32788

OTTAWA, December 10, 1965

NOTE:

The map (Appendix I) is not included in copies of these minutes for members of the Committee to whom copies were sent in advance of December 9.

Pressure of work has prevented completion of the minutes of the November 24 meeting of the Interdepartmental Committee on Forest Spraying Operations. These are being prepared now and will be distributed as soon as possible.

M. L. PREBBLE

Report of Meeting of the Interdepartmental Committee on Forest Spraying Operations

Sir Charles Tupper Building, Ottawa
December 9, 1965

9:00 - 11:30 AM

In Attendance

(a) Members of the Committee

A. L. Pritchard	Department of Fisheries
F. G. Cooch	Canadian Wildlife Service
D. A. S. Dyer (substitute for H.W. Beall)	Department of Forestry
M. L. Prebble, Chairman	Department of Forestry
E. W. Burridge, Secretary	Department of Fisheries

(Fisheries Research Board not represented)

(b) Others

R. R. Logie	Department of Fisheries
J. A. Keith	Canadian Wildlife Service
T. G. Willis	Department of Agriculture (representing Federal Interdepartmental Committee on Pesticides)

* * *

1. The Meeting was convened to review proposals for the 1966 spray program against the spruce budworm in New Brunswick, as advanced by K. B. Brown and B. W. Flieger at the November 24 meeting of the Committee. The proposals comprised a map of the area in which treatment would be required, presented by Mr. Flieger, and an outline of the intended insecticide treatment presented verbally at the meeting of November 24 and as set forth in greater detail in a summary statement prepared at Fredericton November 29. Members of the Committee were provided with copies of the map and the statement prior to the December 9 meeting (see Appendices I and II).

2. The Committee accepted the proposed area of treatment as being reasonable in view of the studies of forest conditions and budworm egg populations that had been conducted by staff of Forest Protection Ltd. and the Department of Forestry in the summer and fall of 1965. The Committee was also in full support of the proposal that buffer zones along the main salmon streams be treated solely with phosphamidon, at one or two applications not exceeding 1/4 pound per acre each.

... 2

3. The Committee could not, however, agree with the proposal that the general dosage rate of DDT be increased from a maximum of 1/2 pound per acre in 1965 to 2/3 pound per acre in 1966. Certain parts of the area to be sprayed in 1966 are regarded as particularly sensitive from the standpoint of risk to fish populations from the use of DDT, viz:

(a) the Nashwaak watershed
(b) the Miramichi watershed
(c) the Arthurette-Sisson Ridge "patch" area
(d) the Juniper Station-Maple Grove "patch" area
(e) the Rocky Brook "patch" area
(f) the Sevogle-Whitney "patch" area

The Committee recommended that in these areas the use of DDT be limited to 1/2 pound per acre maximum, on an acreage basis excluding the buffer zone along streams that will be sprayed with phosphamidon.

4. In other parts of the proposed spray area, there is less risk of injury to fish populations from DDT, and the Committee would not object to the use of DDT to a maximum of 2/3 pound per acre, on an acreage basis excluding the buffer zone along streams that will be sprayed with phosphamidon. The areas in question are as follows:

(a) the area east of Chipman and south of the Salmon River
(b) the area east of the Gaspereau River and north of the Salmon River
(c) the south-central portion of the proposed spray area, in the vicinity of Bantalor
(d) the Tabusintac "patch" area

5. Recognizing that the four "patch" areas, referred to in section 3 as (c), (d), (e) and (f), may be of particular concern with relation to possibility of spread of infestation, the Committee would not object to the use of phosphamidon at 1/4 pound per acre as a supplement to DDT at a maximum of 1/2 pound per acre, as defined in section 3, if that degree of added precaution should be desired.

6. More generally, the Committee recommends:

(a) That in the use of phosphamidon, not more than 1/4 pound per acre be applied at one treatment; that where two treatments are applied, the interval between them be not less than 4 days (as a precaution to reduce risk to birds); and that timing of phosphamidon treatments be scheduled to take account of periods of maximum budworm susceptibility as determined in 1965 studies in New Brunswick.

(b) That in the use of DDT, the maximum quantity per acre, as recommended in section 3 and 4, be applied in two treatments each of one-half the total amount, so timed as to give the best possible foliage protection and budworm mortality. However, the Committee accepts the proposal that if weather permits only one application, a dosage of not more than 1/2 pound of DDT per acre may be used.

(c) That in the use of DDT, as recommended in section 3 especially, (but not excluding section 4) the volume of oil carrier be increased from 1/2 gallon per acre, to say 2/3 or 3/4 gallon per acre to ensure better dispersal and a higher droplet density per unit area, which as shown in previous studies, is the best guarantee of increased budworm mortality.

(d) That critical assessment of DDT spray droplet density/budworm mortality relationships be carried out again in 1966 by staff of the Chemical Control Research Institute in areas treated at the two rates, 1/4 pound per treatment and 1/3 pound per treatment, to determine

  (i) whether there is a measurable difference in budworm mortality rate directly attributable to DDT concentration, when droplet density per unit area is held constant; and

  (ii) whether at either or both DDT concentrations, as applied under operational conditions in 1966, there is further evidence to support that obtained in 1965 experimental studies near Chipman, that budworm mortality at given spray droplet densities per unit area is substantially less than was obtained in earlier years.

(e) That additional study in 1966 be made of low volume/high concentrate sprays, employing the more promising materials investigated by the Chemical Control Research Institute near Chipman in 1965. Areas south of the Cains River or in the vicinity of Chipman would be acceptable for such tests. Other areas would not, however, be unacceptable since little risk appears to be attached to low volume applications.

7. Members of the Committee, or their representatives, will meet with Mr. Brown, Mr. Flieger, and their associates at their convenience, to review these recommendations and arrange for co-operative studies in 1966.

8. It was agreed that the Chairman should communicate the substance of these recommendations by telephone to Mr. Brown, December 9; that copies of the report would be distributed as promptly as possible; and that the report would be submitted to the Federal Interdepartmental Committee on Pesticides for review at its meeting on December 13.

Ottawa, December 10, 1965

M. L. Prebble, Chairman E. W. Burridge, Secretary

REPORT OF MEETING OF THE INTERDEPARTMENTAL COMMITTEE ON FOREST SPRAYING OPERATIONS

Victoria Building, 140 Wellington St., Ottawa
November 24, 1965

9:00 A.M. to 6:30 P.M.

In Attendance:

Members of the Committee

M.L. Prebble, Chairman	Department of Forestry
A.L. Pritchard	Department of Fisheries
F.G. Cooch	Canadian Wildlife Service
D.A.S. Dyer (for H.W. Beall)	Department of Forestry
E.W. Burridge, Secretary	Department of Fisheries

Others

C.P. Ruggles	Department of Fisheries, Halifax
J.R. MacDonald	Department of Fisheries, Halifax
K. Jackson	Department of Fisheries, Vancouver
J.A. Keith	Canadian Wildlife Service, Ottawa
T. McCarthy	Department of Health and Welfare, Ottawa
J.J. Fettes	Department of Forestry, Ottawa
W.A. Reeks	Department of Forestry, Ottawa
D.A. Wilson	Department of Forestry, Ottawa
B.M. McGugan	Department of Forestry, Ottawa
I.C.M. Place	Department of Forestry, Fredericton
D.R. Macdonald	Department of Forestry ~~Fisheries,~~ Fredericton
L. Daviault	Department of Forestry, Quebec
G.T. Silver	Department of Forestry, Victoria
C.D. Fowle	York University, Toronto
K.B. Brown	New Brunswick Department of Lands and Mines, Fredericton
B.W. Flieger	Forest Protection Ltd., Campbellton
H.A. Richomnd	B.C. Loggers' Association, Vancouver

1. Introductory Comments

The Chairman described briefly relations between the Interdepartmental Committee on Forest Spraying Operations and the more recently established Federal Interdepartmental Committee on Pesticides, which is the more senior of the two committees and to which the results of this meeting will be transmitted as promptly as possible.

... 2

2. Agenda

A provisional agenda, distributed by the Chairman, was accepted, and appears below:

A. Experimental control projects, 1965, and proposed experimental projects, 1966
(exclusive of the spruce budworm)

B. Operational control projects, 1965
(exclusive of the spruce budworm)

C. Review of the infestations that might require operational control action in 1966
(exclusive of the spruce budworm)

D. Spruce budworm control and associated problems in New Brunswick:

i) experimental studies of resistance to DDT

ii) experimental studies with other insecticides

iii) operational control project, 1965

iv) studies of hazards to humans

v) studies of hazards to fish and other aquatic life

vi) studies of hazards to wildlife

vii) infestation status in the fall of 1965 and areas of hazard for 1966

viii) proposed spray program in New Brunswick, 1966

ix) cost/benefit analysis

3. Agenda Item A.

Experimental control projects, 1965, and proposed experimental projects, 1966
(exclusive of the spruce budworm)

(i) Balsam woolly aphid, Newfoundland

Fettes described the chemical control trials against the balsam woolly aphid in Newfoundland, the results of which are summarized in Appendix I. Efforts to discover or develop a chemical control method for balsam woolly aphid were started in 1963 and continued through 1965. During that period some 18 insecticides have been tried. It is considered that from a forestry standpoint the material to be successful must show systemic activity and, therefore, all the materials which have been tested are systemic insecticides and have been successful against similar insects on agricultural crops. Of the 18 materials entered in tests over a period of three years, only 4 survive. Although the tests were limited, the material Baygon shows most promise, followed by Sumithion, Diazinon and Sayfos.

Fettes noted that the sprays have been applied at dosages equivalent to 5 or 10 times those that would be applied in aircraft spraying on the assumption that any insecticide that did not show promise at such heavy dosages should be eliminated from further testing. Prebble suggested that it might be opportune in 1966 to test the more promising materials that had emerged in trials up to 1965 at lighter dosages typical of aerial applications.

Fettes indicated a number of new systemic insecticides would be added to the field tests in 1966, drawing on evidence from trials of materials against agricultural pests and taking account of available data on the hazards of the newer insecticides to fish and wildlife.

(ii) Balsam woolly aphid, British Columbia

Silver stated that the balsam woolly aphid infestation on amabilis fir on the mainland, in and north of Vancouver, has been known for several years and encompasses an area of some 900 square miles. More recently infestations on grand fir in the Victoria area and the Saanich Peninsula of Vancouver Island has prompted intensification of detection surveys during 1965. Scattered patches of infested trees have been found on the Gulf Islands and along the east coast of Vancouver Island, which together with the infestations on the Saanich Peninsula aggregate some 200 square miles. Concern has been expressed by the forest industry that potential spread of the insects threatens a huge resource of the more susceptible species of balsam firs throughout the province.

Some nursery stock in the Greater Victoria area has been treated with BHC. Enforcement of quarantine regulations is being considered. Under jurisdiction of the B.C. Forest Service, advanced isolated groups of infested grand fir on Vancouver Island have been felled and burned.

If an effective chemical control treatment were known, doubtlessly all, or at least the peripheral stands of the infested area would be treated. Since a satisfactory chemical control method has not been discovered, experimental work similar to that under way in Newfoundland ought to be initiated locally next year. It is anticipated that only ground-applied systemic chemical sprays will be tested.

Richmond confirmed that the forestry industry is greatly concerned about the balsam woolly aphid in British Columbia because amabilis fir represents the main forest value in some parts of Vancouver Island and alpine fir is a very important constituent of the boreal forest throughout much of the northern interior of British Columbia.

... 4

Fettes indicated that the Chemical Control Research Institute did indeed expect to carry out a series of trials against the balsam woolly aphid in British Columbia, based on experience in Newfoundland. There are differences between the two situations in the distribution of the aphid in the host trees, and there may be differences in translocation of systemic insecticides between the eastern and western species of Abies. Details of the plan have not yet been worked out and will be influenced by availability of assistance.

(iii) Hemlock needle miner, Vancouver Island

Silver reported that during May, 1965, extensive areas of defoliated hemlock were observed on the northwestern portion of Vancouver Island in the vicinity of Holberg Inlet. At least 83,000 acres of hemlock-cedar forests were affected, with severe defoliation covering 18,000 acres. A leaf miner, Epinotia sp., was found to be responsible. The insect hatches in August, overwinters as a larva which completes its feeding in early spring. Consequently, damage is most evident during May and June, just prior to bud burst.

This year the new foliage, although infested, has masked most of the injury.

He referred to a chemical control trial carried out on two infested plots of 40 to 60 acres employing Phosphamidon and Dimethoate at the rate of 1/2 lb. of active material per U.S. gallon of water per acre (see Appendix II). Despite the somewhat faulty timing of the experimental application of the insecticides rather encouraging results were obtained, Phosphamidon yielding an unadjusted mortality of about 72% and Dimethoate an adjusted mortality of about 83%. (With adjustment for natural mortality the effect of these insecticides is estimated at about 64% and about 78% respectively - Chairman).

Cooch felt that the use of Phosphamidon at 1/2 lb. per acre would be hazardous to birds. Jackson commented that Dimethoate appears to be quite safe at 1/2 lb. per acre as far as fish are concerned. Fettes and Cooch believed that Dimethoate would be less hazardous to birds than Phosphamidon.

No plans have been laid as yet for continuation of experimental control in 1966.

4. Agenda Item B

Operational control projects, 1965
(exclusive of the spruce budworm)

(i) Jack pine sawfly, Quebec

Daviault described infestations of the Swaine jack pine sawfly in the St. Maurice watershed of Quebec which required control

... 5

action in 1965 to avoid extensive timber mortality. One of the important considerations in planning insecticide treatment was the avoidance of the use of DDT owing to the prevalence of trout-bearing lakes and streams in the affected area.

Laboratory experiments were carried out by the Chemical Control Research Institute employing N. p. banksianae in the early part of the summer and these indicated that Phosphamidon would probably be effective at a low dosage. Later when N. swainei larvae became available, laboratory trials confirmed the toxicity of Phosphamidon against Neodiprion larvae and indicating that Zectran and Sumithion would probably be equally effective at very low dosages (Appendix III). In contrast, DDT at 1 lb. or more per acre gave poor results in the laboratory trials.

The spray program was organized to treat approximately 150,000 acres of infested jack pine stands distributed in a large number of individual patches in a 5,000 square mile area west of La Tuque (see Figure 1, Appendix IV). The spray consisted of 1/4 lb. of technical Phosphamidon per 0.2 gallons of water per acre, and the operation was conducted between August 10 and 20 inclusive. The treatment was credited with effecting over 99% mortality of the young jack pine sawfly larvae. Equivalent results were obtained in an experimental block that was sprayed at 1/8 lb. of Phosphamidon in 0.2 gallons per acre (Appendix IV). Studies carried out by the Chemical Control Research Institute in selected plots confirmed that very high sawfly mortality occurred where spray droplet deposit was minimal and in fact even in certain leeward areas subject to drift where virtually no deposit was recorded on the sample cards (Appendix V).

Fettes stressed the need for very careful definition of weather conditions under which spraying can be done when very small volumes are to be employed and where spray breakup in very fine particles is to be effected. The field results also point up the need for much more sensitive deposit sampling systems than had been employed in earlier field studies.

Flieger described operational aspects of the project which was conducted by Forest Protection Ltd. under contract to the Quebec Forest Industries Ltd. Stearman aircraft were employed for spraying, the cost of which averaged about $1.10 per acre. Very favourable flying conditions were experienced between August 10 and 20 of 1965 but Flieger cautioned that favourable flying experience of this year did not necessarily represent the availability of flying weather that would typically be experienced in this part of Quebec (Appendix VIII, Section 10).

... 6

Other studies by McLeod and his associates (Appendix IV) showed that parasites of the sawfly were rather seriously reduced in numbers but proportionately less so than the sawfly itself; that there was a general reduction in other insects occurring in jack pine stands; and that of the various species of birds inhabiting jack pine stands the myrtle warbler seemed to be most adversely affected by Phosphamidon spray. Fowle remarked that typically jack pine stands are not a favoured habitat for birds and it is possible that the myrtle warblers were present partly because of the availability of sawflies for food. The experiments in New Brunswick also showed that the myrtle warbler is very sensitive to Phosphamidon. Cooch expressed the hope that wildlife biologists might be able to participate in subsequent field studies relating to the use of insecticides for forest insect control in Quebec.

The discussion on this topic closed with the reference to the virus of the Swaine jack pine sawfly that had given very encouraging results in experimental studies in 1962 but rather less satisfactory results in a larger pilot-scale operation in 1964. Daviault and Prebble reaffirmed continued interest in the virus and the expectation that it would prove to be of value if used at the appropriate time in rising infestations rather than against epidemic numbers already threatening the existence of the host stands.

(ii) Ambrosia beetles, British Columbia

Richmond stated that about 50 million board feet of logs in booms were sprayed with BHC at about 25¢ per thousand as a general preventive action to avoid loss of value many times the cost of spraying. A factor limiting the extent of this program is the need to restrict the spraying of booms in the river estuaries to the period before April 15 to avoid the risk of injury to young salmon. The spraying of log booms is permitted after April 15 if the booms are moved away from the river estuaries, but this represents an additional cost and introduces the hazard of having the booms broken up in storms. Although Phosphamidon and Dimethoate have proven ineffectual as residual insecticides in small-scale trials by Kinghorn, Richmond thought they might have some value as contact sprays applied during the period of active beetle flight in early May. This might make it possible to use these materials, or others relatively non-toxic to young salmon after the present suspension date of April 15 for BHC sprays. Fettes confirmed that Phosphamidon and Dimethoate have a limited effective period (4 days or less) and suggested Malathion, which has a residual effect for about two weeks. Jackson recalled that Malathion was highly toxic to fish and could be considered in the same category as BHC and would therefore be unusable after the present April 15 deadline.

... 7

(iii) Fall cankerworm, Selkirk, Manitoba

Prebble reviewed briefly the 250-acre project for the control of the fall cankerworm in the town of Selkirk, as reported by D.R. Robertson, Provincial entomologist for Manitoba (Appendix VI). Most of the area was treated with DDT but small parcels were treated with Matacil (carbamate) and also with Dylox (organophosphate) which gave comparable protection.

5. Agenda Item C

Review of infestations that might require operational action in 1966
(exclusive of the spruce budworm)

This item was largely bypassed in the discussions November 24 to permit more thorough review of the spruce budworm problem (Agenda Item D). The following notes, based on information supplied to the Department of Forestry and on limited discussion at the meeting, are included for purposes of the record:

(i) Hemlock needle miner, Epinotia sp., British Columbia

Populations of the hemlock needle miner which occurred in the Holberg Inlet area of Vancouver Island (referred to in 3 (iii) above) remained high throughout the season. Very little is known about the life history and damage potential of this species and it is difficult to predict what damage may be expected in 1966, or what reduction in populations might occur during the winter period. Richmond stated that the three companies holding timber limits in the affected area (M.B. and Powell River, Tahsis and Rayonier) are concerned over the possibility of severe injury in 1966. It is possible that the companies may wish to undertake operational control in the spring of 1966 before feeding reaches its peak. Another opportunity for control action would occur during August and September of 1966 aimed at the next generation of the species. Silver felt that the Victoria Laboratory would be so heavily involved in other programs, notably the balsam woolly aphid program, that it could not become actively involved in studies of the control of the hemlock needle miner.

(ii) Swaine jack pine sawfly, Quebec

The report by Mcleod and associates (Appendix IV) indicates that weather in the late summer and fall of 1965 was unfavourable to the jack pine sawfly populations and it is not expected that the species will pose a serious risk in 1966. Daviault stated that a questionnaire had been sent to limit holders in Quebec requesting information on the distribution of jack pine stands and their condition. On the basis of returns, an aerial survey will be conducted as soon as aircraft can be operated on skiis. Examination of cocoon populations in the ground will be necessary in 1966 to confirm the existence of continuing hazard in stands showing moderate to severe defoliation.

(iii) Red-headed jack pine sawfly, New Brunswick

The Fredericton Laboratory has reported the occurrence of an infestation of the red-headed jack pine sawfly in an area of about 8 square miles on the upper waters of the Bartibog River in Gloucester County, New Brunswick. Moderate to severe loss of foliage occurs in mature jack pine stands, and light to moderate defoliation in adjacent cut-over areas. Cutting operations are planned by Fraser Companies Ltd. to include as much as possible of the affected timber. This will not necessarily curb the infestation, as the adults emerging from the ground may fly to nearby uninfested stands to deposit their eggs. The need for control action will, therefore, not be known until about mid-summer of 1966.

(iv) Larch sawfly, British Columbia

Some 360,000 acres of larch trees in the Nelson Forest District were moderately to severely defoliated in 1965 by this sawfly. A preliminary examination of cocoon samples indicates that moderate to severe defoliation will recur in 1966 even more extensively than in 1965. There has been no demand for control action; however, since there is a potential for tree mortality, it is recommended that a small experimental chemical control project be carried out with a helicopter during 1966.

(v) Black-headed budworm, British Columbia

About 200 square miles of hemlock forest in the Kamloops and Nelson Forest Districts were infested by this budworm in 1965. Egg samples indicate that moderate defoliation could occur over this area in 1966. In the past, infestations in this region have been of short duration; therefore, only a small chemical control experiment might be considered during 1966.

6. Agenda Item D

Spruce budworm control and associated problems in New Brunswick

(i) Experimental studies of resistance to DDT

Fettes stated that 1965 laboratory experiments with samples of budworm populations from sprayed areas in New Brunswick confirmed the results of studies in earlier years indicating the development of resistance to DDT sprays. Some field evidence supporting the laboratory studies was also encountered in the 1965 trials of various insecticides in the Chipman area of New Brunswick (see last entry in Table II of Appendix VII). Whereas in spray trials carried out in 1958 and earlier, deposit of 12½% DDT at 5 to 10 droplets per square centimetre produced mortality up to about 90% and a droplet density of from 10 to 15 per square centimetre produced mortality of 95% or better, 1965 series at Chipman with 10 to 15 droplets per square centimetre of 19% concentration of DDT produced only about 73% budworm mortality.

D.R. Macdonald indicated that no evidence of a fall-off in the effectiveness of DDT is detectable in the operational program as a whole where great variations occur in droplet density per unit area, budworm populations levels, etc. However, in his laboratory studies at Fredericton of populations taken from widely scattered plots in New Brunswick he found evidence of a break in the dosage mortality curves broadly comparable to those encountered in the experiments conducted by the Chemical Control Research Institute in Ottawa. Another indication of resistance is encountered in the persistence of infestations over quite large areas that have been sprayed, but the interpretation of this evidence is confounded by the higher prevalence of spruce in these particular areas.

(ii) Experimental studies with other insecticides

The Chemical Control Research Institute continued its program of field experiments in the Chipman area of New Brunswick in 1965 to find insecticides that could be used as substitutes for DDT and Phosphamidon. The 1965 experiments involved low volume applications of highly concentrated insecticides and Fettes referred to the data summarized in Appendix VII. Among the early series of applications applied when the budworms were in the old needles or in the 1965 buds, only Sumithion of the four materials tested (Table II, early series) gave acceptable mortality and this only at a droplet density of 10 to 20 droplets per square centimetre. Zectran, Cygon and Phosphamidon gave poor results in the early spray series. Among the treatments applied when the budworms were larger and inhabited the open shoots, Phosphamidon and Sumithion gave excellent budworm control approaching or attaining 100%. Cygon and Zectran yielded results only slightly less satisfactory. These results are based on the analysis of data from populations on balsam fir. The data from budworm populations on spruce have not as yet been analyzed.

Fettes and his associates are very much interested in further trials of low volumes of highly concentrated insecticides and are aware of additional problems in dispersal and deposit sampling in very finely atomized low-volume applications. Richmond asked whether any work with pyrethrins is contemplated in Canada in view of efforts being expended on these insecticides by the U.S. Service in an attempt to avoid side effects of spraying operations. Fettes doubted whether pyrethrins would have any advantage over other available materials; but it was suggested by Prebble that he get in touch with W.V. Benedict of the U.S. Forest Service on studies being carried out by the Berkeley Laboratory.

Much difficulty has been encountered in the use of the Mini-spin spray equipment in 1965 owing to breakage and other difficulties in service. The Chemical Control Research Institute proposes to issue a separate report on this spray apparatus.

... 10

Flieger described some of the operational problems associated with the large-scale pilot testing of low volume/high concentrate Phosphamidon and Malathion (see sections 11 and 12, pages 6-8, Appendix VIII). Much of the difficulty in the pilot-scale testing of the low volume concentrate sprays in 1965 was due to the faulty Mini-spin spray apparatus and Flieger thought the difficulty could be avoided in experimental trials in 1966 utilizing a portable spray rig developed by the Chevron Chemical Company (see Figure 3, Appendix VIII). Forest Protection Ltd. is acquiring one of these rigs which will be available for experimental studies in 1966.

Flieger stated that Forest Protection Ltd. is not yet in a position to exploit low volume spraying on an operational scale. If this approach should become operationally feasible during the life of the control program in New Brunswick, the Company will prefer the use of small aircraft over larger ones and will probably propose operation of small planes in formation of 4 or 5 units. This will require perfection of the spraying apparatus owing to the difficulty of withdrawal of a faulty unit from formation flying.

Fowle remarked that some evidence of bird mortality was obtained in the area of low volume spraying but unfortunately staff resources were not available for intensive studies in the area.

D.R. Macdonald described the results of the large-scale trials of Phosphamidon and Malathion in terms of budworm mortality (see section 4, pages 3-8, Appendix IX). Not all the data had been fully analyzed as yet but the principal tentative conclusions are as follows:

Phosphamidon

(a) Good levels of control were obtained at 1/4 lb. per acre at 2 periods, the first a very limited period when the young larvae were moving from the first set of needle mines about the third week of May; and during a second period starting about the third week of June when the well-grown larvae were exposed in the expanded new foliage. Very poor control resulted when the spray was applied about mid-May when larvae were protected in their first needle mines, and also when the spray was applied during late May and the first part of June when the larvae were protected in the buds or new shoots. Somewhat better control was effected on balsam fir than on spruce (Fig. 4, Appendix IX).

(b) There was no clear-cut effect traceable to the rate of dilution of 1/4 lb. Phosphamidon within the range of .2 to .8 gallon per acre.

(c) The 1965 experimental series provided no evidence that the addition of Invadine improved effectiveness of the spray.

... 11

Macdonald suggested that very early spraying of Phosphamidon might give good results if applied at the appropriate time to catch the very young budworm larvae leaving their hibernacula for the first needle mines. The feasibility of this could be tested at least in part under laboratory conditions in late winter. Fowle stated that such early application of Phosphamidon would be virtually free of any risk to birds because if operationally feasible it would be applied before many of the migrant birds arrived in the spray area.

Malathion

Malathion at 1 lb. per acre produced quite good results on fir and less satisfactory results on spruce (about 93 and 70% budworm mortality respectively) but very poor results at applications of 1/2 or 1/4 lb. (Table VI, Appendix IX).

Dimethoate (Rogor 40)

Dimethoate at 1 lb. per acre produced only 80% mortality on fir and 63% on spruce.

(iii) Operational control project 1965

Statistics and comments on the operational program of 1965 are contained in Flieger's report (Appendix VIII). He referred to some of the highlights as follows:

(a) About 1.7 million acres were sprayed with DDT at 1/4 lb. in 1/2 gallon water per acre, and of this total .94 million acres were given a second application. An additional .2 million acres were sprayed with Phosphamidon at 1/4 lb. per acre in buffer zones along the salmon streams, and of this buffer zone area approximately 70% was sprayed the second time at the same dosage rate.

In addition to this operational area, about .28 million acres were sprayed experimentally with low volume/high concentrate sprays of Malathion and Dimethoate, and with Phosphamidon at 1/4 lb. to 1/2 lb. per acre in various dilutions of water from .2 to .8 gallons per acre.

(b) A change was made from the block-unit system of previous years to a load-unit system in 1965 for much of the area to be sprayed whereby the acreage that could be sprayed by 2 TBM's in one sortie determined the size of the block-unit. The size varied in relation to the amount of Phosphamidon buffer zone along the streams within the area. This system required very close operational control because the aircraft being loaded for one block-unit could not be diverted to another of different predetermined size.

... 12

(c) Although the early portion of the spray period was characterized by unfavourable weather, the later portion was exceptionally favourable and the operation was completed in record time.

(d) Special precautions were taken to reduce hazard to operating personnel, including a separation of the mixing and loading apparatus for DDT and Phosphamidon, bottom loading aircraft, the use of protective clothing, and the employment of non-drip hose connections. No cases of injury from poisoning were recorded.

The biological effects of the 1965 operational program were described by D.R. Macdonald (see page 3, Tables II and III, and Figure 5 of Appendix IX). The first application of Phosphamidon in the buffer zone along streams gave rather poor budworm control, so a large part of the buffer zone area was treated a second time. In general, foliage protection was very good throughout the operational area (Figure 5), especially in the later "phenological categories" and where two treatments of DDT were applied (Table 2). Results in the earliest phenological categories were less satisfactory in populations on balsam fir and especially on spruce. The over-all weighted average for all phenological categories was 85% population reduction on balsam fir and 62% on spruce. Effective control of the budworm on spruce requires very careful timing of the second application related to fall of the bud caps, and this is difficult to ensure in a large operation. The 1965 results on balsam fir were somewhat better than those obtained in the preceding 5 years, whereas the results obtained on spruce were less satisfactory than those obtained from 1961-1964 inclusive.

(iv) Studies of hazards to humans

Dr. T. McCarthy reported on investigations undertaken by the Occupational Health Division of the Department of Health and Welfare in the 1965 spray operations in New Brunswick (Appendix X). He found that packaging and handling arrangements for the insecticides were much improved over those of 1964, but labelling still leaves something to be desired for Phosphamidon and particularly for Rogor (Dimethoate). Apparently the labelling regulations are more stringent when insecticide materials are sold for operational use than when they are donated for experimental use. The Rogor insecticide arrived quite inadequately labelled. The supply firm was notified. Good co-operation in arranging for periodic blood samples was obtained from the formulators, the loaders, the mechanics and the pilots. No evidence of toxic effects was found, but Dr. McCarthy feels that the mechanics should exercise special precautions because of their exposure to liquid spray in adjusting the spray system apparatus and their reluctance to wear protection on the hands and arms. He and Flieger were much in favour of the incorporation of conspicuous dyes in toxic insecticides, such as Phosphamidon, as was done in 1965.

Dr. McCarthy stated that medical supervision should continue to be supplied in large spraying operations, especially when new insecticides are being used. The Provincial Department of Health should provide required medical supervision although it seemed doubtful that the Department of Health in New Brunswick had a sufficient number of qualified people in this field. Prebble suggested that this need be drawn to the attention of Dr. Glen, Chairman of the Federal Interdepartmental Committee on Pesticides, who might wish to communicate with the Provincial Committee on Pesticides. Dr. McCarthy stated that he will be available to provide limited assistance in future years. He stressed particularly the importance of having a medical toxicologist participate in the planning discussions for operations of this size.

(v) Studies of hazards to fish and other aquatic life

Ruggles summarized briefly the results of laboratory tests on toxicity of Phosphamidon and Invadine carried out by J.B. Sprague and J.A. Dalziel (Appendix (XI). Invadine is a relatively non-toxic constituent; Phosphamidon is safe for fish at the levels that would normally be expected in rivers from forest spraying operations; and Invadine did not enhance the effect of Phosphamidon in the laboratory experiments. He also summarized the results of J.B. MacDonald's field studies on New Brunswick salmon (Appendix XII). Phosphamidon at 1/4 lb. per acre had no significant effect on caged salmon fry and at 1/2 lb. per acre no significant effect on caged salmon parr during a ten-day exposure period. In the Phosphamidon buffer zones mortality of caged salmon parr was variable, apparently reflecting the rate of DDT inflow, and averaged about 40%. DDT sprayed twice at 1/4 lb. per acre produced 100% mortality in caged salmon parr. Malathion produced fish mortality of approximately the same order as DDT. Studies of free salmon populations were also carried out. In DDT sprayed areas there was a short-term mortality of salmon parr amounting to about 15-30%, but no measurable short-term reduction in Phosphamidon sprayed areas. The post-spray samples in August showed parr populations in Phosphamidon treated areas to be about half of those in unsprayed areas and fry populations to be about one-third of those in unsprayed areas. Low over-wintering survival of one-year parr in 1964 DDT spray areas was recorded in 1965. Parr populations in the fall of 1965 appeared to be in better condition than those in 1964.

In conclusion Ruggles stated that the loss of fish from spraying is still serious in spite of the relatively good salmon runs of recent years. He added that if runs go down from natural causes the effect of forest spraying on the reduced populations could be far more pronounced than the effects on high populations.

Fowle enquired about the leaching of DDT into the main salmon streams through the Phosphamidon buffer zones. Fettes pointed out this had not been investigated.

Flieger questioned the validity of the populations in the Sevogle River as a check area, indicating that the evidence suggested the Sevogle River was very highly populated as a consequence of diversion into that stream of fish that would normally enter the Northwest Miramichi were it not for the effect of mine effluent in the latter stream.

Jackson described the results of studies of the toxicity of Dimethoate for coho salmon fry and the use of a fluorometric technique for estimation of the insecticide concentration in water (Appendix XIII). Mortality in liveboxes was nil and no injury was detected in free fish populations. Jackson concluded that Dimethoate is not hazardous to coho salmon at concentration levels that could be expected to result from normal aerial spraying operations. The technique employed is extremely sensitive. He believes the method will be useful for detecting other kinds of insecticides and for the gathering of continuous records on insecticide concentrations in streams following spraying operations. Fettes remarked that several things in the forest environment fluoresce and could cause confusion in interpretation of fluorometric readings. Jackson believed that this difficulty could be overcome by background studies of fluorescence in check streams exempt from spraying.

At the request of the British Columbia Loggers' Association the Department of Fisheries undertook aquaria investigations of the toxicity of 5 herbicides for juvenile coho salmon (Appendix XIV). Jackson stated that the results indicated that a selection may be made among available herbicides that would present essentially no hazard to fish in areas exposed to herbicide treatment.

(vi) Studies of hazards to wildlife

Fowle reported on studies that he had carried out on behalf of the Canadian Wildlife Service in New Brunswick in 1965 (Appendix XV). Phosphamidon at 1/4 lb. per acre produced no serious effects on birds, but where dosages of 1/2 lb. or more were applied, appreciable mortality of birds occurred. The studies were not sufficiently conclusive to detect any differences between morning and evening applications, or between the presence and absence of Invadine in the spray mixture. In addition to the results reported in Appendix XV, some preliminary studies were made on the possible effects of DDT sprays on birds and small mammals. Surveys of nesting birds were made in plots that had received one and two sprayings of DDT but no changes in the numbers of birds or their behaviour could be attributed to DDT. There was a high loss of the nests during observations, but Fowle felt that this may well have been due to "heavy traffic" in the plots rather than to the insecticide.

Small mammals were trapped in DDT sprayed areas but the numbers were small and could not be related to differences in the spray history of the trapping areas.

... 15

Preliminary surveys of bird populations near St. Andrews and in Fundy National Park, where spraying has not been done, revealed no evident contrasts with the results in sprayed areas.

Cooch indicated that the Canadian Wildlife Service will continue to support field studies associated with the spray program in 1966.

(vii) Infestation status in the fall of 1965 and areas of hazard for 1966

D.R. Macdonald referred to page 9 and Figure 6 of Appendix IX, which show the results of the budworm egg-mass survey in the late summer of 1965. There is a large area of approximately 1 million acres in the central part of the infestation with very severe populations. In addition there are numerous outlying areas to the north and west of the main body of infestation that contain severe to very severe infestations. Most of these occur in the western part of the 1965 operational area but others occur considerably to the north, in Gloucester County, and to the west at the mouth of the Tobique River. The total area of severe and very severe infestation is estimated at 1,654,000 acres, and of moderate infestations, 781,000 acres. Areas with moderate egg infestations may contain small patches with sufficient numbers of eggs to cause heavy defoliation in 1966, but in general the moderately infested areas of 1965 are not expected to suffer severe defoliation in 1966.

The high hazard area (severe and very severe egg populations) carries typically a mixed coniferous forest with considerable red spruce. Much mortality of balsam fir has already occurred in this area, but the red spruce is generally in better condition. Some mortality of red spruce has occurred in the Salmon River area.

Budworm populations continue to be very low in the northern part of the Province.

(viii) Proposed spray program in New Brunswick, 1966

Brown stated that Forest Protection Limited believes that an area in excess of 1.6 million acres will need protection in 1966 and that it would be reasonable to assume a safety factor of 20% to allow for the addition of highly hazardous areas discovered in the spring of 1966. Because of the high red spruce content of the affected forest, two spray applications are considered necessary, one early and one late. Brown felt that the use of Phosphamidon could be extended farther up the streams to improve the buffering action. On the other hand, DDT is considered more effective in budworm control and special care will be needed in timing applications. He expressed the hope that the Interdepartmental Committee could provide advice for the development of a spray plan that would be mutually acceptable for presentation to the Directors of Forest Protection Limited.

... 16

Flieger repeated the viewpoint that a "cushion" of about 20% is justified because in their experience hazardous areas have always been discovered in the spring or early summer that were not detected during egg-mass surveys of the preceding fall. He presented a tentative map outlining a basic spray area of some 1.6 million acres which is not identical to that shown on Figure 6 of Appendix IX, but is substantially the same area with minor smoothing of the boundaries and merging of adjacent patches of infestation.

He, too, felt that the Phosphamidon buffer zone could be extended farther up the headwaters of streams. The proposal advanced by Forest Protection Limited is for double treatment of the whole spray area, utilizing Phosphamidon at 1/4 lb. per acre per treatment in the buffer zone, and DDT at 1/3 lb. per acre for each treatment in all the remaining area to be sprayed.

Flieger expected that very careful scheduling would be needed in 1966 because about 70% of the area falls in one phenological category requiring prompt treatment in the first application. He also stressed the importance of concentrated survey effort in the pre-spray period to determine the extent of areas that might need to be added to the program as foreseen in the fall of 1965.

Ruggles stated that it was a hope of the Fisheries people that Phosphamidon might be used more extensively in 1966. Pritchard agreed with this viewpoint and stated that he was opposed to increasing the dosage rate of DDT from 1/4 to 1/3 lb. per treatment. He was also doubtful of the concept of double spraying of DDT over the entire area, whether this be done at 1/3 or 1/4 lb. per treatment.

Brown felt that two treatments of Phosphamidon at 1/4 lb. per acre would give less satisfactory results than two treatments of DDT at 1/4 lb. or 1/3 lb. per acre. Flieger stated that in his opinion the earlier reduction from 1/2 to 1/4 lb. DDT per acre went too far. Fettes, however, emphasized that the earlier experimental studies consistently demonstrated that the budworm mortality was more closely related to the deposit density of spray droplets per unit area than to the concentration of DDT in the spray. Therefore he believed that the volume of spray distributed is, within limits, more important than the concentration of DDT.

Prebble stated that these opposing viewpoints would be carefully reviewed by the members of the Interdepartmental Committee at a meeting to be called as promptly as possible and that the recommendation of the Committee would be conveyed to Mr. Brown and Mr. Flieger without delay.

(ix) Cost/benefit analysis

D.A. Wilson outlined the background of the cost/benefit analysis of the budworm operations in New Brunswick which is being undertaken by the Department of Forestry in co-operation with the Department of Lands and Mines, New Brunswick, as a result of a notification received from Treasury Board in the winter of 1965. For purposes of the analysis the central New Brunswick infestation is being considered separate from the northern infestation of 1952-59; and the starting point is considered to be 1960, with an assumed terminal year of 1969. The control costs of the later years are being projected on the basis of assumed acreage and cost of treatment corresponding to the first six years of the period. The benefits in terms of wood production from the treated area, subsequently converted to dollar value, represent the difference between production that can be realized as result of treatment and that which would have been obtained if the outbreak had been allowed to run its course without protective action.

Other resources have not been forgotten. However it has not been considered appropriate for the Department of Forestry to undertake an analysis of the impact of the spraying program on fish and wildlife resources. Pritchard stated that if requested by Treasury Board to do so the Department of Fisheries could contribute a section relating to the impact of the spraying program on the salmon fishery.

E. W. Burridge
SECRETARY

M. L. Prebble
CHAIRMAN

OTTAWA, December 17, 1965

TESTS OF VARIOUS INSECTICIDES FOR CHEMICAL CONTROL OF BALSAM WOOLLY APHID IN NEWFOUNDLAND - 1965

Small scale tests were continued in search of a method for chemical control of the Balsam Woolly Aphid, Adelges piceae (Ratz.). The insecticides used were those which showed some activity in controlling the aphid in the 1964 tests (Summary Report on Investigation of Methods for the Chemical Control of the Balsam Woolly Aphid, Newfoundland - 1964, J.J.Fettes, in 'Report of the Interdepartmental Committee on Forest Spraying Operations', Ottawa, November 24, 1964) along with some newer compounds which were considered to have promise. The tests were made on 22 and 23 May 1965 near Steady Brook, Newfoundland.

