation, methoxychlor appears to be a suitable replacement for DDT for optimum protection of trees from weevil attack. Relatively large volumes of methoxychlor spray mixture per unit area are required, however, to obtain the high level of protection required. It is recommended that applications during adult emergence (August) in conjunction with spring treatments be made to severely infested plantations to reduce populations to extremely low levels and thereby eliminate the necessity for annual spray treatments. Additional experimentation is required for the selection of substitute chemicals (e.g. Gardona) for aerial application.

TABLE 1

Results of aerial applications of methoxychlor and Gardona[R] for control of white pine weevil in the Kirkwood Forest Management Unit, 1973; Applications April 26-30, Stearman aircraft, 4 micronairs AU2000

Treatment[1]	Acres Treated	Leader injury by white pine weevil: 1972 No. weeviled/ No. examined	1972 Percent weeviled	1973 No. weeviled/ No. examined	1973 Percent weeviled	Percent Reduction in Leader injury (Between Years)
Methoxychlor 2.5 lb ai in 4 gal. oil/ac	94	296/2150	14	28/2710	1	93
Methoxychlor 2.5 lb ai in 4 gal. water*/ac	112	247/2029	12	42/2019	2	83
Methoxychlor 2.5 lb ai in 2 gal. oil/ac	100	261/2033	13	56/2126	3	77
Methoxychlor 2.5 lb ai in 2 gal water*/ac	100	329/2015	16	99/2016	5	69
Gardona[R] 1.0 lb ai in 2 gal. water*/ac	60	184/1069	17	82/1098	7	59
Gardona[R] 2.0 lb ai in 2 gal. water*/ac	30	106/495	21	36/387	9	57
Untreated Check	230	400/2567	16	398/2560	16	0

* Target E (molasses) @ 4 gal./100 gal. spray mix

1 Ranked according to efficacy

Oak Leaf Shredder Aerial Spraying Operations, 1973

by

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and

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Introduction

The oak leaf shredder, Croesia semipurpurana (Kft.) has been a persistent pest of red oak in Ontario. Some stands have shown defoliation each year for more than 15 years. In 1972 defoliation was so severe in parts of Dufferin County that concern was expressed by forest managers over the possible impact, especially if damage was to reach similar levels in 1973.

In May, the Ontario Ministry of Natural Resources sprayed a total of 1,300 acres of oak forest including three privately owned woodlots and part of Dufferin Forest. General Airspray Limited, St. Thomas, Ontario used a Stearman aircraft equipped with four micronair AU3000 units and applied 0.85 lb Sevin 4 oil in 0.78 qt (Imperial) of spray mixture per acre.

The Canadian Forestry Service provided survey-type entomological information and assisted in the timing of sprays and in evaluating the results.

The Spraying Operation

Egg-hatch began before May 3 and was completed by May 10 by which time buds had begun to burst and larval feeding was underway. Pre-spray counts of larvae in 100 randomly selected buds using dissecting microscopes indicated on May 11 a 99% incidence of infested buds with a maximum of 21 larvae per bud. Counts averaged six larvae per bud in both the treatment and check areas. On May 16, the day before spraying commenced, most larvae were instar I with a small proportion instar II. At that time much variation was evident in the amount of leaf flush. On hilltops and in protected areas oak leaves were up to 3 inches long and though still furled they had definitely begun to separate. On slopes and exposed sites leaves were not more than 1 1/2 inches long and a proportion of the buds had barely burst.

Since the objective was to prevent as much defoliation as possible, spraying was begun at this time. Spraying was done on the morning and evening of May 17 and completed on the morning of May 19. Hives of bees had been moved from an area adjacent to one of the spray zones as a precautionary measure.

No dye was added to the spray mixture and the deposit on spray cards was therefore difficult to measure. There were other indications of good deposit however.

On May 24, 5 days following the end of spraying, by which time larvae were mostly instars II and III, post-spray counts were made in both treated and untreated areas. No appreciable change was evident either between the pre- or post-spray counts or between treated and untreated stands.

Defoliation surveys carried out during the third week of June in Dufferin and surrounding counties indicated that defoliation was quite variable but generally much less severe than in 1972. The number of inquiries from woodlot owners and the general public were also fewer than in 1972. As for Dufferin Forest, no consistent differences in the degree of defoliation could be detected between sprayed and unsprayed stands or between high elevations and slopes within sprayed areas.

Since most injury to the foliage is caused by larvae feeding when leaves are small and furled, some difficulty in achieving good protection was anticipated. Our assessments though limited and obviously quite inadequate for a thorough evaluation, indicate that factors related to the secretive nature of feeding larvae were more important than anticipated and suggest that consistently good results cannot be expected with one application of Sevin 4 oil applied before the leaves are 3 inches long and at the dosage and rate applied in these trials.

