SOME RECENT ASPECTS OF FOREST INSECT CONTROL

by
A.P. Randall
Research Scientist, CCRI
Department of Fisheries and Forestry, Ottawa, Ontario

Introduction: Mr. Chairman, fellow colleagues and invited guests: it is always a pleasure to renew old acquaintances and meet new members in the aerial applicators and pesticide field, and particularly so when one had not planned on such an occasion. Dr. Fettes, who was scheduled to present this paper is currently attending a series of departmental meetings in Ottawa; and wishes to express his regrets at being unable to attend your conference. While I am not as qualified as Dr. Fettes to present the in depth picture of forest insect control in Canada, I shall confine my presentation to those subjects that are of current interest to commercial operators and experimentors.

The title of my talk is so broad and all inclusive that it would require a considerable amount of time to cover the subject in depth; so I plan to give a very general outline of what we (CCRI) in Canada are doing in the way of research for the control of forest insects. The work at our Institute can be separated under four broad headings:

(a) Insect Toxicology

(b) Environmental Contamination

(c) Field evaluation of promising pesticides

(d) Research and Development of new methods in aerial spray application.

Insect toxicology (Dr. P.C. Nigam) is primarily concerned with the testing of new insecticides against a wide selection of injurious forest insect species. The insecticides are selected from various classes of chemical compounds i.e. chorinated hydrocarbons, organophosphours, carbamates, organotins etc. and tested against specific groups of insects such as, the defoliators; sawflies, loopers, leaf miners; or the bark feeding insects i.e. bark beetles ambrosia beetles, aphids etc. and other select groups such as budworms. The purpose of the screening program is to provide us with a backlog of toxicological information on old and new insecticide compounds against the major forest insect pests. We plan to expand this particular phase of the program to include the effects of the insecticides against predators and parasites of the host pests. To date we have information on the effects of many new insecticides such as Zectran, fenitrothion (sumithion) Matacil, Lannate and others on most of the primary forest pests insects. Many of the new compounds are much more effective than DDT against many of the injurious forest pests and these are the compounds selected (after careful screening) for future field evaluation.

The next major field of endeavour is Environmental Contamination, which is currently undertaken by Dr. W. Yule. During the past three years the program has been directed to the study of DDT residues in the New Brunswick spruce budworm ecosystem. The current program for 1970 will include a study of the movement of fenitrothion (air, land, water) throughout the spray area in addition to a study of the degradation products of this insecticide.

This brings me to the other phases of our project, i.e. field evaluation of promising insecticides, and research and development of new methods in aerial application, which Dr. Fettes and I have been actively participating in the past few years. When an insecticide has passed initial screening in the Toxicology laboratory, and has been shown to be relatively safe to wildlife particularly fish, birds and small mammals, the compound is then tested in the field against a standard insecticide for a given species of insect. In the case of the spruce budworm our insecticide standard was 1/4 lb. DDT/1/2 gal. fuel oil/ac. Most forest insect outbreaks occur over vast areas of forest land thus the methods of control, if pesticides are to be used, must by necessity be applied from the air. Thus a large part of our research program is tied in with the research and development of spray equipment, the improvement of techniques and methods of aerial spray application and spray assessment.

These are very important aspects of insect control since the most efficient insecticide in the world if improperly formulated and applied will produce negative results. Many examples of poor insect control can be attributed to improper formulation, poor spray equipment and adverse spraying conditions rather than the lack of insecticidal efficiacy of the insecticide.

I would like to move on to the main part of my talk which I think should be considered as the evaluation, and assessment of spray equipment on fixed wing aircraft. Although we have experimented with helicopters, most of our research work has been done on fixed winged aircraft. In the early days of forest insect spraying most of the available aircraft for use had a cruising speed of 90-100 mph. Spray equipment consisted of agricultural equipment adapted to aircraft and usually arranged according to whims or knowledge of the operator. Spray volumes were large and usually considered in gallons per acre. During the war and post war years much valuable research on aerial application of spray liquids was undertaken by the Defense Research Board of Canada. Equipment ranged from straight pipe emission to the testing of spinning bushes, discs, and fans in an endeavour to reduce the droplet size spectrum of the spray. Aircraft of various speeds were also included in the program. It was during this period (1944-45) that DDT entered the scene and became the standard insecticide for forest insect control in Canada.