Each test comprised the spraying of an aphid-infested balsam fir tree 25 to 35 feet in height. One litre of the test formulation was applied to the foliage by use of a "Cooley" Mist Sprayer (skid model) fitted with extra long hoses. The spray was spread evenly over the tree by an operator working on a 20-foot ladder beside the tree.

Eight insecticides were used in 16 different formulations, applied as a water-based solution, emulsion or suspension. Commercially prepared concentrates were diluted with water togive 10% active ingredient in the spray mix, except for Baygon and Aramite which were used at 5% and 2.5% respectively, because of low active content of the concentrates. There were 3 different groups of mixes: (A) those made up as described above, (B) those as in (A) but with Invadine, a wetting and penetrating agent (Ciba Co. Ltd., Dorval, Que.) added at the rate of 2 ml/l, and (C) those with dimethyl sulfoxide (DMSO) added to the same concentration as the active ingredient. Rhodamine B dye was used in all mixes as a tracer (0.2%).

The aphid population of each tree was determined by 2 prespray and 4 postspray counts according to the method of Bryant (ref.here).

Data on the solutions used and the results obtained are given in Table I, arranged in descending order of effectiveness. Baygon, Diazinon, Sayfos and Sumithion seem worthy of further testing, especially the first-named since its effectiveness compares favourably with the others even at one half the dosage (5% active vs 10% for others).

The addition of Invadine appears to have improved the effectiveness of 3 of the compounds with which it was tested but further testing is required to establish this conclusion. The use of DMSO with Diazinon and Sumithion did not increase their effectiveness.

October 27, 1965,
Ottawa, Ont.

W.W.Hopewell and D.G.Bryant
Department of Forestry

APPENDIX I CONT'D

TABLE I

Spray Solutions and Results of Aphid Counts - Balsam Woolly Aphid Tests, 1965

Insecticide (per cent active in concentrate)	Type*	No. nodes with living aphids Prespray counts		Per Cent Mortality Postspray - Days			Found	Weighted Average
		No. 1	No. 2	3	6	13	23	
Baygon (13.9) (a)	B	22	12	100	+	+	100	100
Diazinon (50) (b)	B	19	11	91	100	+	93	94
Sayfos (70) (c)	A	20	17	79	88	88	+	84
Baygon	A	15	16	73	+	100	+	82
Sumithion (50) (d)	B	26	24	100	91	100	100	79
Diazinon	C	18	26	84	56	100	+	78
Diazinon	A	9	21	100	40	80	+	75
Meta Systox-R (25.4) (a)	A	13	19	71	75	100	+	71
Sumithion	C	22	11	84	100	18	18	69
Bayer 37289 (46) (a)	B	27	19	50	84	88	0	62
Sayfos	B	23	24	+	[illegible]	23	0	37
Bayer 37289	A	22	21	50	21	0	0	26
Aramite (15) (e)	B	10	9	42	21	17	0	26
Meta Systox-R	B	20	17	33	28	0	0	22
Cygon (45) (d)	B	20	28	10	46	0	0	18
Aramite	A	7	18	30	+	0	9	18
Control 1	-	11	22	0	0	0	0	0
" 2	-	29	25	0	8	0	7	3
" 3	-	21	19	0	25	20	0	11
" 4	-	12	1	0	0	6	0	1
" 5	-	14	11	6	0	0	13	4
" 6	-	7	2	0	0	0	0	0
" 7	-	13	16	0	0	0	0	0

* A - without Invadine
B - with Invadine (2 ml/l)
C - with DMSO (10%)

+ No aphids on nodes

Sources:
(a) Chemagro Corp., 800 New London Rd., Latham, N.Y.
(b) Fisons (Canada) Ltd., 234 Eglinton Ave. E., Toronto 12, Ont.
(c) Chipman Chemicals Ltd., P.O.Box 100, Hamilton, Ont.
(d) Cyanamid of Canada Ltd., Rexdale, Ontario.
(e) Plant Products Co. Ltd., Port Credit, Ontario.

Chemical Control Research
Institute
Dept. of Forestry.

APPENDIX II

CHEMICAL CONTROL TRIALS AGAINST THE HEMLOCK NEEDLE MINER, VANCOUVER ISLAND, 1965

With the technical help of personnel of the Department of Forestry, Rayonier Canada Limited carried out an experimental spraying near Holberg along the Port Hardy access road. Two systemic insecticides were tested -- phosphamidon and dimethoate. Both materials were formulated at the rate of one-half pound of active material per U.S. gallon of water, and were applied by helicopter at the rate of approximately one U.S. gallon per acre. Although both compounds are absorbed into leaf tissue, Invadine JFC - a surfactant - was added to the formulations to enhance and speed the rate of leaf penetration. Dyes were also added to the sprays to facilitate deposit assessment.

Three plots were selected and sampled for insects on August 16. One plot was left unsprayed as a check; the phosphamidon-treated area was of about 60 acres, and the dimethoate plot was about 40 acres in size. Sprays were applied on the morning of August 18; weather conditions at the time of treatment were optimal for spray deposition.

Five trees sampled in each plot before treatment revealed that 30% of the eggs were unhatched. For five weeks following treatment, one tree per plot per week was felled and sampled. Five branches per tree were examined. Mortality estimates are given in Table 1. The high degree of variability can be attributed to limited sampling, variable insect populations, and varying spray deposits. Dimethoate gave a higher degree of suppression than phosphamidon, although with the limited sampling it is doubtful if a significant difference in average mortalities can be proven.

Table 2 shows the total numbers of living larvae found in pre- and post-spray samples. Pre-spray population in the dimethoate plot was highest and surviving larvae after treatment was least of the three plots. The slight inferiority of phosphamidon is also shown by this summary. A higher degree of control might have been achieved in both treated plots had the spray been applied after all eggs had hatched.

The results indicate that both materials are active against the insect and are capable of effecting at least a moderate degree of suppression. Whether or not suppression is sufficient to avert a serious defoliation will only be evident from field observations next spring.

Preliminary results of a test by Department of Fisheries biologists indicated that dimethoate sprayed on one-half mile of stream did not seriously affect caged coho salmon fry. Earlier tests have demonstrated that phosphamidon is relatively innocuous to fish.

Table 1. Experimental Control of Epinotia in Hemlock Foliage. Holberg, 1965. Average Per Cent Larval Mortality in Current and Previous Years' Leaves

Sampling Date	A Check	B Phosphamidon	C Dimethoate
Pre-spray			
Aug. 16 (5 trees)	63	21	33
Post-spray			
Aug. 25	30	99	80
Sept. 1	36	69	77
Sept. 8	10	72	88
Sept. 15	14	42	76
Sept. 25	18	67	95
Average	23	72	83

Table 2. Experimental Control of Epinotia in Hemlock Foliage. Holberg, 1965. Number of Living Larvae per 18-inch Branch Sample

	A Check	B Phosphamidon	C Dimethoate
Pre-spray	40	92	115
Post-spray	96	29	24

APPENDIX III

SUMMARY OF LABORATORY EXPERIMENTS TO DETERMINE THE TOXICITY OF INSECTICIDES TO TWO NEODIPRION SPECIES

Toxicity of DDT, Phosphamidon, Zectran and Sumithion was determined against 5th and 4th instar of Neodiprion pratti banksianae and Neodiprion swainei respectively. The mortality observations for 72 hours are presented in the following table:

Species		Insecticide and Dose (actual)	Corrected percentage mortality
N. pratti banksianae (5th instar)	(i)	10% DDT at 2 gpa or 2 lb, DDT per acre	84.7
"	(ii)	4% phosphamidon at ¼ gpa or 1.6 oz. per acre	100.00
N. swainei (4th instar)	(i)	10% DDT at 1 gpa or 1 lb, per acre	49.24
"	(ii)	0.25% phosphamidon at ½ gpa or 0.2 oz. per acre	100.00
"	(iii)	0.3% Zectran at ½ gpa or 0.24 oz. per acre	100.00
"	(iv)	0.2% Sumithion at ½ gpa or 0.16 oz. per acre	100.00

Ottawa, Ont.
Nov. 8, 1965

P. C. Nigam
Chemical Control Research Institute
Department of Forestry

APPENDIX IV

AERIAL SPRAYING WITH PHOSPHAMIDON AGAINST THE SWAINE JACK PINE SAWFLY IN QUEBEC - 1965 AND FORECAST OF CONDITIONS IN QUEBEC - 1966

J.M. McLeod, P.W. Price and W. Tostowaryk

November 9, 1965

1. INTRODUCTION

In August of 1965, approximately 150,000 acres of jack pine forest infested by the Swaine jack pine sawfly (Neodiprion swainei Midd.) were sprayed from the air utilizing the insecticide Phosphamidon. This was the first large scale commercial aerial spraying programme against the insect in Canada. The infestations were centered in a 5,000 sq. mile area west of La Tuque, P.Q. (Fig. 1), on the limits of the Consolidated Paper Corporation and Canadian International Paper Company. Costs of the operation were shared equally by the Federal and Quebec Governments and the two above-mentioned companies. The operation was in the hands of the Quebec Forest Industries Limited with supervisory personnel and staff supplied by Forest Protection Limited, Campbellton, New Brunswick. Biological assessment of the programme was supervised by scientists of the Canada Department of Forestry with assistance and personnel supplied by the Department of Lands and Forests, Quebec. This report summarizes the results of the operation.

2. BACKGROUND

The Swaine jack pine sawfly is a defoliator specific to jack pine, Pinus banksiana Lamb. Populations of the insect periodically reach epidemic levels, sometimes at rather short intervals (6 to 7 years) and tree mortality may result if natural control agents do not arrest the infestations. Tree mortality is usually initiated 4 to 5 years after the start of an epidemic, but trees may die if they are completely stripped of foliage as a result of one summer's feeding.

During the past few years, outbreaks of the Swaine jack pine sawfly have increased in severity and extent in the Province of Quebec. The first severe defoliation in this most recent series of outbreaks was located south of Roberval, Quebec, in 1962. The outbreak spread in 1963 and by that time tree mortality was common at the epicentre. Attempts in 1964 to control the infestation and arrest tree mortality through the aerial application of a polyhedral virus suspension proved largely unsuccessful, and by the end of 1964 the area of jack pine mortality had enlarged to nearly 7,000 acres.

In 1964, surveys carried out from the ground in the St. Maurice River watershed indicated a significant resurgence of sawfly populations in that area. An aerial survey of the area revealed the presence of numerous centres of infestation (Fig. 1), many with trees defoliated as severely as was the case in the Roberval infestation in 1962, and extensive tree mortality was expected to occur in the St. Maurice Valley within the next two years. Indeed some tree mortality (ca. 10 per cent) had already resulted from defoliation during 1964 in the most severely affected epicentres. Ground checks in selected epicentres in the fall of 1964 and spring of 1965 yielded high sawfly cocoon counts, low populations of sawfly parasites and predators, pointing to a significant increase in sawfly populations throughout the affected area in 1965.

Most of the affected jack pine stands were about 40 years of age, and had originated from extensive fires in the early 1920's. These stands are only marginally exploitable at present and could not be salvaged profitably in the event of tree mortality. It was therefore recommended that an attempt be made to control the sawfly infestations in the St. Maurice Valley in 1965.

3. AERIAL SURVEY

The aerial survey was carried out in a six-day period ending April 3, 1965. The aircraft, a Dehavilland Beaver owned by the Quebec Department of Transport and Communications, was supplied by the Quebec Department of Lands and Forests. Prior to the survey, the distribution of jack pine stands was plotted on two-mile-to-the-inch maps, and on standard topographic 1:50,000 maps by the Consolidated Paper Corporation and the Canadian International Paper Company.

The survey was carried out from an airstrip at La Tuque, Quebec. In addition to the area indicated in Figure 1, a few hundred square miles of jack pine forests on the Trenche, Bostonnais and Croche Rivers were surveyed. Survey lines were flown in an east-west direction at two-mile intervals at altitudes varying from 500 to 1,000 feet depending on the terrain, and at considerably lower altitudes where infestations were located. The infestations were classified in two categories: severe and moderate. In severely infested areas, many of the trees had a distinctive reddish appearance owing to feeding on the current year's foliage; numerous bare crowns could be observed and some trees were completely or almost completely stripped of foliage; some tree mortality had already occurred or was imminent. In moderately infested areas, some of the tops of crowns, notably on dominant trees, showed a reddish appearance owing to defoliation of the current year's foliage; there were also a few bare tops but the majority of trees were not visibly affected. Infestation boundaries were plotted on the maps as they were observed from the air. Areas of tree mortality were noted.

On completion of the survey, four-mile-to-the-inch reference maps and 1:50,000 working maps were prepared, showing the distribution of jack pine and extent of sawfly infestations. The 1:50,000 maps were used for calculating the extent of areas to be sprayed and also served as flight maps for the spray pilots.

4. TIMING OF OPERATIONS

This was done at twice-weekly or weekly intervals by felling trees, collecting sawfly colonies and observing their state of development in selected localities throughout the area to be sprayed. It was decided that spraying should be carried out when the majority of larvae had reached the second instar. At that time, most of the egg clusters are hatched and larvae are young, and consequently defoliation is at a minimum.

5. THE OPERATION

Approximately 150,000 acres of jack pine forest were designated for spraying. This included all of the moderately and severely infested areas shown in Figure 1 as well as a substantial proportion of lightly infested areas around their borders as a safety factor in the event of spread of the infestations in 1965.

Two 1500-foot airstrips were constructed within the sprayed area. Seven aircraft were based at each airstrip: four Stearman spray aircraft and three Cessna 172's, which were used for navigating the spray aircraft.

The spray aircraft flew in groups of four along rectangular spray blocks; mean swath width was approximately 660 feet. Spray was applied at $\frac{1}{4}$ pound of technical Phosphamidon (Dimecron 90) per 0.2 gallons of water per acre, except in one experimental spray block where the concentration was reduced to 1/8 pound per 0.2 gallons per acre.

It was expected that spraying would commence about the first week of August; usually about that time the peak of the second instar is reached. However, cold rainy weather in July and early August retarded sawfly development and spraying was initiated only on August 10. The job was completed on August 20.

6. BIOLOGICAL ASSESSMENT - METHODS

The biological assessment programme was conducted from a Canada Department of Forestry field station at Lac Chapeau de Paille, Laviolette County, P.Q. Three field crews, each with one forest ranger and two assistants, and four insect counters who worked in the field laboratory were supplied by the Quebec Department of Lands and Forests. This operation was supervised by personnel of the Canada Department of Forestry.

Fifty-two sampling points were selected within the area to be sprayed. Of these, seventeen were in unsprayed localities, and thirty-nine in sprayed localities. The points were sampled not less than four or more than seven days following application of the spray.

Five jack pine trees were sampled in each locality. Sampled trees were selected at one-chain intervals at right angles to pre-determined localities along roadsides. The trees were lowered gently by hand or with the aid of ropes, and all sawfly egg clusters with attendant larval colonies removed. Each colony was classified as in Table II. In addition, fifty individual sawfly colonies (an egg cluster plus hatched larvae if present) were selected from each locality, placed individually in ½ pint "Sealright" containers, and transported to the field laboratory where counts were made of the total number of eggs laid and the number of surviving larvae for each colony. This provided an estimate of generation mortality to the time the samples were selected.

Spray deposit cards, supplied by the Canada Department of Forestry, Chemical Control Institute, were set out in thirty localities within the sprayed area, five per locality. The cards were stapled to small masonite squares on four-foot-high wooden stakes. They were set out a few hours before spraying and collected immediately following spray application.

Population estimates were obtained for birds, small mammals, and other arthropods in sprayed and unsprayed areas before and after the spraying operation. Bird counts were made in thirty-two-acre square grids by walking lines at two-chain intervals and recording all species observed and heard, as well as by walking along roads. Small mammals were counted in ten-acre square grids at one-chain intervals through conventional live trapping techniques. Other arthropods were sampled by pitfall traps placed at one-chain intervals in ten-acre grids, and by sweeping with insect nets.

7. RESULTS

The Effect of Phosphamidon on the Sawfly

The first observed symptoms of toxicity occurred about 15 minutes after application of the spray: larvae abandoned their tendency to aggregate in colonies and started to disperse. Uncoordinated jerking movements of the head and thorax as well as an issuance of fluid from the mouth parts accompanied the dispersal tendency. First mortality was observed a few hours after application of the insecticide and was virtually complete within 3 to 4 days of application. Upon dying, larvae usually dropped from the trees but a few adhered to the branches or needles. It would appear that Phosphamidon acts primarily on the sawfly as a contact insecticide.

Sawfly mortality resulting from application of the insecticide was calculated in two ways; through analyses of individual colonies by counting the number of eggs deposited and the number of larvae surviving at the time the sample was collected (Table I), and by counts of colonies on whole trees (Table II). The analysis of individual sawfly colonies permitted the calculation of generation mortality, i.e. the mortality which occurred from the time of the egg stage to the time the sample was taken. This analysis is possible because the total egg complement of a single female is laid on a single current shoot of jack pine, and because young larvae that hatch from these eggs feed as compact colonies on the previous years' foliage in the immediate vicinity of the egg cluster.

To calculate the effect of the insecticide on the sawfly, generation mortality from samples selected from unsprayed areas was compared with that of samples selected from sprayed areas (Table I). Generation mortality in sprayed areas to the time the samples were collected was 99.2 per cent, whereas in unsprayed areas, it was 37.4 per cent. The interval mortality directly attributable to the action of the spray, that is the difference in mortality between sprayed and unsprayed areas, was 98.1 per cent. These figures are meaningful only if compared with the total generation mortality for the sawfly which would result in a population trend index of 0. A population trend index equals 0 when the egg population of a given generation is equal to that of the next generation. For the Swaine jack pine sawfly, total generation mortality for a population trend index of 0 is usually of the order of 97.2 per cent (assuming a mean fecundity of 65 eggs per female sawfly and a sex ratio of 0.63 in favour of females). Therefore since the interval mortality directly attributable to the action of the spray (98.7 per cent) and generation mortality in sprayed areas to the time the samples were selected (99.2 per cent) exceed the normal total generation mortality for trend index 0, it follows that sawfly populations should be reduced to very low levels in the sprayed areas in 1966. Also, owing to the quick action of the insecticide, feeding on the previous years' foliage was kept to a minimum and the current foliage remained virtually untouched. Thus, trees whih were in danger of dying from sawfly defoliation in 1965 were saved.

Analysis of sawfly colonies of various categories on whole trees showed that 94.3 per cent of the colonies in sprayed areas had no living larvae following the spraying (Table II). An extrapolation of total generation mortality utilizing survival data obtained from analyses of individual colonies yields an estimate of 99.3 per cent, a figure comparable to that obtained from the analysis of individual colonies (c.f. Table I). Thus, it appears that random selections of individual colonies from trees provide sufficiently accurate estimates of sawfly mortality.

The experimental block sprayed at 1/8 pound per acre gave results almost equally as good as the 1/4 pound dosage. Mean sawfly mortality for the six plots sampled was 92.8 per cent. Mortality in one sample point, situated near the edge of the experimental block, was disproportionately low (68 per cent) and consequently may have received poor spray coverage. If this sample is edited from the data, the average mortality for the five remaining samples is 98.6 per cent.

This would suggest that in future operations against the Swaine jack pine sawfly, 1/8 pound of Phosphamidon per 0.2 gallons per acre would suffice to produce adequate interval mortality. The high sawfly mortality caused by Phosphamidon was most welcome and was not expected on the basis of experience with this insecticide against other forest insects (c.f. summary statements for 1963, 1964 and 1965 spruce budworm aerial spraying programmes in New Brunswick).

The Effect of Phosphamidon on Sawfly Parasites

Large numbers of adult sawfly parasites are present in jack pine stands in August, both in the tree canopy and in the litter layer.

Their activity is responsible for considerable sawfly mortality, the impact of which varies from year to year but which is always an integral part of the overall natural control mechanism in sawfly population ecology.

Although the majority of parasites were emerged by the time of spraying, several thousand cocoons per acre, which contained all stages of parasite development, remained in the litter. From this reservoir adult parasites would normally have emerged in August, September and October of 1965 and in the spring of 1966. In addition to the immature parasites in the cocoons at the time of application of Phosphamidon in mid-August, parasites were present as adults in the tree canopy where they attack sawfly larvae and on the ground vegetation cover and litter where they attack sawfly cocoons

A laboratory test indicated that Phosphamidon is highly toxic to parasites of the sawfly and field collections revealed that numbers of ichneumonid parasites, including those of the sawfly, were reduced by 80 per cent within 24 hours of spraying. However, within a week of this reduction, numbers increased and remained at approximately 40 per cent of the level in the unsprayed area until cold weather lessened parasite activity in all jack pine stands. Rearings indicated that no mortality to parasites in cocoons was caused by the spray and, presumably, the numbers of sawfly parasites were replenished by adult emergence from the reservoir of cocoons in the litter.

The effect of Phosphamidon on sawfly parasites was also determined by making observations on the reduction of their oviposition into planted cocoons. Mammal-proof trays containing cocoons were set out in an area scheduled for spraying and in a non-spray area. Part of the sequence of parasite oviposition is shown in Table III.

Although Phosphamidon kills parasites, it appears to be much more lethal to the sawfly itself. However, since alternate hosts for this surplus of parasites were scarce, their numbers will probably be reduced to a small fraction of the pre-spray population.

Further studies will reveal how the low surviving population of parasites is able to respond to any future increase in the jack pine sawfly populations in the sprayed areas. The extent of this response could influence the rate of increase of sawfly numbers and thus influence the time at which it might be considered necessary to respray the forest with phosphamidon.

The Effect of Phosphamidon on Other Insects

To determine the effect of Phosphamidon sprays on other insects, sweepings with a fifteen-inch-in-diameter net were made on the ground cover of stands in one unsprayed plot (check) and two sprayed plots (C-1 and C-2) (Table IV). Each sample consisted of one hundred sweeps with the net. The herbaceous ground cover in the check plot and in Plot C-2 was similar, consisting of a dense layer of *Calliergon*, *Kalmia*, *Vaccinium* and *Cladonia*. In Plot C-1 the ground cover was limited to *Cladonia* and needle cover. Captured insects were classified by order as in Table IV.

The results show a decline in the four orders of insects following application of the spray in Plot C-2, the greatest effect noticeable 3 days following application. However, by the first week of September, the population levels in Plot C-2 were comparable to that in the check plot. Since the insects have not yet been classified to species, it is not yet known what species were most affected by the spray.

No attempt was made to determine the effect of the spray on soil inhabiting insects. It is doubtful that any mortality to these insects occurred due to the protection afforded by the soil cover and the rapid breakdown of the insecticide.

The Effect of Phosphamidon on Vertebrates

Resident bird populations in jack pine stands are quite low in comparison with those found in other forest types in the area, and average in the neighbourhood of 0.5 breeding pairs per acre (Table V). The principal species are the slate-coloured junco and hermit thrush. Of the warblers, only the myrtle warbler and nashville warbler are consistently present in jack pine stands as resident breeders, and these at rather low densities.

The above situation prevails until about the third week in July when the territories break up and fledglings leave the nest. At this time birds flock in family units (i.e., of the same species) or as pre-migratory flocks (of more than one species). Some species, notably the hermit thrush, and to a lesser extent the slate-coloured junco and white-throated sparrow apparently move out of jack pine stands at this time. Other species, such as the myrtle warbler, brown-capped chickadee, black-capped chickadee, red-breasted nuthatch and brown creeper, move into jack pine stands and form more or less stable pre-migratory flocks, which persist in these stands until mid-September at which time the bulk of bird migration is underway.

Since the range of movement of these pre-migratory flocks exceeded by a wide margin the boundaries of the permanent plots used for assessing populations, absolute population levels within the areas studied could not be calculated precisely. In addition, the large size of some of the pre-migratory flocks made accurate counts prohibitive. Consequently it was rather difficult to properly assess bird populations before and after spraying. In making counts, individual birds and pairs were noted as well as flocks in excess of 5, 10, 25, 50 and 100 birds respectively.

The results (Table VI) indicate that the myrtle warbler, the most common species of bird present in jack pine forests at the time of spraying was considerably reduced in numbers in the sprayed areas. Other birds did not appear to have been as seriously affected.

In sprayed areas, pre-migratory flocks were rarely seen in the days immediately following spraying and, when they did reform, warblers, notably the myrtle warbler, were usually absent. Flocks in sprayed areas following spraying consisted mainly of chickadees, juncos and nuthatches. It is difficult to tell whether the warblers died or simply moved out of the sprayed area. During the course of roadside observations immediately following spraying, fourteen dead or dying birds apparently suffering from Phosphamidon poisoning were collected; nine of these were warblers. All that can be presumed from the above is that populations of warblers, mainly the myrtle warbler, appear to have been reduced owing to the application of the insecticide. How much bird mortality was involved was impossible to estimate.

Small mammal population data have not been analysed as yet but it would appear that the application of Phosphamidon had no appreciable effect on populations of shrews or small rodents.

FORECAST OF SAWFLY CONDITIONS IN 1966

Owing to the excellent control achieved through spraying in 1965, it is not expected that populations of the sawfly within the sprayed areas will be sufficiently high to warrant spraying for the next 1 or 2 years at least.

An aerial survey will be carried out in susceptible areas in other parts of the province this coming winter; consequently, an adequate appraisal of conditions prevailing in unsprayed areas will not be available until then. However, it is expected that owing to unseasonably cold wet weather during late summer and fall of 1965, populations of the sawfly throughout Quebec may have been reduced considerably, and it is unlikely that this insect will prove a threat to the forest in 1966.

SUMMARY

1. Some 150,000 acres of jack pine forest in the St. Maurice River Valley west of La Tuque, Quebec, were sprayed from the air between August 10 and 20, 1965, utilizing the insecticide Phosphamidon applied at the rate of 1/4 pound of insecticide per 0.2 gallons per acre, in attempts to control an outbreak of the Swaine jack pine sawfly.
2. The operation was a success in that over 99 per cent control was achieved throughout the sprayed area. This resulted in the reduction of sawfly populations to acceptable levels, and in the saving of jack pine foliage, thus preventing tree mortality.

3. An experimental block was sprayed at 1/8 pound per 0.2 gallons per acre, yielding an efficacy of control comparable to that achieved with the operational dosage of 1/4 pound per acre. It is probable that in future operations, the dosage could be reduced accordingly.

4. Sawfly parasites, although affected by the spray, were reduced in numbers proportionally less than the sawfly itself. Consequently, a "reservoir" exists within the sprayed areas in the event of resurgence of sawfly populations.

5. One species of bird, the myrtle warbler, appeared to have been reduced considerably in numbers in sprayed areas, although the extent of mortality was impossible to estimate. The insecticide apparently had little or no effect on other vertebrates.

6. Owing to continuous unfavourable weather in late summer and fall of 1965, it is not expected that sawfly populations elsewhere in Quebec will pose a serious threat in 1966. However this must be confirmed by an aerial survey of defoliation conditions which will be carried out this winter.

Table I. Mortality Analysis of Individual Sawfly Colonies in Sprayed and Unsprayed Areas. Swaine Jack Pine Sawfly, 1965.

	Number of colonies	Total number of eggs deposited	Number of surviving larvae	Per cent mortality
Unsprayed plots	681	46033	28827	37.4
Sprayed plots	1200	76476	641	99.2

Per cent mortality attributable to spray

$$= \frac{\frac{28827}{681} - \frac{641}{1200}}{\frac{28827}{681}} = 98.7 \text{ per cent}$$

Table II. Whole Tree Analyses - Sprayed Areas. Swaine Jack Pine Sawfly - Spray Programme, 1965.

No. of Samples	Number of Sawfly Colonies of Various Categories						
	Larvae Absent	Larvae Dead	Larvae Living and Dead	Larvae Living	Living but Unhatched	Total	Per Cent Dead or Absent
33	409	2891	80	49	69	3498	94.3*

* Adjusted generation mortality given a mean fecundity of 65 eggs per colony and a mean survival of 8 larvae per colony (from Table I) in sprayed areas.

= 3498 x 65 - (80 + 49 + 69) x 8 = 99.3 per cent

Table III. Percentage of Cocoons Attacked by Parasites after a Ten-Day Exposure.

Date	Unsprayed Area	Sprayed Area	
3 August	37	Pre-spray	53
13 September	80	Post-spray	28
13 October	20		0
25 October	26		6

Table IV. Results of Sweepings with an Insect Net in Sprayed and Unsprayed Plots. Swaine Jack Pine Sawfly Programme - Quebec, 1965.

Date	Before Spray	After Spray	Hymenoptera			Diptera			Hemiptera			Coleoptera			Total		
			Check	C-1	C-2	Check	C-1	C-2	Check	C-1	C-2	Check	C-1	C-2	Check	C-1	C-2
13-8-65	X		57	38	104	25	27	39	45	5	24	28	5	28	145	75	195
15-8-65		X	48	41	21	45	53	23	54	3	17	22	2	22	169	99	83
18-8-65		X	33	13	10	33	13	3	53	6	14	13	11	3	129	43	30
24-8-65		X	60	43	26	19	10	2	55	7	9	31	8	8	165	68	45
30-8-65		X	51	23	23	25	23	8	65	0	18	16	4	4	157	50	63
4-9-65		X	74	65	134	17	15	27	78	9	45	35	12	32	204	101	238
15-9-65		X	0	14	82	1	8	18	3	2	24	4	1	56	8	25	180

Table V. Resident Breeding Birds in 32.4 Acre Square Plots in Jack Pine Stands - St. Maurice Valley, 1964 and 1965.

Species	Number of Breeding Pairs in Plots		
	Plot V 1964	Plot V 1965	Plot II 1965
Slate-coloured junco	6	6	5
Myrtle warbler	4	1	1
Hermit thrush	4	3	4
White-throated sparrow	2	1	1
Nashville warbler	1	1	1
Brown-capped chickadee	1	0	1
Ruby-crowned kinglet	0	1	0
Spruce grouse	1	0	0
Brown creeper	1	0	1
Total	20	13	14
No. of breeding pairs per acre	.0.62	.0.40	0.43

Table VI. Bird Populations in Sprayed and Unsprayed Areas, before and after Spraying, Each Period Comprising Five Consecutive Days of Observation. Swaine Jack Pine Sawfly Spray Programme - Quebec, 1965.

Species	Approximate Number of Birds Observed					
	Unsprayed Plot			Sprayed Plot		
	Before Spray	After Spray	% Change	Before Spray	After Spray	% Change
Myrtle warbler	422	305	- 28%	169	3	- 98%
Other warblers	26	38	46%	0	0	-
Slate coloured junco	129	48	- 63%	84	15	- 82%
Brown-capped chickadee	70	44	- 37%	53	50	- 06%
Black-capped chickadee	52	30	- 42%	0	0	-
Red-breasted nuthatch	36	6	- 83%	1	5	400%
Ruby-crowned kinglet	10	11	10%	0	0	-
Brown creeper	8	5	- 38%	0	0	-
Hermit thrush	4	0	- 100%	5	0	- 100%
Other birds*	9	31	244%	3	2	- 33%
Total	766	518	- 32%	315	75	- 76%
Total, less myrtle warbler	344	213	- 38%	146	72	- 51%

---

* Mostly rusty blackbird flocks

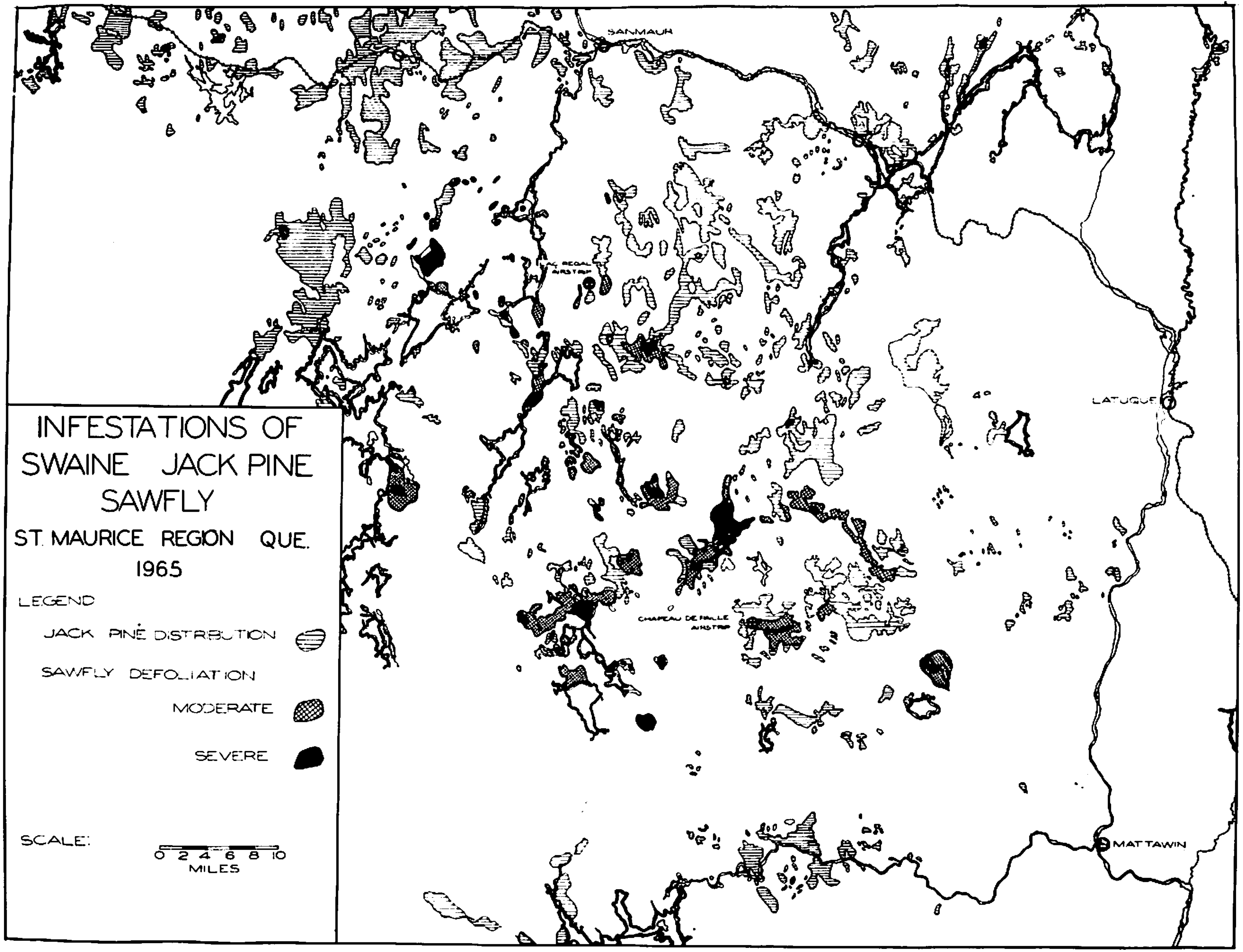

INFESTATIONS OF SWAINE JACK PINE SAWFLY
ST. MAURICE REGION QUE.
1965
LEGEND
JACK PINE DISTRIBUTION
SAWFLY DEFOLIATION
MODERATE
SEVERE
SCALE:
0 2 4 6 8 10
MILES
SANMAUR
LAC REGAL AIRSTRIP
LATUQUE
CHAPEAU DE PAILLE AIRSTRIP
MATTAWIN

FIG I

Aerial Spray Trials of Phosphamidon against *Neodiprion swainei*, Chapeau de Paille, 1965

Early in the summer of 1965 the Chemical Control Research Institute was asked by the Quebec Research Laboratory to advise on insecticide and dosage for use in an emergency control project against *N. swainei* in Northern Quebec. Minimal hazard to aquatic fauna was prerequisite. Laboratory tests of the toxicity of several insecticides to a related species, *N. pratti banksianae* indicated that Phosphamidon was a promising candidate. It was suggested for use at ¼ lb/ac as being probably safe for fish, marginal in hazard tobirds and other wildlife, and adequate to control the sawfly infestation. Stearman spray output and distribution trials (water only) by a spray operator for Forest Protection Limited were observed at St. Jovite, and an application rate of 0.4 gpa suggested. The operator further modified his nozzle configuration to emit spray at a nominal rate of 0.2 gpa on a 2½ chain swath. In the absence of previous experimentation, no spray evaporation retardent, penetrating agent or other adjuvent could be recommended.

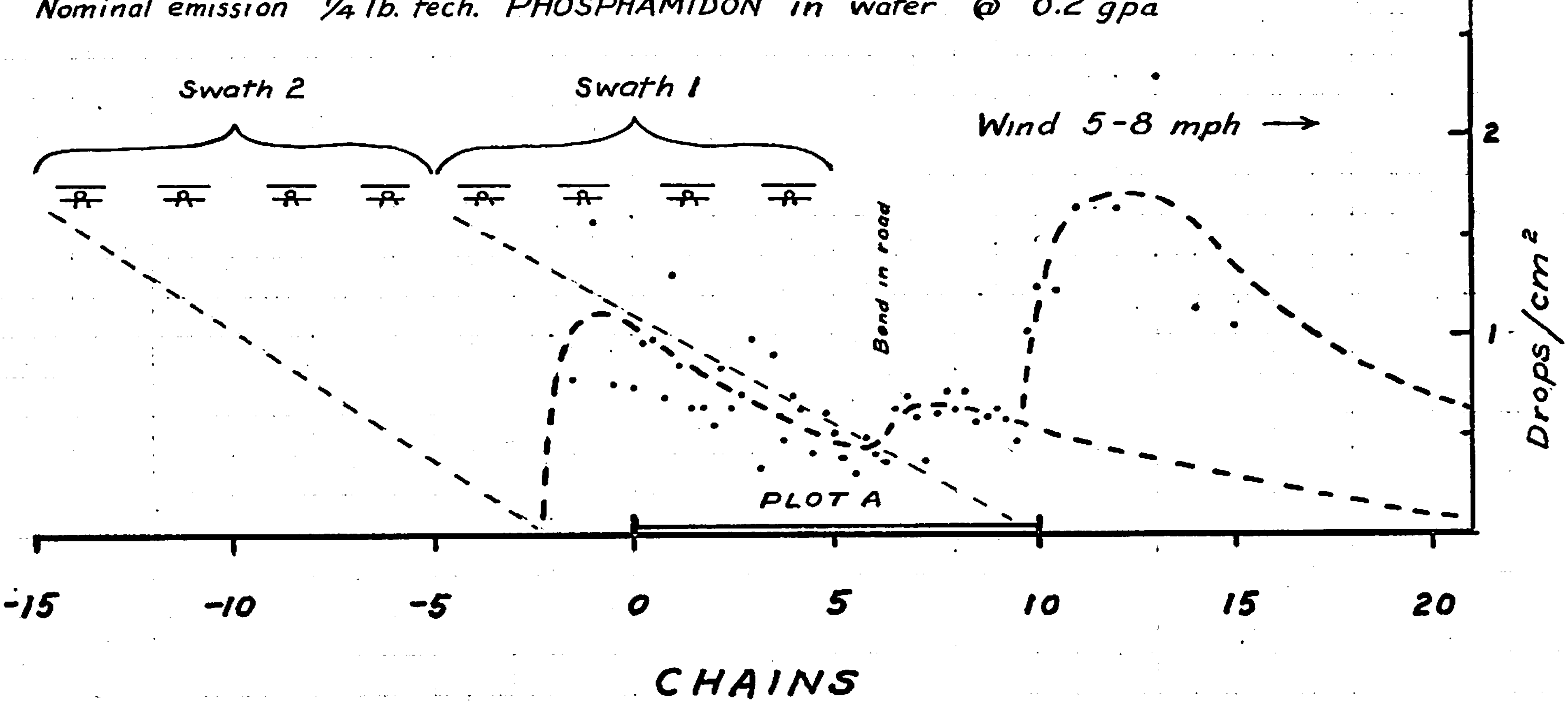
Early in August two officers of the Institute went to Chapeau de Paille Field Station to observe a spray trial prior to the main operation, and to assist and advise on spray deposit measurement. Two trial spray tests were observed:-

Plot M at Lake McLaren was a 20 chain wide strip straddling the road and terminating in a burned-out logging camp site on the shore of the lake. Young trees were available with accessible colonies of larvae for observation before and after spraying. Two swaths, 10 chains wide by a flight of four Stearmans in formation were applied over the windward half of the plot. One plane blew a nozzle, resulting in excessive deposit on part of the plot, and high humidity partially destroyed the deposit record on the paper sampling cards placed adjacent to the marked sawfly colonies. However, appreciable deposit was observed to the leeward edge of the plot, about 15 chains from the swath of the nearest plane, and mortality of 2nd and 3rd instar larvae was 100% except in a few sheltered colonies. Examination of colonies on trees felled at one chain intervals beyond the south boundary indicated that drifted spray was effective for at least another ¼ mile beyond the plot.