A more realistic objective might be the abatement of populations, by applying sprays after leaves are unfurled and larvae more exposed. This way, however, any protection achieved would be evident in the year following treatment rather than in the year of spraying.

Infestation Forecasts and Proposed Aerial Spraying for 1974

No statistically reliable sampling system is available upon which to forecast infestation levels in 1974, but we have no reason to believe that infestation levels have dropped appreciably. The intensity of damage in 1974 depends on the nature of bud development and weather following egg hatch next spring.

Should aerial spraying be carried out in 1974, it would be of small scale and with a modified objective.

Report prepared for the Annual
Forest Pest Control Forum

November 14, 1973

APPENDIX [illegible]

AERIAL SPRAYING OF <u>BACILLUS THURINGIENSIS</u> FOR CONTROL OF THE WESTERN FALSE HEMLOCK LOOPER <u>NEPYTIA FREEMANI</u> MONROE

S. Ilnytzky

Pacific Forest Research Centre

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Prepared for

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OTTAWA, ONTARIO

INTRODUCTION

The western false hemlock looper caused light to severe defoliation of semi-mature Douglas-fir, over approximately 3,250 acres in the vicinity of Salmon Arm, B.C., in 1972. This situation caused considerable concern to private property owners in this recreational area. The British Columbia Forest Service and Abbott Laboratories Inc., collaborated in conducting an experimental aerial spray operation against the defoliator, using "Dipel" (*Bacillus thuringiensis* Berliner) which was monitored by the Canadian Forestry Service.

APPLICATION METHODS AND MATERIALS

The experiment was conducted near Salmon Arm, B.C., at Carlin and Canoe. At Carlin, the plots were in a Douglas-fir - pine stand on a semi-arid site; at Canoe, they were in a mixed Douglas-fir - cedar stand on a wet site. The treatments, applied to second- and third-instar larvae, were 0 (control), 0.25, 0.50 and 1 lb/acre (0.28, 0.56 and 1.1 Kg/hectare) [1/] of Dipel. Beside B.t., the spray mixture contained "Biofilm" sticker-spreader, 16 oz per 100 gal of spray mixture (4.73 mls/3.7 L) and Brilliant Sulpho Flavine FFA dye (0.1% by volume). The mixture was agitated before and during spraying. The spray was applied on June 11 (clear day; wind velocity 0 to 3 mph; mean temperature at the two plots was 66°F). Forty-eight

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1/ Equivalent to 7.26 billion international units of potency per pound of product.

hours after spraying 0.1 inch of rain fell. There were four replicate plots (each 15 to 20 acres in size) for each treatment, with three of the replicates being at the Canoe location and the other at Carlin (see map). The aircraft used for spraying the insecticide was a Cessna, "Agtruck" A188, which flew at 110 mph and carried 120 gal of spray material. The plane was equipped with 40, 8010 "Tee-Jet" nozzles set at 45^{o} into air flow. The boom pressure was 52 psi and delivered 2 U S gal per acre in 100-ft-wide strip released 100 ft above the trees.

Pre-spray estimates of the insect larvae population were determined by counting looper larvae on two whole branch samples (from the lower or mid-crown height) taken from each of 15 trees scattered throughout each plot (replicate), i.e., a total of 180 trees for all treatments. The fresh weight and area of each branch sample was also determined. Post-spray evaluations were made at 7 and 21 days after spraying, except no fresh weights were obtained for sample taken at 7 days.

Beside the experimental plots, an additional 220 acres of recreational area was sprayed with 0.5 lb per acre of B.t.

