Plantation Research: X. Experimental Aerial Applications of Methoxychlor and Gardona® for Control of White Pine Weevil (*Pissodes strobi*) in Ontario, 1973

by

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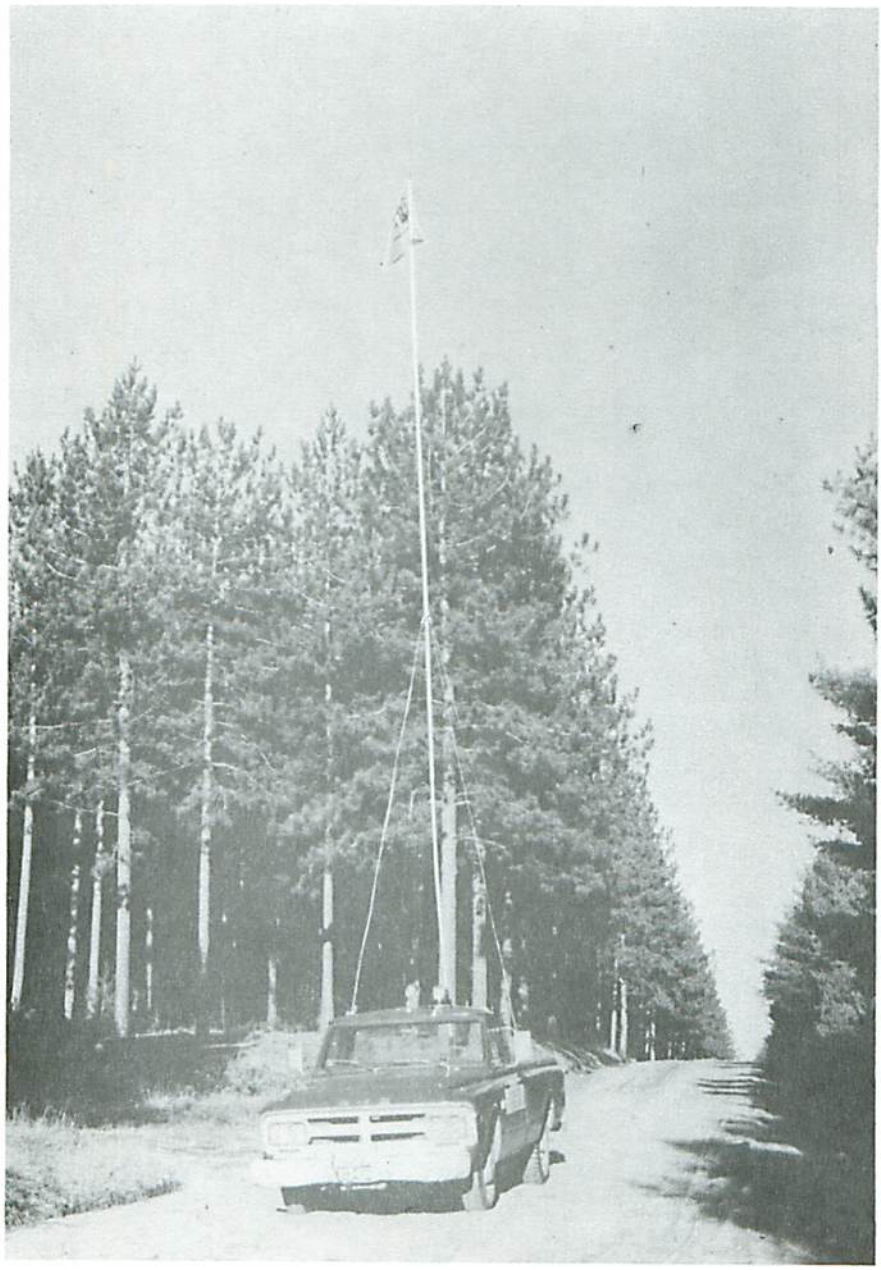

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INTRODUCTION

Previous experiments designed to investigate the suitability of spray treatments for control of the white pine weevil, Pissodes strobi (Peck), have indicated that methoxychlor will provide excellent protection of white pines (Pinus strobus L.) when coverage of spray mixture to the leaders is complete (DeBoo and Campbell 1971, 1972a). Methoxychlor treatments in pine plantations are less effective, however, when sprays are applied as uniformly fine dispersals by aircraft (DeBoo and Campbell 1972b, Howse and Sippell 1972).