Plot A was laid out along the main road to Lake McLaren. Two swaths offset 5 and 15 chains from the plot centre line were sprayed in a 5-8 mph crosswind. Spray drop deposit density averaged only 0.64 drops per sq. cm. on ground sample cards in the plot and 0.95 over all sample locations (see appended figure). Deposit values for colony location samples were somewhat lower. The deposited mass median diameter (MMD) was about 205µ and the mass average diameter about 156µ, yieldigg a deposit estimate on the plot of only 0.016 gpa US. This large discrepancy from the assumed real nominal dose may be ascribable to drift (only part of one swath deposited on the target), unknown evaporation of water from the drops, reduced deposit efficiency on the flat sampling surface in the marginally high wind, and discrepancy in drop spread factor used to assess the cards. The deposit of Phosphamidon on the plot was probably 0.1 lb/ac ± 50%. At about ½ mile downwind from flight line a few drops were detected, the deposit level being perhaps 1% of that on the plot.

Plot A Chapeau de Paille 1965

Air speed 90 MPH Alt. 100'± 24 nozzles delivering 1/4 gpm ea. @ 60 #/in²
Nominal emission 1/4 lb. tech. PHOSPHAMIDON in water @ 0.2 gpa



Aprox. mass median diam.	205μ
" no. median diam.	113μ
" mass average diam.	156μ

Drops/cm² max. 2·3 min. 0.3
mean 0·95 (0.64 on plot)
Est. spray deposit 0.016 gpa US
on plot 0.1 ± lb/ac

Conclusions

¼ lb/ac of Phosphamidon was more than adequate to control N. swainei. Dr. McLeod reported no sample point in the main spray blocks with less than 97% mortality (as of Aug. 24) and drift contamination from 1 : 7 formulation was effective to nearly ½ mile (Plot M). Drift contaminated foliage from Lac Caousacouta was still toxic to 4th instar larvae three weeks after spraying (laboratory bioassay). 1/8 lb/ac in 0.2 gpa (1:15 dilution) was also effective, though there was more survival in sheltered locations. Sprayed foliage was in the LD 50 range of toxicity after two weeks (Lac Rond).

Phosphamidon had little, if any, true systemic action, as colonies protected from falling spray by plastic bags survived.

The proportion of spray in smaller sized drops not deposited on sample cards, and the reduction of volume by evaporation are unknown, but may account in part for the effectiveness of drifted spray. In laboratory tests 0.2 oz/ac in oil at ½ gpa killed all larvae (see appended Table). Certainly much less than the nominal ¼ lb/ac is needed to kill the larvae, so that techniques of applying lower doses should be further investigated.

Items needing further investigation: (1) nozzle type and configuration; (2) plane spacing (could have been wider under the conditions extant and thus reduce the volume per acre); (3) evaporation retardants and/or some non-volatile diluent combined with less toxicant in water formulation; (4) oil formulations (laboratory tests were run with aromatic hydrocarbon diluent).

A dosage rate of 1 oz/ac seems a reasonable target that would offer minimal hazard to wildlife.

Sumithion should be investigated as an alternative.

Ottawa, Ont.,
Nov. 16, 1965

W. Halliburton
P. C. Nigam
Chemical Control Research Institute
Department of Forestry.

APPENDIX VI

FALL CANKERWORM CONTROL TRIAL - SELKIRK

Insecticides Used

Hydro Area - Matacil 1½ lb./gal. S.C. applied at 1 lb./ac in 1 gal. water.

Selkirk Park - Dylox 4 lb./gal. S.C. applied at 1 lb./ac in 1 gal. water.

Selkirk Park (pasture) - DDT 25% E.C. applied at 1 lb./ac in ½ gal. water.

Date of Application - June 10, 1965.

Time of Application and Weather Conditions

Weather data from Winnipeg Meteorological Office.

Conditions at Selkirk were similar.

Hydro Area - Sprayed at 11.00 a.m., wind NNE 9, temp. 57.

Selkirk Park - Sprayed at 1.00 p.m., wind N 8, temp. 62.

Selkirk Park (Pasture) - Sprayed at 3.00 p.m., wind ESE 4, temp. 67.

Assessment of Control

Damage Rating

Very Light - most leaves not damaged - light damage on remainder.

Light - most leaves showing damage but only lightly (approximately 25% of leaf affected).

Moderate - most leaves damaged with approximately 50% of leaf surface damaged.

Sample Size

Sample consisted of one 18" branch tip from lower trunk (8'-10') branches only.

Pre Spray Check

Cankerworm larvae generally 3rd instar about 1/8 to 5/16" long; some green in color and some dark.

Hydro Area - Matacil 1 1/2 lb./gal. S. C.

Pre Spray Check   Post Spray Check
June 7/65   June 11/65   June 18/65

Tree No.	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage
South Side									
1	48	1	VL	68	0	VL	55	1	
2	88	18	VL	67	5	VL	26	1	
3	81	5	VL	31	0	VL	75	0	
4	103	3	VL	149	3	VL	121		
5	183	4	VL	133	0	VL	78	0	
North Side									
1	45	14	L	101	16	L	122	6	
2	48	17	L	103	11	L	52	3	
3	95	17	L	100	9	L	56	0	
4	40	32	L	47	7	L	46	4	
5	61	27	L	116	5		78	1	

Selkirk Park - Dylox 4 lb./gal. S. C.

Pre Spray Check   Post Spray Check
June 7/65   June 11/65   June 18/65

Tree No.	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage
1	95	15	VL	109	2	VL	95	4	VL
2	139	4	VL	107	4	VL	80	0	VL
3	60	7	VL	119	1	VL	84	0	VL
4	114	4	VL	55	0	VL	67	0	VL
5	95	5	VL	125	0	VL	111	0	VL
6	215	42	VL	224	19	VL	129	3	VL
7	50	9	VL	50	3	VL	119	0	VL
8	76	11	VL	60	0	VL	84	0	VL
9	110	22	VL	62	1	VL	76	0	VL
10	197	60	VL	133	3	VL	51	1	VL

June 11 - Counts on table top - 100/yd.^{2} dead larvae.
June 18 - Dead and dying larvae observed on table tops. A few live ones, possibly large enough to pupate.

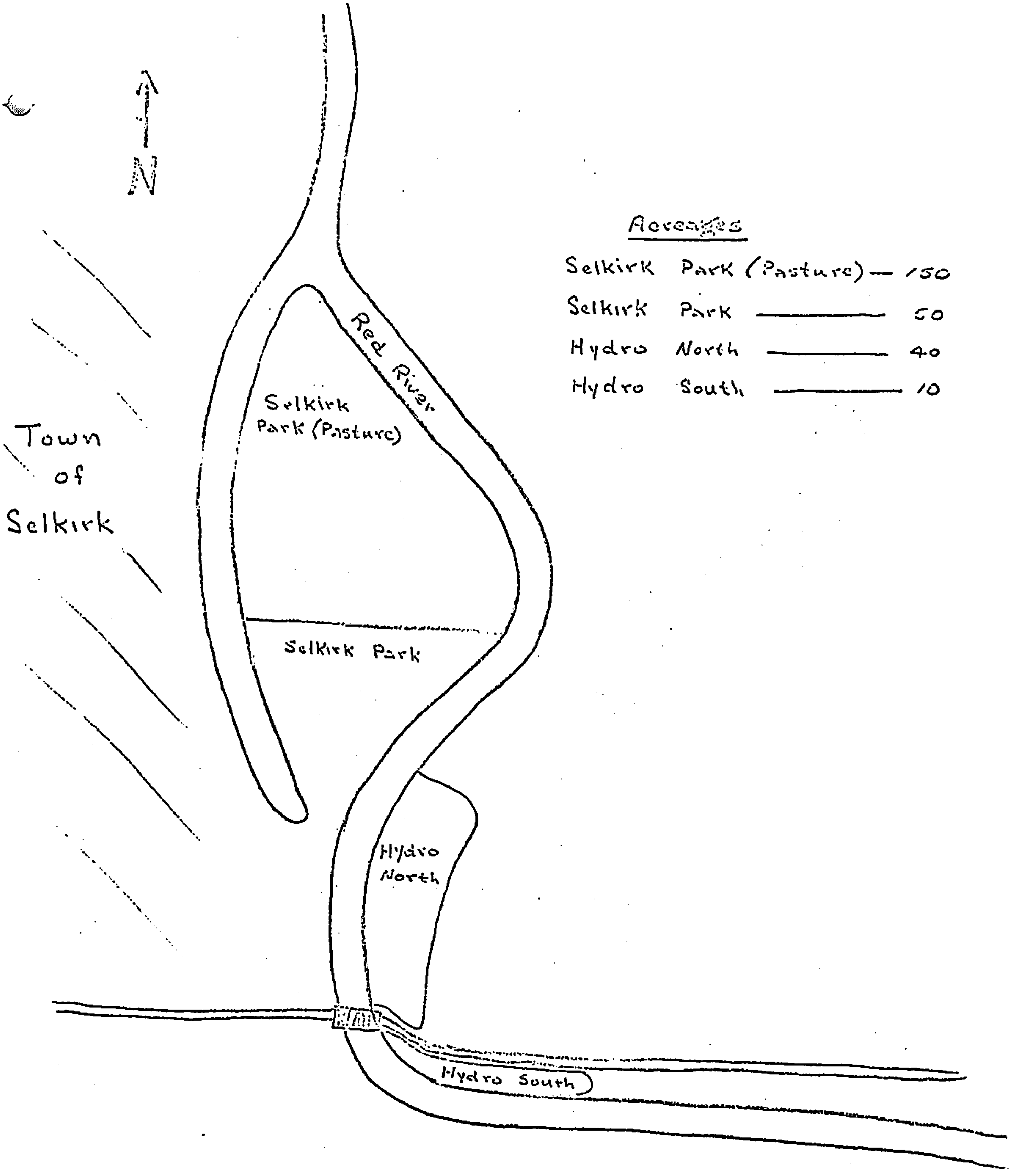
Selkirk Park (Pasture) - DDT 25% E.C.

	Pre Spray Check			Post Spray Check					
	June 7/65			June 11/65			June 18/65		
Tree No.	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage	No. Leaves	No. Larvae	Damage
1	85	89	L	129	18	L-M	122	1	L-M
2	41	70	L	95	13	L-M	48	0	L-M
3	63	77	L	76	18	L-M	50	0	L-M
4	84	88	L	119	13	L-M	111	0	
5	42	60	L	30	6	L-M	124	0	
6	58	43	L	192	32	L-M	110	1	
7	61	73	L	42	14	L-M	126	1	
8	85	76	L	32	30	L	111	9	
9	88	84	VL	79	17	VL	94	0	
10	76	37	VL	61	12	VL	105	2	

June 18 - Noticed frass on ground and on leaves under trees in areas 1 and 8. Many larvae under area #1 trees - all sizes - many dead and showing signs of injury. Some pupating.

June 11 - Many larvae hanging from trees. Also many dead larvae on leaves of undergrowth.

D. R. Robertson
Provincial Entomologist
Manitoba Dept. Mines and
Natural Resources
Winnipeg, Manitoba
June 30, 1965



Acreages

Selkirk Park (Pasture)	150
Selkirk Park	50
Hydro North	40
Hydro South	10

CHEMICAL CONTROL TRIALS AGAINST THE SPRUCE BUDWORM IN NEW BRUNSWICK

by

James J. Fettes and A. P. Randall

Continuing with the stated policy of avoiding the contamination of water with DDT as much as possible and the use of Phosphamidon along the main streams for the control of spruce budworm larvae, the discovery of the severe hazard of Phosphamidon to bird populations and the measurement of the development of resistance of the spruce budworm to DDT resulted in a resumption of chemical control trials against the spruce budworm by the Chemical Control Research Institute in New Brunswick in 1965. Several approaches to the problem were tried:

(a) An attempt to discover a substitute for DDT and Phosphamidon;

(b) An attempt to discover a lower limit of effectiveness against the spruce budworm and which may be compatible with other populations, and

(c) An appraisal of the high concentrate-low volume-Mini-spin system of insecticide application from aircraft.

Although much mechanical difficulty was experienced with the Mini-spin device and the imperfect spray systems of the available aircraft, all of the applications herein reported were done using the Mini-spin device.

Two series of applications were scheduled: (1) An early spray series to determine the systemic activity of several insecticides in an effort to determine whether or not early application, when the insects were within needles or buds, could be effective, and (2) The later series where insecticides could be used as both systemic and contact materials. The general information on the mechanical and physical conditions of the trials is summarized in Table I and the general and still preliminary results are summarized in Table II. In the 2nd series the penetrant Invadine was used in all trials except with Malathion and DDT.

COMMENTS

(1) The early series was generally unsuccessful which is an indication that uptake and translocation of organophosphorus materials is inadequate and is not effective at the period when the insects are protected and relatively immobile. A possible exception is Sumithion which produced 90% control of the young larvae and indicated some systemic activity. The dosage, however, was relatively heavy on the samples where control was good.

(2) Phosphamidon, Sumithion, Cygon and Zectran were effective in relatively low dosages when applied as concentrates using Mini-spin nozzles. The summary in Table II reports dosages only in drops per unit area. Data on dosages, in terms of volume per unit area, are yet inadequately analyzed but several tentative results are of interest. Phosphamidon at 5-7 oz/ac. (technical) produced complete kill of budworm. Sumithion at 4-6 oz/ac. produced complete kill of budworm and a definite systemic activity is indicated. Cygon at 4-8 oz/ac. (actual toxicant) produced complete kill. Zectran at 4 oz/ac. produced complete kill. Malathion at 8-10 oz/ac. produced complete kill.

(3) DDT at 4-8 oz/ac. produced 75% kill. All of the materials, with the exception of DDT, are capable of excellent control of the spruce budworm. It is extremely interesting to note that DDT, at the 10-15 drops per square centimetre dosage, produced only 73% control. In earlier trials with DDT, this dosage would have produced 99 + % control. At 5 to 10 drops per square centimetre negligible control was measured and, in early trials, this dosage would have produced about 75% control. These results suggest that the resistance factor in New Brunswick is developing rapidly.

(4) Malathion which failed in three earlier trials from 1953 to 1960, was relatively successful as a concentrate spray and, because of its economic advantages and its availability, as well as its low mammalian and moderately low fish toxicity, might be considered further.

(5) In consideration of the insecticide candidates for the control of spruce budworm, all of the materials reported on could be used but several may be eliminated at this stage of development for various reasons: Zectran is not yet available commercially and the status of Sumithion continues to be in doubt because no company has been able to establish a clear title for its manufacture. Therefore, materials which may be seriously considered in order of effectiveness are:-

Phosphamidon, Cygon, Malathion and DDT.

(6) Continued investigation is certainly indicated, particularly with a view to the use of the low volume - high concentrate method.

TABLE I

SUMMARY OF OPERATIONAL DATA FOR LOW VOLUME CONCENTRATE SPRAY TRIALS, CHIPMAN, NEW BRUNSWICK, 1965

	SPRAY TRIAL NUMBERS										
	1	2	3	4	5	6	7	8	9	10	11
Date	21/5/65	23/5/65	12/6/65	22/5/65	19/5/65	15/6/65	17/6/65	16/6/65	16/6/65	15/6/65	15/6/65
Time	6:30 P.M.	5:52 A.M.	7:05 A.M.	6:08 A.M.	6:55 P.M.	5:50 A.M.	6:40 A.M.	6:15 A.M.	7:16 P.M.	7:20 A.M.	7:15 P.M.
Treatment	Zectran (2E)	Cygon (4E)	Phosphamidon	Sumithion	Phosphamidon	Sumithion	Phosphamidon	Cygon (4E)	Zectran (2E)	Malathion	DDT
Insecticide contentration (%)	25	45	90	100	90	100	90	45	25	100	19
Invadine	no	no	yes	no	no	yes	yes	yes	yes	no	no
Total gallonage per plot	40	20	10	20	10	20	20	40	40	30	30
Plot Size	400	400	400	400	400	400	400	400	400	400	400
Aircraft (Stearman)											
Flying Speed (mph)	100	95–100	100	95–100	90–100	95–100	100	100	90–100	90–100	100
Approx. Spray Height (feet)	100	90–100	90	95	90–100	100	100	90–100	100	100	90–100
Spray Equipment	Mini-spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin	Mini-Spin
No. of Units/ac.	6	6	4	6	6	6	6	6	6	6	6
Nozzle diaphragm	41	41	41	41	41	41	41	41	41	41	41
Emission rate (GPM)	1.5	1.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pressure (PSI)	40	40	40	40	40	40	40	40	40	40	40
Weather Conditions											
Wind (mph)	1–2	2–3	1–2–6	1–3	3–5	0–3	1–2–5	0–2	1–4–6	5–1–2	4–2–0
Temperature (°F)	72	31–33	45–60	34	60	42	48	40	77	49	58
RH	45	75	90–70	85	71	100	93–85	100–75	56	100–95	67
Atmospheric Stability	Stable	Stable	unstable (gusts)	Inversion	Inversion	Inversion	Inversion	strong inversion	Inversion (gusts)	Inversion	Inversion
Cloud cover/total	2/10	0/10	9/10	5/10	10/10	9/10	0/10	1/10	5/10	4/10	5/10
Post Spray conditions (24 hr)	Clear	Clear	Cold, windy	Clear	Rain (9 hrs)	Cloudy, cool	Clear	Clear	Windy	Clear	Calm, clear
Spray characteristics											
Max. stain size (μ)	600	1600	2000	2400	2900	1600	2200	1400	1100	2300	800
" drop " (μ)			310	340	380	280	310			304	170
M.M.D.											
N.M.D.											
Spray Classific.	Fine	Medium	Coarse	Coarse	Coarse	Coarse	Coarse	med-fine	Fine	Coarse	Fine
Spray coverage	Very good	Light	Light	Good	Light	Light	Good	Good	Light	Good	Good
Max. no. drops/cm^2	16	6	6	21	3	9	50	13	4	16	15
Ave. " " /cm^2	6.0	2.9	1.8	4.8	0.9	2.3	10.0	3.8	1.0	5.1	5.2
Spray duration(min)	50	30	25	29	17	35	25	60	50	20	45

TABLE II

RESULTS OF TREATMENTS - NEW BRUNSWICK SPRUCE BUDWORM CONTROL TRIALS, 1965

EARLY SERIES

Plot No.	Treatment	No. of drops /cm²	No. of Samples	Spray Date	Post Spray Larval Densities			Percentage Population Reduction*			Days after Treatment		
					1st Count	2nd Count	3rd Count	1st Count	2nd Count	3rd Count	1st	2nd	3rd
		0 - 10	20		0.065	0.071	0.152	37	29	0			
1	Zectran (2E)	10 - 20	33	21/5/65	0.054	0.031	0.061	47	69	32	6,	12,	23
	25% conc.	20 - 30	8	P.M.	0.057	0.045	0.053	45	55	41			
		0 - 2	14		0.083	0.041	0.148	33	66	0			
2	Cygon (4E)	2 - 4	20	23/5/65	0.087	0.049	0.167	29	59	0	5,	11,	23
	49% conc.	4 - 7	7	A.M.	0.074	0.095	0.180	40	21	0			
		0 - 2	46		0.068	0.056	0.151	46	54	0			
5	Phosphamidon	2 - 4	5	19/5/65	0.041	0.049	0.068	67	60	38	5,	9,	22
	90% conc.			P.M.									
		0 - 5	40		0.083	0.082	0.119	33	32	0			
4	Sumithion	5 -10	18	22/5/65	0.068	0.048	0.078	45	60	24	5,	10,	23
	100% conc.	10 -20	4	A.M.	0.122	0.012	0.009	0	90	91			

* Corrected for natural mortality and population differences.

TABLE II CONT'D

RESULTS OF TREATMENTS - NEW BRUNSWICK SPRUCE BUDWORM CONTROL TRIALS, 1 9 6 5
LATE SERIES

Plot No.	Treatment	No. of drops /cm²	No. of Samples	Spray Date	Post Spray Larval Densities			Percentage Population Reduction*			Days after Treatment		
					1st Count	2nd Count	3rd Count	1st Count	2nd Count	3rd Count	1st	2nd	3rd
5	Phosphamidon 90% conc.	0 - 2	43	12/6/65 A.M.	0.151	0.119	0.149	0	0	0	3,	10,	13
		2 - 4	21		0.071	0.040	0.048	28	50	31			
		4 - 6	4		0.060	0.000	0.005	39	100	93			
6	Sumithion 100% conc.	0 - 5	57	15/6/65 A.M.	0.110	0.071	0.052	0	17	13	6,	9,	13
		5 - 10	11		0.028	0.015	0.003	67	80	95			
		10 - 14	1		0.000	0.000	0.000	100	100	100			
7	Phosphamidon 90% conc.	0 - 8	28	17/6/65 A.M.	0.026	0.015	0.021	67	75	61	6,	11,	12
		8 - 16	11		0.004	0.009	0.003	95	85	94			
		16 - 50	11		0.000	0.000	0.000	100	100	100			
8	Cygon (4E) 49% conc.	0 - 2	14	16/6/65 A.M.	0.054	0.073	0.049	33	0	18	6,	9,	12
		2 - 5	15		0.057	0.031	0.042	29	56	30			
		5 - 8	10		0.021	0.021	0.039	74	70	35			
		8 - 13	3		0.000	0.000	0.013	100	100	78			
9	Zectran (2E) 25% conc.	0 - 1	38	16/6/65 P.M.	0.022	0.019	0.012	71	72	79	6,	9,	12
		1 - 2	15		0.006	0.004	0.004	92	94	93			
		2 - 4	8		0.021	0.002	0.007	73	97	88			
10	Malathion 100% conc.	0 - 2	9	15/6/65 A.M.	0.058	0.023	0.020	36	69	69	6,	9,	12
		2 - 5	25		0.048	0.032	0.017	48	57	74			
		5 - 8	17		0.018	0.013	0.011	79	82	83			
		8 - 15	9		0.019	0.028	0.010	77	62	85			
11	DDT 19% conc.	0 - 2	10	15/6/65 P.M.	0.090	0.065	0.080	0	7	0	6,	9,	12
		2 - 5	22		0.076	0.050	0.043	5	29	36			
		5 - 10	24		0.080	0.062	0.060	0	11	10			
		10 - 15	7		0.044	0.028	0.018	45	60	73			

* Corrected for natural mortality and population differences.

FOREST PROTECTION LTD.
43 ROSEBERRY STREET
CAMPBELLTON, N.B.

AERIAL FOREST SPRAYING OPERATIONS

1965

B. W. Flieger
November 1965

INDEX

---

*See Phosphamidon

Aerial Spraying Operations of Forest Protection Ltd.

1965

1. Introduction

In response to a request from the Chairman of the Interdepartmental Committee on aerial spraying for a report on its 1965 operations the Company is pleased to present the following account of its business during 1965 and some observations as a result of experience gained during this and past years.

2. General plan for spraying in central New Brunswick

A plan for spraying action was proposed by the Company in November 1964 and was endorsed by the several sponsors. The large-scale and more diverse than usual spraying operations called for in the detailed version of the general plan were carried out in June of this year at a cost of slightly under $1.8 million.

3. By far the largest part of the work-pile and the one most closely controlled was the spraying of some 1.7 million acres with D.D.T. at a rate of 0.5 gallons/acre containing 0.25 pounds of active material and the spraying a second time of some 0.94 million of these acres with a like dosage.

An additional 0.2 million acres interspersed throughout the above 1.7 million was excepted from D.D.T.*

Table I is a rough flow sheet of the spraying.

4. Changes from 1964.

Because the protection of streams in 1963 and to a much greater extent in 1964 seriously compromised and complicated the control of block spraying, it was thought necessary to use another unit this year. This consisted of a rectangle 4.7 miles in the N-S direction X one mile or more in the E-W direction and represents an area which can be sprayed by a single pair of T.B.M. aircraft in one sortie in which full swaths only are sprayed except for the Salmon Stream protected zone.

Since partial swaths are not permitted and streams are randomly distributed, units may vary in width, i.e., in number of swaths and likewise aircraft loadings will vary between a minimum of about 650 gallons and the top allowable 715 gallons.

---

*See Phosphamidon

Once decided upon on a trial basis, units were laid out on maps of the 1:50,000 series in all of the operation area to be sprayed by T.B.M. aircraft. These were numbered, sized and their aircraft loadings listed.

It was felt before spraying that a further complication had been invented but events proved this notion false. The block two direction spraying option was lost and the aircraft loadings were not transferable but these two limitations were not serious, at least not in 1965. In general the changes resulted in an all round improvement.

In another direction an attempt to gain better and fuller use of spray time or, more specifically, a going for the shortest possible length of haul from available fields resulted in a mixed fleet of T.B.M. and Stearman spray aircraft. The T.B.M.'s, 19 in number, were based on Fredericton Juniper and Dunphy. Stearmans, 38 in number, were based on Kesnac and Taxes where runway length and condition is suitable only for the lighter aircraft.

Stearmans sprayed in the conventional F.P.Ltd. manner, i.e., in pairs working blocks 4-5 thousand acres in size and of irregular shape under partial surveillance. The only new feature in this part of the D.D.T. application was the shut-off upon entering the stream buffer zone - a new experience for most Stearman pilots.

Return to the 0.5 gallon application rate from the 0.70 rate of 1964 speeded up the initial coverage and gave a further insurance against the project going incomplete because of foul weather.

Insecticide was formulated at spray strength, some in early winter and stored at fields where spring delivery is an uncertainty and the remainder just prior to and during spraying for the more accessible bases and for replenishment wherever draw-down by operations required it.

All aircraft were calibrated for an applic. rate of 0.5 gallons/acre and for satisfactory break-up of the spray cloud before work began and were checked from time to time during the course of the work. See Table 3 for calibration data.

It is of passing interest that 38 Stearman planes in the 1965 D.D.T. spray fleet were equipped as follows:

Pumps - 34 outside, wind driven
4 inside, generator driven

Booms - 33 trailing edge
4 internal, i.e., in the wing
1 under wing (the style earlier)

Nozzles - 26-29 orifice 5/64ths inches

When calibrated for 0.5 gallon/acre applic. rate, there was some slight variation in boom pressure from plane to plane.

The spray equipment on T.B.M. aircraft is standardized with trailing edge booms, hydraulic pumps, and one nozzle type.

5. Weather, over which scientist nor operator exerts control, was better for spraying this year than last as is indicated by the following log of the work of the past two seasons in which comparable quantities of work were laid out for comparably powered spray fleets.

5 Day Periods	Percentage Work Completed			
	End of Period		Within Period	
	1964	1965	1964	1965
Before June 1	3		3	
June 1- 5 incl.	15	4	12	4
" 6-10 incl.	21	36	6	32
" 11-15 incl.	43	56	22	20
" 16-20 incl.	66	96	23	40
" 21-25 incl.	90	100	24	4
After June 25	100		10	

During the period of operations there were five completely wash-out days in each year. In 1964, if the two periods June 6-10 and June 21-25 had enjoyed each others weather, the outcome of operations would have been much different. In 1965, had there been no work at all in the June 1-5 period, results might have been somewhat better.

6. Company operations using the organo phosphate, Phosphamidon, were also large in scale in the following categories.

a. Experimental plan - block spraying in Cains River Watershed.

b. Operations plan - protection of streams in D.D.T. spray area.

c. Operations plan - J.P. Sawfly, Quebec.

See Table 2 for account of use of Phosphamidon by F.P.Ltd. thus far.

7. There were special preparations for the spraying of Phosphamidon in experimental areas. It was decided to do this work with T.B.M. aircraft only, from one airstrip and to keep the work separated in so far as possible from D.D.T. spraying.

Phosphamidon in 250 Kg. drums was stored at Dunphy airfield on the side of the field opposite D.D.T. storage and this area was declared out of bounds at all times to other than authorized persons.

Loading out facilities were redesigned to provide 4 stations on one side for D.D.T. and 2 on the other for Phosphamidon. It was decided to dilute the technical material in the aircraft tank. A system of storage tanks, pumps, pipes, valves, meters, and hoses, was put together to supply water - then a slug of Phosphamidon - then more water in that order and in the proportions required directly to the airplane. Kam-lock fittings in use for loading D.D.T. solutions into T.B.M. aircraft since 1958 were modified to include Dri-break connections in order to cut down on dribble at break-away and associated blow-back to a few drops and this mostly water. See Fig. 2 for diagram of the mixing system.

To fly insecticide as required on the test areas four T.B.M. aircraft were brought to the field in late April where they were calibrated for the three flow rates to be used in the three experimental dilutions and for an acceptable break-up of the spray cloud in each instance. See Table 3 for calibration data.

Also brought in early was a pointer team and two Cessna 172 aircraft. These flown by special pointer pilots and navigators flag the spray blocks for the sprayer teams. Coordinators were appointed to be responsible for and to direct the operations of the aircraft while on the ground and in the air. Operations began May 16 and continued intermittently until June 20.

8. For the most part little difficulty was encountered in loading aircraft with the correct dilution. There were, however, mistakes made by mechanics in checking equipment and in quick calibration changes and some mistakes were made in flying. Together these caused part of the spraying to be spotty in quality or to deviate markedly from the prescription. Investigation suggested that very few assumptions regarding actions on the part of individuals can be entertained for long in this kind of spraying. It is important to have a close liaison set-up but after that it is nice to have a count-down before take-off.

It was noticeable that performance smoothed out as the work progressed. Probably the best effort went into the several blocks in the Cains watershed sprayed by the Company in one dilution late in the season.

9. Canada Department of Fisheries agreed that certain streams included in the spray plan area be protected from direct contact with D.D.T. spray. Accordingly, Phosphamidon was sprayed on long 1/2 mile wide bands of forest straddling these streams and amounting altogether to about 200,000 acres. The dilution used was almost the same as that of 1963 and 1964 but the dosage was cut in two to 0.25 lbs./ac. Reservations about a less dilute mix disappeared

in time for a portion of the second application to be sprayed in the 1-7 dilution at a rate of 0.2 gallon/ac. This work proceeded concurrently with D.D.T. spraying.

Two small and unrelated events of the past season stemming from use of Phosphamidon are: 1. Investigation of the manner of spraying a small part of one sortie by the Minister of Forestry on the demand of the Manager of the Miramichi Salmon Association and 2. A report in the Press of the proceedings of the Municipal council of York Co. in which a slur was cast upon the quality of spraying in 1965. Members said it wasn't worth a damn and didn't even kill the flies.

This opinion only served to strengthen an opposite one held by the Company in regard to the effect of its stream protection spraying.

A much smaller use of Phosphamidon but perhaps of even more interest to Fisheries was the treatment of infested forest in the Stewart Bk. watershed as worked out between the Department of Fisheries and the Province. This is the stream which supplies the South Esk Hatchery with water. About 2000gallons of the 1-15 dilution was used here to establish a zone between no spraying and D.D.T. spraying. There were no incidents.

10. In May, the Company was asked to plan a forest spraying project on the St. Maurice River watershed, P.Q., which called for spraying about 140,000 acres of young Jack Pine infested with Jack Pine Sawfly. The work took place in August. Approximately 35,000 pounds of Phosphamidon were sprayed in the 1-7 dilution by Stearman spray aircraft flying formation and flagged by Cessna pointers. The work was done from two hastily built minimum runway strips well inside the project general area. Cost was in the vicinity of $155,000 or $1.10/ac. For this project insecticide was batch formulated.

Stearman were modified for bottom loading of insecticide using Dri-break connections and were equipped with Marconi Minipak radio. Calibration was carried out on site with some assistance from Dr. Fettes unit for applic. rate of 0.2 gallons/ac. and for a very complete break-up of the spray cloud. Insecticide was employed in the calibration after earlier attempts to get planes ready using water had led only to confusion. Pilots were trained quickly in the 4 plane modification of the flying drill developed by the Company earlier for stearmans.

Fifty widely separated areas of various irregular shapes and sizes but all consisting of pure or almost pure Jack Pine dating from 1923 fire were sprayed once, in little more than one week in which there was some excellent spraying weather (Aug. 13-22).

Significant in this experience is the extent to which it drew upon the knowledge gained, in June, in the course of experimental spraying from Dunphy and Chipman. Spraying conditions in this Lat.-Long. in August is not to be assessed by a lone experience. It was noted, however, in this instance that the local air mass did not boil up as it does in the mornings in June in New Brunswick. In fact, the spraying pattern seemed to consist of a later start after the fog moved off and continuation of spraying through the middle part of the day sometimes terminated by turbulence and sometimes by wind speed.

Reports are that the insecticide worked quickly to reduce populations.

11. Chipman airstrip on the South side of the spruce budworm infestation was selected by the Company as a base for low volume concentrate experiments. At this base the Company shared facilities with Dr. Fettes' field testing project.

In preparation for the supplying of spraying service to the field testing project and for the large scale L.V.C. trials of its own the Company took the following steps:

40,000 pounds of L.V.C. Malathion and 675 Imp. gallons of Rogor 40 (4 pounds Di-methoate/Imp. gallon) were purchased for the tests.

The plumbing (so called, means all spraying equipment) on 5 Stearman aircraft owned by Wheeler Airlines (1960) Ltd. was modified for L.V.C. work according to instructions from U.S.D.A. This consisted mainly of rerouting insecticide around the pump and attaching bleed lines to remove air which might trap in the system. To equip the planes, thirty-six Mini-spin nozzles were purchased from Buffalo Turbine, Gowanda, N.Y. These were temporarily lost in transit so a second issue was obtained through Dr. Cooper of Cyanamid of Canada Ltd.

Personnel selected included 5 Stearman pilots, one mechanic, responsible to a coordinator who headed up the project. An excellent beginning was made by the coordinator who succeeded in working out a method of flying 5 Stearman in formation in a safe manner. Partly in parody of the now defunct R.C.A.F. Golden Hawks and partly because of the nature of the work and the equipment, these 5 Stearman pilots were dubbed "The Brass Cocks".

Formation flying turned out to be the easy part of the assignment. What followed was never very far away from being a sprayer's nightmare.

It was found to be impossible with available equipment to fly 5 aircraft on a single sortie with all parts of all nozzles present and working satisfactorily. So they were scrapped in favor of conventional nozzles except for one aircraft which carried on L.V.C. field test spraying for Dr. Fettes.

Malathion surprised with its solvent and penetrative properties. It worked through threaded joints, through bearing seals, hose connections, in fact through anything except a seamless tube. After it had permeated the plumbing equipment, this became a mixture of blocks and leaks. Responsible for most of the trouble were the aircraft which had equipment O.K. for D.D.T. or Phosphamidon spraying but not for Malathion.

Because the tests were in part to check out the chemicals as budworm insecticides, spraying was done at three dosages. Otherwise, the plan would have been given up, temporarily at least. In view of the inability of the aircraft to maintain calibration throughout the series of tests using Malathion and Rogor 40 estimates of the insecticidal values of the chemicals based on rather fragmentary post spray sampling, should be taken lightly.

12. A series of invalid assumptions had much to do with the kind of knowledge gained in L.V.C. experiments. For instance, that it did not matter if the good housekeeping label was missing from Mini-spin nozzles, that any sprayer aircraft could qualify for the work simply by complicating the outside plumbing, that Malathion was the ideal material for the tests because others used it, mainly because it was safe. These and others like them caused much frustration but also brought some clear gain.

It is now suspected that Mini-spins of the kind used this year, can be mounted in some fashion on a spray plane so that they will operate for a long time without flying apart or taking off into orbit. It is known now that dirt of any kind, whether it be runway dust, dirt in the chemical, materials in the system dissolved or loosened by the chemical, or residues from earlier use of the equipment, etc., will lead to trouble in getting and maintaining proper calibration. Some chemicals will handle more easily than others in L.V.C. spraying.

Information indicates that Buffalo Turbine Mini-spin nozzles performed poorly in the U.S. and Canada in 1965. However, Chevron Chemical in an attempt to get on the L.V.C. bandwagon produced a few units of a portable type spray rig which can be used in any kind of spray plane. This model uses the same vintage nozzle as those tried by the Company and are mounted very close to the boom. After replacement of original bearings and seals, these performed without difficulty.

Light aircraft can be used in forest L.V.C. work provided they can be kept in calibration. There is no insurmountable difficulty in establishing radio communication, safe loading, or safe flying in formation. The problem now is whittled down a bit but the proper flow of material from x nozzles mounted on y aircraft at one time still has to be resolved.

Use of Phosphamidon in the 1-7 dilution borders on low volume but of course is still a watered down concentrate.

13. In all of the work of this year, an attempt was made to reduce hazard to operating personnel. This took a number of forms, viz:

(a) Reduction of exposure to the smallest possible number of persons. For example, there was no need for a D.D.T. worker to ever be near Phosphamidon and vice-versa.

(b) Dilution procedures were designed to reduce exposure stations to the minimum number.

(c) Bottom loading of aircraft by-passed the pilot.

(d) Dri-break connections minimized exposure to loaders.

(e) Protective clothing was worn by handlers, safety helmets and respirators by pilots.

Attention was given to:

(a) Development of a respect for poisons.

(b) What to do in case of accident.

(c) Arranging for a doctor to be close to the major areas of danger. This was simplified for us by the Department of Health and welfare programmes which brought Dr. McCarthy and his helper Mr. Hall to Dunphy for the duration of spraying operations.

The most hazardous area but one involving the smallest number was Chipman where Canada Department of Forestry was engaged in testing several materials with which even the Doctor was unfamiliar. However, here we were relying on the Scientists to keep the camp safe and were within half an hour of medical aid.

The 1965 experience was good. In spite of the occurrence of several incidents, no case of poisoning was recorded. It is already apparent to the Company that making poisoning difficult is only part of safety in use of chemicals. The hard thing to keep is an untarnished picture of a killer. Workers who begin by having more than enough caution sometimes change and pick up a casual attitude after a long accident-free period. The person most likely to get into trouble is the mechanic who has trained to work with his bare hands and who most often must clean the plumbing or adjust and replace pieces which are wet with chemical. Gloves not only are a nuisance for him and may also turn out to be a trap.

It can be reported that there was an improvement in labelling and in care in handling in transit of Phosphamidon.

Rogor 40 in 5 gallon cans on the other hand looked like cans of paint or lubricating oil or anything that moves in 5 gallon cans.

The Company recommends that colour (dye) used to date in aerial spraying operations so that scientists may detect small amounts of spray be a mandatory additive wherever technical grade chemicals or concentrates or potent dilutions of these are being used so that ground and air operating personnel may better know when they are in danger.

14. Whether it be from the standpoint of being able to cover area at the right time or quality of effort or the nature of results obtained, there is a clear-cut superiority in two sprays of the same total dosage over a single spray. Nobody seriously can discount this statement. It is suggested that the time is over-ripe for finding out what opposition exists to the two spray techniques and for what reasons.

No change is indicated for the immediate future in choice of chemicals for large-scale spraying operations. A combination of D.D.T. and Phosphamidon must be used until a better one is found. In further use of D.D.T. the Company would like to increase dosage somewhat in the case of two applications and more than somewhat in those instances where there is time only for one. In further use of Phosphamidon the evidence from Canadian Wildlife Service suggests that a single dosage should not exceed 0.25 lbs. per acre. Some further work should be done to find the ideal formulation.

The technique of applying two insecticides in such a way as to afford protection to salmon producing streams has been improved in 1965 over 1964. The Company believes that it needs to improve it further in order to achieve its ends in budworm population reduction. Canada Department of Fisheries would agree that any further improvement would be to the advantage of aquatic life.

There is always conflicting opinion as to exactly which acres should be in a spray plan. However, once settled, there remains a problem in finding out if the insect has behaved between August and May as predicted. Over the years it has shown an ability to act in unpredicted fashion. This means early checking in the spring. More and more information on development of trees and insects is needed if timing is to be improved. Both kinds of information gathering employ the same kind of persons. The Company would like to see personnel added here believing this service to be under-manned.

In central New Brunswick where an outbreak of budworm (circa 1960?) is being opposed, the insect is the spruce spruce budworm, not the balsam fir spruce budworm. The Company is of the opinion that further improvements in protection will depend on study of the insect on spruce. In timing sprays, balsam could be disregarded. In this connection it is suggested that a series of tests be made using D.D.T. and Phosphamidon too in order to check the Mott spruce spray timing theory arrived at several years back as the result of a series of seven tests at three day intervals and to find out if timing is the main key to successful results.

Forest Protection Limited should continue experiments in the technique of low volume concentrate spraying. In this connection (Dr. Fettes please note) the Company is obtaining from Chevron Chemical one of its portable spray rigs for study and for the possible servicing of field testing.

15. Comparisons of a general nature of results of spraying over the years hide more information than they illuminate. It is difficult to tell the difference between a good job in a poor year and a poor one in a good year.

This year it is even more confusing. It will be interesting to hear how the results are rated in a good operating year which was also a fine year for the pest.

The Company believes it got some good results where they were most needed. This is perhaps the most important difference of all between 1964 and 1965 spraying operations.

16. Services provided by the Company other than spraying:

1. Provision of living quarters and meals:
    - (a) At Chipman for the field testing programme - Dr. J.J. Fettes.
    - (b) For scientific personnel of Canada Departments of Fisheries, Forestry and Northern Affairs (called Taxes Annex).
    - (c) For National Health and Welfare at Dunphy.
2. Made a post-spray aerial survey of defoliation 1965, results of which were turned over to Canada Department of Forestry.
3. Assisted in collection of data and in the operation of an insect counting house in connection with Phosphamidon experiment programme.
4. Assisted Canada Department of Forestry in carrying out the egg-mass survey.
5. Shared a helicopter with Canada Department of Forestry and New Brunswick Forest Service.