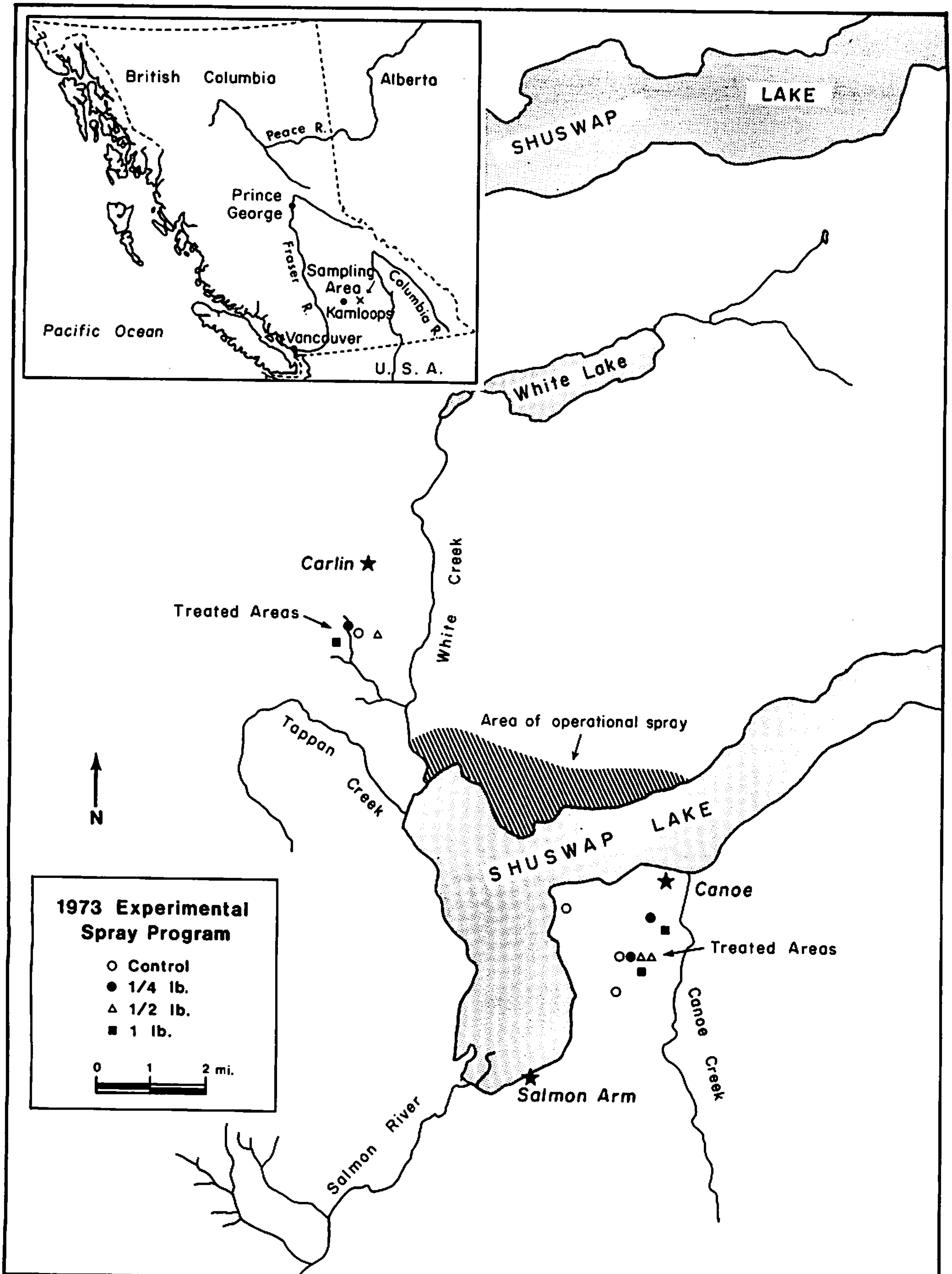
RESULT AND DISCUSSION

The insect mortality and branch sample weight data will be subjected to analysis of variance but preliminary analysis of insect mortality data using Abbott's formula (Shepard, H.H. 1947.

The chemistry and toxicology of insecticides. Burgess Publ., Minneapolis.) showed that no insect mortality occurred until 21 days after spraying when 39 and 23% of the loopers were killed in the 0.5 and 1.0 lb per acre B.t. plots respectively (see Table). The analysis of variance may explain why greater mortality occurred at the 0.50 than the 1.0 lb dosage.

Days after spraying	Dosage (lb per acre) of B.t.	Per cent looper mortality
7	0.25	0
	0.50	0
	1.00	0
21	0.25	0
	0.50	39
	1.00	23

The effectiveness of B.t. in reducing looper populations was confirmed by operational spray (0.50 lb B.t. per acre) results in a 220 acre-recreational area (see map) near the experimental plots. In this area recent counts showed that looper eggs averaged 12 per 18-inch branch in sprayed areas and 135 in unsprayed areas.


British Columbia
Alberta
Peace R.
Prince George
Fraser R.
Sampling Area
Kamloops
Columbia R.
Pacific Ocean
Vancouver
U. S. A.
SHUSWAP LAKE
White Lake
Carlin
Treated Areas
White Creek
Tappan Creek
Area of operational spray
N
SHUSWAP LAKE
Canoe
Treated Areas
Canoe Creek
1973 Experimental Spray Program
Control
1/4 lb.
1/2 lb.
1 lb.
0 1 2 mi.
Salmon Arm
Salmon River

APPENDIX 30

APPARATUS AND METHOD FOR APPLYING MEASURED DOSES OF SIMULATED AERIAL SPRAY TO SMALL TREES

(Study Reference No. CC-1-022)
CC-1-019)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

W.W. Hopewell

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Canadian Forestry Service
Environment Canada
Ottawa, Ontario.