Thus much of the research for forest insect control was centered around a fuel oil DDT formulation and 90 mph. Stearman aircraft equipped with boom and spraying systems nozzles (as shown in Fig. 1). It was not uncommon to find a large assortment of nozzles and sizes on the aircraft since the aircraft were usually calibrated for spray output per minute rather than for droplet spectrum size. It was not until 1956 that calibration of aircraft spray equipment included specification for a definite droplet spectrum size i.e. a (MMD) mass median diameter of 225 microns (min) for the spray cloud. (Figure 2)

The aircraft used for the 1956 black headed budworm spray program were "TBM" Grumman Avengers fitted with straight pip nozzle emission units. We managed to get some very interesting photos of the vortex formation on the wing tips as shown in Figure 3a and 3b.

The size and density of the spray cloud is a very good indicator of the size of the spray droplets formed by the spray equipment. If you can't see the spray swath very clearly, then the droplets are large indicating a course spray.

During the 1958 to 1965 interval we were actively engaged in screening new insecticides to replace DDT as the chemical for the control of the spruce budworm in New Brunswick. DDT had been shown to be relatively toxic to young salmon and trout fry. In addition the spruce budworm was showing signs of becoming resistant to this material. Any increase above the recommended dosage of 1/4 lb./1/2 gal/acre would result in a further increase in hazards to fish and aquatic fauna. Thus, we were committed to an insecticide selection program which resulted in the recommendation of the organophosphous (phosphamidon and sumithion) and carbamate (zectran, matacil) insecticides as potential candidate materials for budworm control. It was during this period that we found insecticides which exhibited systemic activity in conifers.

In 1965 we embarked on a program of ultra-low volume spraying for forest insect control. We like to say that we were responsible for introducing ULV spraying for forest insect control, but actually many of the events that happen in a program occur because you are there and actively involved. Dr. G. Cooper (Cyanamid of Canada) introduced the ULV concept to us when he suggested the use of technical Malathion for spruce budworm control. Our three previous experiments using a 10% malathion formulation showed this material to be less effective than DDT at comparable dosages. Laboratory toxicity tests confirmed the hypothesis of ULV concentrate spraying and established an approximate dosage of 6 oz/ac. Field trials with technical Malathion showed it to be highly effective against the budworm at dosages of 4-6 oz/ac. but unfortunately the 6 oz/ac. represented a toxicity rating that was lethal to fish.

The ultra low volume (ULV) concept is extremely simple when based on the premise of insect toxicity and adequate coverage. The material must be toxic to the insect at a certain dosage and the coverage must exceed 10 drops/cm^2 to ensure over 90% mortality. The following chart (Fig. 4) illustrates the ULV concept. The chart is constructed on the basis of drops/cm^2 and volume. Thus one 600 micron (μ) drop per cm^2 is equivalent to a dosage of 1 gallon/acre, where as one 60μ drop is equivalent to 0.001 gal/ac or 1/1000 less in volume. Results from repeated