TABLE I - FLOWSHEET OF D.D.T. OPERATIONS, 1965

FLOW SHEET F.P.LTD. OPERATIONS ON APPROX. 1.7 MILLION ACRES IN CENTRAL NEW BRUNSWICK; SPRAYED WITH DDT INSECTICIDE, JUNE 1965

Numbers under dates in body of table are cumulative % of acreage in Col. 2. Horizontal rectangles include 80%+ area in the row.

Ph. Cat. No.	Acres	%	DATE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
			FIRST APPLICATION																										
0	199,000	12	2	19	22	X	32	47	90	93	95	97	X		X	X	100												
1	447,000	28	1	3			9	33	51	56	72	84	X	87	X	X	90		92	94	95	100							
2	343,000	20						1	18	22	32	41	46	59	X	X	64	70	98	100									
3	478,000	27							9	11	21		X	37	X	X	59	74	82	93	98	100							
4	221,000	13							9	12	32	59	X	79	X	X	83	91	96	97	100								
Tot.	1,688,000	100					6							68								100							
			SECOND APPLICATION																										% Cat. Area
0	84,000	9												61	X	X	75	96	100										42
1	252,000	27												11	X	X	43	95	98			100							56
2	163,000	17												2	X	X	4	25	62	66	82	86	X	X	100				48
3	240,000	26															2	10	34	47	53	72	X	X	100				50
4	199,000	21																	6	39	70	95			100				90
Tot.	938,000	100					0							9								89			100				
			SCHEDULE FOR AREAS SPRAYED ONCE																										% Cat. Area
0	115,000	15						26	83	88	91	95	X		X	X	100												58
1	195,000	26									36	64	X	70	X	X	77		82	86	89	100							44
2	180,000	24												21	X	X	31	42	96	100									52
3	238,000	32															18	48	64	86	96	100							50
4	22,000	3																10	60	70	100								10
Tot.	750,000	100					0							37								100							
No spraying on 6 days marked X			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	

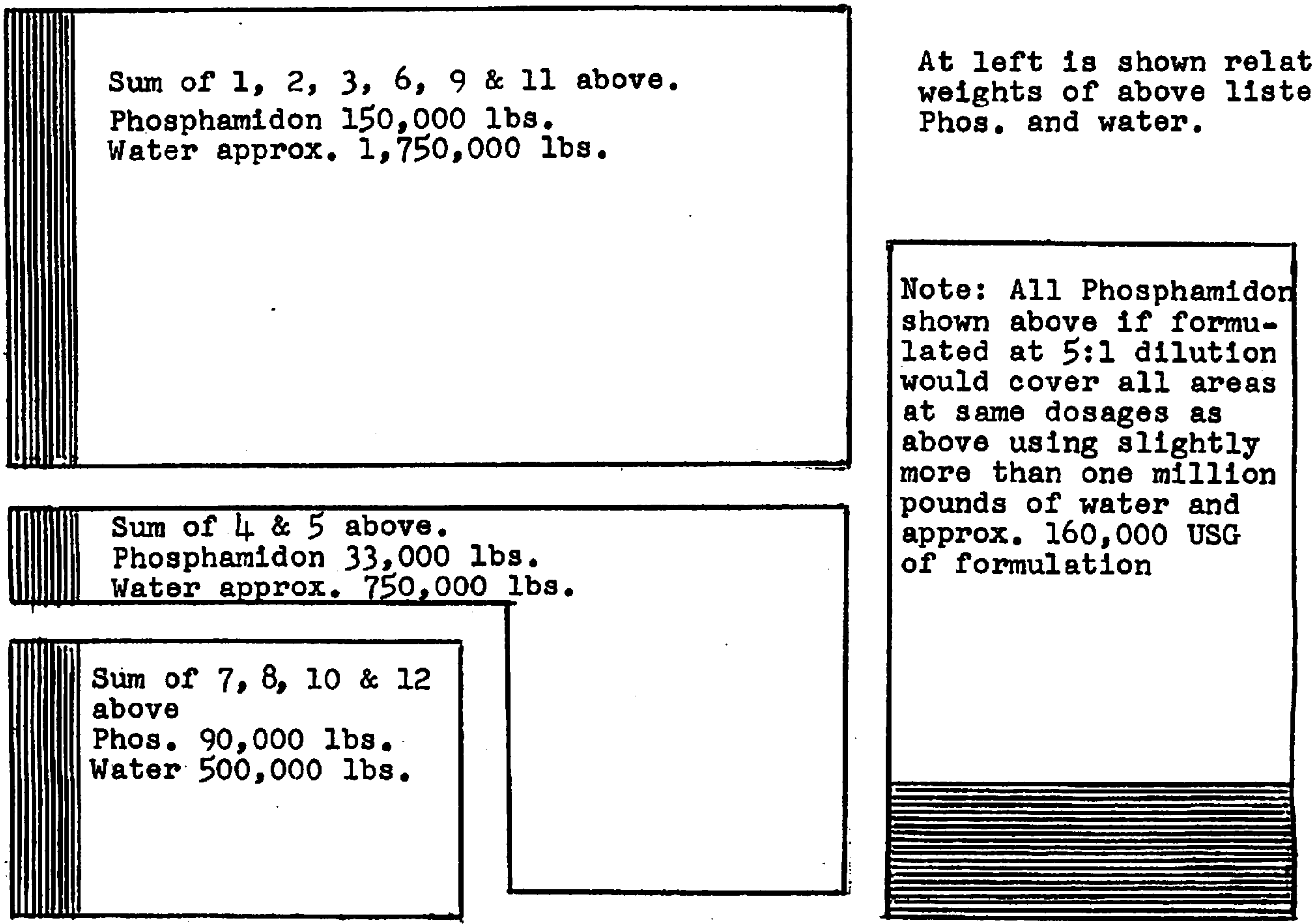
1964 defoliation showing from air in area still to be sprayed.

1964 pupation noticeable

TABLE - 2

Dilutions, application rates, dosages and total quantities of technical Phosphamidon used by F.P.Ltd. in aerial spraying, by years.

Year	Dilution	App. rate USG/ac.	Dosage lbs/ac.	Total USG	Lbs. water	Lbs. Phos.	Designation	No.
1963	14:1	0.75	0.5	15,000	125,000	11,000	Op., streams	1
1964	14:1	0.75	0.5	77,000	595,000	52,000	Op. streams	2
	14:1	0.75	0.5	38,000	295,000	26,000)	Op. & Exp. Blocks	3
	29:1	0.75	0.25	6,000	47,000	2,000)		4
1965	31:1	0.80	0.25	98,000	790,000	31,000	Exp. Cains River	5
	15:1	0.40	0.25	6,000	48,000	4,000	" " "	6
	7:1	0.20	0.25	12,000	86,000	15,000	" " "	7
	7:1	0.20	0.25	8,000	60,000	11,000	" " F.P.Ltd.	8
	15:1	0.40	0.25	88,000	685,000	56,000	Op. streams	9
	7:1	0.20	0.25	22,000	164,000	29,000	" (part 2nd app.)	10
	15:1	0.40	0.25	2,000	15,000	1,000	Op. Hatchery Bk.	11
	7:1	0.20	0.25	27,000	198,000	35,000	Op. Quebec J.P.S.	12
Tot.	*Approx. 373,500 U.S.G.			400,000	*3,110,000	**273,000	**Approx. 26,500 USG	



Sum of 1, 2, 3, 6, 9 & 11 above.
Phosphamidon 150,000 lbs.
Water approx. 1,750,000 lbs.

At left is shown relative weights of above listed Phos. and water.

Sum of 4 & 5 above.
Phosphamidon 33,000 lbs.
Water approx. 750,000 lbs.

Sum of 7, 8, 10 & 12 above
Phos. 90,000 lbs.
Water 500,000 lbs.

Note: All Phosphamidon shown above if formulated at 5:1 dilution would cover all areas at same dosages as above using slightly more than one million pounds of water and approx. 160,000 USG of formulation

TABLE - 3

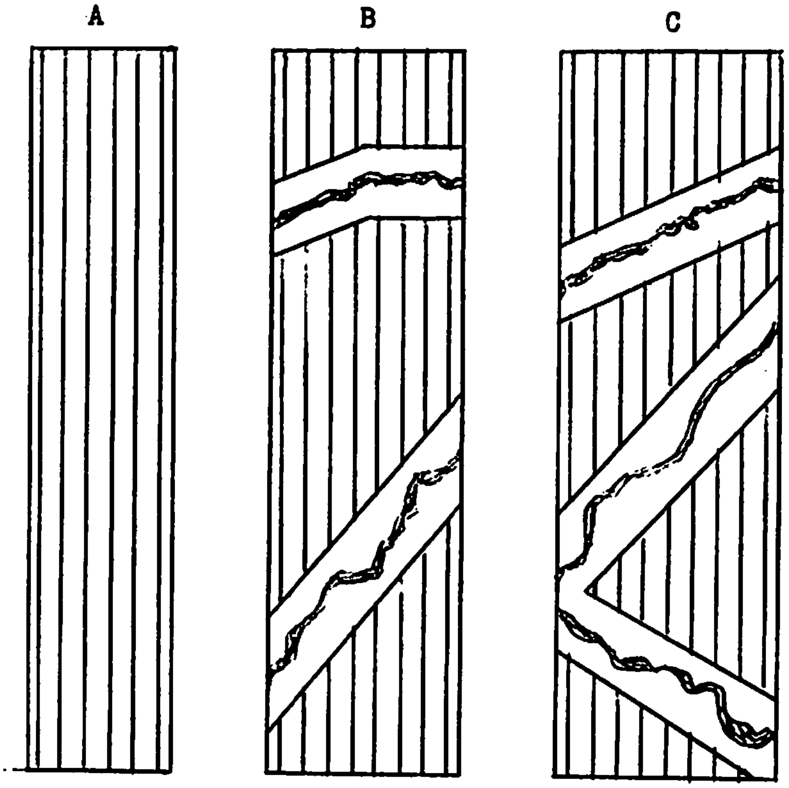
Forest Protection Ltd. Calibration Date 1965 (excepting L.V.C.)

Item	Operational	Operational	Exp.	Exp. & Op.	Exp. & Op.	Operational	Operational
Insecticide	DDT 0.5 lb. in 1 U.S.G.	DDT 0.5 lb. in 1 U.S.G.	Phospham. 31-1	Phospham. 15-1	Phospham. 7-1	Phospham. 15-1	Phospham. 7-1
Dosage in lbs./ac of active mat.	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Aircraft type	T.B.M.	Stearman	T.B.M.	T.B.M.	T.B.M.	Stearman	Stearman
Theoretical swath width in chains	6.25	3.0	5.0	5.0	5.0	2.5	2.5
Air speed in miles per hour	160	100	160	160	160	90	100
Application rate in U.S. gallons/ac.	0.5	0.5	0.8	0.4	0.2	0.4	0.2
Aircraft emission rate in U.S. gallons/min.	62-63	20	80	40	20	12	6.6
Nozzle description and number	18 #4664 Tee-jet	*#26-29 Tee-jet	21-22 #4664 Tee-jet	9-10 #4664 Tee-jet	20 #4664 Tee-jet	14 #4664 Tee-jet	27 #4664 Tee-jet
System screens & mesh	X	X	X	X	50 mesh on each side Y	X	X
Nozzle screens and type	X	Yes	X	X	X	X	#5053 50 mesh
Nozzle core	X	Yes	X	X	X	X	#45
Nozzle tip	X	5/64" orifice	X	X	#8010 flat spray	#5 disc type	#2 disc type
Boom orientation in degrees from vertical	0 down	0 down	0 down	20 forward	90 back	45 forward	45 forward
Boom pressure p.s.i.	40	40-43	40	35-37	40	60	60

N.B. Part numbers are those of Spraying System Co.

*Typical only, hardware not standardized on operations Stearman.

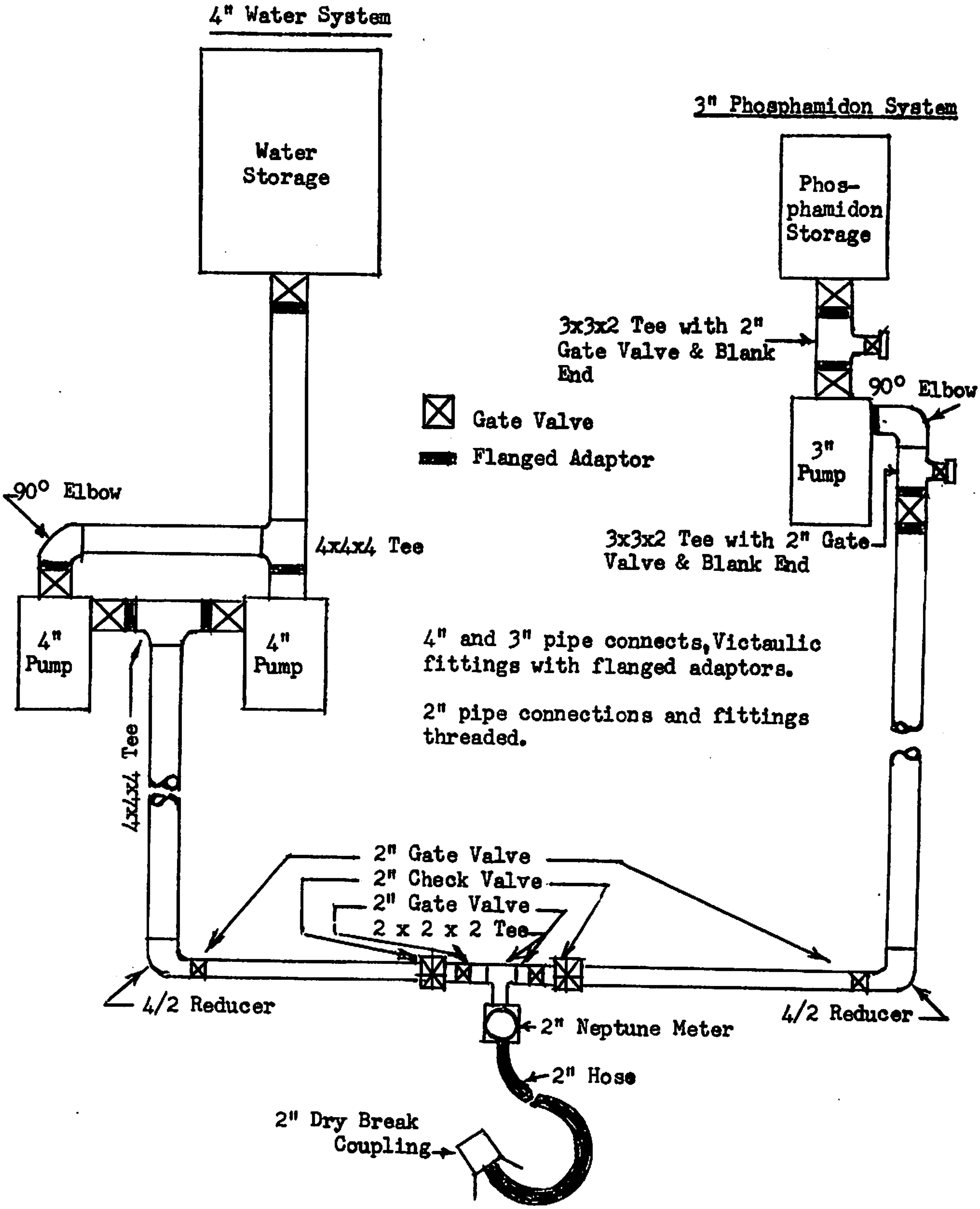
Examples of D.D.T. Spray Unit Shape,
Size, Gallons per Aircraft, Loadings
and Number of Swaths



Unit	Dimensions in Chains	Total Area	Protected Zone Area	Area to Spray	No. Passes	Load Gallons
A	374 x 75	2800	None	2800	6	700
B	374 x 100	3748	1028	2712	8	678
C	374x112.5	4207	1600	2600	9	650

FIG.--2

FOREST PROTECTION LIMITED
1965 PHOSPHAMIDON LOADING OUT SYSTEM

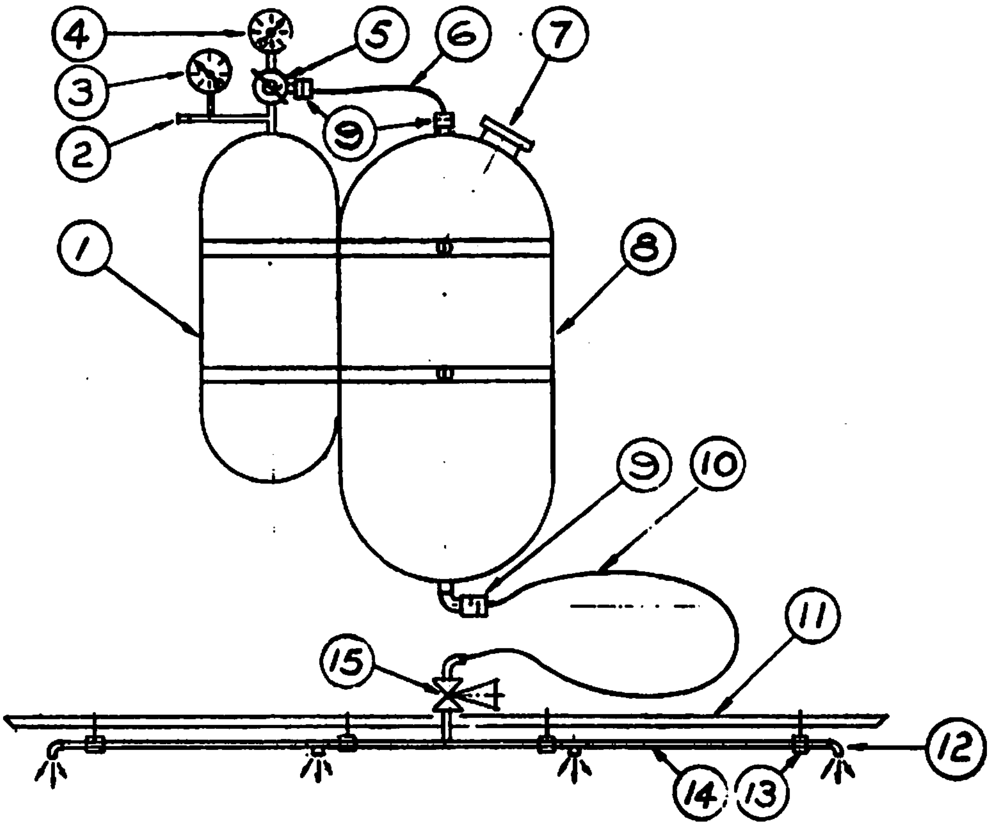


4" and 3" pipe connects, Victaulic fittings with flanged adaptors.

2" pipe connections and fittings threaded.

FIG.-3

CHEVRON CHEMICAL MODEL PORTABLE SPRAY RIG



DESCRIPTION FOR PORTABLE LVC SPRAYER

1. 280 cu.in. stainless steel air tank (Type A-6, O_2 Tank). Alternate: 2-1/2 lb. CO_2 bottle - 900 psi.
2. Air Valve. To fill from compresser or air nurse tank.
3. Air Tank Pressure Gauge. (Not required, but desirable.)
4. Discharge Pressure Gauge.
5. Pressure Regulator.
6. Neoprene Air Line.
7. Opening to Liquid Tank. 2-1/2" stainless steel pipe stub with cap.
8. 1,000 cu.in. stainless steel liquid tank (Type F-1, O_2 Tank).
9. Quick Couple Connection. Stainless steel. Spring loaded automatic open-close ('Aire Quip'.)
10. Liquid Supply Line. 1/2" I.D. Neoprene.
11. Hydraulic Boom on Conventional Aircraft Rig (for support only).
12. Nozzle attachment to Neoprene Boom with Brass Tee or Ell.
13. Clamps to hold LVC Boom on conventional Boom.
14. Neoprene Boom. 1/2" I.D. (alternate: 1/4" for 4 nozzles or less).
15. Liquid 'off-on' valve in cockpit.

APPENDIX IX

DEPARTMENT OF FORESTRY
CANADA

FOREST RESEARCH LABORATORY
FREDERICTON , NEW BRUNSWICK

SUMMARY STATEMENT ON THE ENTOMOLOGICAL ASSESSMENT OF THE 1965 SPRUCE BUDWORM AERIAL SPRAYING PROGRAM IN NEW BRUNSWICK AND FORECAST OF CONDITIONS FOR 1966

D R. Macdonald
October 15, 1965

Summary Statement on The Entomological Assessment of the 1965 Spruce Budworm Aerial Spraying Program in New Brunswick and Forecast of Conditions for 1966

1. Introduction

The 1965 aerial spraying operation was the sixth in the current series to protect the forests in central New Brunswick from the spruce budworm. It was also the thirteenth operation since the commencement of large-scale aerial spraying operations in the Province in 1952. Increased emphasis was given to experimental studies this year in addition to the usual operational program. A preliminary assessment of the effectiveness of the operational program is provided herein together with a forecast of budworm populations for 1966. Analyses of the data collected in 1965 are still in progress; conclusions drawn in this statement are therefore based on partial analysis of data only and may be subject to change.

2. The 1965 Spraying Plan and Operation

The 1964 egg-mass infestation survey indicated that severe defoliation could be expected over some two million acres in 1965 if left unsprayed. Surveys of tree condition indicated that 162,000 acres of forest were in a serious hazard category and another 325,000 acres were in a moderately serious condition. Most of these areas were located in the northwest portion of the infestation area. In developing the plan for the 1965 operation the infested area was divided into the following five categories:

1. Areas with high populations in need of immediate protection from budworm defoliation to prevent tree mortality or further serious damage.

2. Areas with high populations where the forest was in better condition than in category 1.

3. Areas geographically between 1 and 2 with light to moderate budworm populations.

4. Areas on the northern fringe of the infestation with rising budworm populations but with forests in good condition.

5. Other areas with high budworm populations but where the forest was in good condition.

After much deliberation it was decided that the operational plan would call for categories 1, 2, and 3 amounting to 1.8 million acres to be sprayed once with DDT at one-quarter pound in one-half gallon formulation per acre. Category 1, (975,000 acres) was to be sprayed a second time at the same dose because of severe tree hazard. The condition of the forest and the budworm populations in category 3 were to be surveyed in May and early June and those areas with high populations were to be given a second application, while the balance would be sprayed only once as in category 2. Phosphamidon was to be sprayed along the banks of salmon-producing streams designated by the Department of Fisheries.

It was further decided that a series of large-scale experimental sprayings with insecticides other than DDT were required by various agencies concerned with studies of the effects of forest spraying, and by Forest Protection Ltd. as well.

The most extensive experiments were to be made with Phosphamidon, an organophosphate insecticide which had been tested in 1962 by the Fisheries Research Board and the Chemical Control Section and found to be less harmful to fish than DDT while still effective against spruce budworm. It was tested in 1963 and 1964 but detailed assessment in 1964 showed that Phosphamidon applied at the one-half pound dosage did cause some bird mortality. The 1965 experiments with Phosphamidon were designed to develop dosage, formulation and timing schedules that would be less harmful to the birds but would still be effective against the budworm. The western half of the Cains River watershed was chosen for the experiments. This area was heavily infested and the forest was in a variable condition of vigor, with some small localized areas of mortality throughout. Approximately 225,000 acres were reserved for this experimental area.

Another area of 115,000 acres on the Salmon River watershed was reserved for a series of experiments to develop techniques for spraying low volumes of concentrated Malathion and other concentrate insecticides. Dead balsam fir, killed a few years ago by prolonged budworm feeding is common in this area while the spruce was generally in good condition.

Spraying was conducted from Fredericton, Juniper, Dunphy, Taxes, Kesnac and Chipman airports. Both Stearman and the larger TBM Grumman Avenger aircraft were used in the operation. Some 2,140,000 acres were sprayed (Table I). Of this total 1,688,000 acres made up the operational area sprayed with DDT (Figure 1). The banks of over 530 miles of salmon-producing streams within the operational area were sprayed with Phosphamidon (Figure 2). Most of the first application of Phosphamidon was sprayed at the rate of 1/4 pound Phosphamidon plus Invadine JFC in 0.4 gallons water formulation per acre, but most of the second application was applied at the rate of 1/4 pound Phosphamidon plus Invadine JFC in 0.2 gallons water formulation per acre. Some 211,100 acres were included in the Phosphamidon experimental area and 72,300 acres were included in the low-volume spraying experiments (Figure 3).

Experimental spraying commenced on May 16 and the full schedule of experiments is described in Section 4. Operational spraying commenced on May 27 when the spraying of Phosphamidon along the banks of salmon rivers started. The timing of the Phosphamidon was dictated by operational considerations since extensive timing experiments have not been conducted for Phosphamidon. It was assumed that the possible systemic action of Phosphamidon might warrant early application. A survey of larval populations along rivers that had been sprayed with Phosphamidon indicated that survival was relatively high and the

Table 1. Areas Sprayed in the 1965 Aerial Spraying Operation Against the Spruce Budworm in New Brunswick. (Data Supplied by Forest Protection Ltd., December 15, 1965).

Operational Program		Acres	
DDT Sprayed only once		749,800	
Sprayed twice		938,200	
	Sub-total	1,688,000	
Phosphamidon along salmon-breeding rivers (Approximately 570 linear miles of stream were sprayed; approximately 80 per cent of the streams were sprayed twice)		185,000	
	Total Operational		1,856,600*
Experimental Program			
Phosphamidon			
Sprayed only once		183,200	
Sprayed twice		27,900	
	Sub-total	211,100	
Malathion			
Sprayed only once		59,900	
Sprayed twice		3,100	
	Sub-total	63,000	
Rogor 40 (Dimethoate)		9,300	
	Total Experimental		283,400
	Total Area Sprayed		2,140,000

* The total operational area is not the direct sum of the acreages sprayed with DDT and Phosphamidon because there is an overlap of these treatments in the buffer zones along the streams.

Figure 1.

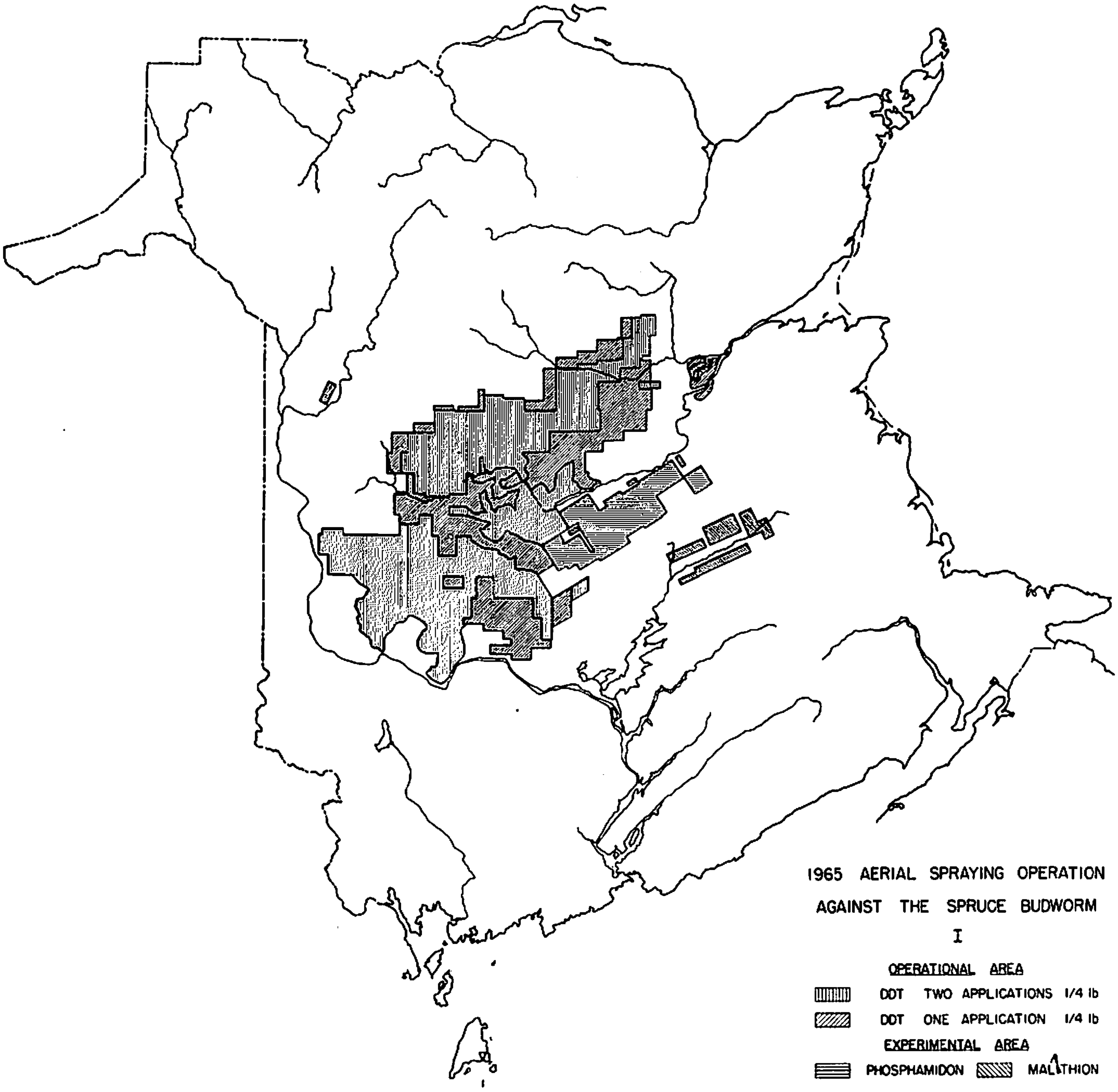
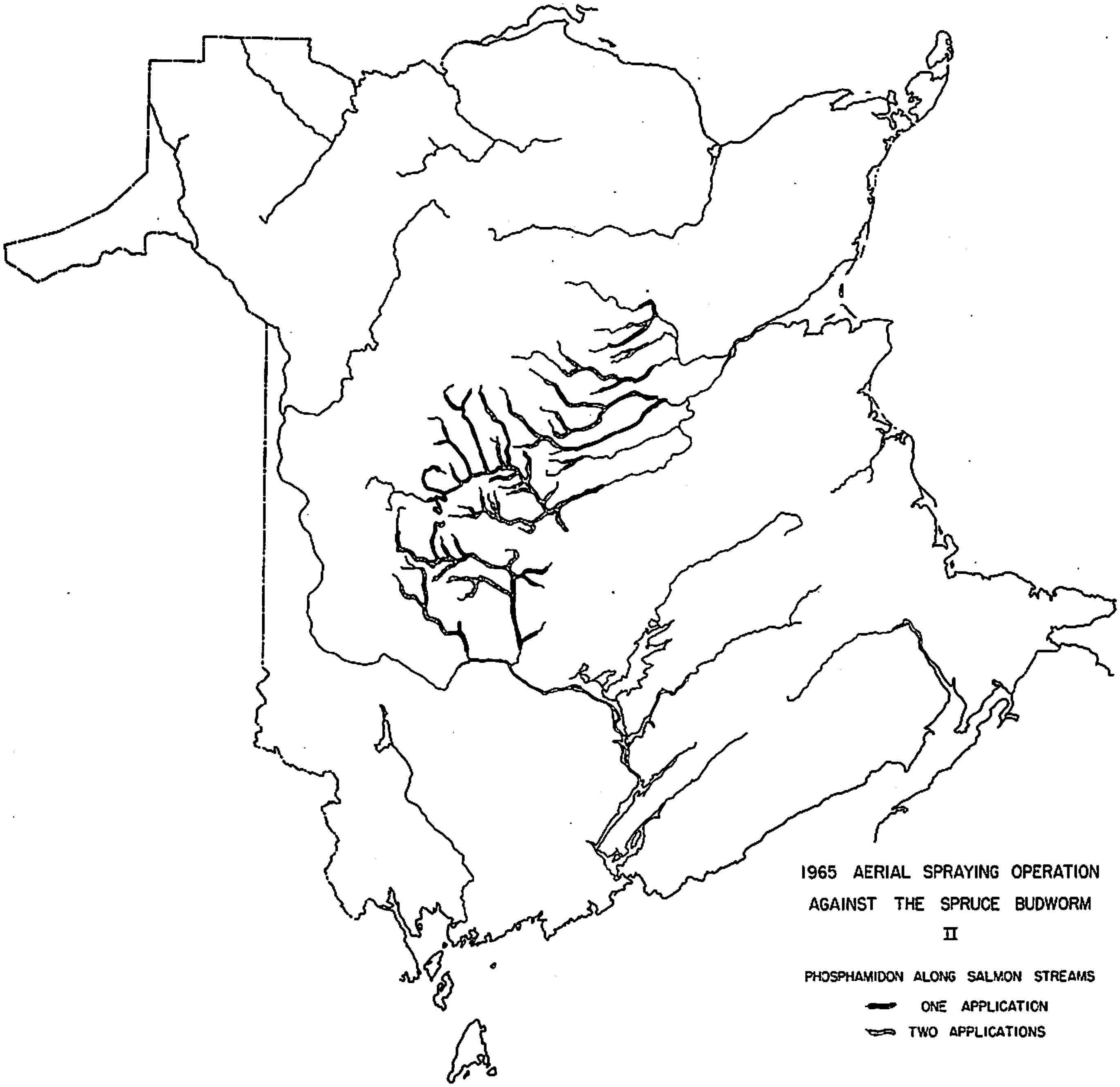

1965 AERIAL SPRAYING OPERATION
AGAINST THE SPRUCE BUDWORM
I
OPERATIONAL AREA
DDT TWO APPLICATIONS 1/4 lb
DDT ONE APPLICATION 1/4 lb
EXPERIMENTAL AREA
PHOSPHAMIDON
MALATHION

Figure 2.


1965 AERIAL SPRAYING OPERATION
AGAINST THE SPRUCE BUDWORM
II
PHOSPHAMIDON ALONG SALMON STREAMS
ONE APPLICATION
TWO APPLICATIONS

banks of most of the streams in the area sprayed twice with DDT were sprayed again with Phosphamidon (Figure 2). Operational spraying with DDT commenced on June 1. The weather conditions were particularly good for spraying this year and the operation was completed on June 20 which is one of the earliest closing dates on record.

An innovation in 1965 was the formation of a scientific coordinating committee. This group, consisting of the project leaders from the entomological, fisheries and wildlife study groups and Forest Protection Ltd's manager and operations co-ordinator, met twice-weekly to review the time-table and progress of the experiments. It was able to review the immediate results of the experiments and detect and correct certain errors and make several useful adjustments to the program.

3. Population Reduction in Operational Area in 1965

The percentage reduction in budworm populations caused by spraying was estimated from data gathered on the annual post-spray survey for surviving budworm pupae made in July. The data were separated by phenological categories and the percentage reductions in population in each category were determined. These are based on comparisons of the surviving population within the sprayed area in each phenological category and the population in the unsprayed infested area. The calculated percentage reductions were then weighted according to the percentage of the operational area in each phenological category to derive an estimate of the percentage reduction by spraying in budworm populations on balsam fir and on red spruce over the entire area (Table II).

The reduction on balsam fir, 85.3%, is the highest that has been achieved since this series of spraying operations started in 1960 (Table III). This is a result of the high degree of protection that was obtained in the large proportion of the area that was sprayed twice, and also because conditions for spraying were generally much better than in some of the earlier years, especially 1964. Population reduction on red spruce was less than that obtained in earlier years. Forest Protection Limited decided to start the second application before most of the bud-caps on red spruce had fallen to insure that all of the area scheduled for two treatments would receive the second treatment. The early timing of this second application probably accounts for the lower per cent reduction on spruce.

4. Population Reduction in the Experimental Areas

Three series of experiments were conducted in 1965:

(1) Experiments with Phosphamidon to evaluate the effect of lighter dosages than had been used in 1963 and 1964 on the budworm and on birds and fish. These were carried out by the Department of Forestry and the Department of Fisheries and the Canadian Wildlife Service, and were confined to the Cains River watershed. Forest Protection Ltd. also carried out some operational experiments in this area with Phosphamidon.

Table II. Per Cent Reduction in Population by Spraying with DDT for the 1965 Operational Area Estimated on an Area Basis - Determined from Pupal Survey Data.

Pheno. cat.	Treatment	% of Total area (1)	No. of Samples Fir	No. of Samples Spruce	Percent Reduction in population Fir (2)	Percent Reduction in population Spruce (3)	Contribution to weighted total Fir (1)x(2)	Contribution to weighted total Spruce (1)x(3)	Area
0	DDT 1x	5	18	18	46	0	2,3	0	St. John R. valley and Nashwaak R. north to Cross Creek Stat.
	2x	9	29	23	81	53	7.2	4.8	
1	DDT 1x	8	35	34	80	51	6.4	4.1	Millville to Stanley to Boiestown and S.W. Miramichi to Chatham.
	2x	19	46	33	88	58	16.7	11.0	
2	DDT 1x	10	23	23	81	61	8.1	6.1	A 10-mile-wide band running N.E. Crosses S.W. Miramichi from Boiestown to Salmon Bk. includes middle of Renous and Dungarvon drainage, Taxis and Upper Nashwaak drainages.
	2x	14	14	13	96	79	13.4	11.1	
3	DDT 1x	11	26	25	85	63	9.4	6.9	An 8-mile-wide band running N.E. Includes most of S.W. Miramichi drainage from Salmon Bk. to Juniper.
	2x	12	16	15	97	76	11.6	9.1	
4	DDT 1x & 2x x	12	21	21	84	75	10.1	9.0	Headwaters of McKiel, Burnthill, Clearwater, and Rocky Bks.
	Total per cent reduction in population in operational area						85.3	62.1	

Table III. Summary of Annual Estimates of Per Cent Reduction in Population on Balsam Fir and on Spruce Throughout Areas in the Original Operational Plan From Annual Pupal Surveys 1960 to 1965 Inclusive.

Year	Balsam Fir	Spruce
1965	85.3%	62.1%
1964	82.9%	65.0%
1963	80.6%	78.5%
1962	81.8%	69.5%
1961	84.7%	81.9%
1960	81.2%	42.0%

(2) Experiments with Malathion on the Salmon River watershed to develop an operational procedure for applying ultra-low volumes of concentrated insecticide. These experiments were made by Forest Protection Ltd. and were monitored by the entomological, fisheries and wildlife scientists only when time and staff could be spared from the investigations on Phosphamidon. The entomological assessment was confined to a general survey of surviving pupae.

(3) Experiments with other new insecticides which were conducted by the Chemical Control Research Institute of Department of Forestry on the Salmon River watershed. The results of these experiments will be reported elsewhere.

4.1 Experiments with Phosphamidon

The Phosphamidon experiments tested:

(1) the amount of Phosphamidon applied per acre and included a comparison of ¼ pound and ½ pound dosages.

(2) the formulation of the poison in the water solvent. Three dilutions were used, 0.8 g.p.a. which was the operational formulation used in 1964 and 1963, and 0.4 g.p.a. and 0.2 g.p.a.

(3) the effect of a wetting agent, Invadine JFC. An experiment in 1964 had suggested that the wetting agent improved the effectiveness of Phosphamidon by hastening absorption into the plant tissue and possibly promoting systemic activity.

(4) the time of application in terms of morning versus evening spraying. Work in 1963 and 1964 indicated that Phosphamidon was slightly more effective when it was sprayed in the evening, and a trial in 1964 had suggested that the birds were not as severely affected following an evening application.

(5) the time of application during the season.

(6) the effectiveness of two applications applied several days apart.

Nineteen different blocks, or partial blocks, were sprayed to test these variables (Table IV). The standard blocks covered approximately 13,000 acres each, and were made this large so that the full impact of the treatment on the bird population would not be obscured by migration. Budworm populations were measured twice weekly from early May in four blocks and an extensive survey was made throughout the area after spraying to measure surviving pupal populations in each block.