November, 1973

Apparatus and Method for Applying Measured Doses of Simulated Aerial Spray to Small Trees

by

W.W. Hopewell

The apparatus and technique were successfully field tested on plantation grown spruce, 8-10 ft high, with a natural infestation of SBW. The opportunity was taken to run a series of tests on the Bt formulations being investigated by C.C.R.I. in aerial application trials in Algonquin park. Eight different formulations were applied to 50 trees. A portable tower was placed around each tree and a measured volume of the test mix emitted (66 fl. oz/acre, nominal) by a spinning disc device being moved systematically over the area within the tower. Samples of deposit showed good distribution of drops, with size ranges similar to that obtained in aerial spray deposits. Observations of budworm populations on treated and control trees before and after treatment were made.

The effect of the various treatments on budworm control were judged by comparison of treated tree budworm levels with that on control trees. There are two parameters here: (1) the number of budworm at final count related to the number of mined needles. There was good correlation between these two counts and most emphasis was placed on this criterion when judging effectiveness. (2) The average infestation level as measured by number of budworm per 100 buds. Infestation levels between trees on this basis varied widely but was also taken into account in judging effectiveness.

The indications are:

1. Dipel alone gave a small reduction in population compared with control; Thuricide alone resulted in an increased population over control.

2. Addition of chitinase did not change effectiveness of Dipel: chitinase added to Thuricide improved it significantly to make it more effective than Dipel with or without chitinase.

3. Chitinase alone gave a slight reduction from control, the same as Dipel with and without chitinase.

4. The addition of a very small amount of fenitrothion (0.4%) to Thuricide activated this formulation and reversed population change from 35% increase (Thuricide alone) to 13% decrease. Fenitrothion added to Dipel in the same amount, again showed Dipel to be more active than Thuricide with 43% reduction.

5. Fenitrothion at 6 oz. a.i./acre (average measured deposit) gave better control than any other treatment (50% reduction) and at 2.2 oz a.i./acre was not as effective as Thuricide + chitinase or Dipel + 0.4% fenitrothion.

As a check for other possible activity of the various mixes the percent of budworm in each stage of development at time of final count was determined. In the cases of Dipel, Dipel + chitinase, Dipel + fenitrothion and Thuricide, budworm development seems to have been slowed as indicated by a small percent in the pupal stage as compared with control. Thuricide + chitinase however had normal distribution as did chitinase alone. In the case of heavy fenitrothion (5.9 oz. a.i./acre) there is a much higher percent in pupal stage, probably as a result of smaller larvae being more susceptible to the insecticide and eliminated from sample.

APPENDIX 31

NOT FOR PUBLICATION

A STUDY OF THE EFFECT OF FOREST METEOROLOGICAL CONDITIONS ON SPRAY DROPLETS AND AN ANALYSIS OF THE SPRAY CLOUD

(Study Ref. No. CC-1-011)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

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The meteorological equipment was used to provide data to study and record meteorological conditions for a series of experiments. Expertise gained through the use of the equipment was used to make recommendations to members of PFES and IPRI as to what equipment is required to provide the basic information to determine optimum spray conditions.

A. Aerial Application of Fenitrothion at PFES:

In 1972 the Institute was responsible for the aerial application of fenitrothion at PFES. Although there was some improvement over previous year's applications the level of control was not considered adequate. The 1973 program was set up to test the effectiveness of increasing the volume of material emitted yet maintaining the same amount of insecticide. Four blocks were treated with a fenitrothion-arotex preparation applied by aircraft fitted with Au-2000 Micronairs. Sprays were applied under conditions ranging from neutral to very stable. In each spray block selected white spruce and balsam fir were used to assess insect mortality and cards and plates were set out for each application to measure the average deposit in the block.

The table shows the treatment each area received and the effectiveness in terms of population reduction on fir and spruce.

Results of Application of Fenitrothion
at PFES, 1973

Block	No. of Treatments	Emitted Per Treatment		Total Insecticide (oz/acre)		% Population Reduction 1	
		Vol. of Formulation gals/acre	Ounces wt. of Fenitrothion	Emitted	Deposited	Balsam Fir	White Spruce
A1	1	0.5	3.0	3.0	1.1	No data	78*
A2	2	0.5	3.0	6.0	3.0	53	25
A3	3	0.5	3.0	9.0	5.3	98	30
B	3	1.0	3.0	9.0	5.8	90	37
C	3	2.0	3.0	9.0	5.3	97	59
D	1	0.25	4.0	4.0	θ	65	0

1 Corrected to account for normal mortality

* Based on a sample of 5 exposed trees

θ Data analysis not yet completed

The spray regime shows that three applications of fenitrothion at 3 oz. wt/acre/treatment applied in a minimum volume of 0.5 gpa/treatment cause 90-98% population reduction on fir and at the best only about 50% population reduction on white spruce. A single application of 4 oz. wt/acre did not provide effective control.

An aerial survey of sprayed and unsprayed areas showed protection provided to the tops of white spruce, and good protection to fir in the areas which received the three applications. The single treatment area was in as bad condition as the unsprayed areas.