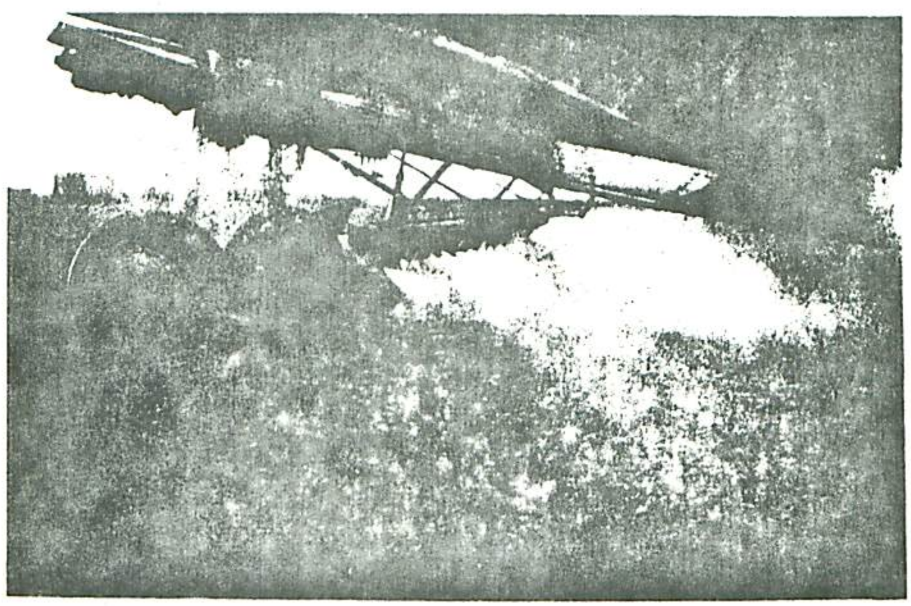

Fig. 1 Stearman aircraft fitted with boom and Spraying Systems' whirljet nozzles.