The average number of surviving budworm per sample unit found during the post-spray survey is listed in Table V and the percentage reduction in

Table IV. Summary of Experiments with Phosphamidon, Malathion and Rogor 40 - 1965

Date Sprayed	Time	Pounds Phosph'n	Dilution g.p.a.	Invadine JFC	Block No.*	Map No. Fig. 3 +
Phosphamidon						
One Application						
May 16	a.m.	¼	0.2	yes	2 (270)	1
16	p.m.	¼	0.8	yes	7 (274)	2
19	p.m.	¼	0.8	yes	9 (276)	3
21	a.m.	¼	0.8	yes	10 (277) West 2/3)	4
25	a.m.	¼	0.8	yes	10 (277) East 1/3)	
30	a.m. & p.m.	¼	0.8	no	273A	5
June 5	p.m.	¼	0.8	yes	5 (272)	6
6	a.m.	¼	0.2	no	560	7
6	a.m.	¼	0.4	yes	2 (269)	8
6	a.m.	¼	0.8	no	559**	9
7	a.m.	¼	0.8	no	8 (275)	10
12	a.m.	¼	0.8	yes	6 (273)	11
15	p.m.	½	0.8	yes	563	12
15	p.m.	½+	0.4?	yes	1 (268) centre 8 passes	13
16	a.m.	¼+	0.4?	yes	1 (268) North 12 passes	14
20	a.m.	¼	0.2	yes	1 (268) South	15
Two Applications						
May 22 & June 9	a.m.	¼	0.8	yes	4 (271)	16
May 30 & June 19	a.m.	¼	0.2	yes	558	17
June 7	a.m.	¼	0.8	yes	275A***	18
MALATHION						
June 15		8 oz.	0	-	600	19
8 & 12		8 oz.	0	-	606W	20
16		8 oz.	0	-	606E, 605W	21
17		8 oz.	0	-	602	23
21		4 oz.	0	-	605E	24
22		4 oz.	0	-	603	25
18		16 oz.	0	-	607S	26
ROGOR 40 (DIMETHOATE)						
June 19		16 oz.	0	-	601	22

---

* F.P.L. block numbers are given in parentheses

** Includes one swath that was resprayed immediately

*** Two applications on same morning on west side of block

\+ Unnumbered blocks were sprayed as part of Forest Protection Ltd.'s operational experiments.

EXPERIMENTAL SPRAY PROGRAM - 1965

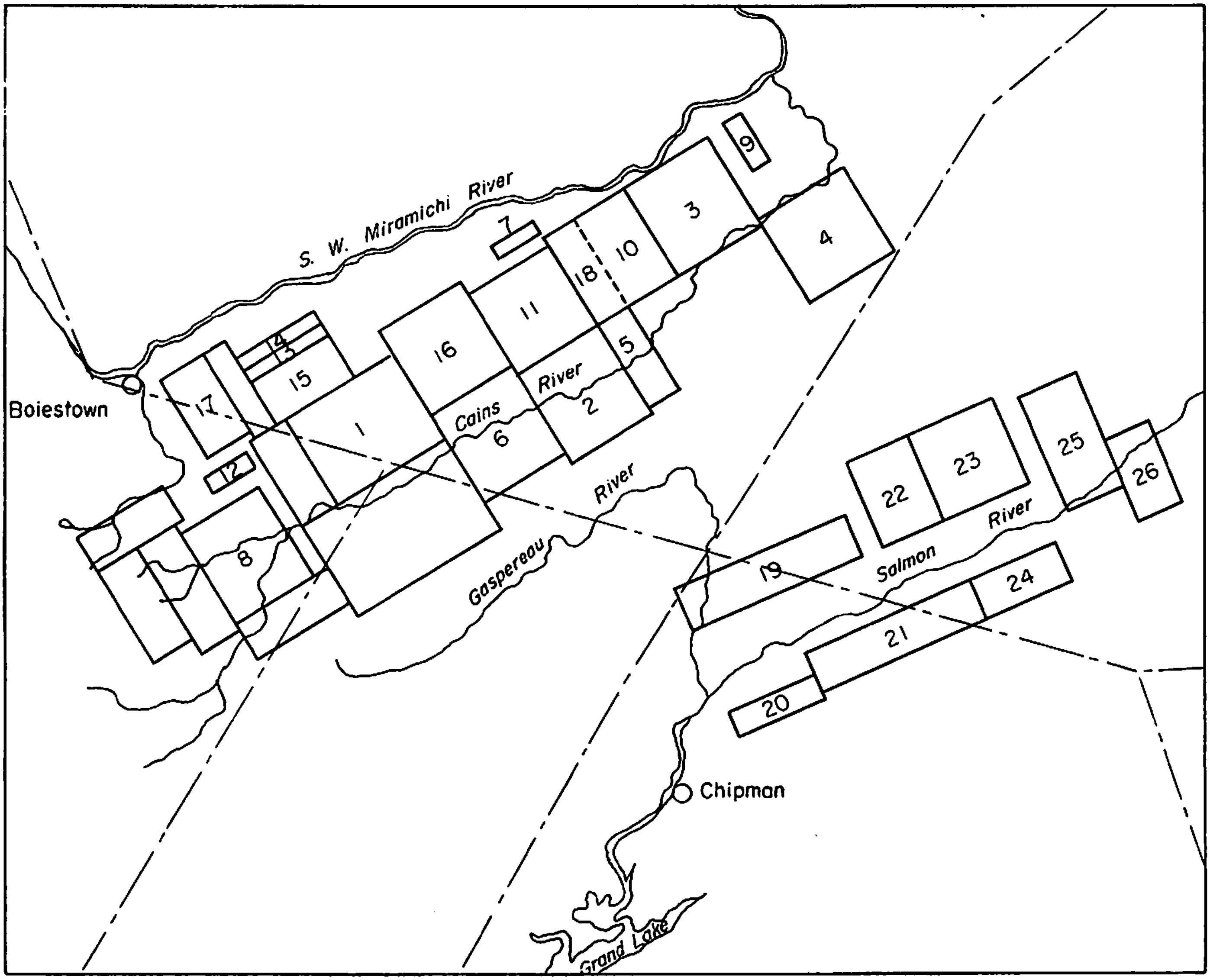


Figure 3. Treatment applied to each block is listed in Table IV.

population is shown in Figure 4. The analysis of these and other data, is not complete but certain preliminary interpretations have been made which are presented below.

The Phosphamidon experiments can be divided into three distinct sets depending on the development and behavior of the larvae. The first set occurred early in the season, shortly after the larvae had emerged from hibernation and had mined into their first needles. The second occurred shortly before the larvae started to mine their second or third needles. The third occurred after the larvae had migrated to the shoots and continued until the larvae were nearly fully grown.

It had been suggested that the small, second-instar larvae would be very vulnerable to light doses of any poison that could be translocated to their feeding sites. The larvae emerged from hibernation on May 5 and the first set of experiments started on May 16 when most of the larvae were well established in needle mines. Both experiments in this set failed to cause an important reduction in population (Figure 4) and it has been concluded that the poor percentage reduction was related to the feeding behavior of the young larvae. When the larvae started to mine into the base of the needles they quickly cut the vascular tissue. They then fed on tissue which was relatively free of the systemic poison that was applied after the mine was established. The larvae moved to new needles about a week later, but much of the Phosphamidon had already decomposed and most of the population survived.

The second set of experiments, which were conducted on May 19 and 21 when most of the larvae had nearly finished mining their first needles, were much more successful (Figure 4). Detailed population counts and development data taken at this time indicated that there was a general dispersal of the population between May 20 and May 24 as the larvae moved from completely mined needles to fresh needles. In this case they fed on needles that were sprayed a few days earlier and mortality was high. An application four days later (May 25), after the dispersal was completed, and after most of the larvae had established new needle mines resulted in very poor control.

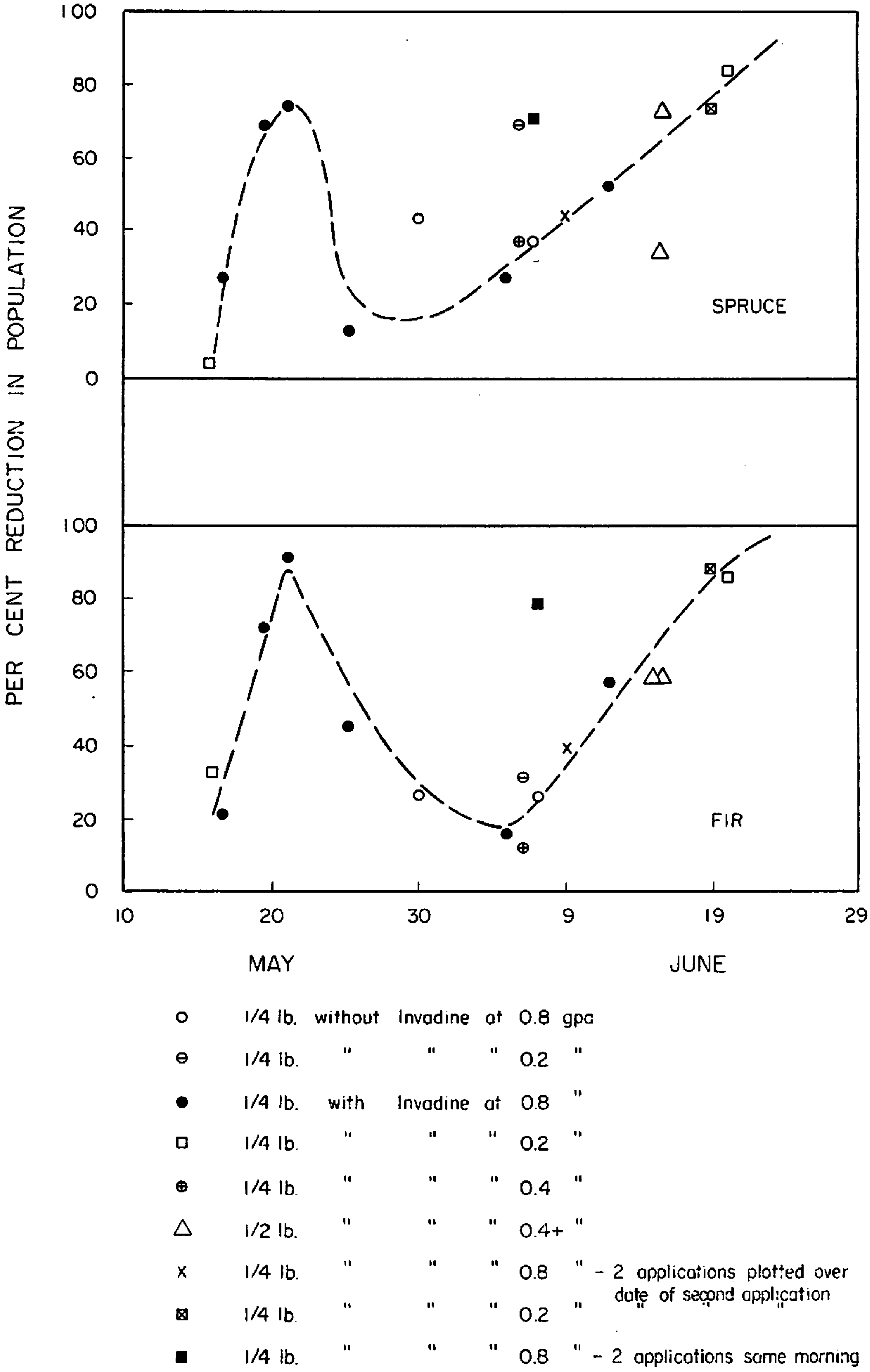
The final set of experiments began on June 5 when the fir buds had started to open, and it continued until June 20. During this series of experiments the following observations on development were noted. The fir foliage had flared by June 14, at which time the red spruce buds started to swell. Approximately 80 per cent of the population was in the third instar when the experiments started on June 5, and the population had developed past the peak of the fifth-instar by June 20. The balsam fir shoots completed about 75 per cent of their growth by June 20, while the red spruce shoots were only half-grown. Bud-caps on red spruce started to fall on June 15 and about 75 per cent had fallen by June 20.

Population reduction increased linearly from a very low level on June 5 to more than 80 per cent on June 20 (Figure 4). Inspection of the data in Figure 4 shows that the modifications to the one-quarter pound dosage are all of secondary importance in comparison with the effect of the develop-

Table V. Average Number of Surviving Spruce Budworm per 18-inch Branch-tip on Balsam Fir and Red Spruce in the Experimental Blocks Sprayed With Phosphamidon.

Date Sprayed		Block No.	No. of Samples		Ave. No. per Branch-tip	
			Fir	Spruce	Fir	Spruce
One Application						
May	16 a.m.	3 (270)			3.60	2.38
	16 p.m.	7 (274)	26	28	4.39	2.33
	19 p.m.	9 (276)	20	21	1.28	0.84
	21 a.m.	10 (277West)	12	13	0.43	0.48
	25 a.m.	10 (277East)	8	8	2.49	1.62
	30 a.m. & p.m.	273A	13	14	3.46	1.36
June	5 p.m.	5 (272)	28	29	6.40	2.63
	6 a.m.	560	11	14	3.24	0.58
	6 a.m.	2 (269)	10	10	4.40	1.94
	6 a.m.	559	-	-	-	-
	7 a.m.	8 (275)	20	17	4.53	2.02
	12 a.m.	6 (273)	20	25	2.23	1.16
	15 a.m.	563	13	16	2.14	1.51
	15 p.m.	1 (268)Centre)	25	24	3.28	0.67
	16 a.m.	1 (268)North)				
	20 a.m.	1 (268)South	10	10	0.96	0.39
Two Applications						
May 22 & June 9	a.m.	4 (271)	22	25	3.79	1.60
May 30 & June 19	a.m.	558	12	15	0.58	0.47
June	7 a.m.	275A	17	18	0.98	0.66

Figure 4.


PER CENT REDUCTION IN POPULATION
100
80
60
40
20
0
SPRUCE
100
80
60
40
20
0
FIR
10
20
30
9
19
29
MAY
JUNE
○ 1/4 lb. without Invadine at 0.8 gpa
⊖ 1/4 lb. " " " 0.2 "
● 1/4 lb. with Invadine at 0.8 "
□ 1/4 lb. " " " 0.2 "
⊕ 1/4 lb. " " " 0.4 "
△ 1/2 lb. " " " 0.4+ "
× 1/4 lb. " " " 0.8 " - 2 applications plotted over date of second application
⊠ 1/4 lb. " " " 0.2 " " " "
■ 1/4 lb. " " " 0.8 " - 2 applications same morning

ment of the insect and the host tree on survival. It is apparent that the 0.2 g.p.a. formulation is as effective as the more dilute formulations when it is properly applied. The effects of the wetting agent, Invadine JFC, and of morning versus evening application times are confused in this preliminary analysis and no conclusions have been made about these modifications.

The percentage reduction found on the two blocks sprayed 18 to 20 days apart is plotted over the date of the second application in Figure 4. This technique does not appear to be any more effective than a single application on the later date. The experiment with two applications of one-quarter pound Phosphamidon on the same morning (Block 275A, June 7) was made to simulate the effect of overlapping swaths on bird populations. It gave very good budworm control at a time when a single one-quarter pound application was ineffective because of the increase in dosage and the improved spray droplet coverage. It also caused appreciable bird mortality.

This preliminary analysis suggests that there are two periods during the season when effective control of the budworm can be obtained with a light dose of Phosphamidon, and probably with other systemic insecticides. The first period occurs early in the season when the small larvae are very susceptible to light doses of the poison. During this period they are generally well protected from contact insecticides by their habit of mining into needles and buds, but mortality will be high if the foliage that they feed on has been poisoned by a systemic insecticide before they start feeding. From the 1965 experiments we can infer that spraying with one-quarter pound Phosphamidon can be started shortly before emergence from hibernation, and can continue until most of the larvae have started to mine needles. Further early spraying can be done a few days before the larvae finish mining the first needle and move to the next needle. Poor control will result in the interval when the larvae are feeding on tissue that is separated from the vascular system of the tree. The intervals between these periods will depend on the weather and on the expected duration of a lethal dose in the needle tissue, which will depend on the decay rate of the insecticide chosen and the dose applied. The 1965 experiments gave no indication of the degree of control that might be achieved in a heavy flowering year when many of the larvae would start to mine staminate flower buds instead of a second or third needle.

The second period of effective control with light dosages of Phosphamidon occurs relatively late in the season when the larvae are no longer protected by the bud-caps or foliage. This will occur around the peak of the fifth-instar and will extend into the early part of the sixth-instar. Later applications will probably be of reduced effectiveness because of the increased tolerance of the mature larvae to light doses of poison. In fact these later applications may be detrimental to the long-term use of the insecticide because they will increase the chances of selecting insecticide-tolerant strains in the population. It is of interest to note that contact effects, rather than the systemic, are the more important during the second period. This may mean that additives to promote systemic activity should only be included early in the season, and that they could be left out of formulations made for late season spraying to promote the contact effect of the insecticide when the light dosage is used.

The results of the analyses to this point tend to raise the question whether Phosphamidon at the light dosage of one-quarter pound per acre, should be applied in the future very early in the season. Some advantages of very early applications are:

1. The budworm population will be reduced before appreciable bud destruction or defoliation can occur.

2. The larvae will be more susceptible to the light doses of the insecticide than later in the season.

3. The whole fleet of spraying aircraft can be made available to spray Phosphamidon at this time, and large areas or several hundred miles of stream, could be sprayed in a short time.

4. There will be a second chance later in the season to spray areas that could not be covered during the early period, or to respray areas where the early application proved to be ineffective.

The disadvantages associated with early spraying will include the problem of determining the development of the insect over large areas, and the probability of getting sufficient spraying weather during the short period available to spray the area designated for this type of treatment.

4.2 Experiments with Ultra-low Volume Concentrations of Malathion

Considerable interest has developed recently in the use of low volumes of concentrate insecticides. The technique, using undiluted technical Malathion at dosages in the order of one pint per acre, has been found to be very effective against certain forage, range, and forest insects, and may lead to revoluntionary changes in large-scale forest spraying operation procedures. Forest Protection Ltd. was anxious to conduct operational experiments with fleets of aircraft using this technique in order to gain experience and learn some of the operational and logistic problems involved. The experiments were conducted along the Salmon River watershed using five radio equipped Stearman aircraft with a flag team of two Cessna 172 aircraft. The Stearman were originally equipped with six small spinning spray nozzles. The prototype nozzle was developed by the Plant Pest Control Division of the U. S. Department of Agriculture to provide a uniform atomization of concentrated pesticides sprayed at low volumes. Unfortunately, the commercial version, the 'Mini-Spin Nozzle', proved to be defective and had to be abandoned during these experiments. The aircraft were then equipped with various flat face spray nozzles and tips.

Malathion was sprayed at the theoretical rate of four, eight, and sixteen ounces per acre over some 63,000 acres. A 9,300 acre block was also sprayed with undiluted 'Rogor 40', which is a commercial formulation containing four pounds of Dimethoate per Imperial gallon with wetting agents and solvent. The average number of surviving budworms per branch-tip and the average percentage reduction in population by each treatment are shown in Table VI. These results suggest that a one pound per acre treatment of undiluted Technical Malathion will provide good budworm control when applied under the proper conditions and with equipment that will give a uniform atomization. Dimethoate may also give reasonably good control although further trials should be made to determine the best combination of equipment and insecticide formulation.

5. Defoliation by Spruce Budworm in 1965

The annual aerial survey for defoliation was conducted by Forest Protection Ltd. in early July and the resultant map is shown in Figure 5. In general, foliage protection within the operational area was very good. The most extensive areas of severe defoliation were found on the headwaters of Burnthill and Clearwater Brooks, around Beadle Mountain, on the Nashwaak River drainage around Christmas Lake and the Chainy Lakes, on the Porter Brook watershed and along the South Bartholomew River. There were other isolated areas of severe defoliation within the operational area but these were scattered and relatively small in area.

Moderate defoliation was fairly extensive along the northern and northwestern sides of the operational area and on the Dungarvon River watershed and on Fork Brook on the southwest side, but otherwise it was restricted to fairly small patches scattered throughout the area.

Most of the experimental area on the Cains River watershed was severely to moderately defoliated, but defoliation was much less severe in the Salmon River experimental area.

Severe defoliation outside the sprayed areas was common on the height of land between the Cains and the Gasperaux and Salmon River watersheds and extended over onto the Kouchibouquacis River watershed. There was also a large area on the operational boundary southeast of Juniper, and another near the mouth of the Sevogle River and along the Northwest Millstream in Northumberland County.

An infestation of approximately 18,500 acres was also mapped on the North Tabusintac River watershed in Gloucester County.

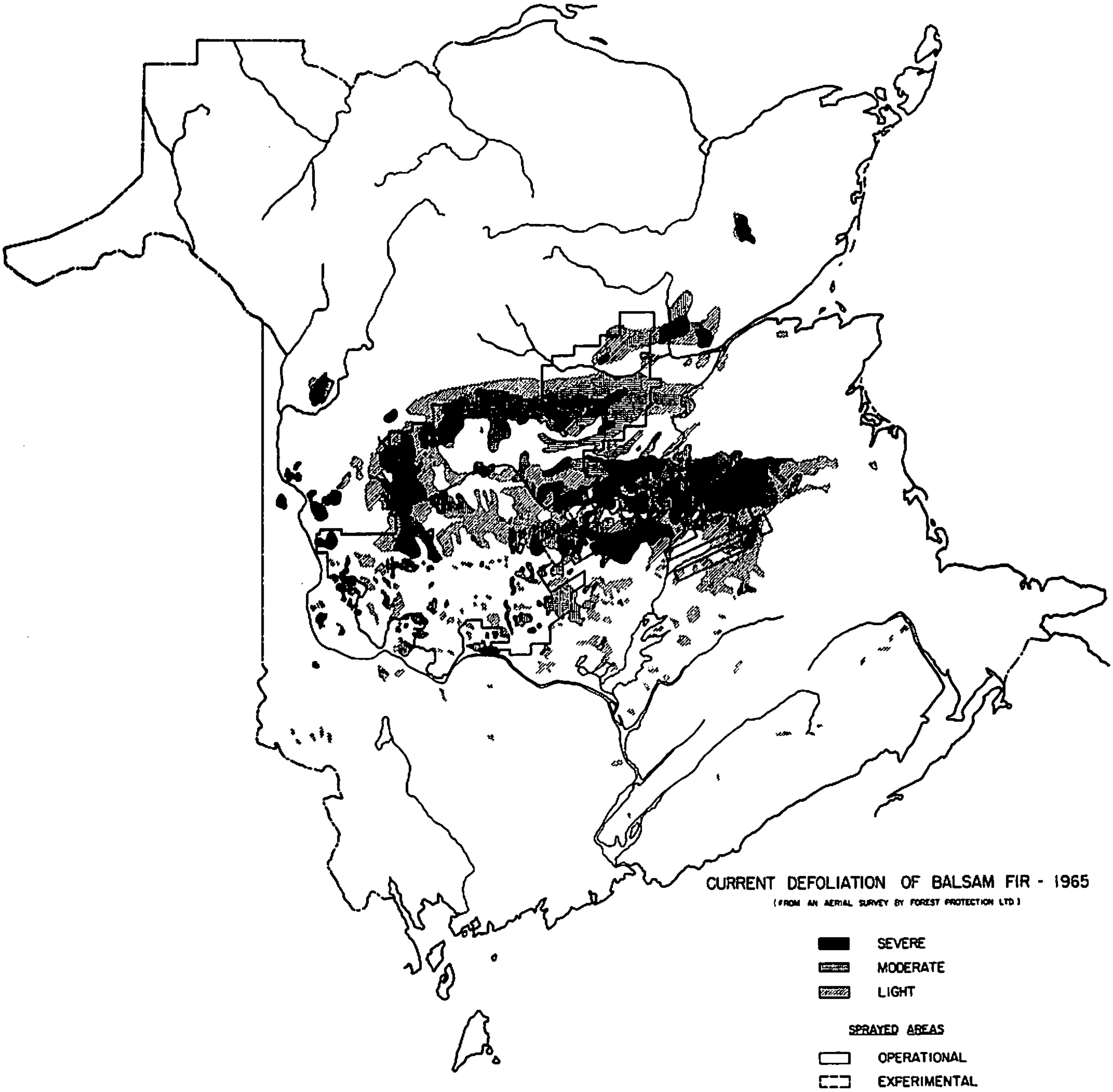
Scattered patches of moderate and severe defoliation were also found near Bath in Victoria County and on the Pokiok Brook watershed near the mouth of the Tobique River in Victoria County.

It is also of interest to note that on the southern side of the infestation moderate defoliation was observed on the headwaters of Forks Stream in Queens County and scattered light defoliation was observed on the southeast side of Grand Lake in Queens County and near Waterford and Pollett Lake in Kings County. This represents the most extensive defoliation observed in this area in several years.

Table VI. Average Per Cent Reduction in Budworm Population on Balsam Fir and Red Spruce on Blocks Sprayed Experimentally With Ultra-low Volume Concentrations of Malathion and Rogor 40 (Dimethoate).

Volume per acre	Block No.	Date sprayed	No. of Samples		Ave. Pop. Per 18-in. branch		Average Per Cent reduction	
			Fir	Spruce	Fir	Spruce	Fir	Spruce
Malathion								
4 oz.	603 & 605	21 June	9	12	3.88	2.50	28.8	17.7
8 oz.	600	15 June	8	12	3.19	1.46	22.2	19.0
16 oz.	607	18 June	10	10	0.23	0.24	93.7	70.8
Rogor 40								
16 oz.	601	19 June	5	8	0.45	0.33	80.0	63.5

Figure 5.



CURRENT DEFOLIATION OF BALSAM FIR - 1965

(FROM AN AERIAL SURVEY BY FOREST PROTECTION LTD)

6. 1965 Egg-mass Survey and Forecast of Population for 1966

The results of the annual egg-mass survey are presented in Figure 6. The map is based on sequential counts of egg masses on mid-crown balsam fir branches at some 1062 locations.

The largest infestation is bounded by a line that extends from Boiestown southeast to head of Grand Lake then east to the mouth of the South Canaan River, north to Kent Junction on Highway 33 and west to Upper Blackville and along the Southwest Miramichi River and Bartholomew River drainages and back to Boiestown. This infestation amounts to approximately 1,010,000 acres.

There are several smaller scattered infestations where serious defoliation can be expected in 1966. The most noteworthy are along the valley of Rocky Brook north of Young's Dam, 49,000 acres, and near Half Moon and Dearsdale and Napadogan, 118,000 acres.

There are several scattered points along the valley of the lower Nashwaak River where defoliation will be severe, particularly along McKenzie Brook near Lower Durham, Manzer Brook, Penniac and along the Dunbar Stream and on the Killarney Lake Road, 200,000 acres.

Some moderate to severe defoliation will occur between Grand and Washdemoak Lakes 65,000 acres, and in Camp Gagetown near the Rockwell Stream, 14,000 acres.

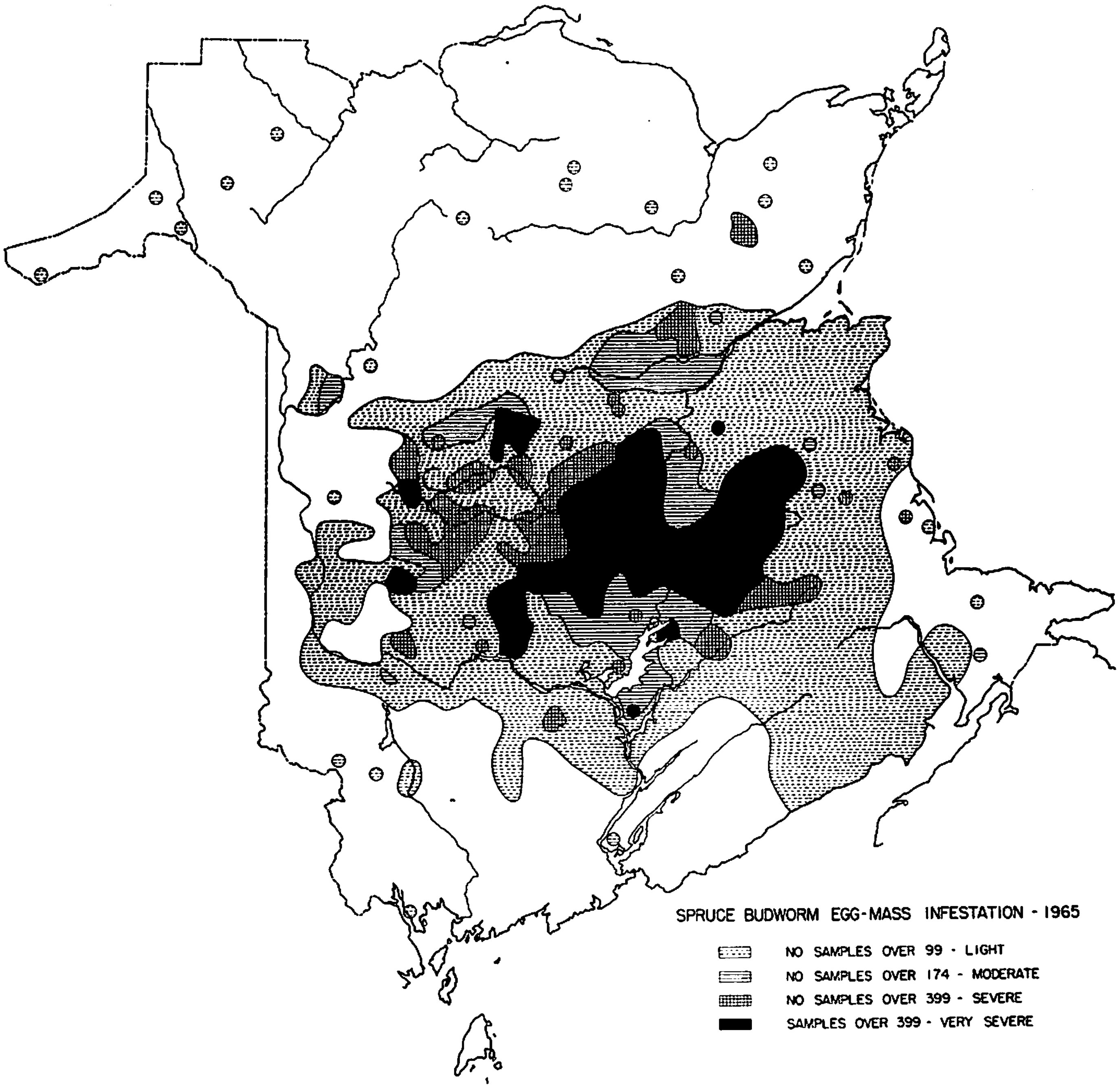
Moderate to severe defoliation can also be expected along the N.W. Miramichi River drainage near Curventon, Ashton Hill and along the Boom Road, 48,000 acres.

Severe defoliation will also occur again in 1966 in the isolated infestation on the North Tabusintac River at Tabu airstrip, 21,000 acres. Other scattered areas of severe infestation will extend over some 129,000 acres.

The areas where potentially severe defoliation will occur in 1966 amount to 1,654,000 acres and an additional 781,000 acres will probably suffer moderate defoliation.

The trends in egg-mass populations from 1960 to 1965 are shown in Table VII for the 1965 sprayed and the unsprayed areas in the Province. The data from the sprayed portion are broken down to show trends in the different treatment areas. Effective control in the areas sprayed twice with DDT, revealed by the pupal survey, is also evident in these data. The data from the unsprayed portion are sub-divided into northern, central and southern regions, and major infestation areas within these regions are shown separately. There was no detectable change in the very low populations in the northern part of the Province except for the small infestation on the North Tabusintac River which had not been sampled previously. The population

Figure 6.


SPRUCE BUDWORM EGG-MASS INFESTATION - 1965
NO SAMPLES OVER 99 - LIGHT
NO SAMPLES OVER 174 - MODERATE
NO SAMPLES OVER 399 - SEVERE
SAMPLES OVER 399 - VERY SEVERE

in the Miramichi Bay area declined by one-half this year. In central New Brunswick populations increased 2.4 fold on the eastern side of the Province but declined slightly on the west. Populations increased 2.8 fold in the Canaan River area but there was also a 60 per cent increase throughout southern New Brunswick.

7. Summary

1. The 1965 aerial spraying operation against the spruce budworm comprised a total of 2,119,000 acres; 1,688,000 acres were sprayed with 1/4 lb. DDT in 0.5 U.S. gal. formulation of DDT in solvent oil per acre and of this total 938,200 acres were sprayed a second time with the same formulation. Some 185,000 acres were sprayed with 1/4 lb. Phosphamidon per acre and 4/5ths of this total were sprayed twice. The total operational area amounted to 2,140,000 acres. Large scale experiments were carried out on 283,400 acres. Some 211,100 acres were sprayed with Phosphamidon, 63,000 acres were sprayed with low volumes of concentrated Malathion and 9,300 acres were sprayed with Rogor 40 (Dimethoate).

2. Experimental spraying commenced on May 16, and operational spraying of Phosphamidon along salmon-producing rivers commenced on May 27. Operational spraying with DDT commenced on June 1 and the operation was completed on June 20 which was one of the earliest closing dates in the program.

3. Surveys of surviving budworm pupae showed that an 85.3 per cent reduction in population was achieved on balsam fir and a 62.1 per cent reduction on red spruce throughout the entire operational area. This result was above average for balsam fir but was lower for spruce.

4. The results of the experiments with Phosphamidon indicate that the one-quarter pound dosage is effective against the budworm at two different periods: first, when it is sprayed early in the season, before the second-instar larvae mine into the needles; and second, when the fifth-instar larvae become fully exposed to the contact effects of the poison by the flaring of the needles and the dropping of the red spruce bud-caps. No other tested factors appeared to influence the effectiveness of the one-quarter pound dosage, although the 0.2 g.p.a. formulation appeared to be as effective as the 0.8 g.p.a. formulation.

5. Limited surveys in areas sprayed with technical Malathion indicated that a theoretical application of 16 ounces per acre gave 94 per cent population reduction on fir and 71 per cent on red spruce. A 16 ounces per acre application of Rogor 40, which is primarily Dimethoate, gave 80 and 64 per cent reductions respectively.

6. Aerial and ground surveys of defoliation revealed that crop protection was generally very good throughout most of the operational area. Moderate and severe defoliation was common on the Cains River experimental study area but defoliation was generally less severe on the Salmon River

study area. Severe defoliation was common on the height of land between the Cains and Gasperaux Rivers and in several other widely scattered areas.

7. The total area of severe egg-mass infestation, where serious defoliation can be expected in 1966 covers 1,654,000 acres and 781,000 acres are moderately infested.

Table VII. Trends in Spruce Budworm Egg-mass Population by Areas, 1960-1965 (Number of Sample Points in Brackets)

	Av. No. Egg-masses/100 sq.ft. Foliage						Ratio of No. Egg-masses				
	1960	1961	1962	1963	1964	1965	61/60	62/61	63/62	64/63	65/64
Sprayed in 1965											
DDT 1x	138 (46)	44 (43)	56 (46)	192 (58)	158 (68)	169 (75)	0.32	1.28	3.43	0.82	1.07
DDT 2x	105 (78)	49 (74)	51 (76)	134 (97)	265 (112)	86 (122)	0.47	1.04	2.64	1.99	0.33
River Phosphamidon	177 (35)	51 (35)	54 (34)	201 (46)	349 (52)	172 (56)	0.29	1.07	3.72	1.73	0.49
Experimental Phosphamidon	151 (15)	181 (14)	34 (17)	214 (17)	664 (18)	614 (31)	1.20	0.19	6.24	3.10	0.92
Experimental Malathion	202 (2)	205 (7)	287 (5)	139 (7)	138 (9)	394 (12)	1.01	1.40	0.49	0.99	2.85
Unsprayed in 1965											
East-Central, N.B.	263 (112)	95 (128)	56 (128)	120 (139)	106 (147)	257 (191)	0.36	0.59	2.14	0.88	2.44
West " "	90 (95)	47 (113)	12 (110)	50 (122)	25 (148)	17 (163)	0.52	0.25	4.21	0.49	0.70
North -	12 (274)	5 (255)	0.7 (224)	0.3 (198)	2 (194)	1 (174)					
Miramichi Bay	46 (53)	38 (45)	7 (46)	36 (47)	65 (50)	38 (52)	0.83	0.17	5.40	1.83	0.57
Tabusintac	190 (2)	16 (2)	-	-	-	212 (6)	-	-	-	-	-
South -	14 (133)	8 (153)	2 (148)	3 (136)	10 (116)	16 (116)	0.57	0.27	1.16	3.94	1.60
Canaan River	13 (11)	19 (11)	2 (10)	19 (10)	44 (11)	126 (30)	1.51	0.08	11.69	2.38	2.83

APPENDIX X

Department of National Health and Welfare

Occupational Health Division

Ottawa

The Occupational Health Division is concerned with service, research, and teaching in all matters affecting the protection and improvement of the health of workers and the effects of air pollution on the health of all Canadians. The Division's activities include environmental and clinical surveys; physical, chemical, and biological laboratory services; consultative services in the field of medical, nursing, engineering and other sciences; publication of educational material; and the promotion of teaching and research in occupational health and air pollution in Canada.

REPORT ON ACTIVITY OF OCCUPATIONAL HEALTH DIVISION IN THE NEW BRUNSWICK FOREST SPRAYING OPERATION 1965

Large scale aerial application of pesticides has been carried on over the forests of New Brunswick almost annually for the past thirteen years. DDT has been used over the vast acreage without any apparent acute effect on the health of those engaged in the operation. The long-term effects of DDT exposure have not been studied.

In 1964, when the decision was made to supplement the use of DDT with the organo phosphate pesticide, phosphamidon, a new area of possible occupational hazard was introduced. The organo phosphates are, as a group, much more acutely toxic than DDT and very little is known about the long-term effects of exposure. Accordingly, the Occupational Health Division of the Department of National Health and Welfare requested and obtained permission to conduct observations and examinations of exposed workers in the field.

The participation of the Division in the 1964 operation, although limited, did indicate that some potentially hazardous situations existed in transportation, storage, formulation and loading of pesticides. At the conclusion of the 1964 operation, recommendations were made for improvement in techniques of handling and application of phosphamidon.

In planning the 1965 operation, the decision was made to increase the use of phosphamidon. The Occupational Health Division was represented at some of the planning sessions and was able to plan for more extensive participation in the spraying programme.

From the study of the data collected in 1964, the conclusion was reached that the workers most at risk were the loaders and formulators. Sufficient information was not available on the pilots or mechanics to enable one to assess confidently the magnitude of the risk to which they were exposed.

For the purposes of investigation, the workers were divided into three groups: (a) loaders and formulators (b) pilots, and (c) mechanics.

Pre-exposure blood specimens were taken and the state of health evaluated by clinical examination. Because the observers lived and worked in close contact with the men during the period of observation, their state of health was capable of being estimated reasonably well on a day to day basis.

Blood studies were repeated at intervals depending upon the opportunity for exposure that had occurred in the preceding seven days.

A new clinical screening procedure using a relatively simple method was tested in the field and the results compared with the more precise laboratory methods in Ottawa.

Observations

Comparing the 1964 and the 1965 operations, there were important improvements from the occupational health point of view. Transportation of the pesticide from the port of entry to the operations site was much improved. There was little evidence this year of mishandling of containers. The labels were placed on the sides of the drums rather than the tops and the containers themselves are of a heavier gauge metal. Storage and disposal of "empty" containers followed an established and approved pattern and due care and attention was given to this part of health maintenance. Personal protective gear was improved consistent with recommendations made last year and loading procedures and equipment were altered to eliminate some of the potential hazards that previously caused concern.

The personnel at risk co-operated in the investigative programme and made themselves available for examination and sampling as requested.

The clinical examinations and laboratory investigations conducted during 1965 did not demonstrate any conclusive evidence of toxic exposure.

There is no doubt that skin contamination of the mechanics in particular did occur. The deep violet staining of their hands and arms was apparent even to the casual observer.

Pilots reported experiencing a metallic taste when flying phosphamidon and it is suspected that they were minimally exposed.

The loaders and formulators wore protective gear most of the time but were inclined to neglect wearing parts of their gear unless closely supervised.

Conclusions

No clinical or laboratory evidence of intoxication by the organo phosphate insecticide, phosphamidon, could be detected with the methods available in the field during a seven-week period of observation of exposed workers.

Discussion

No attempt was made to determine whether or not a delayed or long-term effect results from exposure to phosphamidon.

It was apparent that skin contamination had occurred in some of the mechanics. This exposure occurred in healthy young men in an intermittent manner. The weather was cool and damp and no exposed worker had any skin lesions. All men washed thoroughly after each exposure and, under the most difficult conditions, each exposure did not exceed two hours in length. Their exposure was to the dilute formulation rather than the concentrate. The loaders and formulators were apparently adequately protected from exposure to the concentrate but supervision to ensure safe practice seems to be essential.

The degree of exposure of the pilots is unknown. Studies of the pilots' breathing air would be necessary to determine the significance of cockpit contamination. One pilot wore a respirator with no apparent discomfort and this practice should be encouraged.

Cholinesterase determinations in the field using the acholest tests are practical and reproducible. The use of potent pesticides such as phosphamidon require that pre-exposure determinations of the cholinesterase levels be made in order that changes can be detected before clinical symptoms develop.

New chemicals will no doubt be developed to meet the pest problems of the future. All such developments should be carefully examined to determine the human health hazards associated with their use. If large-scale or long-term use of new pesticides is proposed, such a screening procedure becomes even more important.

Medical care should be available at the site of operation. Prevention and treatment of organo phosphate poisoning requires a familiarity with toxicity and with treatment methods unlikely to be possessed by the occasional practitioner. Instructions on this subject could be delivered with the product to be used and supplied by the manufacturer.

It is our opinion that large-scale spraying operations of this type place a worker under sufficient potential hazard to warrant full-time medical supervision throughout the period of spraying.

Field use of potent experimental pesticides increase the health hazards associated with any spraying operation. Laboratory conditions afford an opportunity for control that is lacking in the field, particularly when the time available for field testing is limited.