Preliminary studies of aerial applications (DeBoo and Campbell 1972b) have shown that 2.5 lb. active ingredient applied in 4 gal. fuel oil/acre can provide satisfactory protection of leaders (i.e. less than 1% weeviling), and that oil-base sprays are superior to water sprays containing equal amounts of the toxicant. The problem of optimum spray coverage by aircraft and the less than ideal residual characteristics of methoxychlor (Sundaram et al 1972), however, may be considered as key factors limiting control of the weevil during operational spray programs. During 1973, therefore, the research study was continued to: (1) further evaluate the importance of spray volumes, formulations and adjuvants, (2) determine the efficacy of Gardona® as a possible alternative insecticide, and (3) evaluate spray deposition by Micronair emission equipment (vs. boom and nozzle equipment used in 1972).

The study was conducted at the Kirkwood Forest Management Unit north of Thessalon, Ontario, in conjunction with the operational spray program of the Ontario Ministry of Natural Resources (OMNR).

MATERIAL AND METHODS

Treatment Areas

White pine plantations located in the Kirkwood Forest Management Unit were selected for treatment on the recommendation of the Great Lakes Forest Research Centre (GLFRC). The plantations were located in Kirkwood and Rose Townships north of Thessalon (Fig. 1). Weevil injury during 1972 ranged from 12 to 21% at these locations, indicating high probability of continued serious leader damage in 1973.

Plantation trees ranged in size from 10 to 25 ft. tall, the growth differential being due mainly to the influence of a scattered hardwood overstory. Untreated check areas for comparison with treatment blocks were located in Rose, Kirkwood and Lefroy Townships. A total of 498 acres were selected for treatment by chemical spray, while 230 acres were reserved as untreated check areas for monitoring leader attack by the white pine weevil.

Spray Formulations

Methoxychlor sprays were mixed as for 1972 experiments (DeBoo and Campbell 1972b) with one exception: all volumes were applied in U.S. liquid measure. Sprays were prepared to give 2.5 lbs. active ingredient (a.i.) at either two or four gallons per acre (gpa). Niagara's Methoxol® 2.4 emulsifiable concentrate was used for aqueous preparations and technical grade methoxychlor was supplied by DuPont Canada Ltd. for oil-base sprays. Water was obtained from the Little Rapids office of OMNR, while No. 2 fuel oil was purchased from the Esso bulk dealer at Thessalon. Rhodamine B and DuPont Oil Red were added as dyes to water and oil-base sprays, respectively, for droplet and deposit analysis.

Two plantations were sprayed with Gardona®, an insecticide which provided good protection of trees during groundspray experiments in Simcoe County (DeBoo and Campbell 1971, 1972a). The Gardona sprays were prepared at 1 and 2 lb. a.i. (each at 2 gal. water-base spray/acre) using the 75% wettable powder formulation.

Target E®, a molasses-type (anti-drift/anti-evaporant) adjuvant, was added to all aqueous spray mixtures at the rate of 4 gal./100 gal.

Spray Mixing and Application Equipment

Facilities for mixing sprays and loading the aircraft were located at an airstrip approximately one mile northeast of the OMNR office at Little Rapids. Mixing and loading equipment was similar to that used during 1972: electric transfer pump, mixer, and the CCRI experimental hydraulic sprayer (Fig. 2, 3). Water was stored in an OMNR tanker, and fuel oil in two 200-gal. tanks supplied by the bulk dealer. An office trailer (CCRI) was used as the airstrip headquarters.

A Stearman biplane fitted with four Micronair AU2000 spray atomizers (Fig. 4) was contracted from Midair (Canada) Ltd. for the applications. The aircraft was calibrated at the airstrip to deliver 2 and 4 gpa in 50-ft. swath widths.

Project Staff

As during 1972, operational ground support staff during the project was composed of members from GLFRC, OMNR and CCRI. The photographic unit at GLFRC was present to film various aspects of the spray operation. The pilot of the aircraft had previous experience with white pine weevil airsprays during the 1972 program in Simcoe County.

Experimental Design

Four plantation blocks approximately 100 acres in size were selected for methoxychlor treatments while two smaller blocks (30 and 60 acres) were selected for treatment with Gardona. All treatments were applied as single-block, unreplicated sprays in the Kirkwood area. Three representative untreated plantations of white pine ranging from 50 to 100 acres in size were selected for comparison with the treated blocks.

Spray Applications

Sprays were applied during periods of satisfactory weather conditions from April 26 to 30 (Table I) in the following sequence:

(1) methoxychlor in water; 2.5 lb. a.i. @ 4 gpa

(2) methoxychlor in fuel oil; 2.5 lb. a.i. @ 4 gpa

(3) methoxychlor in fuel oil; 2.5 lb. a.i. @ 2 gpa

(4) methoxychlor in water; 2.5 lb. a.i. @ 2 gpa

(5) gardona in water; 1 lb. a.i. @ 2 gpa

(6) gardona in water; 2 lb. a.i. @ 2 gpa

All applications were made during morning (0700 to 1015 hrs) or early evening (1800 to 2030 hrs) periods. Weather records (Table I) were obtained from instrument readings at the airstrip during the course of the operations.