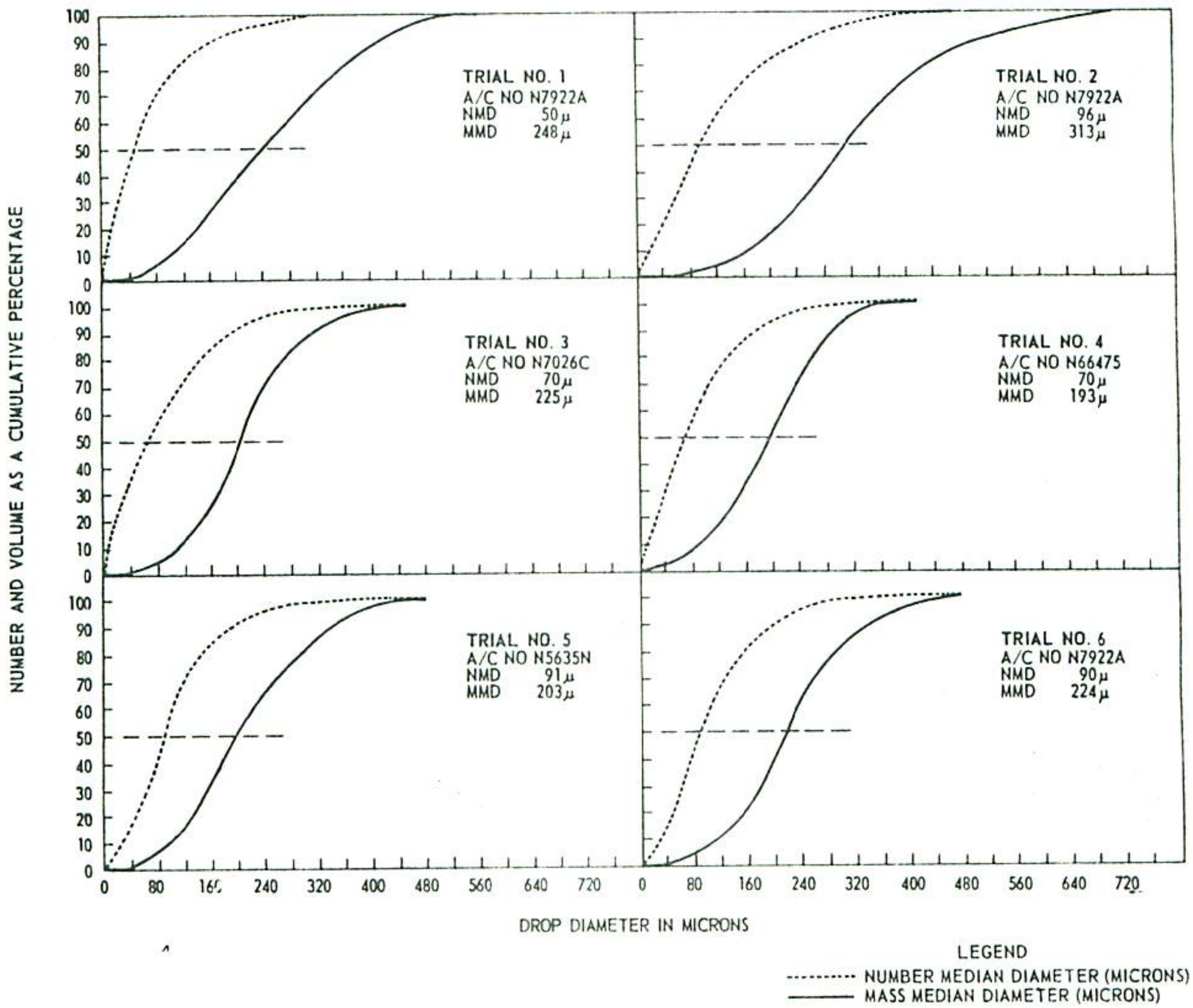

Fig. 2 Frequency distribution of spray cloud in terms of droplet numbers (NMD) and mass MMD).

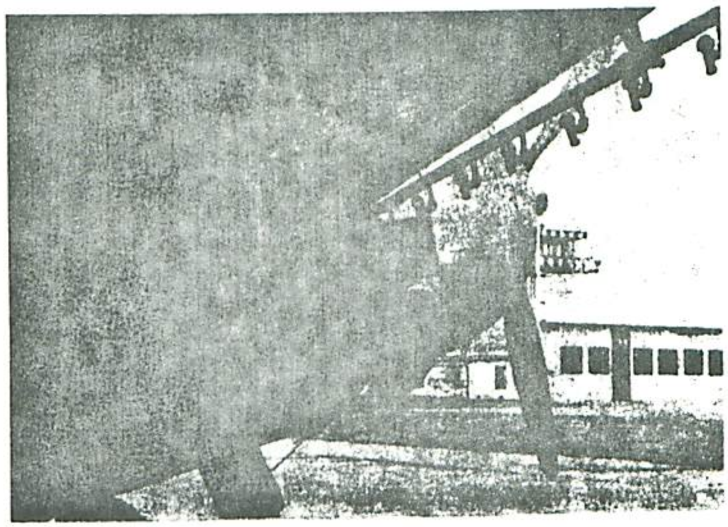

Fig. 3a "TBM" Grumman Avenger fitted with straight pipe emission nozzles.

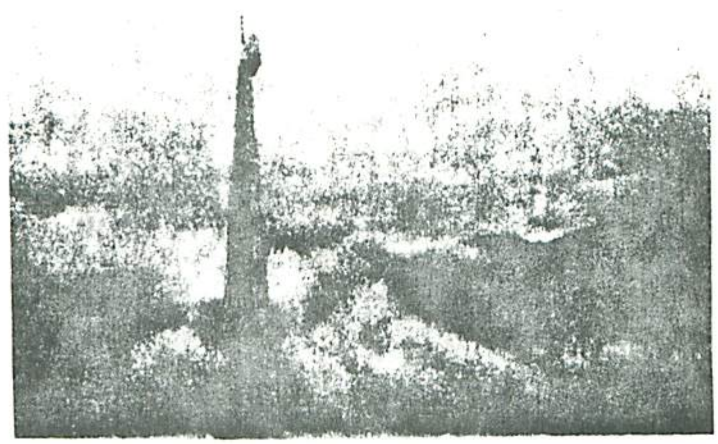

Fig. 3b Tunnel effect of spray cloud as produced by the wing tip vortices during flight.

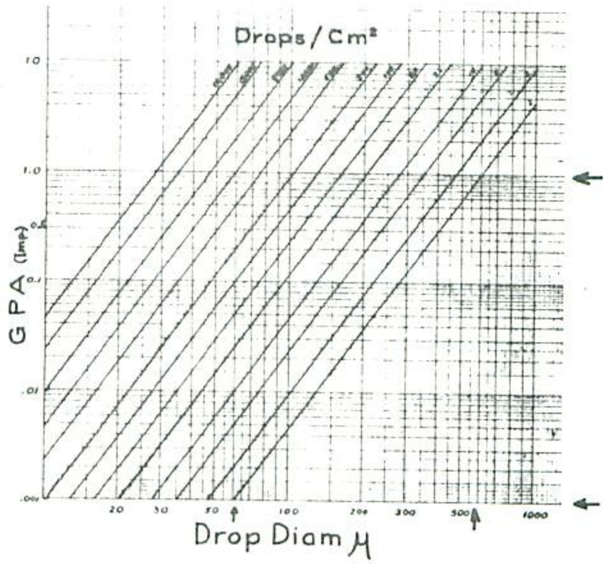

Fig. 4 Relationships of drop size and number/cm^2 in terms of volume.