In order to prevent serious health consequences resulting from the field testing of experimental pesticides, informed medical supervision is necessary until safe practices are established and operating.

To accomplish the desired result, medical advice and consultation should be available at the planning stage of large-scale operations. The constant evolution of new pesticides to meet new problems will no doubt continue. Keeping abreast of the advances in diagnosis and treatment of pesticide poisoning will require a continuing effort on the part of public health authorities at all levels of responsibility.

Laboratory tests on toxicity of Phosphamidon and Invadine to young salmon

A report for the Interdepartmental Committee on Forest Spraying Operations

November 15, 1965

J.B. Sprague
Fisheries Research Board of Canada
Biological Station
St. Andrews, N.B.

J.A. Dalziel
Fish Culture Development Branch
Canada Department of Fisheries
Halifax, N.S.

SUMMARY

The organophosphate insecticide Phosphamidon has been used in forest-spraying operations against the spruce budworm, sometimes with the addition of the penetrating agent Invadine. The toxicity of these chemicals to juvenile Atlantic salmon (*Salmo salar* L.) was tested in the laboratory. The lethal threshold of Phosphamidon for a one-hour exposure, after which fish were removed to clean water, was about 220 mg./litre. This is much higher than the concentrations which might be expected in streams following aerial spraying operations, perhaps of the order of 0.1 mg./l.

Static tests in 60 litres of Phosphamidon, without renewal during the 2-week test period, showed essentially the same acute toxicity as continuous-flow experiments lasting as long as six weeks. Concentrations from 100 mg./l. down to about 25 mg./l. killed fish rapidly, in 4 to 10 hours. Lower concentrations, from 20 mg./l. down to about 5 mg./l. had a slower acute toxicity requiring up to two weeks exposure. Survival times were linearly related to concentrations in each of these two ranges of toxicity.

There was no apparent lethal threshold for continuous exposure to Phosphamidon. From about 4 mg./l. down to 0.1 mg./l. the lowest concentration tested, at least half of the fish died in two to six weeks. Survival time did not seem to be related to concentration over this range. For usual operating conditions, this insecticide is relatively safe from the point of view of damage to young salmon.

The penetrating agent Invadine JFC 100 had a lethal threshold of about 70 mg./l. This is not particularly toxic, being comparable to the activity of household detergent. Invadine added to Phosphamidon in the ratio 0.03 by weight did not noticeably change the toxicity of the insecticide.

INTRODUCTION

It is hoped that this report on Phosphamidon toxicity will be followed by others from the Biological Station at St. Andrews. Present plans are to test each year, one or two insecticides which seem "promising" for the forest-spraying program. It is hoped that the Committee can give advice on which insecticides could most usefully be tested for toxicity to fish.

The present laboratory tests were undertaken to estimate the relative safety of the insecticide Phosphamidon for juvenile Atlantic salmon (Salmo salar L.). The tests were also designed to show whether the addition of Invadine to the Phosphamidon mix changes the toxicity greatly. Invadine is a "penetrating agent" which has characteristics not unlike a detergent. It was used in forest-spraying operations in 1965 in an attempt to get Phosphamidon into the tissues of trees as rapidly as possible.

The laboratory tests on fish were more detailed than necessary for answering the question of toxicity. In particular, results from simple static tests were compared with results from continuous-flow tests which require more complicated gadgetry. The purpose was to find out whether the easily-done static tests gave adequate and unbiased results for this soluble insecticide. It is hoped that static tests may be used for bioassays of similar insecticides in the future, thus avoiding an expensive problem of waste disposal at our laboratory.

METHODS

Tests were carried out from February to June of 1965. Fish were about one year old at that time, and ranged from about 6 to 11 cm. in length. They had been hatched and reared at the Saint John Fish Culture Station from Miramichi River stock. Fish were acclimated upwards to the test-temperature, 15°C., during 4 to 10 weeks of holding at St. Andrews prior to the experiments. They were fed beef liver during this time.

Each continuous-flow test was done with 10 fish in 25 litres of solution in an oval polyethylene tank. There was a constant inflow of 300 ml. of fresh solution of Phosphamidon per minute. This was made by a continuous drip of stock solution into the inflowing water. New stock solutions were made up every three days to avoid excessive variation from decomposition of the insecticide. Technical grade Phosphamidon, nominally 90% active ingredient, was supplied by Ciba Company Limited of Dorval, Quebec. All concentrations in this report refer to the technical Phosphamidon.

Some continuous-flow tests were carried on as long as six weeks, when this proved necessary in order to follow the mortality within a group. Inspections for mortality followed a series of increasing logarithmic intervals of time. Fish were fed daily during these tests and excess food and debris was removed by siphoning. The control experiment suffered only 14% mortality during six weeks, indicating generally satisfactory conditions.

Static tests were carried out with 10 fish in 60 litres of solution in suitable rectangular tanks. There was no replacement of the solution during the two weeks which the tests ran. However, these and other tests were aerated with compressed air through porous diffusing-stones. Fish were not fed in the static tests. Control tests suffered only 10% mortality in two weeks.

To simulate exposure to a surge of Phosphamidon, such as might occur in streams during forest-spraying operations, groups of fish were exposed to various concentrations of the insecticide for one hour, then removed to clean flowing water in circumstances similar to the continuous-flow tests. These were called "dip tests".

In some of the static tests, Invadine was added to the stock solution in the ratio Invadine/Phosphamidon = 0.03 by weight. This proportion represents relative strengths if Phosphamidon were sprayed at 1/4 pound per 3/4 U.S. gallon per acre, and Invadine were added at 100 lbs. per 10,000 U.S. gallons of spray mixture. These were the specifications forecast for the 1965 operations. Other tests were carried out using Invadine by itself, under static conditions as described above. The material was "Invadine JFC 100" or "Single strength Invadine" also supplied by Ciba.

All tanks used in the static tests and dip tests were newly-lined with polyethylene sheeting before each test. Each continuous-flow test was done in a new polyethylene tank. Plastic tubing used to convey Phosphamidon solution was also renewed before each continuous-flow test, while glass parts of the system were thoroughly scrubbed.

TOXICITY OF INVADINE ALONE

The threshold for lethal action of Invadine alone was approximately 70 mg./l. of "Invadine JFC 100". A concentration of 100 mg./l. killed fish in 6 hours. A concentration of 75 mg/l. immovilized most of the fish in 10 or 12 hours, but only half of them died, in about 24 hours. The others recovered and apparently remained in good shape for the rest of the two-week test. Only minor disturbance and mortality was caused by 56 mg./l.

These concentrations are of course very much higher than those which would result in the stream from forest-spraying. Actually they are about four orders of magnitude higher. The toxicity of Invadine is approximately the same as common household detergents.

EFFECT OF INVADINE ON PHOSPHAMIDON TOXICITY

In the static tests with Phosphamidon, duplicate runs were made at each concentration, one with Invadine added and one without. There were differences in survival times between some of the paired tests, but these did not seem to be significant. Nor was there any consistent tendency for survival times to be longer for either of the conditions.

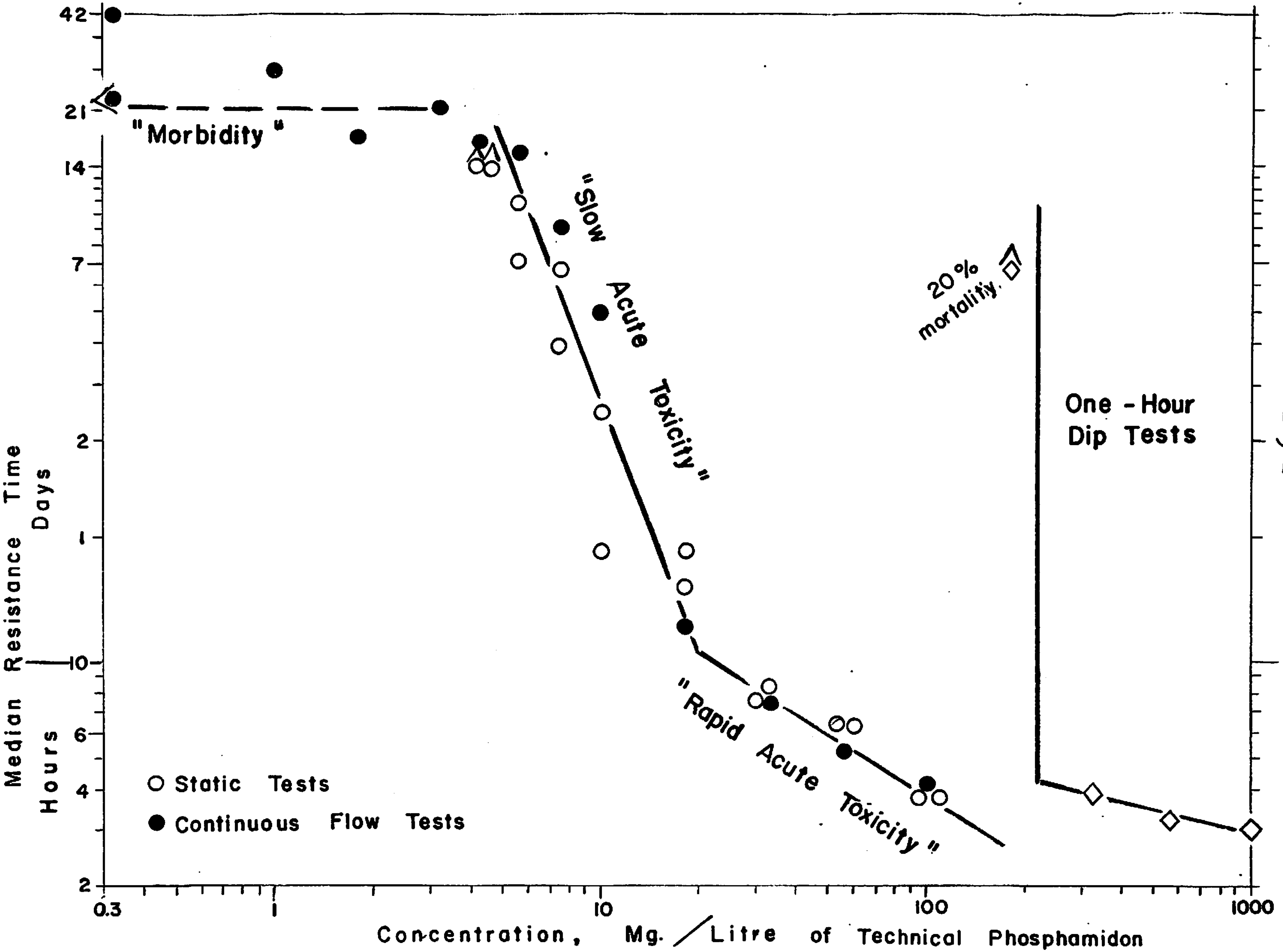
In other words, the addition of 3% Invadine to Phosphamidon did not appreciably change the toxicity of the insecticide to fish. Accordingly, no distinction has been made in the results. Static tests with and without Invadine have been indicated by the same symbol in the Figure which shows results.

TOXICITY ON CONTINUOUS EXPOSURE

All results are given in the Figure. It is immediately apparent that the static tests gave approximately the same resistance times as the continuous-flow tests, at least in tests lasting up to a week or ten days. The points in the Figure seem to be adequately described by three straight lines. There seems to be a linear relation for very high concentrations of 25 to 100 mg./l., and for convenience of designation this has been called "rapid acute toxicity".

At lower concentrations of 5 to 20 mg./l., there is again a more or less linear relation which must also be considered as acute toxicity. The significant point in this relationship is that there is no apparent threshold for lethal action. Although the static tests at 4.2 mg./l. did not have significant mortality, this was presumably the result of decreasing Phosphamidon concentration during the two-week test period because of decomposition or sorption. The continuous-flow test at 4.2 mg./l. would be more meaningful, and this caused 50% mortality in about 17 days.

The relationship between survival time and concentration for "slow acute toxicity" was interrupted by chronic toxicity or so-called "morbidity". This was a somewhat peculiar reaction in that survival time did not seem to be related to concentration. Some indication of morbidity at these concentrations was that fish did not eat except at the two lowest concentrations tested. Even in these tests, fish succumbed to chronic toxicity. All of the concentrations 0.1, 1.0, 1.8, and 3.2 mg./l. caused 90% or 100% mortality, with median survival-times from 2.5 to 4 weeks. The test at 0.32 mg./l. caused only 50% mortality, and this required 6 weeks exposure. There seemed to be a critical period for the action of chronic toxicity between 2 and 4 weeks, and the surviving fish in the test at 0.32 mg./l. seemed to recover their vitality after this period had passed.


42
21
14
7
2
1
10
6
4
2
Median Resistance Time
Days
Hours
"Morbidity"
"Slow Acute Toxicity"
"Rapid Acute Toxicity"
20% mortality.
One - Hour Dip Tests
○ Static Tests
● Continuous Flow Tests
0.3
1
10
100
1000
Concentration, Mg./Litre of Technical Phosphamidon

CONCLUSIONS

The practical significance of the long-term tests is probably small as regards forest-spraying operations. It is possible to visualize situations in which organophosphate insecticides would be carried into natural waters over periods of days or weeks, causing slow acute toxicity or morbidity of fish. However, in aerial forest spraying, we would expect that fish in streams would be exposed for only a few hours as this soluble insecticide washed downstream.

Therefore the results for the dip tests and the rapid acute toxicity are of most interest. These tests deal with concentrations in the range 20 to 200 mg./l., which are much higher than would be expected from forest spraying. Assuming an average stream depth of about one foot, and spraying at 1/4 lb. per acre, we might expect stream concentrations of the order of 0.1 mg./l. The safety factor for normal forest spraying operations would seem to be about 200.

The addition of Invadine to Phosphamidon spray does not affect its toxicity to fish. If absorption of the insecticide into trees is hastened, the stream pollution problem would tend to decrease.

These experiments also help in orienting future insecticide tests. When investigating toxicity to fish of water-soluble organophosphates similar to Phosphamidon, simple static tests would seem to give adequate results for routine studies lasting as long as a week. Such static tests are more easily accomplished because continuous-flow tests may lead to a problem of disposing of rather large quantities of waste-water.

Appendix XII

EFFECTS OF FOREST SPRAYING

on

NEW BRUNSWICK SALMON

by

J. R. MacDONALD

CANADA DEPARTMENT OF FISHERIES
FISH CULTURE DEVELOPMENT BRANCH

HALIFAX, N.S.

1965

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1965
82

EFFECTS OF FOREST SPRAYING
ON NEW BRUNSWICK SALMON

BY

J. R. MacDONALD

CANADA DEPARTMENT OF FISHERIES
FISH CULTURE DEVELOPMENT BRANCH
HALIFAX, N. S.
1965

CONTENTS

Effects of Forest Spraying on New Brunswick Salmon

INTRODUCTION

During the past 14 years aerial spraying of DDT has been extensively used in an attempt to control spruce budworm infestation in New Brunswick. In 1952, about 200,000 acres of forest land were sprayed, but since then the area sprayed has increased to between one-half and five million acres annually. The only exception was in 1959 when no aerial spraying was carried out due to a low incidence of infestation.

The initial concentration of DDT in 1952 was sprayed at the rate of one pound per acre. From 1953 to 1958 the rate of application was one-half pound per acre, and between 1960 and 1963 spraying was done at one-quarter pound per acre, with a second application of one-quarter pound in high hazard areas. In 1962 a new systemic insecticide, Phosphamidon, was sprayed experimentally on a 640-acre plot at the rate of one pound per acre. Use of Phosphamidon was extended to include 22,500 acres in 1963 at the rate of one-half pound per acre. In 1964 DDT was sprayed at one-half pound per acre and Phosphamidon was used extensively along salmon streams.

Bio-assays on trout and salmon juveniles have shown DDT to be toxic when concentrations were 0.32 ppm (Hatch, 1957 and Gagnon, 1958). The latter investigator showed younger salmon to be more susceptible to the insecticide than older salmon. Alderdice and Worthington (1959) showed DDT to be lethal to coho underyearlings at 0.05 ppm. Keenleyside (1958) found the 48 hour median tolerance limit of DDT to young salmon to be .047 ppm, and showed Malathion to be toxic to young salmon at 0.033 ppm.

In addition to the bio-assay technique, several field investigations, designed to assess the effects of DDT on fish life, have shown that this insecticide caused severe fish mortalities: Kerswill, 1955; Burden, 1956; Crouter and Vernon, 1959; Keenleyside, 1959; Warner et al., 1960; Graham, 1959. Cottam and Higgins (1946) stated that less than 0.2 pounds of DDT per acre should be used to avoid damage to fishes, and that DDT should not be applied directly, in any concentration, to streams.

Several other investigations have indicated that DDT adversely affects aquatic insects: Ide, 1956; Crouter and Vernon, 1959; Cope, 1961; Graham, 1959.

In 1963 the Department of Fisheries in British Columbia tested the effects of Phosphamidon sprayed at the rate of one pound per acre on a small coastal salmon stream. There was no effect on caged coho fry but caged caddis larvae died within 24 hours.

The assessment of damage to fish from forest spraying in New Brunswick was investigated by the Fisheries Research Board in 1954. It was found by quantitative sampling of native salmon from 1951 to 1963 that DDT sprayed at one-half pound per acre reduced fish of the year by about 90 percent, yearling salmon by about 70 percent and two-year old parr by about 50 percent. Areas sprayed with one-quarter pound per acre showed fish of the year reduction to be in the order of 50 percent over pre-spray levels. The older fish were affected to a much lesser degree. It was also shown that double applications of one-quarter pound DDT per acre caused as much damage to fish as the single application of one-half pound per acre (Anom. 1964).

Since 1960, the Fish Culture Development Branch of the Canada Department of Fisheries has monitored the effects of forest spraying by comparing the mortalities of caged salmon and trout of hatchery origin in sprayed and unsprayed areas. The results of these tests can be summarized as follows:

1. Severe mortality occurred to salmon and trout juveniles when exposed to applications of DDT at the rate of one-half pound per acre.
2. Application of DDT at the rate of one-quarter pound per acre reduced caged fish mortality by about one-half.
3. Double applications of one-quarter pound of DDT per acre caused mortalities similar to that observed in areas receiving a single one-half pound per acre application.

4. Mortalities in caged juvenile salmon held in areas sprayed with Phosphamidon were similar to those found in unsprayed areas.
5. In areas sprayed with Phosphamidon, but receiving water from tributary streams sprayed with DDT, mortalities were moderate to high apparently reflecting the amount of DDT reaching the lower areas.

In 1965 approximately two million acres of New Brunswick forest land were sprayed with insecticides in an attempt to control spruce budworm infestation. An area of 1.7 million acres was sprayed with DDT at the rate of one-quarter pound per acre. 0.94 million of these acres received a second application of one quarter pound DDT per acre. In the operations area forest lands adjacent to streams or lakes were sprayed with Phosphamidon. These buffer zones, approximately one thousand feet wide, were on each side of streams or around lakes which could be seen from the air. A total of 370 miles on the Miramichi River system, 120 miles of the Nashwaak River and 32 miles on the Keswick River were sprayed with Phosphamidon in this manner.

A Phosphamidon experimental area, 0.2 million acres in extent, was sprayed in the Cains River watershed. Various Phosphamidon concentrations and different rates of application were tested. The penetrating agent Invadine JFC was combined with Phosphamidon in many of the tests.

A third general spray area consisted of approximately 72,000 acres in the Salmon River-Chipman area, where Malathion was subjected to operational trials. Several other insecticides were also tested here. The spray areas described above are shown in Fig. 1.

The forest area to the west and southwest of the South Esk Fish Culture Station was sprayed partly with Phosphamidon and partly with DDT. The forest area immediately adjacent to the station and to the hatchery water supply brook system was not sprayed. Figure 2 shows the spraying schedule followed in this area.

This report gives the results of studies conducted by the Fish Culture Development Branch in 1965. Caged fish tests were used to show the comparative effects of various insecticides and dosages on juvenile hatchery salmon; pre spray-post spray salmon parr population density changes were studied in Phosphamidon strip sprayed streams and DDT sprayed streams; an assessment was made of juvenile salmon populations two months after spraying; physical condition of surviving fish was studied as a background for a continuing fall survival study; spray sensitized cards were used to monitor DDT spray deposition near Phosphamidon protected streams.

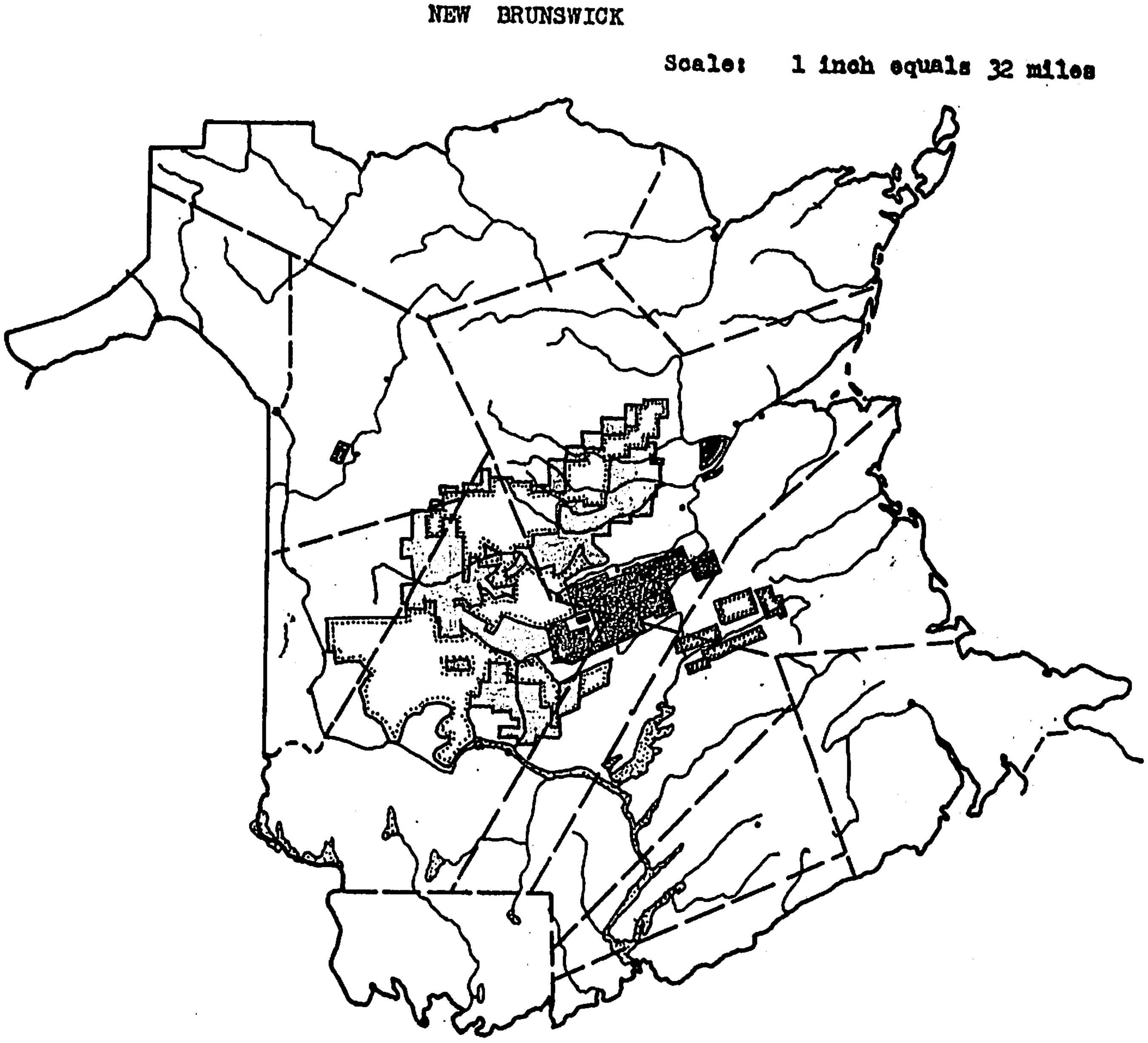


Figure 1 Forest Spraying in New Brunswick 1965

Legend

DDT sprayed twice @ ¼ lb/acre - ▒
DDT sprayed once @ ½ lb/acre - ▨
Phosphamidon Experimental Area - ■
Malathion - ▤

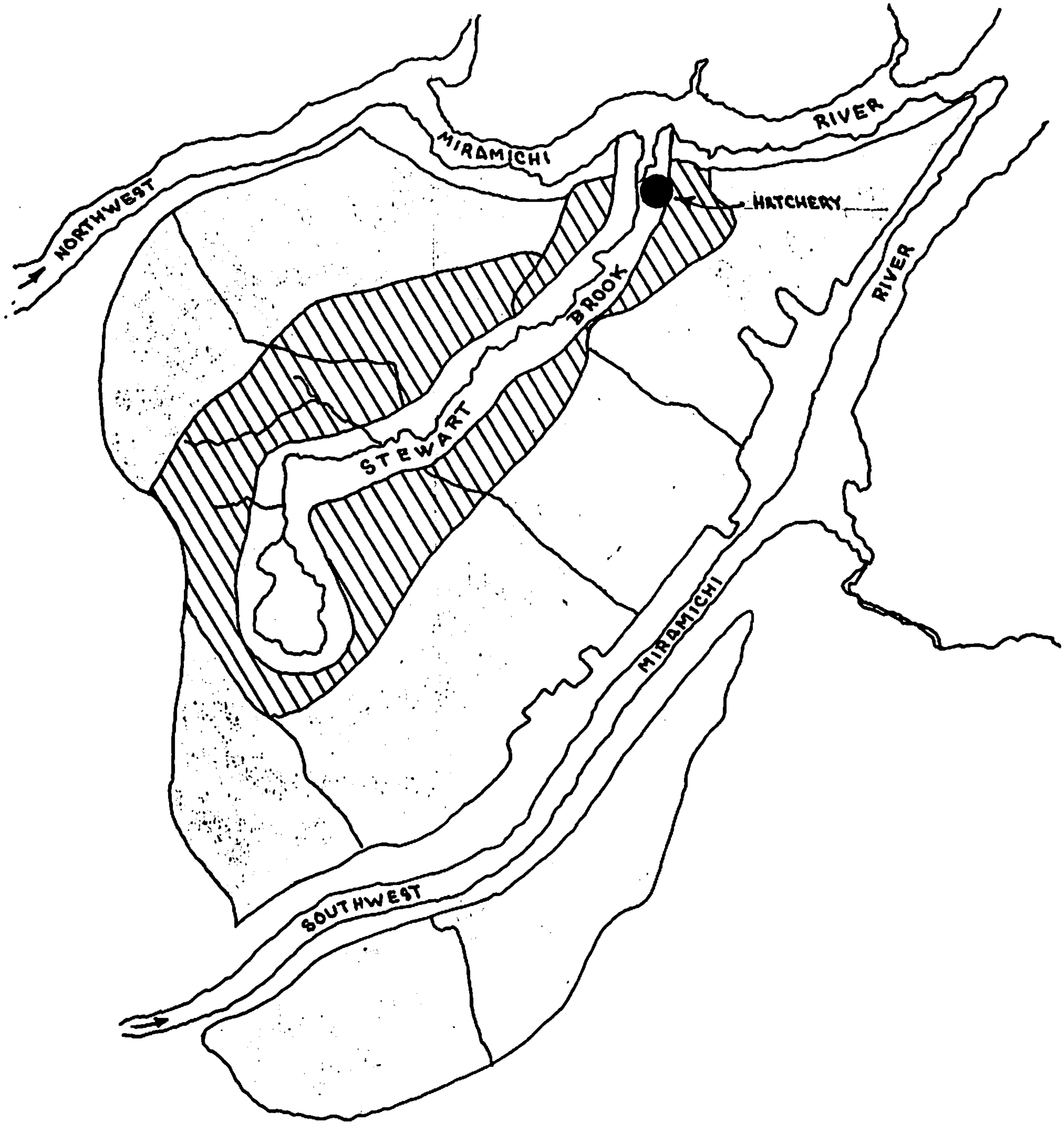


Figure 2 Spray plan of forest lands near South Esk Fish Culture Station. Shaded area was sprayed once with DDT at ½ pound per acre. Cross-hatched area was sprayed with Phosphamidon. The remaining areas were not sprayed.

METHODS

Caged Fish Studies

Salmon yearlings of hatchery origin were held in live-cars at stations in spray area streams and in unsprayed control streams. Two or three live-cars, 36" x 15" x 15", were held at each station, and twenty-five 3" hatchery parr were placed in each cage at least one week prior to spraying. Daily inspections were made at each station to the tenth day following spraying and records were kept of fish mortality, maximum-minimum water temperatures and water levels. Salmon fry were used as the test organism at one station in the Phosphamidon spray area. Test stations were as follows:

1. Stewart Brook - sprayed twice with DDT at the rate of one-quarter pound per acre with no Phosphamidon buffer zone protection.
2. Taxis River - four stations positioned along the length of the river and protected by Phosphamidon buffer zones except for the head waters and smaller tributaries.
3. Trout Brook - an unsprayed control for the above listed stations.
4. Cains River, North Branch - sprayed once with Phosphamidon, one-quarter pound per acre.

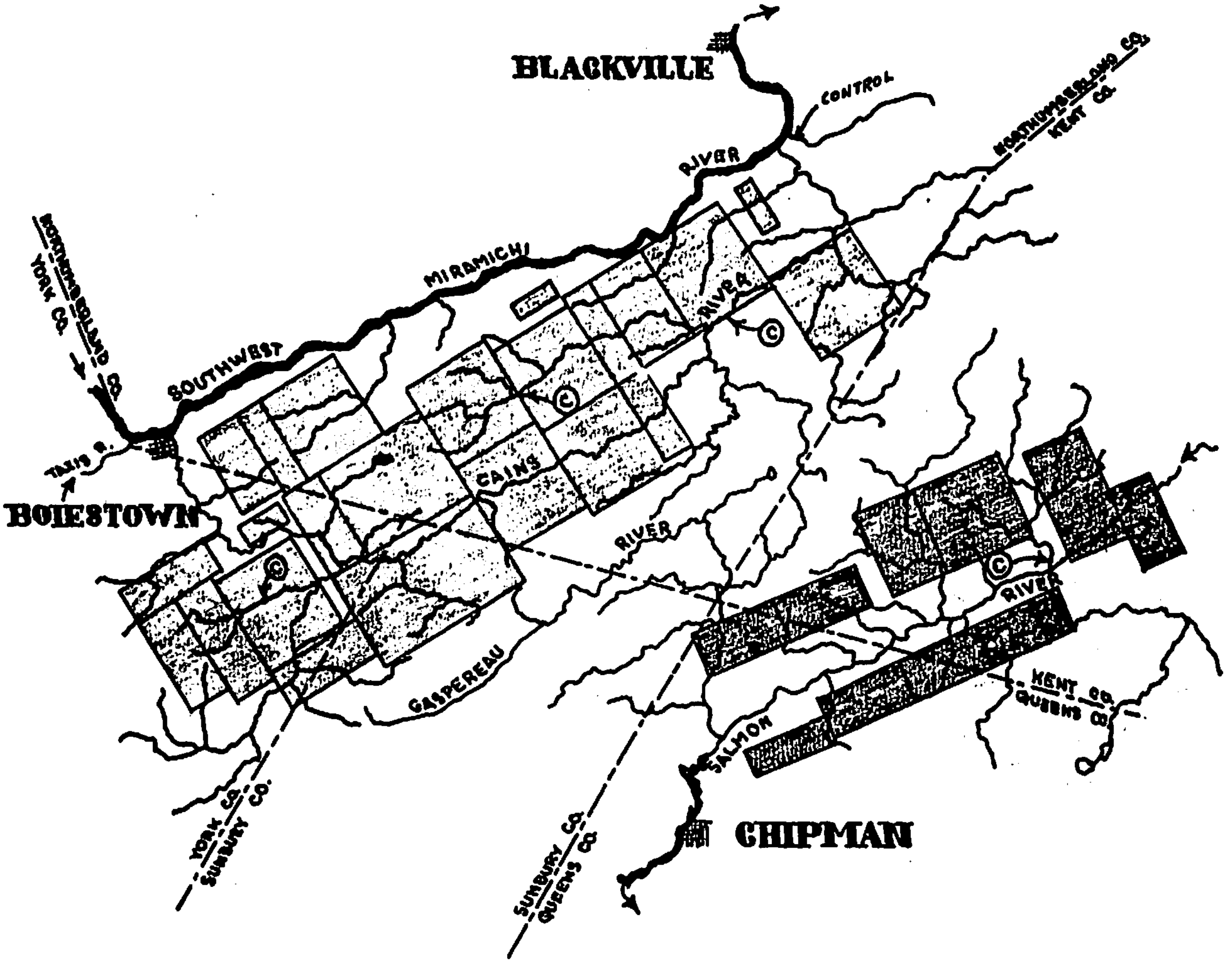


Figure 3 Phosphamidon experimental spray area at Cains River, shaded light; Malathion spray area at Salmon River, dark shading.
Caged fish are indicated as ©→

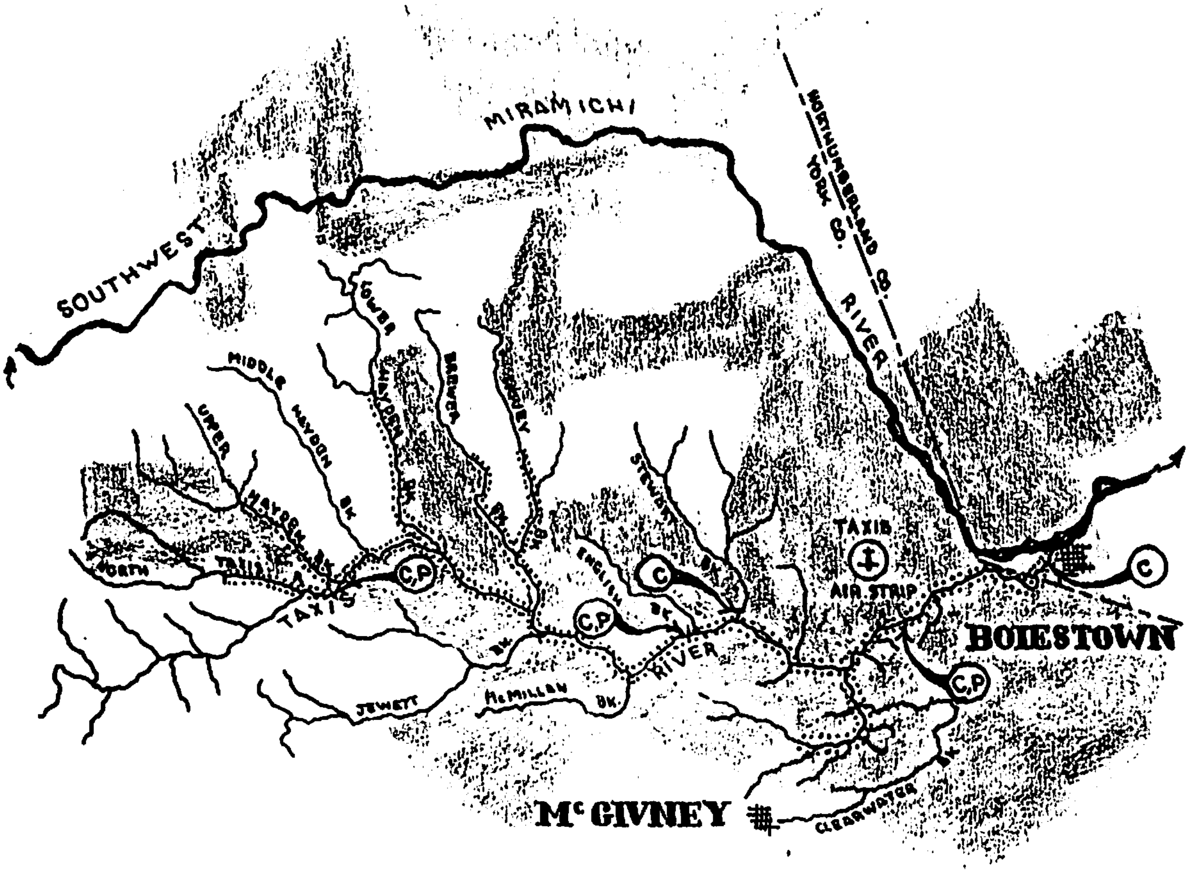


Figure 4 Taxis River watershed showing areas sprayed twice with DDT at one-quarter pound per acre, shaded; riverside Phosphamidon spraying indicated by dotted lines; unshaded areas of the watershed were sprayed once with DDT at one-quarter pound per acre. Caged fish stations indicated ©→
Population study areas indicated Ⓟ↗

5. Muzeroll Brook, a Cains River tributary- sprayed twice with Phosphamidon at one-quarter pound per acre.
6. Cains River at Shinnikburn - a general test of the Cains system, located at the downstream boundary of the Phosphamidon experimental spray area and, therefore, receiving drainage from various concentrations of Phosphamidon.
7. Black Brook - unsprayed control for the Cains River stations.
8. Little Forks Brook - below area sprayed with Malathion at one-quarter pound per acre.

The locations of the stations are shown in Figures 3 and 4.

Pre-spray - Post-spray Population Studies

Population studies were conducted in spray area streams to assess effects of spraying on salmon parr. Two stations were on streams which had Phosphamidon buffer zone protection, and two were on streams receiving no Phosphamidon protection.

At each station 1,000 feet of stream was electroseined once, one week before the area was sprayed. No barrier nets were used to enclose the area. All salmon parr were counted, marked with the removal of one-half of the left pelvic fin, and released to the section of the stream from which they had been seined. One week after spray the same area was electro-fished once more. Marked and unmarked parr were counted, and a second mark applied by removal of one-half of the dorsal fin, and all were released into the immediate area from which they had been seined. Data from the second seining allowed for the calculation of pre-spray parr populations. A third seining was made within a few days and all marked recaptures were recorded. The third seining provided for calculation of post-spray parr populations and for a second calculation of the pre-spray parr populations. Calculations of population estimates were by the Petersen mark recapture method as described by Lagler (1956). The two areas which received Phosphamidon protection were McBean Brook and Porter Brook. The unprotected areas were Stewart Brook and Big Hole Brook.

Assessment of Juvenile Salmon Populations

In addition to the study of population change described above, an assessment of juvenile salmon populations was carried out two months after spraying. Fourteen stations were sampled two of which were at unsprayed control streams, the Sevogle and Little Southwest Miramichi Rivers. Three stations were sampled at the Cains River which had been sprayed with Phosphamidon.

Three stations were located on each of the Dungarvon, Taxis and Southwest Miramichi Rivers. These latter three rivers were protected by Phosphamidon buffer zones. All sampling stations were of a similar physical character and were considered as being representative of good salmon rearing area. Fine mesh barrier nets were erected to enclose approximately five hundred square yards of stream. The enclosed area was electro-fished five times in succession. After each seining, the numbers, size and species of all fish were recorded. No fish were returned to the area, so with each successive sweep the number of fish caught became smaller. A regression of catch per unit effort was thereby obtained. A projection of this regression by the method of Delury (1951) yielded an estimate of fish in the area.

Spray Card Monitoring of DDT Deposition Near Streams

Eight lines of spray-sensitized cards were laid out in an effort to determine how well DDT spray was kept away from Phosphamidon protected streams. Spray card lines extended one thousand feet perpendicular to the water course and cards were laid at 100 foot intervals. Five card lines were located at the Taxis River, one at McKenzie Brook, one at Burnthill on the Southwest Miramichi and one at McBean Brook.

RESULTS

Caged Fish Studies

Percent mortality was based on mortalities occurring during a period extending from the first spraying in the area of the test station to the tenth day after the last spraying in that area. Although all caged fish results are based on a similar period of time, tests did not necessarily run simultaneously, but rather were dependent on spray dates of the areas where caged tests were being conducted. Table 1 summarizes the data obtained from various spray treatment areas and the control.

Data in Table 1 indicate that the use of Phosphamidon at concentrations up to one-half pound per acre did not cause significant mortality to caged salmon parr. The use of the penetrant Invadine did not significantly alter the effects of Phosphamidon in these tests. These data agree with results of studies conducted in 1963 and 1964. Salmon fry also appear to have suffered no immediate mortality under the conditions tested.

	Salmon Parr				Salmon Fry
	Cage No.				
Phosphamidon only	(1)	(2)	(3)	Mean	
Black Brook - unsprayed control	13	9	12	11	0.5
Muzeroll Brook - Phosphamidon 1 x 1/4 lb./acre					1.8
Muzeroll Brook - Phosphamidon 2 x 1/4 lb./acre	0	4	8	4	
Cains River, N.Branch - " 1 x 1/4 lb./acre	8	4	*	6	
Cains River Shinnikburn - general Phosphamidon test	18	17	*	17	
	Mean of all sprayed Parr tests			8.4%	
Phosphamidon Safety Zone					
Trout Brook - unsprayed control	16	+	+	16	
Taxis River, Boiestown Phos.zones + DDT twice	25	21	*	23	
" " , Mile 4 " " + " "	50	47	44	47	
" " , Red Bridge " " + " "	43	79	28	50	
" " , Maple Grove " " DDT once	33	33	34	33	
	Mean of all sprayed Parr tests			40.6%	
DDT Only					
Stewart Brook DDT twice 1/4 lb./acre	100	100	*	100	
Malathion					
Little Forks Brook Malathion 1/4 lb/acre few miles upstream	27	31	31	30	

Table 1 Percent mortality of caged salmon parr and fry, to the tenth day after spraying with Phosphamidon only, Phosphamidon safety zones, DDT only, Malathion, and unsprayed controls.