B. Application of Bt in Algonquin Park: (Project CC-0)

Meteorological equipment was used to determine spray conditions for the *Bacillus thuringiensis* applications in Algonquin Park. The separate report on the application of Bt gives the conditions under which spray was applied.

C. Application of Bt Formulations at PFES: (Project CC-015)

Bacillus thuringiensis formulations were applied to experimental plots at PFES under conditions ranging from slight lapse to very stable. The exact conditions are enumerated in the report reference CC-01.

D. Application of Fenitrothion at LaRose Forest: (Project CC-014)

Continuing the previous year's studies the meteorological equipment was used to determine and measure conditions at the time of spray application for project CC-014. The results of this study are reported under project CC-014.

E. Correlation of Meteorological Conditions with Spray Deposit:(Project CC-011)

The C.C.R.I. research aircraft, CF-BZA, was used to apply a fixed volume of dyed arotex to a 40 acre spray block in La Rose Forest. A total of 22 spray applications were made on the same block under a series of varying temperatures, relative humidites, and stability ratios. The large number of applications will permit valid analysis to study the effect of each weather variable on percentage of spray deposit and variation in spray characteristic.

One of the spray applications was a joint study with the chemistry section to determine distribution of deposit on target trees, and to correlate deposit measured using GLC analysis, kromekote cards, glass slides, petri dishes and aluminum pans.

F. Meteorological Studies for the Adult Spruce Budworm Study Project:

This joint project with members of the Maritime Regions Laboratory started in 1970. The full set of meteorological equipment has been used to provide information in this study. In 1973 the full set of equipment plus high tower was used on the joint project during the period 30 June - 13 July 1973.

APPENDIX 32

NOT FOR PUBLICATION

SUMMARY REPORT TO THE ANALYTICAL CHEMISTRY SERVICE SECTION AND METHODOLOGY RESEARCH FOR INSECTICIDE RESIDUES IN THE FOREST ENVIRONMENT

(Study Ref. No. CC-3-018)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

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October, 1973

APPENDIX 33

NOT FOR PUBLICATION

SUMMARY OF LABORATORY EVALUATIONS OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1973

(Study Ref. No. CC-2-006)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

By

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October, 1973

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1973

By

P. C. NIGAM

Twenty six insecticides were tested for contact, stomach, and residual toxicity using a modified Potter's tower. Nine of these were new insecticides and formulations. The results are summarized under contact, stomach, and residual toxicity studies. Unless otherwise specified mortality counts were made at 72 hours after treatment.

CONTACT TOXICITY

Insecticides were tested for contact toxicity against insects from British Columbia, Ontario, and Quebec. The results are summarized by area of origin and by species. Insect collections were provided by the staff of the Forest Insect and Disease Survey and personnel of the Insect Toxicology Section, Chemical Control Research Institute. Insecticides are arranged in descending order of toxicity.

BRITISH COLUMBIA

Sitka-spruce weevil - *Pissodes sitchensis* Hopk

Four insecticides were tested in 1973 against Sitka-spruce weevil adults which emerged during 1972. The corrected percentage mortality ranged form 93% to 100%.

Phoxim > fenitrothion > Gardona > lindane

Western Hemlock Looper - *Lambdina fiscellaria* lugubrosa (Hulst)

Orthene was tested against III and IV instar larvae of western hemlock looper. The corrected percentage mortality was 100% at 4% concentration and 0.6 gpa (2.69 $\mu g/cm^2$)

ONTARIO

European Pine Sawfly - *Neodiprion sertifer* (Geoffroy)

Four new insecticides were tested against fourth instar larvae of European pine sawfly. The corrected percentage mortality ranged from 14% to 92%.

RU 11679 > Dowco 214 > RU 11483 > SP 2539

Larch Sawfly - Pristiphora erichsonii (Hartig)

Three insecticides were tested against fourth instar larvae of larch sawfly. The corrected percentage mortality ranged from 50% to 96%.

Cygon > PP484 > Bay 78182

Red-headed Pine Sawfly - Neodiprion lecontei (Fitch)

Ten insecticides were tested against fourth instar larvae of red-headed pine sawfly. The corrected percentage mortality ranged from 22% to 100%.

Dowco 214 > Gardona > RU11679 > Dimetilan > RU11483 > Bay 78182 > Imidan > SP2539 > Phosvel > Orthene

White-pine Weevil - Pissodes strobi (Peck)

Ten insecticides formulations were tested against white-pine weevil adults. The corrected percentage mortality ranged from 97% to 100%.

Fenitrothion + pinolene > Fenitrothion = Gardona > Phoxim + Pinolene > phoxim > SBP 1382 > Dursban > Lindane > DDT > Methoxychlor

Spruce Budworm - Choristoneura fumiferana (Clemens)

Three insecticides were tested against fifth instar larvae of spruce budworm collected in the Ottawa area. The corrected percentage mortality ranged from 0% to 100%.