field tests indicated 10 to 15 drops/cm^2 were sufficient to provide 95% mortality of budworm, thus by decreasing drop size we could increase our coverage and use less liquid.

The ULV spray equipment we tested from 1965 to 1969, included, flat fans, swirl fans, mini spins, turbairs (mk. 1, 2, 3, 4) and the British made AU3000 micronaires. All of the equipment tested proved to be effective. The mechanical devices were far superior to non-mechanical devices such as the swirl fans and flat fans. The mini spin experiments were conducted in 1965. The theory behind the mini spins was very good, but the equipment was poorly engineered and tended to disintegrate in flight. In addition the concentrate insecticides would creep along the shaft into the bearings up through the front of the mini spin and along the blades as shown on the next slide (Fig. 5). Many of our results with the mini spins were extremely interesting and worthwhile because they allowed us to confirm the effectiveness of the ULV concept for forest insect spraying and introduced us to new problems, methods, and concepts.

Our next series of experiments were conducted using the British made Turbair as shown on Figure 6. This particular model Mk.1 was experimental and had to be taped on to the spray boom to test out the principle of the spinning disc method of droplet formation. Many of you are no doubt familiar with the spinning disc apparatus for producing a series of uniform drop sizes. The Turbair uses this principle but has a series of discs mounted on a shaft to produce a larger number of droplets of uniform size, hence a very narrow droplet spectrum. Flat fan nozzles on the other hand produce a broad droplet spectrum thus when the maximum drop size is decreased there is a preponderance of very fine droplets in the fog range which usually are too fine for spray application.

Our early experiments with the Turbair spray nozzles indicated that a great deal more time was needed on the engineering of the equipment. The early Turbair units were under powered and susceptible to internal damage from the insecticides in the same manner as were the mini spins. Streamlining of the brackets reduced drag and turbulence and prevented the impaction of spray droplets on the booms. The later models had the motor offset from the spinning discs and thus removed the flooding problem of the main bearings and motor. The latest development of this type of equipment is shown on the Pilatus Porter aircraft. This aircraft is also fitted with Decca navigation equipment. This combination of S.T.O.L. aircraft, Decca, and Turbair sprayer units represent one of the finest pieces of modern ULV spraying equipment available. The cost factor prohibits the use of such a system in a territory not already Decca chained particularly when the TBM aircraft is still available. I do not think I am wrong in saying that spraying in the future will be a highly scientific affair in which specification such as, mode of application, spray drop spectrum, environmental contamination, ecological tolerance to a pesticide; short and long term effects of chemical on biological systems in that particular environment will be required, plus Department of Transport standards for aircraft, spray equipment and meterological limits for spray application.