* only two cages used   + only one cage used

Table 1 also indicates the effectiveness of the Phosphamidon buffer zone spraying technique on the Taxis River. At the Boiestown station results showed parr mortality to be only slightly higher than at unsprayed control. The stations at Mile 4 and Red Bridge showed approximately 50 percent mortality to caged parr after two DDT sprayings over adjacent forests. At the Mile 4 station the caged parr mortality may have been influenced by extremely high, but not lethal, water temperatures during the fourth week of June. Mortality was 20 percent before high water temperatures occurred. The 50 percent mortality at Red Bridge station occurred following DDT spray dates and preceding dates of high water temperature. The 33 percent parr mortality at Maple Grove, where water temperatures remained moderate, probably reflects the proximity of single DDT spraying over unprotected headwater tributaries. At Stewart Brook, following double DDT spraying with no Phosphamidon protection, 100 percent parr mortality occurred.

The Little Forks Brook test, 30 percent parr mortality, is not considered a complete test of the lethal effects of Malathion on caged salmon parr due to the fact that Malathion was not sprayed over the test station area but rather some miles upstream. Dilution of the Malathion concentration in the stream would be expected over a long distance.

Malathion had been shown by Keenleyside (1958) to be one and one-half times as toxic to young salmon as DDT.

The caged fish test data of Table 1 show decreasing incidence of short-term parr mortality, from double DDT, to the safety zone protection spraying technique, to the relatively harmless Phosphamidon, with the mortality rate being apparently dependent on the amount of DDT to which the fish were exposed. The current Phosphamidon safety zone spraying technique results in varying degrees of hazard to fish but comparatively there is a much reduced short-term mortality than that resulting from direct DDT spraying. The variations in the Taxis River results indicate that Phosphamidon safety zone protection can greatly reduce short-term parr mortalities. In some parts of the river, however, it appears that there was insufficient control over DDT spray deposition to gain maximum benefit from this spraying technique.

Pre-spray - Post-spray Population Studies

Two sets of pre-spray population estimates were calculated as described in the methods, one from the mark recaptures of the first post-spray sampling and one from the mark recaptures of the second post-spray sampling. The mean of these two was used to compare with the post-spray densities.

The population change, therefore, can be expressed as a percentage increase or decrease of the pre-spray parr density. The following are the parr population densities in numbers of fish per 100 yards^2:

Station	Spray Type	Pre-spray Estimates 1	2	Mean	Post-spray Estimate	% Change
Porter Bk.	Phos.prot.	9.7	13.2	11.4	10.4	-9
Stewart Bk.	DDT	13.1	14.6	13.9	11.9	-14
McBean Bk.	Phos.prot.	10.0	9.8	9.9	10.8	+9
Big Hole Bk.	DDT	36.2	39.0	37.6	26.9	-28

Examination of these data reveals an increase in the pre-spray population estimates generally, from the first estimate to the second. Such an increase in population estimates could have been caused by either a disproportionately greater mortality to fin-clipped parr over unmarked parr, or by recruitment of new fish to the area during the sampling period. Recruitment to study areas was suspect prior to conducting the sampling and for this reason a barrier net was erected on Stewart Brook below the sampling area to prevent any parr migration during hot weather from the warm river water to the cooler brook water. At Porter Brook a low falls was expected to stop any river-to-brook parr movement. Both of these stations were located within a few hundred feet of main rivers. At Porter Brook it was found that small fish (trout) had moved in from the river over the falls, while at Stewart Brook the barrier net was washed out once. Recruitment may have occurred at the other stations but it seems less likely, although the Big Hole Brook (1.5 miles from the main river) data suggest an increase in the unmarked parr population of the area as indicated by comparing the two pre-spray estimates. McBean Brook station was three miles from the main river. If recruitment did occur, estimates of the post-spray populations are too high.

These data show the populations of the two stations adjacent to main rivers to have decreased slightly, with the DDT-sprayed Stewart Brook showing the greater decrease of the two. At McBean Brook a slight population increase was observed. The Big Hole Brook parr populations show a 28 percent reduction. Most of the Big Hole Brook watershed was sprayed with DDT once, and in part twice at the rate of one-quarter pound per acre per application. The mean decrease in parr populations at the two DDT-sprayed streams is 21 percent in the few days immediately after spraying while the average population change of Phosphamidon protected streams is zero.

Population Assessment of Juvenile Salmon August 1965

In addition to assessment of immediate mortality as discussed in the preceding section, longer term effects were evaluated by population studies conducted during August. Salmon parr and fry populations, expressed as numbers of fish per 100 square yards of stream bottom, are presented in Table 11. Populations of fry and parr at the Cains River stations were good, indicating a rehabilitation of salmon stocks in a stream where juvenile salmon populations had been depleted following the 1962 DDT spraying. Little DDT has been sprayed on the Cains River since 1962.

In the three rivers where Phosphamidon safety zone spraying was done, the parr populations in August were found to be, on the average, less than one-half of the average control population. Five of the stations show fair parr populations while four stations have poor parr stocks. Post-spray parr survival in 1965 is generally better than that of earlier spray years, but some stations do not reflect this improvement. Similarly, fry survival in protected rivers generally shows an improvement over post-spray survival of the 1950's. Here again the data show areas of low fry survival suggesting DDT contamination of some protected streams.

Spray Card Monitoring of DDT in Phosphamidon Zones Near Streams

All but one of the eight spray card lines showed that DDT was kept at least 1,000 feet from Phosphamidon sprayed streams. At one point on the Taxis River, DDT spray

Station		Fry	Mean	Small Parr	Mean	Large Parr	Mean
Sevogle River	Unsprayed Control	138		38		10	
Little S.W. Miramichi	" "	71		8		7	
			104		23		9
Taxis River, Maple Grove	Phosphamidon Protection	113		3		2	
" " , Red Bridge	" "	20		12		6	
" " , Mile 4	" "	4		9		4	
			46		8		4
S.W. Miramichi, Grey Lodge	" "	5		18		4	
" " " , Ansel Bk.	" "	8		2		2	
" " " , Duff Pond	" "	38		13		5	
			17		11		4
Dungarvon R., Pineville	" "	17		3		3	
" " , Salmon Hole	" "	57		16		3	
" " , Ledgy Landing	" "	4		4		4	
			26		8		3
Cains R., Six Mile	Phosphamidon	70		28		17	
" " , Bantalor Rd.	"	18		3		16	
" " , Ferguson, Below	Phosphamidon	38		11		12	
			42		14		15

Table II Population densities of juvenile salmon on August 1965, given as numbers of fish per 100 square yards of test area.

fell with 300 feet of the river. Although other data in this report suggest that some DDT did reach protected streams, it appears feasible to minimize the overlap of DDT spraying on areas receiving Phosphamidon strip spray zones. Two of the card lines were in TBM sprayed areas at upper McKenzie Brook and Miramichi River at Burnthill, while the other lines were in Stearman area at Taxis River and McBean Brook.

DISCUSSION

The 1965 studies indicate that short-term mortality of young salmon was considerably lower in streams receiving Phosphamidon protection than in streams sprayed directly with DDT. The spraying of forest lands adjacent to the water supply brook at the South Esk Fish Culture Station, where no significant post-spray fish mortality occurred, shows that it is possible to avoid killing fish while spraying forests. The numbers of salmon fry found at some of the operational spray area streams in August also suggest adequate protection. However, despite the Phosphamidon protection, very low post-spray fry populations at other sampling stations are indicative of significant DDT contamination in these areas.

A review of these data suggests that whereas the current spraying technique can greatly reduce the hazard of insecticide spraying to fish, in some instances these benefits are being obscured by DDT contamination.

The juvenile salmon population data collected in 1965 suggest a low survival of 1964 one-year-old parr. These fish would normally be represented as two-year-old parr in the 1965 sampling. At three sampling stations on the Taxis River in 1964, there was an estimated mean density of 37 one-year parr per 100 square yards. The same three stations in 1965 had a mean of 4, two-year-old parr per 100 square yards, representing a survival of 11 percent. The normal expected survival of small parr to large parr is 60 percent, Elson (1962). The one-year-old parr found in 1964 were very thin at sampling time. The 1964 population of parr was exposed to DDT despite Phosphamidon protection, as was evidenced by the low fry survival at these stations in 1964. The exposure of this parr population to DDT preceded an extensive parr mortality observed in October and November of 1964. Large numbers of dead salmon parr were observed on the Taxis and S.W. Miramichi Rivers. A survey of 1964 spray area streams revealed dead and dying parr in every stream examined. No dead parr could be located despite intensive searching in an unsprayed stream. Samples of dead and live parr were collected from these streams and were weighed and measured. Body condition, a function of length and weight, of spray area streams was significantly lower than the condition of live fish taken from an unsprayed stream. Frozen samples of these parr were sent to Saint Dunstan University, Charlottetown, where chromatographic analysis for DDT or metabolites was done on several fish. Seventeen spray area fish yielded the following average contents in parts per million. Results of three control fish from an unsprayed stream are in brackets: ppDDT 2.5 (.03); opDDT 1.1 (0.0); DDE 15.3 (0.2); DDD 1.4 (0.02).

Body condition coefficients were determined for several hundred spray area and control fish in 1965 and delayed mortality studies are currently being conducted on the Miramichi River to study extent of mortality of fish which were exposed to various spray conditions. The particular hazard to fish, delayed mortality, appears to be serious and must be considered in the light of future forest sprayings.

A comparison of the post-spray data on stocks of juvenile salmon show that in the operational spray area parr were generally less than one-half as numerous as in the unsprayed control stations or at the Phosphamidon sprayed Cains River stations. The mean salmon fry population of the operational area stations was fairly high though much lower than at the control stations or the Cains River.

At four of the nine operational area stations, however, post-spray fry survival was extremely low. The Sevogle and Little S.W. Miramichi Rivers, where the sampling areas have not been sprayed for several years, appear to be regaining natural levels of salmon productivity. Similarly, the Cains River, which has had very little DDT spraying since 1962, appears to have almost normal salmon stocks. The Cains River watershed in 1962 was sprayed with DDT; caged parr were all dead following the first application. In 1965, Phosphamidon spraying of the Cains system resulted in insignificant caged parr mortality.

Aerial spraying of insecticides in New Brunswick continues to deplete stocks of young salmon, but data indicate that the reduction was less severe in 1965 than in preceding years. The stocks of young salmon in spray area streams, if not further depleted by delayed mortality, show about one-half potential production as compared to streams unsprayed with DDT.

Reduction of salmon stocks can be minimized, in the event of future spraying, by the extended use of Phosphamidon to more salmon-bearing waters and by exercising greater control over the deposition of DDT adjacent to safety zones.

Literature Cited

Alderdice, D.F. and M.E. Worthington. 1953. Toxicity of a DDT Forest Spray to Young Salmon. Can. Fish Cult., 24: 41-48.

Anon., 1964. Investigation and Management of Atlantic Salmon and Trout. The Research Program. Trade News. July 1964: 4-11.

Burden, E.H. 1956. A Case of DDT Poisoning in Fish. Nature, 178 (4532): 546-547.

Cope, O.B. 1961. Effects of DDT Spraying for Spruce Budworm on Fish in the Yellowstone System. Trans. Amer. Fish. Soc., 90 (3): 239-251.

Cottam, C. and E. Higgins, 1946. DDT and Its Effect on Fish and Wildlife. Jour. Econ. Ent. 39 (1): 44-52.

Crouter, R.A. and Vernon, E.H. 1959. Effects of Black-Headed Budworm Control on Salmon and Trout in British Columbia. Can. Fish. Cult., 24: 23-40.

Delury, D.B. 1951. On the Planning of Experiments for the Estimations of Fish Populations. Jour. Fish. Res. Bd. Can., 8 (4): 281-307.

Elson, P.F. 1962. Atlantic Salmon Can be Maintained in Maritime Waters. Atlantic Salmon Journal. 1962. (2): 16-18.

Gagnon, Andre. 1958. La Toxicite du DDT Pour Le Saumon de L'Atlantique et Les Alevins De Truite. Can. Jour. of Zool., 36 (4): 479-487.

Graham, R.J. 1959. Effects of Forest Insect Spraying on Trout and Aquatic Insects in Some Montana Streams. Trans. Second Seminar Biol. Problems Water Pollut. Robert A. Taft Sanit. Engin. Centre, Tech. Rept., W60-3: 62-65.

Hatch, R.W. 1957. Relative Sensitivity of Salmonids to DDT. Prog. Fish Cult., 19 (2): 89-91.

Ide, F.P. 1956. Effect of Forest Spraying with DDT on Aquatic Insects of Salmon Streams. Trans. Amer. Fish Soc., 86: 208-219.

Keenleyside, M.H.A. 1958. Comparative Effects of the Insecticides DDT and Malathion on Young Atlantic Salmon. Fish. Res. Bd. Can. Prog. Rep. 69: 1958.

Keenleyside, M.H.A. 1959. Effects of Spruce Budworm Control on Salmon and Other Fishes in New Brunswick. Can. Fish Cult., 24: 17-22.

Kerswill, C.J. and P.F. Elson. 1955. Preliminary Observations on Effects of 1954 DDT Spraying on Miramichi Salmon Stocks. Fish. Res. Bd. Can. Atlantic Prog. Rep. No. 62, 17-23.

Lagler, K.F. 1956. Freshwater Fishery Biology. 2nd Ed. Wm. C. Brown Co., Dubuque, Iowa. 167-177.

MacDonald, J.R. and H.E. Edwards. 1962. Effects of DDT and Phosphamidon on Caged Salmonid Fish. Unpublished Report, Can. Dept. Fish., Halifax, 16 pp.

MacDonald, J.R. and R.W. Dunfield. 1963. Effects of Forest Spraying on Salmonids. Unpublished Report, Can. Dept. Fish., Halifax, 9 pp.

MacDonald, J.R. 1964. Effects of Forest Spraying on New Brunswick Salmon. Unpublished Report, Can. Dept. Fish., Halifax, 12 pp.

Warner, K. and D. C. Fenderson. 1960. Effects of DDT Spraying for Forest Insects on Maine Trout Streams. Jour. Wildlife Management, 26 (1): 86-93.

An Interim Report on the use of a fluorometric technique for the purpose of determining the concentration and duration of exposure of fish to an insecticide (Dimethoate) in small coho salmon streams in British Columbia.

An experimental spraying to determine the suitability of Dimethoate for controlling an outbreak of hemlock needle miner was undertaken in the Holberg area on August 18, 1965, in co-operation with Mr. H.A. Richmond, consulting entomologist for the B.C. Loggers Association. In addition to the evaluation of Dimethoate as an insect controlling agent, an evaluation was made of the hazards to fish imposed by its use. This was accomplished by directly treating a half mile section of the Goodspeed River (discharge <5 cfs) with Dimethoate to which Rhodamine dye had been added.

Liveboxes and aquaria containing 20 and 10 coho salmon fry respectively were placed at four equidistant points in the treated area and in an unsprayed control area two days before the application of the spray.

The spray solution was mixed one half-hour before application on August 18 in the following proportions:

4½ gallons of Cygon 4E (4 lbs active/USG)
31½ gallons of water
70 grams of Rhodamine Red B 500

The helicopter was calibrated to deliver one U.S. gallon of mix per acre (equivalent to ½ lb Dimethoate/acre). Because of the width of the river (150') in portions of the selected area, the helicopter pilot was instructed to deliver two swaths of insecticide along the riverbed with a minimum of overlapping. It was felt this would provide a more uniform spray deposition simulating actual spray conditions more closely than would a single swatch on the riverbed which would miss the margins of the river in the wide areas or possibly miss the river altogether in manoeuvering around sharp bends. It was calculated that a deposition of 1½ to 2 grams of dye per acre would be necessary to obtain significant readings of fluorescence from river water samples which would be passed through the Turner Model III Fluorometer.

Prior to spraying the river, it was found that the continuous flow door for the fluorometer was not operating properly and that a continuous sampling of the river water throughout the period of exposure could not be obtained. It was then necessary to use the standard door and to obtain grab samples of the river water for analysis. Samples were obtained at the downstream boundary of the experimental area on the assumption that concentrations would be greatest at that point over the longest period of time. Approximately five hours after spray deposition fluorometer readings dropped to approximately 1, the point arbitrarily selected as the point at which readings become insignificant. At that time a series of grab samples was obtained from various points in the spray area and these indicated that there would not be a return to higher readings at the downstream sample site. It was concluded that only trace amounts of the insecticide remained and that continued sampling would not be necessary. In addition to the fluorometer readings obtained at the downstream boundary, readings were obtained from each aquarium to demonstrate the variations of spray deposition within the spray area.

In order to determine the concentration of dye represented by each division on the fluorometer scale, standards of river water with Rhodamine, and, Rhodamine with river water and with Dimethoate were made in the laboratory upon returning to Vancouver. In future the preparation of standards will be conducted in the field. In this case it was necessary to prepare standards in the laboratory because the analytical balance necessary for preparation of standards was broken in transit. The possibility of fluorescence interference by the Dimethoate necessitated the preparation of standards using Rhodamine, Dimethoate and water. It was established that Dimethoate did not interfere with the fluorescence of Rhodamine under simulated field conditions nor did it cause a difference in readings of standards left standing for five days. Standards of 10 ppb and 5 ppb Rhodamine of each solution were made. Readings of 36 and 35.5 for 10 ppb solution of water and water-Dimethoate respectively and 17.0 and 17.5 for 5 ppb of water and water-Dimethoate respectively were obtained at a temperature of 20°C. On this basis each ppb of Rhodamine represented 3.6 fluorometer divisions. Raising the temperature one degree centrigrade reduced the fluorometer reading by approximately 2.5 percent.

The concentration of Dimethoate in each sample was determined by multiplying the Dimethoate to dye ratio (117:1) in the mix by the concentration of dye measured by the fluorometer. The fluorometer readings, temperature, temperature corrections, calculated concentration of dye and calculated concentration of Dimethoate are presented in the appended Table.

The caged fish were released after a 72-hour exposure during which time only three deaths occurred which could in all probability be attributed to delayed handling mortality. One mortality occurred in livebox #3, 200 yds upstream from the downstream spray boundary and two mortalities occurred in Aquarium #4 at the downstream spray boundary. Juvenile trout indigenous to the stream did not show any adverse effects although a heavy feeding on Dimethoate-killed insects did take place.

The results of this experiment suggest that the hazards would be minimal to coho salmon and trout in small streams traversing an area treated with Dimethoate at $\frac{1}{2}$ lb per acre. Lower concentrations of the insecticide and therefore a greater margin of safety would be available in larger rivers with greater flows than are typical of small coho-producing streams. Although this finding is useful it is considered that it is incomplete unless accompanied by the relationship between the field dosage of Dimethoate and dosages which would be acutely toxic to fish. It is therefore intended to carry out a bioassay this fall.

In the author's estimation the fluorometric technique of insecticide concentration determination is very superior to methods formerly used and supplies the deficiencies of interpretation which have been encountered in the past when insecticide dosages have been expressed in terms of pounds per acre. The fluorometric technique allows dosages to be expressed in terms of concentration of toxin and exposure time. It is simple, accurate and certainly much cheaper than chemical analysis of samples. It may be used in conjunction with bioassays (based on 100 percent survival or threshold concentrations) to assess the safe dosage which could be permitted to exist in small open streams traversing a spray area. Because the instrument is portable the method could be used for spot checking to see whether prescribed limits of insecticide concentration were being met in the course of a control program.

TABLE 1. Fluorometer readings, temperature correction, calculated dye concentration and calculated Dimethoate concentration for the duration of the experiment.

Aug.18/65	A Fluorometer Reading	B Temp.	C Reading Corrected to 20°C	D (C/3.6) ppb dye	E (D x 117) ppb Dimethoate
1150 hrs	spray applied				
1223	5.25	20°C	5.25	1.45	170
1234	5.50	20°C	5.50	1.53	179
1248	5.80	20°C	5.80	1.61	188
1300	5.00	21°C	5.10	1.42	166
1310	5.00	21°C	5.10	1.42	166
1323	4.3	21°C	4.4	1.22	143
1335	3.8	21°C	3.9	1.08	126
1345	3.3	21°C	3.4	.94	110
1400	3.3	22°C	3.5	.97	113
1410	3.6	22°C	3.8	1.06	124
1420	3.2	22°C	3.4	.94	110
1435	2.4	22°C	2.5	.69	81
1445	2.2	22°C	2.3	.64	75
1615	1.1	23°C	1.2	.33	37
1625	1.5	23°C	1.6	.44	51
1638	1.2	23°C	1.3	.36	42
1718	1.4	23°C	1.5	.42	49
Aug.19/65					
0820	.5	18°C	.25	.07	8.2
1500	Zero	18°C	Zero	Zero	Zero
Aquarium 1	19.5	18°C	18.5	5.14	601
Aquarium 2	11.7	18°C	11.1	3.08	360
Aquarium 3	3.2	18°C	3.0	.83	97
Aquarium 4	10.3	18°C	9.8	2.72	318
Control	Zero	18°C	Zero	Zero	Zero

APPENDIX XIV

A report on the relative toxicity to juvenile coho salmon of herbicides used in British Columbia

The utilization of herbicides to accelerate portions of the chain secondary succession taking place in logged off areas is receiving increasing recognition as a forest management technique. A dense growth of alder, for example, can retard the development of the conifers underneath by as much as 40-50 years and occasionally as much as a full cutting cycle. The application of herbicides to kill the alder at a time when the coniferous growth is sufficiently advanced to prevent the re-establishment of the alder can greatly reduce the setback suffered by valuable coniferous species.

The greatest proportion of the herbicides used for the purpose of forest management has been applied in river valleys and low damp areas where broad leaf growth flourishes. These points of application are often in close proximity to salmon streams. In reviewing the literature on the toxicity of 2,4-D and 2,4,5-T it was noted that the toxicity of esters commonly in use varied very substantially. This data indicated that the use of certain esters could result in the delivery of lethal concentrations of the herbicide into streams and shallow bodies of water inhabited by salmon, but with others it would be unlikely, if not impossible, to deposit concentrations which would kill fish at the rates of application needed to control deciduous growth. For some of the preparations which had been used in British Columbia, there was no reference to their toxicity to fish. To remedy this deficiency and to provide a guide to applicators where an element of choice should be exercised in selecting a herbicide for use in areas of high hazard to fish, bioassays were conducted. Juvenile coho salmon were used as test specimens. The choice of this species was considered to be appropriate because coho salmon fry often occupy the small and shallow streams in the valley bottoms in which broad leaf growth flourishes.

The bioassays were conducted at the Robertson Creek Eyeing Station during the period August 27 - September 14, 1964. Reference to records in the Department's Vancouver Office indicated the herbicides which had been utilized to the greatest extent over the past year have been: B.A. Iso-Octyl 2,4-D, Later's Iso-Octyl, Kuron, Esteron and Green Cross Brushkil

Methods

Each herbicide concentrate was diluted with water from Robertson Creek to give five solutions containing 1, 3, 9, 27, and 81 parts per million (ppm) of concentrate. Because of the low toxicity of B.A. Iso-Octyl 2,4-D it was necessary to prepare a solution containing 243 ppm of the concentrate.

Aquaria containing 10 litres of each solution and 20 juvenile coho salmon were kept at the same temperature as Robertson Creek by immersion in a bath fed by water from the creek. The aquaria were aerated.

Test fish were exposed for a period of 96 hours. During this time they were continuously observed in order to identify symptoms of distress. The combination of immobility, cessation of opercular movements and relaxation of the operculum served as the criterion of death.

Results

The time to death and the percent mortality during the period of exposure are presented in Appendix I. Graphs showing the median tolerance limits for each test concentration are presented in Appendix II. The estimated 96 hour median tolerance limits translated from ppm of concentrate and expressed as ppm of total acid equivalent were as follows:

Kuron [propylene glycol butyl ether ester of 2(2,4,5-trichlorophenoxy) propionic acid]	2.1 ppm.
Green Cross Brushkil [butyl esters of 2,4-D and 2,4,5-T at 2 lbs. per gallon 2,4-D and 2 lbs. per gallon 2,4,5-T acid equivalents]	6.0 ppm.
Esteron [propylene glycol butyl ether ester of 2(2,4,5-Trichlorophenoxy) propionic acid at 2.4 lbs. per gallon and propylene glycol butyl ether ester of 2,4-D at 2.4 lbs. per gallon]	6.3 ppm.
Laters Iso-Octyl [Iso-octyl esters of 2,4-D and 2,4,5-T at 3 lbs. each per gallon acid equivalent]	10.2 ppm.
B.A. Iso-Octyl 2,4-D [Iso-octyl ester of 2,4-D, at 6 lbs. per gallon acid equivalent]	54 ppm.

Discussions

With some exceptions juvenile sockeye salmon spend their early freshwater residence period in a lake where their protection presents fewer difficulties than the protection of coho salmon fry which rear in shallow streams, pools and sloughs. The surface area of these streams is large in comparison to their discharge which means that heavy deposits of the spray materials may arrive in streams which do not have much capacity for dilution. The speed at which spray aircraft must travel and the dense cover which often obscures coho salmon streams makes them difficult for the pilot to see, and to avoid, whereas it is obviously quite easy to avoid spraying over a lake and it is also possible to make allowance for spray drift by leaving buffer swaths untreated if it is known that the lake margins are inhabited by fish. During periods of low summer flow, many coho salmon streams have an average depth of between 6 to 12 inches. Disregarding the minor effects of dilution and displacement caused by stream flow the following table shows the initial concentrations which would be found at application rates varying between 1 and 7 lbs per acre in such streams.

Theoretical Concentration at various rates of application per Acre

Rate of application	Concentration of 6" depth	Concentration of 12" depth
1 lb/acre	.74 ppm	.37 ppm
2 lbs/acre	1.47 ppm	.74 ppm
3 "	2.20 ppm	1.10 ppm
4 "	2.94 ppm	1.47 ppm
5 "	3.65 ppm	1.85 ppm
6 "	4.41 ppm	2.20 ppm
7 "	5.15 ppm	2.57 ppm

It can be readily seen that a hypothetical field application of Kuron at a rate of 3 lbs. active ingredient per acre would give a concentration of 2.2 ppm in a six inch deep coho salmon stream receiving a direct application of the spray. The median tolerance limit of Kuron was 2.1 ppm which means that one could expect about a 50 percent mortality of coho salmon fry to take place in 96 hours. On the supposition that B.A. Iso-Octyl 2,4-D would give a comparable kill of deciduous growth, it is quite readily seen that it would be very unlikely to harm fish at the same rate of application.

The purpose of this illustration is to demonstrate that some herbicides may be used without presenting a high hazard to fish, whereas the use of others could be very hazardous. The chief purpose of presenting the results of the bioassays is to provide prospective users of herbicides with a guide for selecting low hazard compounds for use in important fish-producing areas.

While the Department endorses the use of compounds having a low toxicity to fish, it is not intended to recommend the use of specific products by their commercial names. Any chemicals endorsed will be referred to by their chemical names.

Appendix I. Cumulative mortalities of coho fry exposed to various concentrations of Esteron concentrate (2.4 lbs. of propylene glycol butyl ether ester of 2(2,4,5-Trichlorophenoxy) propionic acid and 2.4 lbs. of propylene glycol butyl ether ester of 2,4-D acid equivalent per Imperial Gallon) Duration 96 hours.

Time to Death	81 ppm*	27 ppm*	9 ppm*	3 ppm*	1 ppm*
150 mins.	19				
185 "	20	4			
240 "		14			
285 "		17			
330 "		20			
1755 "				1	
2220 "				2	
4185 "			4		
% Mortality	100	100	20	10	0

* Concentration expressed as ppm concentrate

Control Mortality nil

Temperature Range 65-68°F

Appendix I. Cumulative mortalities of coho fry exposed to various concentrations of Laters Iso-Octyl concentrate (3 lbs. 2,4-D and 3 lbs. 2,4,5-T acid equivalent per Imperial Gallon) Duration 96 hours.

Time to Death	81 ppm*	27 ppm*	9 ppm*	3 ppm*	1 ppm*
150 mins.	12				
180 "	19				
270 "	20				
460 "		1			1
536 "		2			
810 "		3			
1320 "		4			
1415 "		6			
1470 "		7			
1535 "		8			
1920 "		11			
2100 "		12			
2980 "					2
3480 "			1	1	
3855 "			2		
4140 "			4		
4410 "			5		3
4680 "					4
5410 "					5
5760 "			6		
% Mortality	100	60	30	5	25

* Concentrations expressed as ppm concentrate

Control Mortality 10%

Temperature Range 63-65°F

Appendix I. Cumulative mortalities of coho fry exposed to various concentrations of Kuron concentrate (4.8 lbs. acid equivalent of propylene glycol butyl ether ester of 2(2,4,5-Trichlorophenoxy) propionic acid per Imperial gallon) Duration 96 hours.

Time to Death	81 ppm*	27 ppm*	9 ppm*	3 ppm*	1 ppm*
195 mins.	3				
285 "	7				
340 "	15				
370 "	18				
390 "	20				
540 "		1			
685 "		3			
740 "		4			
790 "		6			
825 "		7			
855 "		11			
1110 "		19			
1200 "		20			
1545 "			1		
1595 "			2		
1630 "			3		
1715 "			4		
1800 "			5		
1845 "			6		
2010 "			7		
2130 "			8		
2220 "			9		
2310 "			13		
2430 "			14		
2490 "			16		
2610 "			17		
2670 "			18		
2790 "			19		
3630 "			20		
5700 "					3
% Mortality	100	100	100	0	15

* Concentrations expressed as ppm concentrate

Control plortality nil

Temperature Range 65-68°F

Appendix I. Cumulative Mortalities of coho fry exposed to various concentrations of Green Cross Brushkil (Acid equivalent of 2 lbs. butyl ester 2,4-D and 2 lbs. butyl ester 2,4,5-T per Imperial gallon) Duration 96 hours.

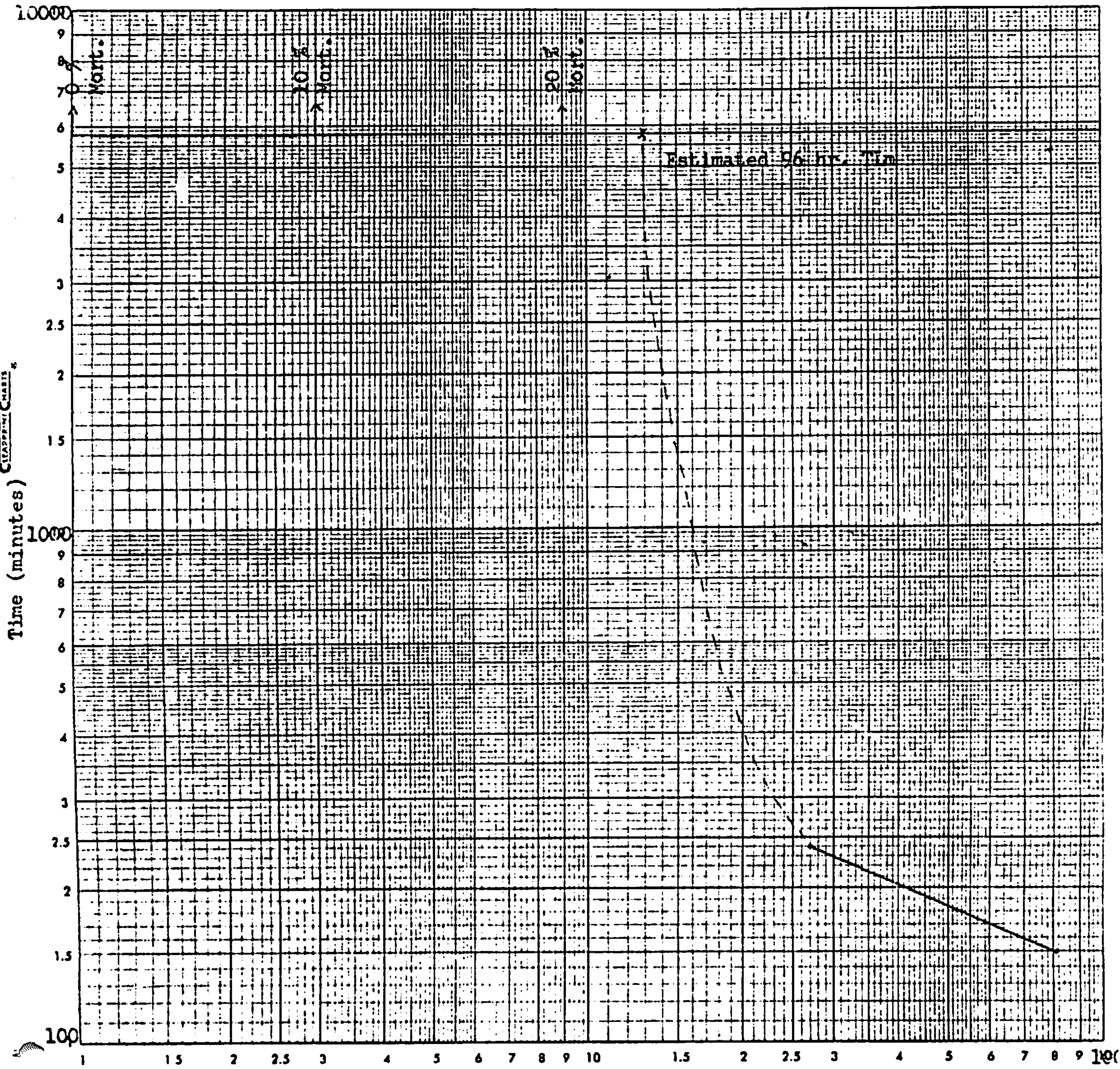
Time to Death	81 ppm*	27 ppm *	9 ppm *	3 ppm*	1 ppm*
150 mins.	3				
180 mins.	12	1			
270 "	20	2			
360 "		12			
420 "		16			
490 "		17			
540 "		18			
600 "		19			
635 "		20			
1920 "					1
2880 "					2
3390 "				1	
5050 "				2	
5200 "					3
5530 "					4
5760 "					5
% Mortality	100	100	0	10	25

* Concentrations expressed as ppm concentrate

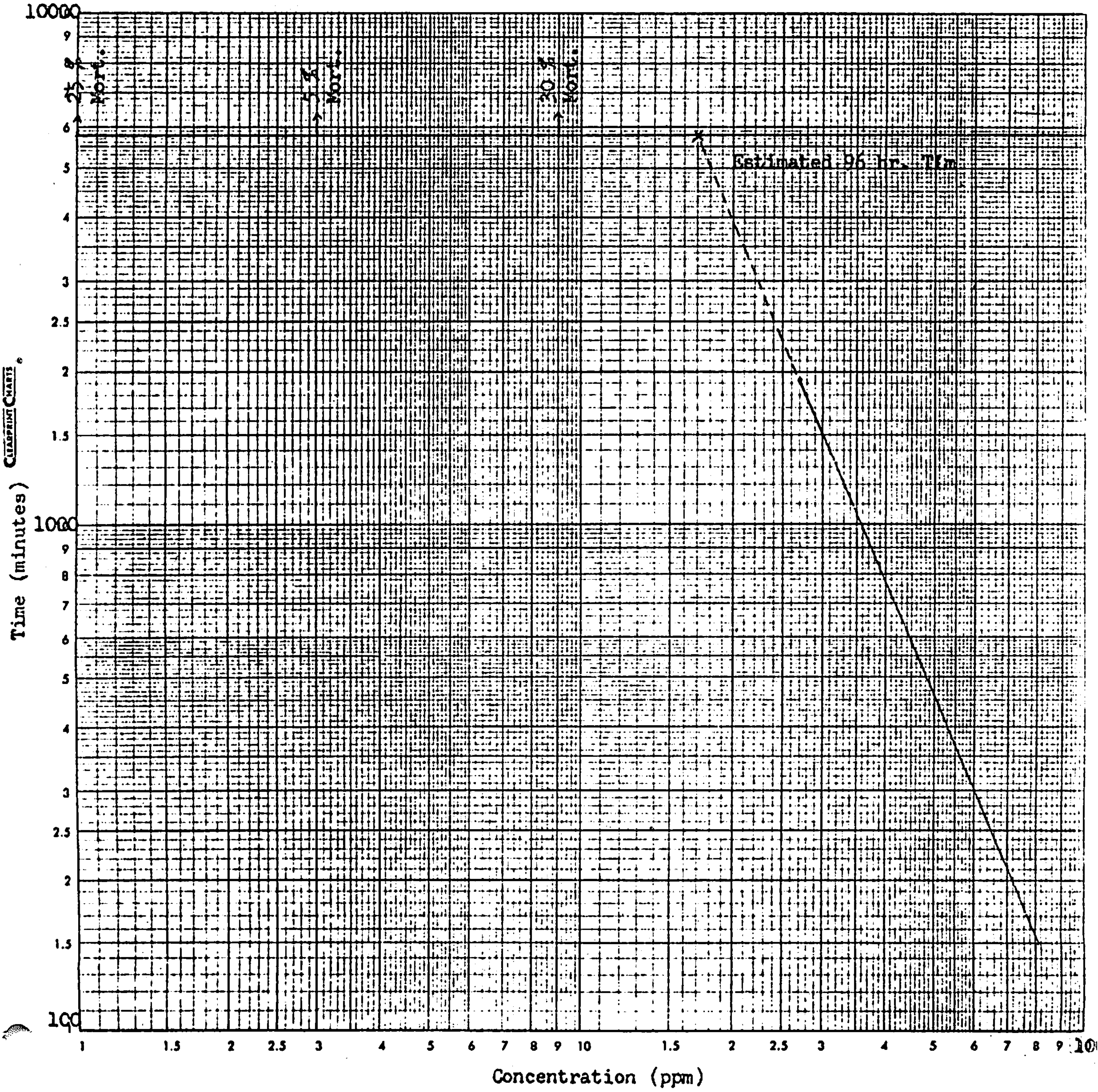
Control Mortality 10%

Temperature Range 63-65°F

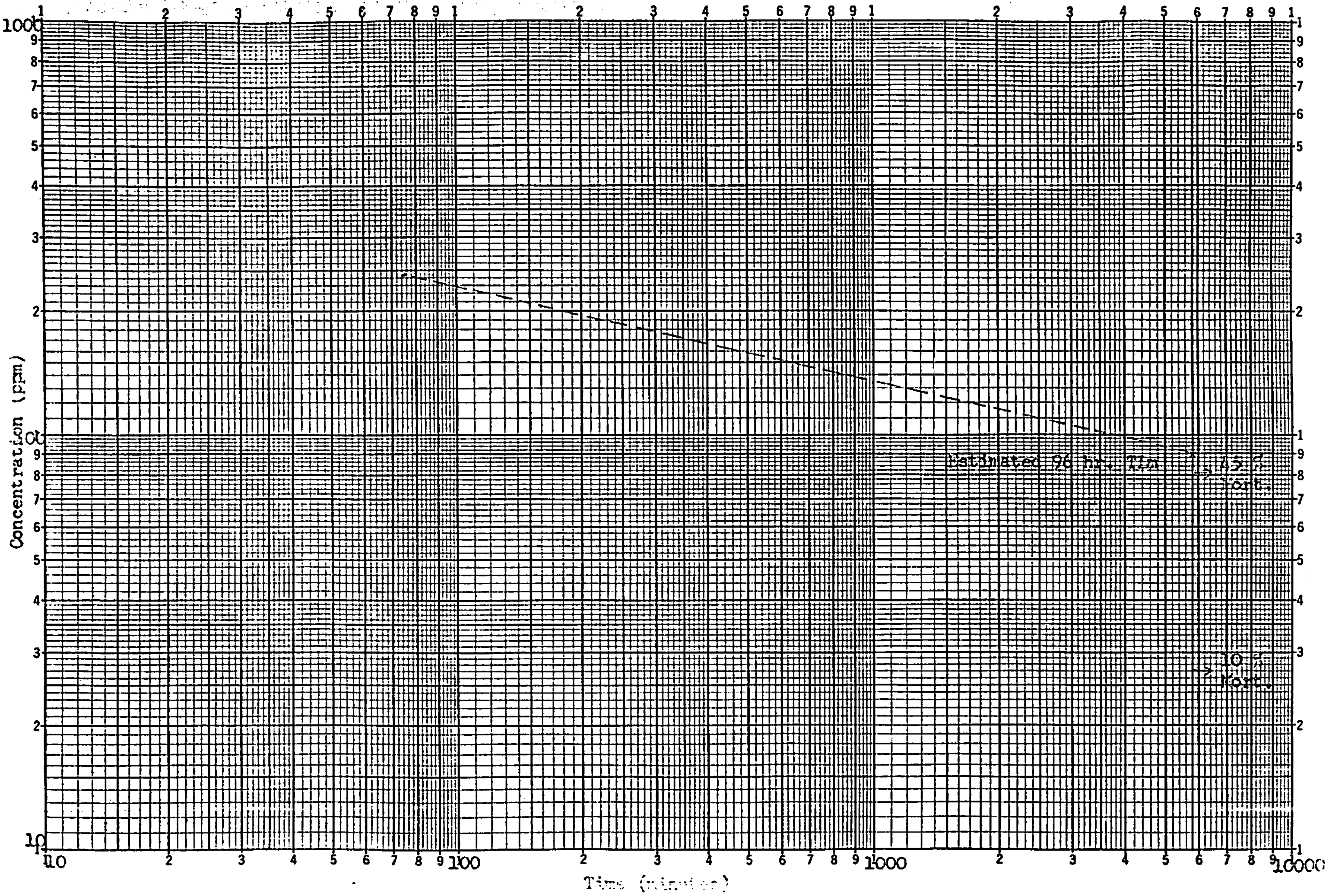
APPENDIX II. Estimated 96 hr. TLm for Esteron concentrate (acid equivalents of 2.4 lbs. of the propylene glycol butyl ether ester of 2 (2,4,5-Trichlorophenoxy) proprionic acid and 2.4 lbs. of the propylene glycol butyl ether ester of 2,4-D per Imperial Gallon).