The aircraft was guided across spray blocks using two vehicle-mounted flags (title page) along roadways and also, occasionally, using one additional manually-carried flagpole across the centre of the larger plantations. Detail manoeuvering during each treatment was similar to the technique used during 1972 in Simcoe County (DeBoo and Campbell 1972b).

Spray Deposit Analysis

Kromekote cards (65 x 100 mm) and microscope slides (total surface area of 75 cm^2) were placed on aluminum stands at about 30 cm above ground level along roadways and fireguards for chemical and physical analyses of spray deposit. The spray deposit sampling units were spaced at 100 ft. intervals along roadways and fireguards at right angles to the swath direction.

Droplets collected on the cards were counted using a microcard reader for density (number/cm^2) and estimates of spray coverage (diameter range in microns) and volume deposits (oz./acre). The microscope slide droplet collections also were used for colorimetric determination of spray volumes deposited.

Treatment Assessments

The incidence of leader destruction during 1972 (i.e. before treatment) and after treatment in 1973 was used as criterion for estimating efficacy of the aerial sprays on populations of the white pine weevil. Examinations of tree tops were made along transects within each plantation block, but with bias of observations toward trees bordering stand openings. Sampling intensity was set at approximately 1000 trees per 50 acres of plantation. The percent weeviling during each year of attack was calculated and the percentage change in population density was calculated using Abbott's Formula (1925):

$$\text{"Percent" Reduction} = \frac{(\%\ \text{weeviled in 1972}) - (\%\ \text{weeviled in 1973})}{(\%\ \text{weeviled in 1972})} \times 100$$

Spray Residue

As part of a continuing project on pesticide residues (Sundaram et al 1972), leaders from representative trees treated with both methoxychlor

and Gardona were collected periodically for analysis by gas chromatography. The major objective in this study was to determine the residual toxicity of each pesticide when applied to control adult populations of the white pine weevil.

Environmental Impact

Populations of small mammals in treated and untreated plantations were censused for evidence of spray impact using standard trapping procedures (Buckner, McLeod and Ray 1973).

Table I. Aerial spray treatments, plantation descriptions, and meteorological conditions during white pine weevil control experiments, Kirkwood Forest Management Unit, 1973.

Treatment[1]	Plantation		Meteorological Conditions			
	Location (Twp., Block No.)	Size (Acres)	Spray Date (April)	Wind (mph)	Temp. (°F)	R.H.
Methoxychlor 2.5 lb. a.i. in 4 gal. oil/acre	Kirkwood 6	94	29 (a.m.)	0-5	40	60
Methoxychlor 2.5 lb. a.i. in 4 gal. water */acre	Kirkwood 5	112	29 (p.m.) 30 (a.m.)	3-6 2-4	48 36	36 81
Methoxichlor 2.5 lb. a.i. in 2 gal. oil/acre	Kirkwood 3	100	26 (a.m.) 26 (p.m.)	3-7 2-8	45 50	45 33
Methoxichlor 2.5 lb. a.i. in 2 gal. water */acre	Rose 5	100	30 (p.m.)	0-5	43	54
Gardona 2.0 lb. a.i. in 2 gal. water */acre	Rose 2A	30	30 (p.m.)	Calm	46	65
Gardona 2.0 lb. a.i. in 2 gal. water */acre	Rose 2A	60	30 (p.m.)	Calm	50	55