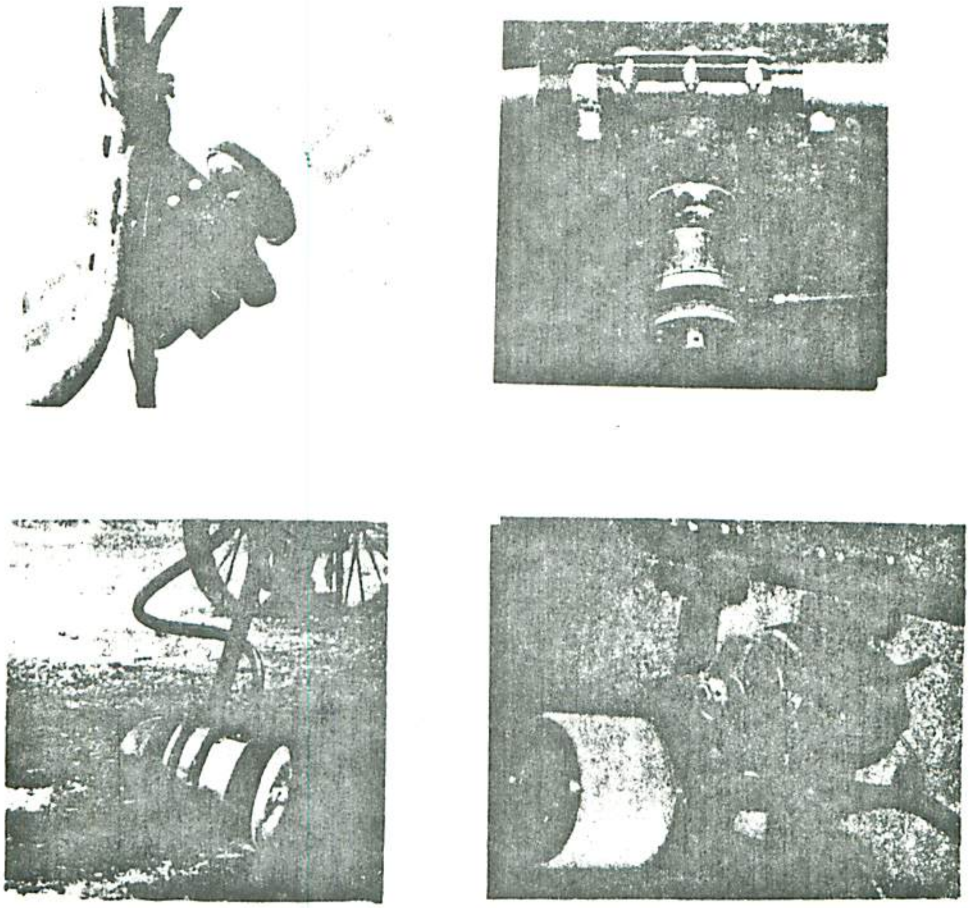

Fig. 6 The Turbair series of ULV spray devices

At this point I would like to bring to your attention the fact that Fairchild Hiller has a Pilatus Porter S.T.O.L. aircraft at the airport. These machines have a record of ULV spraying of 5 million acres/yr.

In 1968-69 we tried out the British made AU3000 Micronair units. It is a well engineered piece of equipment and resembles a large mini spin, as shown in Figure 7. The equipment is mounted on a Grumman Ag. Cat. and can be locked hydraulically while in flight. We experienced some mechanical problems with the early models particularly with the nylon spacers but by and large the equipment is well engineered and can withstand constant usage. The equipment is suitable for ULV application only when the 15" blades were set at maximum rotation and the flow rate per unit reduced to less than 1/2 gallon per unit per minute. Flooding of the units produced droplet size spectrum comparable to that obtained with flat fan nozzles.

I have briefly outlined our program in equipment testing and would now like to summarize the results of this work in terms of insect control. Since most of my efforts have been directed to the control of the spruce budworm in New Brunswick, the results are only applicable to this particular insect and its host trees. Earlier in my talk I mentioned systemic insecticides and the effectiveness of concentrate materials. In the early 1960's, laboratory experiments confirmed that some of the organophosphorus (dimethoate, phosphamidon and sumithion) and carbamates (Zectran) insecticides exhibited systemic activity in spruce and balsam fir foliage. This knowledge provided us with a new approach to the control of the budworm.

The standard method of control, with a residual insecticide such as DDT, depended on having the insect or food source fully exposed to the spray. Thus the timing for DDT application occurred at the 4th instar stage when the insect had emerged from the buds and the new shoots were in the fully flared stage. Usually by this time a considerable amount of defoliation had already occurred and the insect was half way through its larval development. Spray application was therefore committed to a very short period of time which on a large spray operation of 2 or 3 million acres could become one of the critical factors for the success or failure of the spray program.

In our ULV spray program we included a comparison of ULV concentrate sprays versus boom and nozzle spray application using both systemic and residual type of insecticides.

In addition, we expanded our program to include, early (2nd instar) and late (5th instar) spray application for both residual (DDT) and systemic (Phosphamidon, sumithion) insecticides.