SBP1382 > Bay 78182 > Orthene

Eight insecticides were tested against sixth instar spruce budworm larvae collected in the Ottawa area. The corrected percentage mortality ranged from 29% to 100%.

RU11679 > RU11483 > Supracide > Bay 78182 > SP2539 > PP484 > Phosvel > Orthene

Spruce Budworm Adults Choristoneura fumiferana (Clemens)

Two insecticides were tested against spruce budworm adults. The corrected percentage mortality was 100% with fenitrothion at 0.5% concentration at 0.6 gpa (0.336 $\mu g/cm^2$) 48 hours after treatment, and 100% with phosphamidon at 0.5% concentration at 0.4 gpa (0.224 $\mu g/cm^2$) 72 hours after treatment.

Spruce Budworm *Choristoneura fumiferana* (Clemens)

Laboratory Reared

Six insecticides were tested against fifth instar larvae of the spruce budworm reared in the laboratory on artificial diet. The solvent AR60 was also tested. The corrected percentage mortality for the insecticides ranged from 77% to 100% and for the solvent (AR60) from 6% to 28%.

RU11679 > RU11483 > Bay 78182 > PP484 > Phosvel > Orthene

Eastern Hemlock Looper - *Lambdina fiscellaria fiscellaria* (Guen)

Fenitrothion was tested against adults of eastern hemlock looper. The mortality in two spray trials at 0.5% concentration at 0.6 gpa (0.336 $\mu g/cm^2$) was 100% after 48 hours.

QUEBEC

Spruce Budworm *Choristoneura fumiferana* (Clemens)

Late sixth instar larvae of the spruce budworm were collected at Shawville in Quebec for rearing to the adult stage for spray trials. The larvae appeared to be infected with disease organisms and insufficient adults emerged for experimental purposes.

Chain Spotted Geometer - *Cingilla catenaria* (Drury)

Two spray trials were carried out against a combination of fifth and sixth instar larvae of the chain spotted looper, using fenitrothion. The corrected percentage mortality was 82% at 1.121 $\mu g/cm^2$ and 100% at 1.344 $\mu g/cm^2$.

Swaine's Jack-pine Sawfly - *Neodiprion swainei* (Middleton)

Five insecticides were tested against fourth instar larvae of Swaine's jack-pine sawfly. The corrected percentage mortality ranged from 6% to 100%. The larval mortality during the rearing period indicated the presence of disease organisms in the population.

SBP1382 > Dowco 214 > Cygon > Dylox > Phoxim

Red-headed Pine Sawfly *Neodiprion lecontei* (Fitch)

Six insecticides were tested against fifth instar larvae of red-headed pine sawfly larvae. The corrected percentage mortality ranged from 55% to 100%.

Dimetilan > Dowco 214 > RU11679 > Bay 78182 >
Imidan > Gardona

STOMACH TOXICITY

Five concentrations of Thuricide® and Dipel® were tested against fifth instar laboratory reared spruce budworm larvae, in order to compare the stomach toxicity of Bt formulations with and without Chitinase. The formulations were sprayed on larch foliage @ .5, 1 and 2 gpa and given to larvae as food. The observations were taken three, five and seven days after treatment. The final observations after seven days are arranged in descending order of toxicity.

Dipel = Dipel + Chitinase > Thuricide + Chitinase > Thuricide

RESIDUAL TOXICITY

The insecticides were tested for residual toxicity by spraying potted host plants in the spraying chamber. The sprayed plants were then exposed to weathering conditions for 10 days. The insects used for bioassay of residues were collected in the field and maintained in the laboratory until their release on the insecticide treated foliage. The residue of the insecticides bioassayed on the same day of spraying (i.e. 4 ± 2 hours after spraying) are referred to as 0 day and these host trees were not exposed to weathering. The insecticides are arranged in descending order of residual toxicity at 0 and 10 days of residual life. The corrected percentage of mortality is given in brackets and is that observed 72 hours after releasing of insects.

Spruce Budworm - *Choristoneura fumiferana* (Clemens)

Residual toxicity of eight insecticides was tested against fifth instar larvae of spruce budworm. Two percent fenitrothion, aminocarb, Zectran, and 5% DDT at the rate of 1 GPA were repeated from previous year using white spruce and balsam fir as hosts (series I). Eight percent carbaryl and Imidan, and five percent Orthene and resmethrin, at the rate of 1 GPA were also repeated at a higher concentration from previous year using white spruce (series II).