[1] Ranked according to efficacy per Table II

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

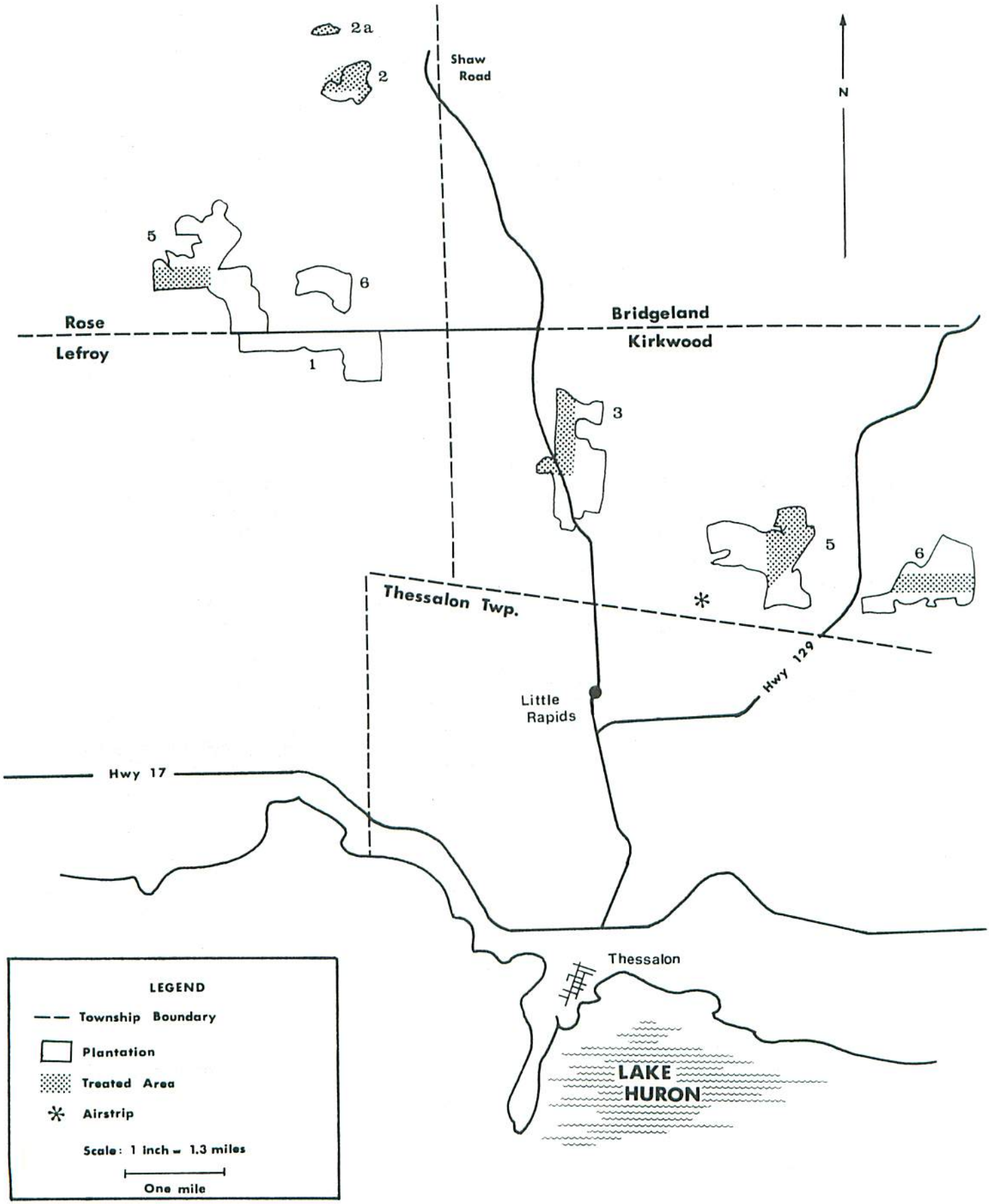

Figure 1. Location of aerial spray areas within the Kirkwood Forest Management Unit (OMNR), 1973.