The results of our early tests in systems comparison i.e. ULV technical concentrates (mini spin) versus low concentrate high volume sprays using boom and Spraying Systems 8010 nozzles showed no significant difference in insect mortality at 10 to 15 drops/cm^2 as shown in Table 1. The major difference was to be found in volume emitted and flying time i.e. 20 gallons (ULV) versus 200 gallons (boom and nozzle) for plots of similar size (400 acres).

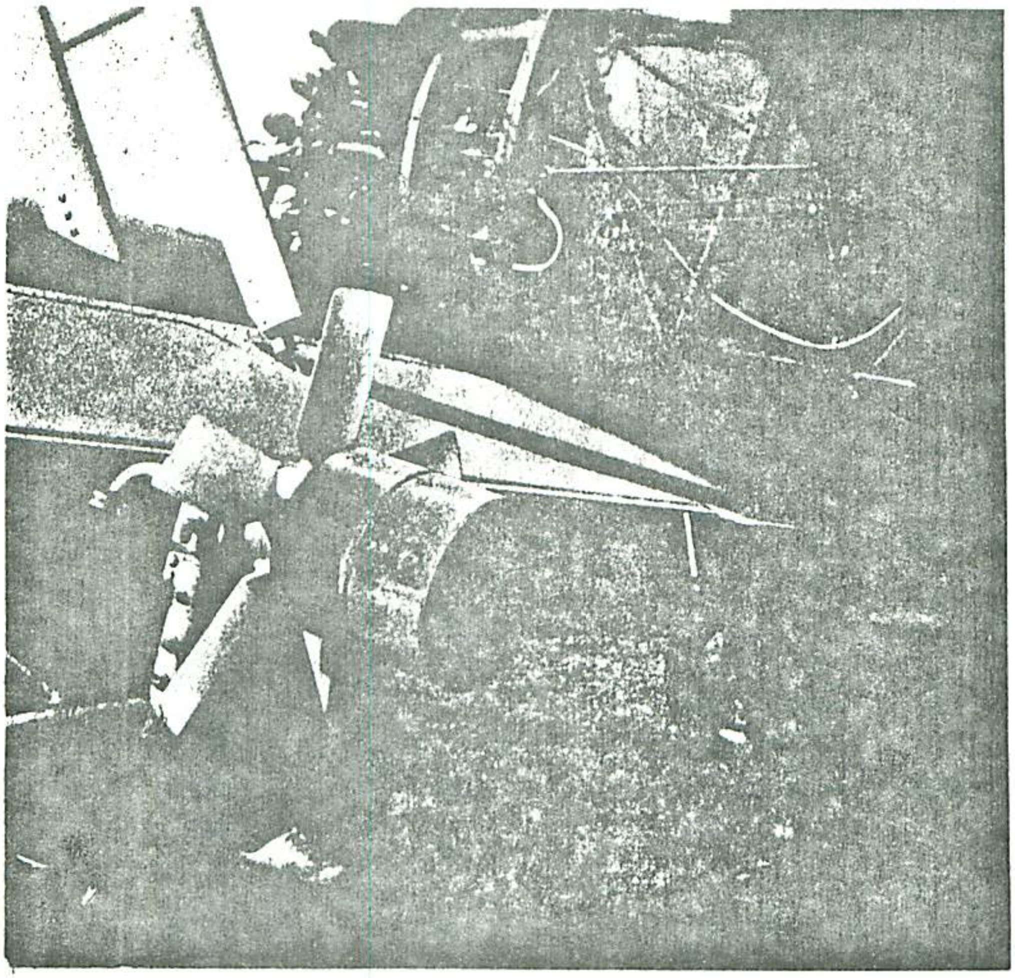

Fig. 7 AU3000 Micronair mounted on a Gruman AgCat.