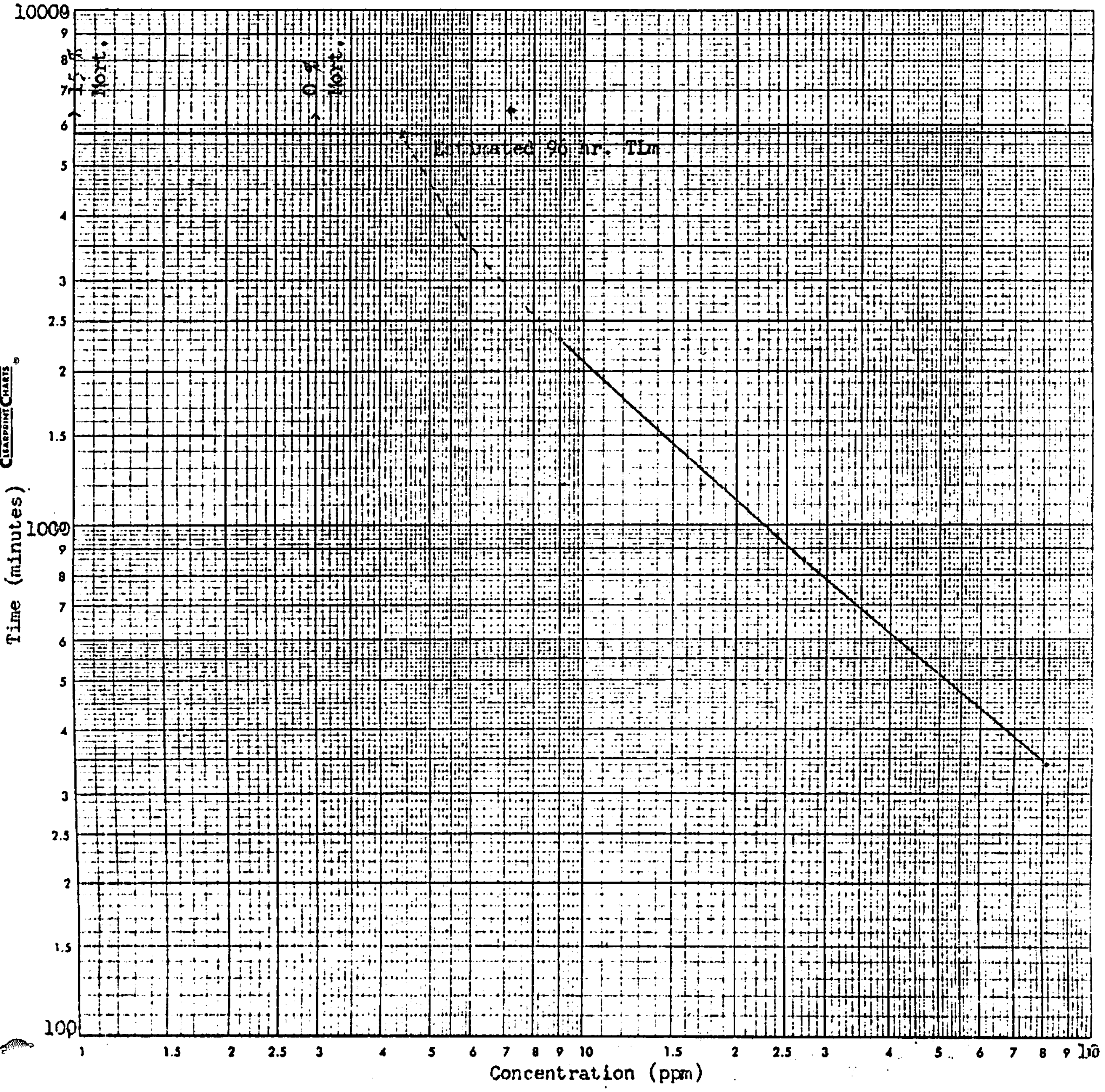
APPENDIX II. Estimated 96 hr. TLm for Later's Iso-Octyl concentrate (acid equivalents of 3 lbs 2,4-D and 3 lbs. 2,4,5-T per Imperial Gallon)



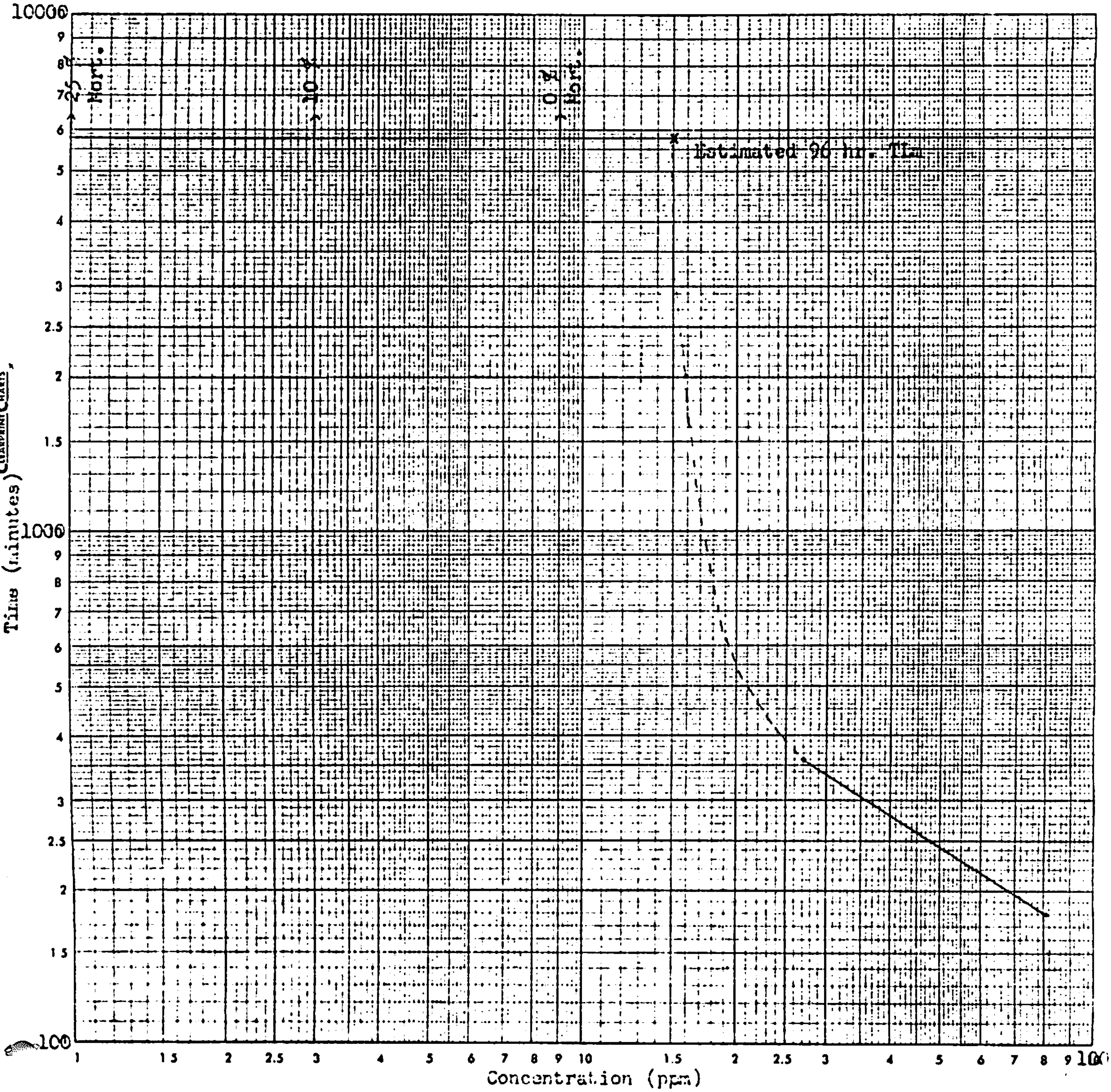
APPENDIX II. Estimated 96 hr. TLm for B.A. Iso-octyl 2,4-D concentrate (6 lbs. acid equivalent per Imperial Gallon)



APPENDIX II. Estimated 96 hr. TLm for Kuron concentrate (4.8 lbs. acid equivalent of the propylene glycol butyl ether ester of 2 (2,4,5-Trichlorophenoxy) proprionic acid per Imperial Gallon).



APPENDIX II. Estimated 96 hr. TLm for Green Cross Brushkil concentrate (acid equivalent of 2 lbs. of the butyl ester of 2,4-D and 2 lbs. of the butyl ester of 2,4,5-T per Imperial Gallon).



SUMMARY STATEMENT
ON THE EFFECTS OF PHOSPHAMIDON
ON BIRDS, 1965

by

C. David Fowle

For Interdepartmental Committee on
Forest Spraying Operations.

November, 1965.

Preliminary experiments with phosphamidon as a possible insecticide for the control of spruce budworm were carried out in 1962 and 1963 (Macdonald, 1964). As these were encouraging, further experimental work was undertaken in 1964 on a fairly large operational scale. A study of the effects of the spraying on forest birds revealed that under the conditions of application in 1964 a number of birds were killed (Fowle, 1965).

In 1965 it was decided that enough preliminary information on phosphamidon had been accumulated to warrant a large scale field experiment to:

(a) assess more accurately the effects on birds and to find a method of application which would eliminate avian mortality;

(b) to assess the insecticidal effectiveness under a variety of conditions; and to

(c) gain experience in large scale operational application.

This report deals with the first of these objectives.

The study was sponsored by the Canadian Wildlife Service and was carried out by a party of six working under the direction of Dr. C.D. Fowle of York University in Toronto. The field work began late in April and continued until the end of July from a headquarters provided by Forest Protection Limited near the Taxis Airstrip, Boiestown, New Brunswick.

THE EXPERIMENTAL DESIGN

The initial design of the experiment was established well before the field work began and included nine experimental plots and a control of about 21 square miles each (approx. 13,000 acres), located in an area of heavy budworm infestation lying between the South West Miramichi River and the

Gaspereau River in the Cains watershed and extending from the vicinity of Boiestown in the west to a few miles east of Upper Blackville. In all about 225,000 acres were set aside for experimental work.

The objective was to test the effect of:

(a) the amounts of phosphamidon applied per acre (0.25 and 0.5 lbs.),

(b) the degree of dilution with water (0.2, 0.4, 0.8 U.S.G. per acre),

(c) spraying early and late in the season,

(d) spraying in the morning and the evening,

(e) the surfactant Invadine JFC,

(f) two applications.

As field work progressed it became necessary to make some modification in the original design to add plots for testing new ideas arising in the field or for checking results of first applications. In the end we were working with 15 plots and a control. The distribution of the plots is shown in Figure 1 and treatments, spray and censusing histories of each are set out in Table 1.

METHODS

The effects of spraying on birds were assessed by:

(a) obtaining indices to changes in population before and after spraying according to the method used in 1964 (Fowle, 1965);

(b) careful searching of sample areas for evidence of mortality or "sick" birds;

(c) carrying out experiments with caged birds.

The spray was applied from modified Grumman Avenger (TBM) aircraft according to the procedure outlined by Flieger (1964).

RESULTS

No attempt will be made in this preliminary report to analyse the results in detail. What follows is simply a summary.

Effects of the amount of phosphamidon applied

The original design required the application of 0.25 lbs. of phosphamidon per acre in three aqueous dilutions of 0.2, 0.4 and 0.8 U.S. gallons per acre. However, after the field work started and we began to see some results it was decided to add experiments which would complement those already planned. On Plot 18 0.5 lbs. per acre were applied by a double treatment with 0.25 lbs. in 0.8 U.S.G. One swath at this rate was also applied on Plot 9. On Plot 12 0.5 lbs. per acre in 0.8 U.S.G. were applied in order to repeat the 1964 treatment and confirm the observations of that year. A further fortuitous experiment was possible on Plots 13 and 14 when apparently a miscalculation in formulation and calibration of the aircraft resulted in a very heavy application, probably in excess of 0.5 lbs. per acre on Plot 13 and more than 0.25 lbs. on Plot 14.

Half pound applications

In all areas where half a pound per acre or more was applied varying degrees of population reduction and mortality were observed. On all other plots where the application rate was 0.25 lb. per acre there seemed to be little change in bird populations.

The effect of the spraying on the numbers of birds seen, species and song frequency on Plot 18 are shown in Table 2. Here the dose was 0.5 lbs. in 1.6 U.S.G. put on in two applications of 0.25 lbs. in 0.8 U.S.G. The relatively low figures for June 3 are accountable to adverse weather conditions which resulted in similar low counts on two other plots censused on that day. The plot was searched 9 hours after spraying on June 7 and 14 incapacitated birds were seen or captured (8 warblers, 2 ovenbirds, 1 red-breasted nuthatch, 1 least flycatcher, 1 Swainson's thrush, 1 white-throated sparrow). Song frequency in the area ranged between 0.2 and 2.8 songs per minute, while outside the plot 23 songs per minute were recorded. On June 8, 26 hours after spraying, several birds were captured easily and a number of others which were in obvious difficulties escaped capture. A few incapacitated birds were seen on June 9 and some dead birds were found in subsequent searches.

Similar but less spectacular results were obtained on Plot 9 where the aircraft applied two doses of 0.25 lb. in 0.8 U.S.G. per acre by flying over the same swath twice. The plot was sprayed in the morning of June 6 and searched in the afternoon and the next morning. Song was noticeably reduced and six or seven sick birds were observed or captured.

On Plot 12 the procedure of 1964 was repeated and 0.5 lbs. of phosphamidon in 0.8 U.S.G. was put down on the evening of June 16. The results were similar to those obtained in 1964 - a reduction in birds and song frequency and capture or observation of many (30+) incapacitated birds.

On Plots 13 and 14 a miscalculation in formulation and calibration resulted in a heavy dose. Moreover, observers reported that the aircraft applying the spray in the area of the census route flew at least twice over portions of the ~~census~~ area and drifting of the spray further added to its heavier concentration. Most of the area probably received better than 0.5 lbs. per acre. A reduction in population occurred and numerous dead and incapacitated birds were found

(Table 3). For the first time we recovered larger birds such as jays, evening grossbeaks and many robins. A total of 105 birds representing 19 species were recovered without much effort. Last year 75 sick or dead birds, representing 20 species were collected on the same area following the application of 0.5 lbs. per acre in 0.75 U.S.G.

This was the only area censused in 1964 and 1965. The 1965 figures suggest that the total population as indicated by the number of birds seen, and song frequency was lower than in 1964. They are, however, consistent with the figures from other experimental plots in 1965 and with those of the control. It is, therefore, impossible to draw any conclusions with respect to the possible effects of the 1964 spraying on the 1965 population.

Quarter pound applications

On all plots where 0.25 lbs. per acre were applied the effect of spraying seemed slight in comparison with those discussed above. It is true that some dead and sick birds were found and there were indications of reductions in some species. There were apparently small population changes on plots 1, 2, 5, 8, 11 and 16.

Plot 1. (0.25 lbs. in 0.2 U.S.G.)

There was an apparent reduction in ruby-crowned kinglets and myrtle warblers (Table 4) but otherwise no other change was detected. Bush workers living in a camp in the plot reported that a few incapacitated robins and white-throated sparrows were seen in the camp yard the day following the spraying.

In an effort to check these results two operational spray blocks (530 and 558) treated with the same concentration of spray as Plot 1 were searched but no sick or dead birds were found. Plot 7 also received the same treatment except for the exclusion of Invadine and again careful seach failed to reveal incapacitated birds. Caged white-throated sparrows exposed to the spray and others exposed to foliage sprayed in this application showed no ill effects. As there were no census routes in the area it is impossible to assess small population changes.

Plots 2, 5, 11, and 16 (0.25 lbs. in 0.8 U.S.G.)

Plots 2, 11 and 16 all received the same treatment. Invadine was excluded on Plot 5.

The results from 2, 11 and 16 are not entirely consistent. Tables 5, 6, 7 and 8 show that on Plots 2 and 11 there was a reduction in ruby-crowned kinglets and some warblers but probably not on Plot 16. The results from Plot 11 are somewhat obscurred by the unfavourable census weather on the first post-spray census on June 16. Strong winds and cool weather reduced counts on experimental plots and on the control on that day. Two dead Tennessee and one Blackburnian warbler and one sick Swainson's thrush were found near the beginning of the census route in an area where song frequency was near zero.

On Plot 16 there seems to have been little detectable change in population after both spray applications (May 22 and June 9). However, a few birds (yellow-bellied flycatcher, ruby-crowned kinglet and white-throated sparrow) which appeared to be incapacitated were observed on the ground after both applications.

As there were no census routes established on Plot 5, population changes could not be measured. Most of the plot was sprayed on the morning of May 30 and finished in the evening. Two searchers went in by helicopter in the morning of May 31 to search an area sprayed the previous morning. Another pair of searchers worked the same area in the evening. Bird activity seemed low with little song. Five incapacitated warblers were caught in the morning and a number of others which appeared to be in difficulties eluded capture. In the evening several warblers allowed close approach but could not be caught. All these birds were seen along the bank of the Cains River in the same general area.

Plot 8 also received 0.25 lbs. per acre but in a dilution of 0.4 U.S.G. Results were similar to those on Plots 1 and 2 (Table 9).

In summary it appears that dosages in the order of half a pound per acre caused mortality and incapacitated many birds. Quarter pound applications are probably below the lethal level for most species except those such as ruby-crowned kinglets and myrtle warblers and perhaps Tennessee warblers whose feeding habits and behaviour exposes them to the heavier applications in the treetops or on the branch tips. When incapacitated and dead birds were found on plots receiving quarter pound doses we are at a loss to know whether the birds have been affected by this low dose rate or have succumbed to the effects of double application resulting from overlapping spray swaths or by increased concentration in some areas resulting from drift. The discovery of dead birds in a small area on Plot 11 and the apparent concentration of incapacitated birds on Plot 5 suggests that mortality may be concentrated in small areas where the dose rate is in excess of a quarter of a pound. We know from experiments with double applications on Plots 9 and 18 that mortality is increased in areas receiving a total of 0.5 lbs. in two applications.

Effects of Dilution

In attempting to assess the effects of dilution the plots can be grouped.

0.2 U.S.G. - Plots 1, 7, 17 and Spray Blocks 530 and 558

It has already been noted that there was a reduction in ruby-crowned kinglets and myrtle warblers on Plot 1, but this is probably not related to the dilution since similar results were seen on Plots 8 and 2 in which other dilutions were used. No census routes were established on Plots 7 and 17 but searches of these areas failed to reveal any dead or incapacitated birds. Searches on Spray blocks 530 and 558 also failed to reveal any effects.

0.4 U.S.G. - Plot 8 and Spray Blocks 500, 501 and 527

This was the only plot available for testing the 0.4 dilution. Results were similar to those on Plots 1 and 2. Limited searching of three operational spray blocks using this dilution (500, 501 and 527) did not reveal any detectable effects of spraying.

0.8 U.S.G. - Plots 2, 4, 5, 6, 9, 11 and 16

All these plots were sprayed with 0.8 dilution. Invadine was omitted from Plots 5 and 9. The results on Plots 1, 2, 8, 11 and 16 are all very much the same in spite of variations in dilution. Plot 6 is not consistent with the rest but results resemble those from Plot 16 (Tables 8 and 10).

In Plots 5 and 7 where Invadine was omitted there was some mortality but as has been noted it is probably accountable to intentional application of a double dose or to accidental overlapping of swaths.

In summary it was impossible to detect any effects of dilution in so far as bird population were concerned.

Effects of Spray Early and Late in the Season

The original design of the experiments called for the application of spray early in the season for comparison with later application. We had hoped to start as early as the first week of May before the bulk of the migrants had returned and to compare the results of spraying at this time with those from applications later in June. Unfortunately weather and the slow development of the budworm made it impossible to apply spray before May 16, about two weeks earlier than the first application in 1964.

The best that can be done with the available data is to compare the results for Plots 2 and 11 and those from the two applications on Plot 16. In comparing Plots 2 and 11 the main difference lies in the numbers of warblers present at the time of spraying. Very few species (myrtle and Cape May) had arrived by May 16 when Plot 2 was sprayed. In contrast seven commonly occurring species which might have been expected were all present on Plot 11 when it was treated on June 12. The effects are shown in Table 5 and 6. On Plot 2 only kinglets and myrtle warblers were affected as these were the most abundant species present at that time. On Plot 11 other species of warblers which arrived later in the season were affected as the table shows.

The very slight effect after each application on Plot 16 is difficult to explain and not consistent with the other results.

In summary the results of early and late spraying were as might be expected. Later in the season the abundant warblers were affected merely because they were there. If early application of phosphamidon seems to be effective in controlling budworm this principal might be employed to avoid unnecessary mortality among birds.

Effects of Spraying in the Morning and Evening

In 1964 one sample area (Ludlow) was treated in the evening with 0.25 lbs. in 0.75 U.S.G. per acre and subsequent observations suggested that the bird population was virtually unaffected, (Fowle, 1965). With present knowledge we might now conclude that the reduction in dose from 0.5 to 0.25 lbs. per acre was the critical factor and that time of day was immaterial. However at the time of designing the experiments for 1965 it was considered necessary to test morning and evening applications.

If, as was shown in 1964, poisoning of birds results from contact with sprayed foliage, evening applications might be expected to reduce the danger to birds, as they tend to be less active later in the evening and hence not so likely to pick up toxic doses. Moreover, if phosphamidon is taken up fairly quickly by the foliage and hydrolysis proceeds rapidly it might be expected that the concentration of toxic material on the foliage on the morning following application might be reduced. On the other hand, absorption of the insecticide might be slowed down at night when trees are metabolically less active and hydrolysis might proceed slowly at the lower temperatures. In spite of these considerations and having regard for the diurnal variations in avian behaviour it is reasonable to expect that time of application might influence the effect of spraying on birds.

It was originally planned that all applications on the experimental plots would be made in the morning except on selected plots where evening applications would be made. Unfortunately this scheme had to be abandoned in the field as operational considerations sometimes forced us to spray in the evening when morning applications would have been preferred (Plots 2, 3, 4, 6, 12, 13 and 16).

For this reason it appears to be impossible to sort out the effects of morning and evening application. We may for example compare results on Plots 2 and 6, both of which were sprayed in the evening in the same way. On Plot 2 some effect was observed and on Plot 6 there was very little or none. On the other hand the results on Plot 11 which received the same treatment but were sprayed in the morning yielded results similar to those on Plot 2. There was little measureable effect on Plot 16 but even if there had been, the significance would not have been clearly established since one application was made in the morning and the other in the evening.

The Effect of Invadine JFC

Invadine was included in all formulations except those used on Plots 5, 7, 9 and 18. The mortality on Plots 9 and 18 is assignable to the half pound doses and that on Plot 5 could have resulted from overlapping swaths. If there is any effect from Invadine it is obscured by the variation in the data.

If the general effect of Invadine is to reduce droplet size and to spread the spray solution on the surface of the foliage it might be expected to enhance the chances of birds picking up a toxic dose. However, it remains for further experiments to confirm this.

The Effect of Two Applications

Two applications were made on Plot 16. Myrtle warblers may have been slightly reduced by the first spraying but, on the whole, virtually no change was detected on this plot after either spraying (Table 8.)

Experiments with Caged Birds

A number of experiments were carried out with caged birds. These have not yet been completely analysed but some of them clearly demonstrate that birds can pick up a lethal dose of phosphamidon through their feet. Exposure of birds to perches and plastic surfaces sprayed with various concentrations produced symptoms of poisoning and, in some cases, killed the birds.

DISCUSSION AND CONCLUSIONS

From the work done so far it seems reasonable to conclude that operational spraying of phosphamidon at a dose rate of 0.5 lbs. or more per acre will result in substantial mortality of birds. However, 0.25 lbs. per acre is apparently almost harmless, although a few species may be affected. It would be of interest to try an intermediate rate to determine the toxic level more accurately.

A substantial advance was made in 1965 in terms of the organization and intergration of the investigational programs. A coordinating committee under the chairmanship of Mr. Ross Macdonald provided an excellent mechanism for prompt exchange of information and adjustments so necessary in a research program depending heavily on operational facilities. A major problem in experimental work of the kind required to assess pesticides in operational application is the reasonable control of the many variables that can effect results. The coordinating committee helped us to overcome some of these but we still have a long way to go if we are to gain the maximum return for dollars and time spent on research.

If it is operational application that is being assessed, it will always be necessary to have a proportion of the experimental work closely associated with the operational program. On the other hand, research effort in some other areas might pay larger dividends if experimental facilities were available in which the variables in formulation, application and assessment could be more closely controlled. This would involve assignment of aircraft and other facilities to experimental work. It may also be that we have reached a stage when the various investigational groups could make good use of analytical facilities in the field.

In the case of fish and wildlife investigations, it is often impossible to establish clear cause and effect relationship unless we know how much insecticide is actually present in the water or on foliage. Moreover, we assume, without periodic spot checks, that the forumulation and calibration of the aircraft are, in fact, what they are supposed to be and treat this aspect of the experimental design as if they were constants. In general, this is probably a reasonable assumption but if precise work is to be done, periodic analytical checks are essential. We should actually know in each experimental situation how much insecticide is actually deposited in the environments we are studying.

In the 1965 program, for example, the variations in effect observed on Plots 2 and 4 cannot really be interpreted without knowing how much insecticide was actually deposited. Plot 2 could have received an overdose or Plot 4 too little. In the case of the possible differences between morning and evening spraying, meaningful results can only be obtained if the fate of the insecticide can be followed and related to possible differences in responses of the birds. The possible effects on reproduction and other physiological processes cannot be explored without first establishing that the animals being studied do actually contain residues.

An analytical laboratory set up in the field and available to all research groups would contribute substantially to the improvement of the experimental work. If such a facility could be made available together with aircraft specifically assigned to research, the prospects of solving some of our problems more quickly would be improved.

ACKNOWLEDGEMENTS

I wish to acknowledge the assistance and support of the many people who contributed to this project.

The program was sponsored by the Canadian Wildlife Service and carried out under the guidance and encouragement of Dr. Graham Cooch.

The field work was conducted by a team of enthusiastic workers including Stanley Teeple of the Canadian Wildlife Service, Peter Pearce of the New Brunswick Department of Lands and Mines, Robert Gibbon and Wayne Neilly who together carried out most of the censusing. Malcolm Jackson and Fred Boehm assisted with various aspects of the program.

Again we received generous assistance and cooperation from local agencies including the Fish and Wildlife Branch of the New Brunswick Department of Lands and Mines and the Forest Entomology and Pathology Laboratory of the Canada Department of Forestry. We are particularly indebted to Ross Macdonald and Donald Cameron who assisted us in many ways.

As usual, we were encouraged by the interest and support of Messrs. B.W. Flieger and B.A. McDougall of Forest Protection Limited who, together with various members of their staff, provided us with living and working facilities and assisted us in every way they could.

REFERENCES

Flieger, B.W., 1964: A new method for guiding spray aircraft. Canada Dept. of Forestry. Bi-Monthly Prog. Report 20 (1): 2-4.

Fowle, C.D., 1965: A Preliminary report on the effects of phosphamidon on bird populations in central New Brunswick. Dept. of Northern Affairs and National Resources, Can. Wildl. Service, Occ. Paper No. 7 (in press)

Macdonald, D.R., 1964: Aerial spraying against the spruce budworm in New Brunswick, 1960 and 1963. Canada Dept. of Forestry Bi-Monthly Prog. Report, 20 (1): 1-2.

November, 1965.

TABLE 1.

Summary of spray and censusing history on experimental areas.

Plot Number	Spray Block	Amt. Applied (lbs.)	Invadine Included	Dilution	Date Sprayed	Time	Censuses		Results
							Pre	Post	
1	270	0.25	YES	0.2	May 16	AM	7	3	Reduction in kinglets, M. warblers, sick robins and white-throats reported
2	274	0.25	YES	0.8	May 16	PM	8	4	Reduction in kinglets and myrtle warblers, 1 sick myrtle picked up
3	276	0.25	YES	0.8	May 19	PM	6	1	Rained out - no useful data
4	277	0.25	YES	0.8	May 21 May 25	PM AM	0	0	Search revealed no sick or dead birds (May 22)
5	273A	0.25	NO	0.8	May 30	AM	0	0	Two dead magnolia warblers, 1 least flycatcher, three sick warblers
6	272	0.25	YES	0.8	June 5	PM	4	2	Apparently no effect
7	560	0.25	NO	0.2	June 6	AM	-	-	Apparently no effect
8	269	0.25	YES	0.4	June 6	AM	5	2	Slight population depression, sick Tennessee Warbler
9	559	0.25	NO	0.8	June 6	AM	-	-	Sick and dead birds found in area covered by double swath (0.5 lbs. in 1.6 U.S.G.)

TABLE 1. (cont.)

Summary of spray and censusing history on experimental areas.

Plot Number	Spray Block	Amt. Applied (lbs.)	Invadine Included	Dilution	Date Sprayed	Time	Censuses Pre	Censuses Post	Results
10	275	NO BIRD STUDY AREA ON THIS PLOT (TREATMENT AS IN PLOT 11)							
11	273	0.25	YES	0.8	June 12	AM	6	2	Dead Blackburnian warbler, 2 white-throated sparrows, 1 Swainson's thrush, some other species reduced in number
12	563	0.5	YES	0.8	June 15	PM	3	4	Considerable mortality
13	268	0.5+	YES	0.4?	June 15	PM	6	5	High mortality
14	268	0.25+	YES	0.4?	June 16	AM	6	5	High mortality
15	268	0.25	YES	0.2	June 20	AM	-	-	No observations
16	271	0.25	YES	0.8	May 22 June 9	PM AM	5 4	6 2	Little effect
17	558	0.25	YES	0.2	May 30	AM	-	-	Apparently no effect
18	275	0.25 twice	NO	0.8 twice	June 7	AM twice	5	7	Considerable mortality
CONTROL	-	-	-	-	May 5 July 3	-	20	-	

TABLE 2.

Population indices, Plot 18

Date	Total birds	Time mins.	Birds/ min.	Total Songs	Songs/ min.	Total Species
May 24	152	88	1.7	415	4.7	35
May 26	202	123	1.6	1086	8.8	37
May 29	215	107	2.0	1054	9.8	37
June 1	222	106	2.1	1531	14.4	33
June 3	167	116	1.4	414	3.6	33
June 7	Spray applied in morning					
June 8	85	99	0.8	121	1.2	25
June 9	70	94	0.7	205	2.2	19
June 12	83	93	0.9	343	3.7	21
June 15	87	100	0.9	527	5.3	28
June 19	97	89	1.1	861	9.7	27
June 25	98	88	1.1	890	10.1	28
July 2	105	83	1.3	654	7.9	26

TABLE 3.

Population indices, Plots 13,14

Date	Total birds	Time mins.	Birds/ min.	Total Songs	Songs/ min.	Total Species
May 24	183	95	1.9	692	7.3	32
May 28	190	117	1.6	139	15.4	41
June 1	235	89	2.6	1192	13.4	36
June 3	165	92	1.8	388	4.2	29
June 7	237	88	2.7	1083	12.3	36
June 12	202	94	2.1	987	10.5	38
June 15	213	96	2.2	935	9.7	35
Spray applied in evening June 15 and morning June 16.						
June 16	167	94	1.8	723	7.7	35
June 17	90	90	1.0	429	4.8	26
June 23	106	65	1.6	611	9.4	25
June 30	202	102	2.0	1194	11.7	35

TABLE 4.

Reduction in ruby-crowned kinglets and myrtle warblers on Plot 1.

Date -	May 5	6	10	12	13	14	15	16	17	19	22
Ruby-crowned kinglet	10	15	17	15	17	11	16	Spray	2	1	0
Myrtle warblers	0	2	13	9	20	15	19		4	2	0

TABLE 5.

Reduction in ruby-crowned kinglets and myrtle warblers on Plot 2.

Date - May	5	6	7	9	12	13	15	16	16 PM	17	19	21	24
Ruby-crowned kinglet	11	24	25	36	25	22	25	23	Spray	0	0	0	0
Myrtle warbler	0	0	3	7	6	11	5	20		2	0	0	1

TABLE 6.

Reduction in least flycatcher, ruby-crowned kinglets and warblers, purple finch and white-throated sparrow on Plot 11.

Date -	May 24	28	29	June 1	3	9	12	13	15
Least flycatcher	4	0	14	17	0	11	Spray	0	0
Ruby-crowned kinglet	16	17	14	14	13	22		1	3
Tennessee warbler	12	5	49	69	31	51		20	33
Magnolia warbler	8	3	13	8	4	11		0	1
Cape May warbler	13	5	10	6	8	7		0	2
Myrtle warbler	7	4	8	4	2	2		3	0
Bay-breasted warbler	12	1	8	11	5	26		4	6
Ovenbird	21	16	20	17	12	39		4	10
Canada warbler	0	0	3	7	1	7		0	1
Purple finch	15	19	15	19	20	26		3	9
White-throated sparrow	23	21	16	22	20	25		8	9

TABLE 7.

Population indices, Plot 11.

Date	Total birds	Time mins.	Birds/ min.	Total Songs	Songs/ min.	Total Species
May 24	210	105	2.0	936	8.9	35
May 28	187	105	1.8	589	5.6	32
May 29	245	99	2.5	1736	17.5	33
June 1	298	114	2.6	2140	18.8	37
June 3	194	98	2.0	853	8.7	34
June 9	339	115	2.9	1790	15.6	33
June 12	Spray applied in morning.					
June 13	106	77	1.4	432	5.6	24
June 15	141	90	1.6	692	7.7	31

TABLE 8.

Possible effects of spraying on winter wren, ruby-crowned kinglet, warblers, purple finch and white-throated sparrow, Plot 16.

Date –	May 7	11	16	20	21	22	23	31	June 2	5	9	10	12
Winter wren	5	5	7	9	8	Spray	4	6	5	4	Spray	3	3
Ruby-crowned kinglet	22	16	19	18	11		11	10	7	8		10	4
Tennessee warbler	0	0	0	1	1		7	66	75	29		54	40
Magnolia warbler	0	0	0	5	8		5	8	12	1		10	8
Cape May warbler	0	3	13	14	14		9	7	11	4		4	2
Myrtle warbler	7	14	16	7	13		6	2	6	2		3	2
Bay-breasted warbler	0	0	0	0	1		8	1	6	1		9	15
Ovenbird	0	0	11	37	26		24	20	21	20		28	26
Canada warbler	0	0	0	0	0		0	0	1	0		1	4
Purple finch	22	12	13	19	13		11	13	16	15		11	12
White-throated sparrow	15	32	31	32	26		20	19	20	18		24	16

TABLE 9.

Reduction in ruby-crowned kinglets, myrtle and Tennessee warblers on Plot 8.

Date -	May 22	26	29	June 1	3	6	7	10
Ruby-crowned kinglet	6	10	8	6	5	Spray	0	4
Myrtle warbler	7	3	8	2	8		1	2
Tennessee warbler	16	11	11	43	34		12	16

TABLE 10.

Possible effects of spraying on winter wren, ruby-crowned kinglet, warblers, purple finch and white-throated sparrow, Plot 6.

Date -	May 28	31	June 2	5	5 PM	6	8
Winter wren	4	2	1	1	Spray	1	2
Ruby-crowned kinglet	11	19	16	15		11	5
Tennessee warbler	0	43	52	4		53	49
Magnolia warbler	1	7	4	0		6	8
Cape May warbler	0	9	8	1		15	12
Myrtle warbler	4	3	5	1		4	3
Bay-breasted warbler	1	7	10	4		10	13
Ovenbird	32	33	34	19		31	36
Canada warbler	0	2	1	0		0	0
Purple finch	2	4	7	10		7	8
White-throated sparrow	37	42	29	18		33	24

EXPERIMENTAL SPRAY PROGRAM - 1965

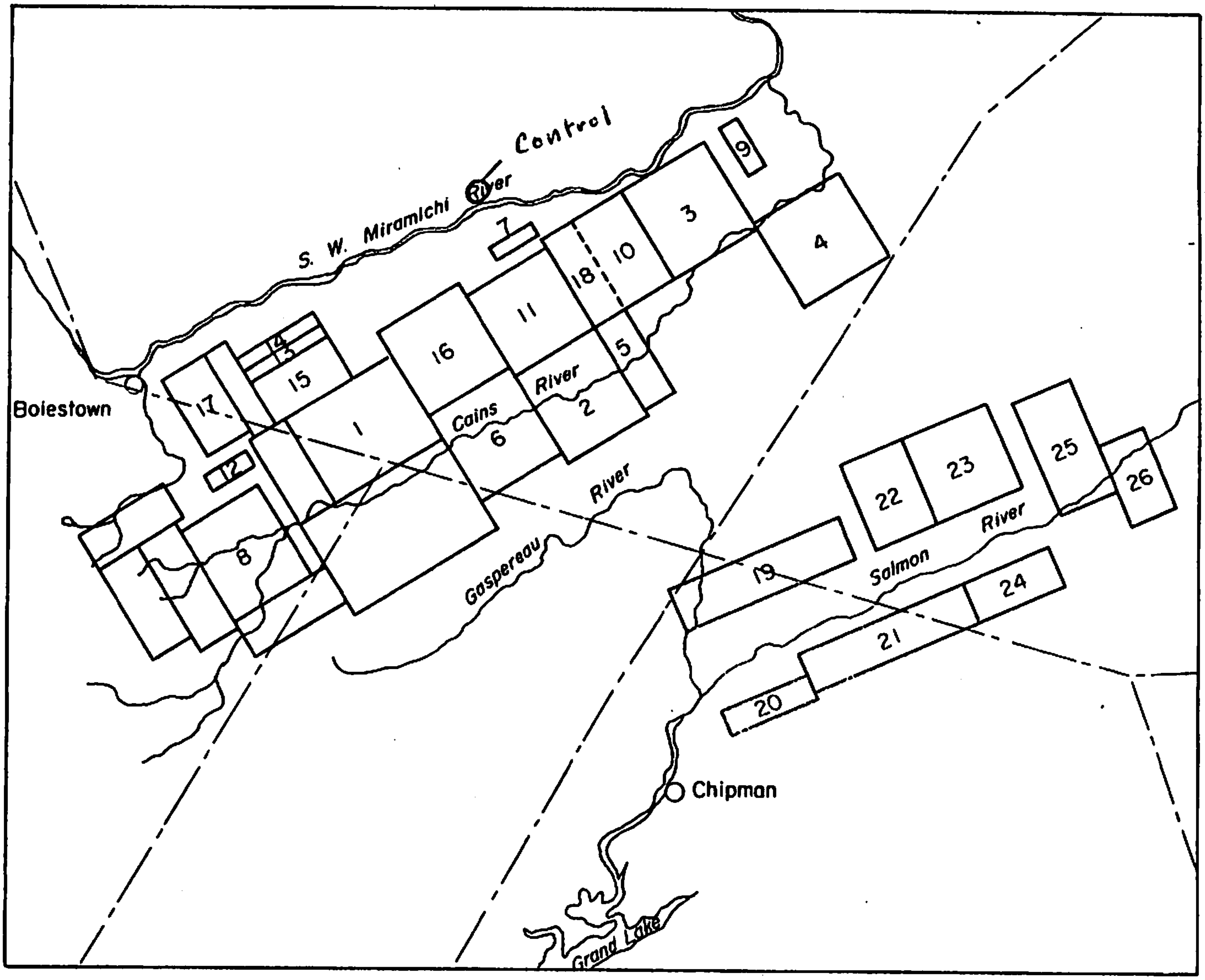


Figure 1.