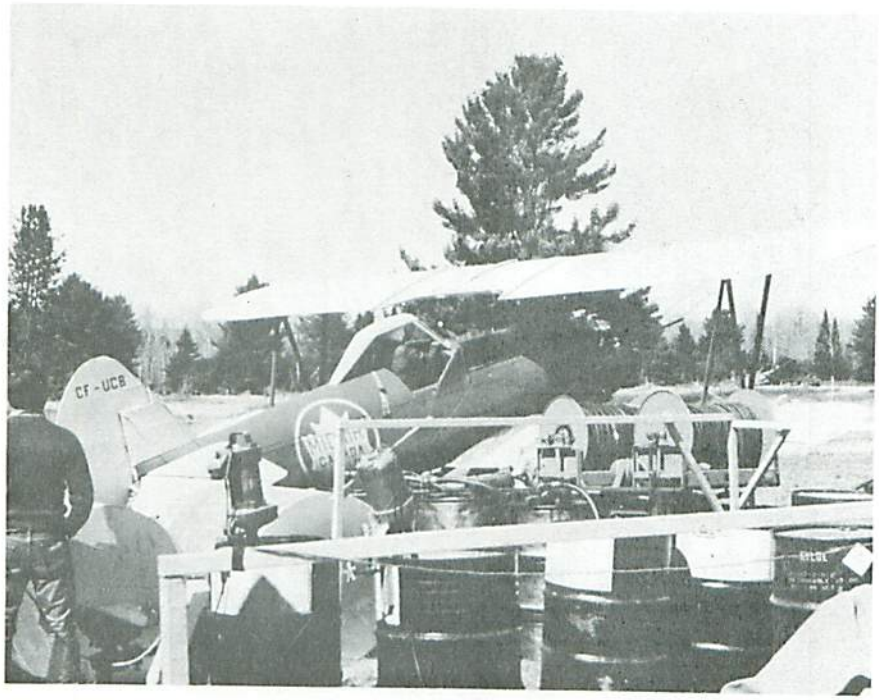

Figure 2. Loading the Stearman at the Kirkwood Forest Management Unit, 1973.

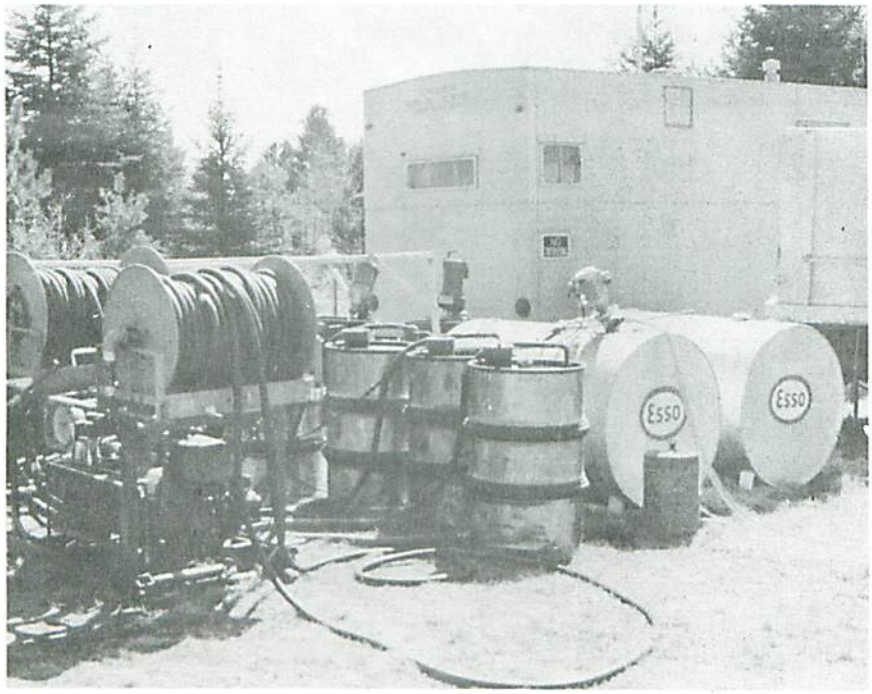

Figure 3. The mobile mixing-loading facility at the airstrip.