TABLE I

COMPARISON OF ULV vs. HIGH VOLUME AERIAL SPRAYING
EARLY APPLICATION WITH MICRONAIR UNITS (1968)

Plot	Date Sprayed	Treatment	Spray Category	Drops/cm^2	% Mortality 9-12 day	Instar Sprayed
1	3/6/68	PHOSPHAMIDON 6.25%	BOOM (200 gal.)	5-10 10-15	26% 62%	3rd-39% 4th-51%
2	23/5/68	PHOSPHAMIDON 90%	ULV (15 gal.)	5-10 10-15	54% 53%	2nd-98%
3	2/6/68	DDT 6.25%	BOOM (200 gal.)	10-20 20-30	0% 13%	2nd-33% 3rd-62%
4	28/5/68	SUMITHION 6.25%	BOOM (200 gal.)	5-10 10-15	86% 85%	2nd-74%
5	28/5/68	SUMITHION 98%	ULV (2x10 gal.)	5-10 10-15	70% 85%	2nd-70%
10	19/6/68	DDT 12.5%	BOOM (100 gal.)	10-20 20-30	74% 76%	6th

TABLE II

PROTECTION OF BALSAM FIR AS RELATED TO SPRAY TREATMENT

Plot No.	Date Sprayed	Treatment	Spray Category	% Defoliation by Drop Deposit Class (B.Fir)						
				0-1	1-5	5-10	10-15	15-20	20-30	30-40
1	3/6/68	PHOSPHAMIDON 6.25%	BOOM (200 gal.)	60	58	38	33	--	30	25
2	23/5/68	PHOSPHAMIDON 90%	ULV (15 gal.)	--	40	35	38	18	15	--
3	2/6/68	DDT 6.25%	BOOM (200 gal.)	100	--	73	--	70	58	36
4	28/5/68	SUMITHION 6.25%	BOOM (200 gal.)	61	30	12	6	--	--	--
5	28/5/68	SUMITHION 98%	ULV (2x10 gal.)	48	30	32	15	--	--	--
10	19/6/68	DDT 12.5%	BOOM (100 gal.)	100	--	72	--	68	56	38

A comparison of the effectiveness of systemic versus residual sprays became evident only in the early spray trial in which DDT produced very little control of the budworm (10-15%) where as the systemic insecticides gave a remarkable high degree of control (60-70%). In the late sprays (5th instar) a relatively high degree of budworm control was obtained by both the residual and systemic insecticides.

When the above experiments are analyzed in terms of foliage protection to the host trees, it was immediately evident that the systemic insecticides were far superior to the residual type compounds such as DDT (as shown in Table II). The degree of defoliation that occurred in the early and late DDT plots were approximately the same for spray droplet coverage on a square centimeter base i.e. 40% to 90% defoliation of foliage at 10 drops/cm^2. A similar degree of defoliation occurred in the late systemic insecticide treated plots. In the early treatments, however, the systemic insecticides showed a striking degree of foliage protection which showed a progressive increase for deposit coverages over 15 drops/cm^2.

We in the Institute are intrigued with the systemic insecticides and feel they will play a very positive role in future forest insect control.

Before closing I would like to mention that we have applied Zectran (2 oz/actual/ac.) on a semi operational basis in a cooperative project with Mr. B. Flieger (Forest Protedtion Ltd., N.B.) and Mr. E. Kettela (Department of Fisheries and Forestry, Fredericton, N.B.) The results were very encouraging from the standpoint of insect control and foliage protection.

I have a series of slides that you may find quite interesting since they were taken on location of various spray projects. These I will put through quite rapidly and ad lib as I go along.

May I thank you for the opportunity to attend your meeting and to express some of our findings to you.

Question: What percentage of defoliation will kill a balsam fir?

Answer: It depends on the site, age of tree and number of years of insect infestation. I do not have any percentage figure but under epidemic conditions, three to four years of heavy defoliation will result in the death of the tree. The time interval can be shortened, however, under conditions of extremely high budworm populations (500-1000 egg masses/100 sq. ft. of foliage) and severe back feeding by the larvae in which case more than 100% defoliation can occur. This latter figure would include 100% defoliation of current years growth plus back feeding.

Question: Do you have deciduous defoliators in the same complex?

Answer: Yes, this does occur in mixed stand.

Question: Do you have any figures for the economic return for the input of F.P.L.?

Answer: No, I do not, however, may I suggest that you pose that question to Mr. Flieger.