Series I

White Spruce	0 day-Zectran (98) > DDT (88) > aminocarb (86) > fenitrothion (68)
	10 day-Zectran (83) > aminocarb (54) > DDT (33) > fenitrothion (21)
Balsam Fir	0 day-Zectran (100) = aminocarb (100) > fenitrothion (89) > DDT (87)
	10 day-Zectran (92) = aminocarb (92) > fenitrothion (53) > DDT (16)

Series II

White Spruce	0 day-Orthene (100) = Imidan (100) > resmethrin (79) > carbaryl (68)
	10 day-Orthene (21) > Imidan (20) > resmentrin (0) = carbaryl (0)

Jack-Pine Sawfly-Neodiprion pratti banksianae (Rohwer)

Five insecticides were tested against fourth instar larvae of jack-pine sawfly. One percent aminocarb, Gardona, Zectran, and two percent phoxim and propoxur, at the rate of 1 GPA, were repeated from previous year using jack-pine as hosts. The concentration of phoxim and propoxur is double that of last year.

0 day-Gardona = propoxur = Zectran = aminocarb = phoxim-all 100%
10 day-Gardona (41) > propoxur (38) > aminocarb (35) > Zectran (14) > phoxim (9)

Larch Sawfly - Pristiphora erichsonii (Hartig)

One percent concentration of three insecticides at the rate of 1 GPA were tested against fourth instar larvae of larch sawfly using tamarack as a host. This was a repeat of previous year's test.

0 day-dimethoate (100) = propoxur (100) > Gardona (98)
10 days-dimethoate (100) > propoxur (97) > Gardona (82)

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List of Insecticides

No.	Insecticide	Formulation	Type	Source
1	Aminocarb	75%	Carbamate Contact	Chemagro
2	Bay 78182	23%	Organo-phosphate contact	Bayer
3	DDT	100% tech	Chlorinated hydrocarbon contact	Math. Col. & Bell
4	Dimethoate	43.5%	Organo-phosphate contact	Chemagro
5	Dimetilan®	25% EC	Carbamate contact	Geigy
6	Dipel®	3.2% W.P.	Bacterial derivative	Abbott Laboratories
7	Dowco 214	60.6% Solut.	Organo-phosphate contact	Dow
8	Dursban®	28.8% EC	Organo-phosphate contact	Dow
9	Dylox®	29% EC	Organo-phosphate contact	Chemagro
10	Fenitrothion®	98% premium	Organo-phosphate contact	Sumitomo
11	Gardona®	99% Tech	Organo-phosphate contact	Shell
12	Imidan	11.92%	Organo-phosphate contact	Stauffer

No.	Insecticide	Formulation	Type	Source
13	Lindane	99%	Chlorinated Ayrl hydrocarbon	Hooker
14	Methoxychlor	88% tech	Chlorinated hydrocarbon	DuPont
15	Orthene	97.6% tech	Organo-phosphate contact	Chevron
16	Phosvel	92% tech	Organo-phosphate contact	Velsicol
17	Phoxim	73% tech	Organo-phosphate contact	Chemagro
18	PP484	95% tech	Contact	Chipman Chemicals
19	Propoxur	94% tech	carbamate contact	Chemagro
20	RU11483	100%	Contact	McLaughlin Gormley King Co.
21	RU11679	100%	Contact	McLaughlin Gormley King Co.
22	SBP1382	84.5% tech	Botanical derivative contact	S.B. Penick
23	SP2539	97.7%	Contact	Sumitomo
24	Supracide®	40% EC	Organo-phosphate contact	Geigy
25	Thuricide®	0.65%	Bacterial derivative	International Minerals and Chemical Corporation
26	Zectran	92%	Carbamate systemic	Dow

LIST OF INSECTS 1973

Insect	Area of origin	Instar Stage	Number Used
	CONTACT TOXICITY		
Western Hemlock Looper	Nakusp B.C.	III & IV	420
Sitka spruce weevil	British Columbia	Adult	1540
European pine sawfly	Angus Ontario	IV	880
Larch Sawfly	Ottawa Ontario	IV	660
Red-headed pine sawfly	Smiths Falls Ont	IV	4180
Red-headed pine sawfly	St. Albert & Lost River Quebec	V	1760
White-pine weevil	Sault Ste. Marie Ont	Adult-72	7600
White-pine weevil	Angus & Sault Ste. Marie Ontario	Adult-73	5300
Eastern hemlock looper	Sault Ste. Marie Ont	Adult	440
Spruce Budworm	Ottawa Ontario	V	660
Spruce Budworm	Ottawa Ontario	VI	2420
Spruce Budworm	Ottawa Ontario	Adult	440
Spruce Budworm	Laboratory reared	V	2420
Chain spotted looper	Quebec	V & VI	440
Swaine jack-pine Sawfly	Quebec	IV	1760