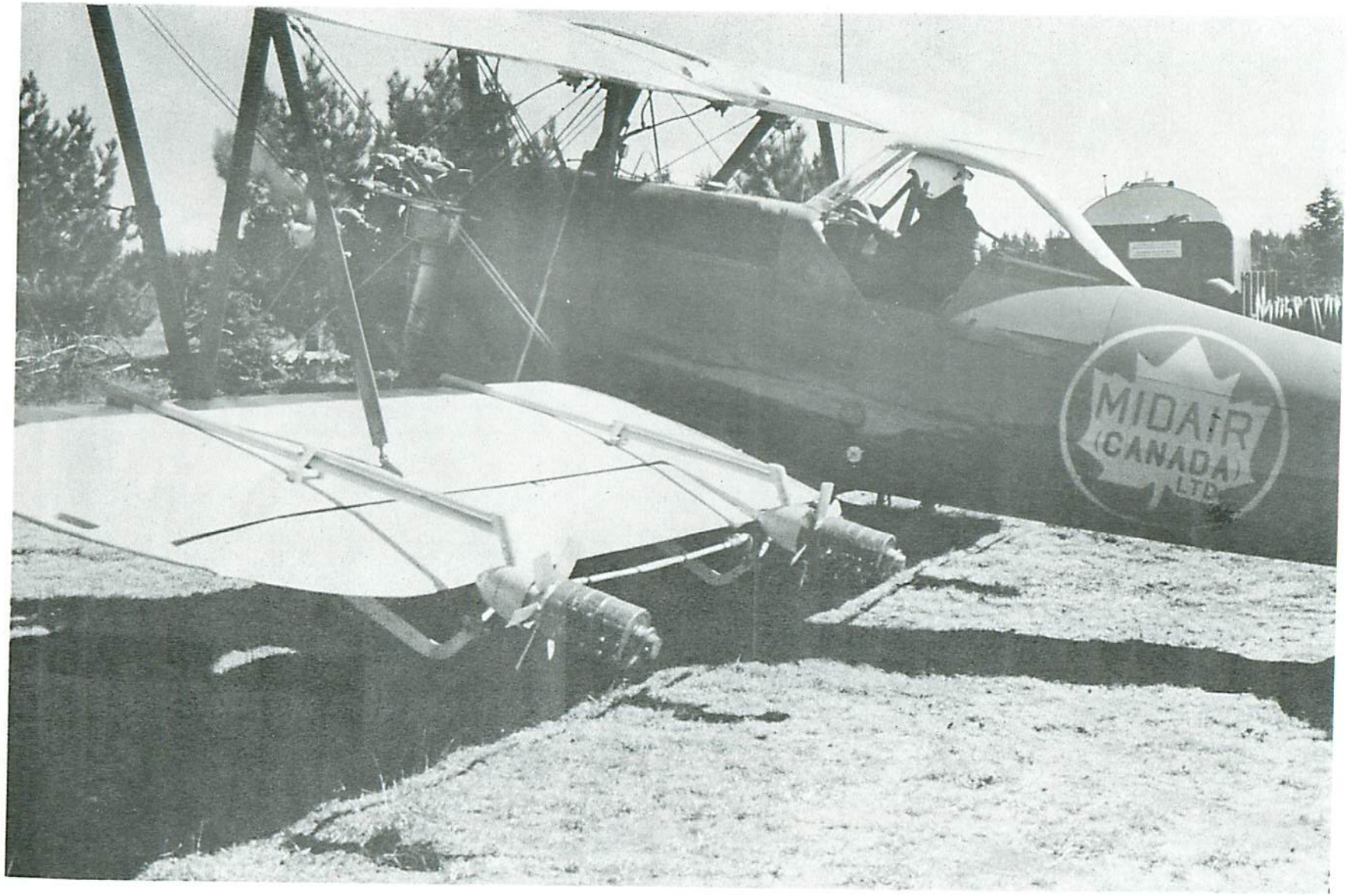

Figure 4. The Stearman equipped with Micronair AU2000 spray atomizers.

RESULTS AND DISCUSSION

Efficacy of Treatments

Results of the aerial applications of methoxychlor (Table II) were in the same order of efficacy as those results obtained from similar experiments during 1972 in Simcoe County"

(1) All applications of methoxychlor (2.5 lb. a.i./acre) at 4 gpa provided greater protection of white pine leaders from weevil attack than at 2 gpa,

(2) Oil-base sprays were more effective than aqueous solutions of equal volume and concentration of toxicant,

(3) The addition of the adjuvant Target E to aqueous sprays did not improve spray efficacy to the levels of leader protection obtained with the oil treatments, but protection was again superior to those levels attained during 1972 using aqueous sprays without the adjuvant (DeBoo and Campbell 1972b).

Methoxychlor treatments in the Kirkwood forest effectively reduced leader damage to within the limits generally acceptable to forest managers. The upper limits of the leader infestation range (i.e. 1-5%) after treatment, however, could be rated unsatisfactory due to the rapid population rebound capability of the weevil and thereby necessitate reapplication of sprays in 1974. Reproductive potential of the weevil and its capacity for reinvasion from nearby infested and untreated stands must be considered, and the probability is great that population densities will increase to levels much greater than 5 to 10% weeviling (as attained after most of the Kirkwood sprays). Accordingly, only that plantation which received 2.5 lb. a.i. in 4 gal. oil/ac. and where weeviling was reduced to 1% might be considered as successfully treated with regard to weevil population control over a two-year or longer

period of time.

The application of Gardona at 2 lb. a.i./2 gal. water/acre was superior to the spray at 1 lb./2gal./acre. The reduction in leader attack, however, was inferior to the results obtained with methoxychlor at 2.5 lb. a.i. in 2 gal. water/acre (Table II).

Spray Deposit Measurement

As mentioned previously, spray emission equipment was changed from boom and nozzle to Micronair AU2000 units for all airsprays at Kirkwood during 1974 (Fig. 5). The major objective of this transition was to obtain a dense (ca 150 droplets/cm^2), uniformly fine dispersal of droplets (ca 100-125μ) to leaders of trees and to non-tree resting sites of weevil adults.

The analysis of droplet deposit indicated that the required droplet size range was achieved during the Kirkwood experiments (Table III). The characteristics as expressed by mass median diameter (MMD) and number median diameter (NMD) suggest that greater droplet break-up is possible with water sprays than oil preparations, a reflection of the physical characteristics of the mixes and the Micronair atomizers as influenced by meteorological conditions.

Evaporation rates and drift of fine droplets are important factors for consideration in all applications utilizing sophisticated spray equipment such as the Micronair system. Both meteorological and swath application parameters may be much narrower than for conventional boom and nozzle equipment. The two factors which limited droplet density (No. of droplets/cm^2) at Kirkwood were considered to have been (1) marginal to poor weather conditions during application (Table I) and (2) a 50 ft. hardwood overstory in most plantations which necessitated an increased emission altitude to about twice the normal

distance above tree tops. Droplet densities ranged far below the objective of 150 or more/cm^2 (Table III).

Deposit of droplets (No./cm^2) at ground level during the boom and nozzle sprays in Simcoe Co. during 1972 (DeBoo and Campbell 1972b) was similar at Kirkwood utilizing the Micronair-equipped Stearman. Because of the droplet size differentials (e.g. Micronair ca. 68-135μ vs boom and nozzle ca. 130-220μ), however, the apparent percentage of the spray volumes collected at ground level in the Kirkwood was about 10 times smaller than those amounts collected in Simcoe Co. Whereas from 17-68% of the sprays were recovered in 1972 using the boom and nozzle equipment, only 2-20% of the sprays were collected at ground-level sampling stations in 1973. The results of both the Simcoe Co. and the Kirkwood FMU spray experiments suggest that the Micronair system will provide excellent coverage of spray droplets in pine plantations, but that very strict observance of weather limitations is required, particularly where the aircraft cannot approach treetops. Accordingly, the 1973 experience suggests that wind limitations might be 3-4 mph and that humidity should be 80% RH or more for successful applications of those described spray mixtures and deposit requirements.

Spray Residues

Analyses of methoxychlor and Gardona residues on leaders of white pine trees samples during 1973 have been reported by Sundaram (1973, 1974). Of particular interest regarding efficacy of spray treatments for control of the white pine weevil was the greatly reduced chemical half-life of methoxychlor when applied by aircraft (5 days) vs. the 2-3 weeks of effective residual activity when the insecticide is applied by ground spray equipment. The rapid decomposition of the small and scattered aerial spray droplets is

suspected to be a reflection of the impact of weathering on both their physical and chemical properties. Similar chemical degradation was found to occur with Gardona airsprays. Residual half-life was also 5 days.

The shortened period of chemical activity which occurs from aerial spray applications also emphasizes once again the importance in timing of sprays to coincide with peak activity of adults during April and May. Sprays too early or too late will be ineffective when the toxicity of the chemical persists for only one week or so.

Environmental Impact of Airsprays

The resident small mammal complex in sprayed plantations was sampled several weeks after applications in April. Species trapped included the southern bog lemming, red-backed vole, woodland jumping mouse, deer mouse, and chipmunk. According to results of observation by staff CCRI's Environmental Impact Group who conducted this project, no deleterious side-effects could be attributed to the methoxychlor and Gardona sprays (B.B. McLeod, personal communication).

Table II. Results of aerial applications of methoxychlor and Gardona® for control of the white pine weevil in the Kirkwood Forest Management Unit, 1973.

Treatment[1]	OMNR Comp. No.	Acres Treated	Leader Injury by white pine weevil				Percent Reduction in Leader Inquiry (Between Years)
			1972		1973		
			No. weeviled/ No. examined	Percent Weeviled	No. weeviled/ No. examined	Percent Weeviled	
Methoxychlor 2.5 lb. a.i. in 4 gal. oil/ac.	Kirkwood 6	94	296/2150	14	28/2710	1	91
Methoxychlor 2.5 lb. a.i. in 4 gal. water */ac.	Kirkwood 5	112	247/2029	12	42/2019	2	83
Methoxychlor 2.5 lb. a.i. in 2 gal. oil/ac.	Kirkwood 3	100	261/2033	13	56/2126	3	78
Methoxychlor 2.5 lb. a.i. in 2 gal. water */ac.	Rose 5	100	329/2015	16	99/2016	5	70
Gardona 2.0 lb. a.i. in 2 gal. water */ac.	Rose 2A	30	106/495	21	36/387	9	66
Gardona 1.0 lb. a.i. in 2 gal. water */ac.	Rose 2	60	184/1069	17	82/1098	7	55
Untreated check	Rose 5 Kirkwood 5 Lefroy 1	230	400/2567	16	398/2560	16	0

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

[1] Ranked according to efficacy.