Insect	Area of Origin	Instar Stage	Number Used
	STOMACH TOXICITY		
Spruce budworm	Ottawa Ontario	V	440
Spruce budworm	Ottawa Ontario	VI	440
Eastern tent caterpillar	Ottawa Ontario	IV	660
Black-headed budworm	Port Alice B.C.	IV	440
Western hemlock looper	Nakusp B.C.	IV	880
	RESIDUAL TOXICITY		
Spruce budworm	Ottawa Ontario	V	4780
Black-headed jack-pine sawfly	Ottawa Ontario	IV	2340
Larch sawfly	Ottawa Ontario	IV	2460

AERIAL SPRAY APPLICATIONS OF FENITROTHION AND CARBARYL FOR CONTROL OF SPRUCE BUDWORM IN MANITOBA

An outbreak of the spruce budworm (Choristoneura fumiferana Clem.) has persisted throughout the Spruce Woods Provincial Park and Forest of southwestern Manitoba since 1969. Severe defoliation for four consecutive years has resulted in rapid deterioration of near mature and mature white spruce stands and almost complete destruction of regeneration in numerous localized areas. Because the Park and Forest are considered to be prime recreation areas, the Manitoba Department of Tourism, Recreation and Cultural Affairs decided to undertake an aerial spray program to prevent serious tree damage and mortality that could ultimately lead to loss of aesthetic values. The spray program was approved and licenced through "An Order of the Clean Environment Commission under the Clean Environment Act of Manitoba (c-b-600.1) dated March 16, 1973." The Canadian Forestry Service's primary involvement was to advise on spray techniques and determine the effectiveness of the spray operation. Other elements of Environment Canada and the University of Manitoba became involved in the environmental impact, especially as it applied to fish, birds and wildlife of the area.

In June of 1973 approximately 8,000 acres of white spruce forest were sprayed under licence with the chemical Fenitrothion supplied by Forest Protection Limited, Fredericton, New Brunswick. An additional 125 acres were sprayed experimentally with the chemical Carbaryl (Sevin-4-oil). The Fenitrothion was applied at the rate of 4 oz. active (the maximum allowable rate for one application) in 1 gal. water per acre. The formulated chemical Sevin-4-oil was mixed at the rate of 32 oz. to 8 oz. No. 2 fuel oil and the total mixture emitted from the aircraft at the rate of 32 oz. per acre, or 9.6 oz. active chemical per acre.

Spraying was carried out with two Cessna Ag-wagon aircraft equipped with Micronair 2000 and 3000 spray systems and one Piper Pawnee 235B aircraft equipped with conventional boom and nozzle. The aircraft covered an effective swath width of 50 feet flying at a height of 8 to 15 feet above treetops. Swath lines were marked at each end by white flags or colored helium-filled weather balloons on aluminum poles. Spraying was limited generally to early morning (0530 to 0930) and late afternoon and evening (1700 to 2130) when winds were less than 8 m.p.h. and humidity was high. Counts taken on selected sample plots showed that spruce budworm larval numbers ranged from 2 to 191 per 18-inch branch tip prior to spraying.

Both chemicals at the rates applied substantially reduced larval population levels (Table 1). The data, however, indicate that Sevin-4-oil was the most effective, reducing larval incidence by 86 per cent 5 days after application. Fenitrothion was less effective when applied with Micronair equipment than with conventional boom and nozzle, reducing populations 36 and 72 per cent respectively after 5 days. Fenitrothion plus an added adjuvant "Target-E" applied with Micronair equipment gave 82 per cent larval reduction over the same period.

The larger and heavier droplets produced by boom and nozzle together with a more experienced pilot are the probable reasons that this type of equipment gave the best results. Micronair systems would be ideal for budworm sprays but they require much more exact weather conditions. The small droplets produced by this equipment evaporate rapidly and increase spray drift. Even at wind speeds of less than 5 m.p.h. droplets were not reaching the target in all cases. Tests showed that when the aircraft was flying 10 feet above spray-deposit cards set out on the landing strip spray drift ranged up to 25 feet under almost calm conditions. Wind is an important factor in aerial spray operations on the Prairies, especially regarding time of application. During the 1973 budworm spray operations in the Spruce Woods, only 20 hours of suitable spray time was experienced over a two-week period.

Results of the spray operation are summarized in the following table. Data concerning foliage protection achieved are not available at this time but will be provided in a complete report to follow.

TABLE 1

Summary of Larval Mortality After Spray Treatment

Treatment	Spray Equipment	Rate/acre* (Mixture)	Rate/acre* (active chem.)	% Larval Reduction
Sevin-4-oil	Boom & Nozzle	1 qt.	9.6 oz.	86.3
Fenitrothion + Target E	Micronairs	1 gal.	4 oz.	82.3
Fenitrothion	Boom & Nozzle	1 gal.	4 oz.	72.2
Fenitrothion	Micronairs	1 gal.	4 oz.	36.0

*U.S. Measurements

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