Table III. Results of spray droplet analysis: experimental aerial applications of methoxychlor and Gardona, Kirkwood Forest Management Unit, 1973.

Treatment[1]	Droplet[2]			
	MMD (μ)	NMD	Avg. No./cm^2	Range (No./cm^2)
Methoxychlor 2.5 lb. a.i. in 4 gal. oil/acre	135	70	21	7-55
Methoxychlor 2.5 lb. a.i. in 4 gal. water */acre	77	38	65	16-114
Methoxychlor 2.5 lb. a.i. in 2 gal. oil/acre	132	75	45	7-92
Methoxychlor 2.5 lb. a.i. in 2 gal. water */acre	68	32	31	12-55
Gardona (R) 2.0 lb. a.i. in 2 gal. water */acre	N.A.	N.A.	N.A.	N.A.
Gardona (R) 1.0 lb. a.i. in 2 gal. water */acre	115	87	19	9-26

1 - Ranked according to efficacy per Table II.

2 - Approximate; not necessarily indicative of droplets at leader heights.

* - Target E added at 4 gal./100 gal. spray mixture.

Figure 5. Application of methoxychlor at 4 gallons spray mixture per acre.

SUMMARY AND CONCLUSIONS

Experimental aerial applications of methoxychlor and Gardona in Ontario during 1973 were designed specifically to acquire additional information on methods and materials for control of white pine weevil infestations in valuable stands of eastern white pine. The results of these experiments and others conducted the preceeding year have indicated that:

(1) Reduction of weevil population densities to acceptable levels (e.g. not more than 1% leader attack after treatment) has been possible using groundspray equipment for treatment of individual leaders. Applications of insecticide by aircraft have been less successful, however, and population reductions in the range of only 50-80% may be expected. Depending upon initial population densities, damaged leader incidence may remain relatively high (e.g. 5 to 10% +) at these levels of "control" thereby necessitating repetitive annual spray programs to ensure tree quality requirements of the forest managers.

(2) Of the several aerial application treatments evaluated to date, only one has provided the level of protection selected as the goal for this study: Applications of methoxychlor at 2.5 lb. active ingredient mixed with No. 2 fuel oil and applied at 4 gallons of spray mixture per acre reduced weevil injury 87% (0.6% weeviling) in 1972 and by 91% (1% weeviling) in 1973.

(3) Spray droplet size, spray coverage to the target area, and the timing of applications were considered to be three of

the most important factors in the successful treatment of pine stands using aircraft. Two spray emission systems have been evaluated during the course of the study: (1) conventional boom and nozzle, (2) Micronair AU2000. The micronair system has provided the optimum droplet size spectrum (100-125μ) but coverage (150 droplets/cm^2) has not been achieved due to losses of spray volume due to drift and evaporation. Narrower range limits of restrictive meteorological conditions (e.g. wind 3-4 mph, high stability factor, humidity 80% RH) may be required to attain the necessary deposit using the Micronair units.

(4) Associated studies of spray residue persistence of methoxychlor and Gardona indicated that effectiveness of the deposits from aerial application may be only one week in length, about one-third the timespan determined for equivalent dosage by ground application. The differential was related to the chemical and physical properties of the small spray droplets.

(5) Assessments of trapped specimens of five species of small plantation mammals indicated that neither methoxychlor nor Gardona airsprays caused measureable disturbance to this population complex.

(6) It is recommended that experimentation continue during 1974 to ultimately achieve the desired level of protection from attack by the white pine weevil.

RÉSUMÉ ET CONCLUSIONS

Les applications aériennes et expérimentales de méthoxychlore et de Gardona effectuées en Ontario en 1973 visaient à accroître les connaissances portant sur les méthodes et sur les substances à utiliser pour lutter contre les infestations de charançon dans les peuplements de pin blanc de valeur économique importante. Les résultats de ces expériences et de celles de 1972 sont les suivants:

(1) il a été possible de réduire la densité des populations de charançon à des niveaux acceptables (pour que par ex., il n'y ait, après traitement, pas plus de 1% des pousses terminales qui soient attaquées) par la pulvérisation au sol des pousses terminales individuelles. Les applications aériennes d'insecticides, ont toutefois connu moins de succès, l'efficacité prévue variant entre 50 et 80%. Pour ce rendement et selon la densité initiale des populations, la proportion de pousses terminales attaquées peut demeurer relativement élevée (de 5 à 10% et plus), d'où la nécessité de répéter les pulvérisations annuelles afin d'atteindre le degré de qualité exigé par les gestionnaires forestiers pour les arbres.

(2) Parmi les types de traitements par pulvérisation aérienne étudiés à ce jour, il n'y en a qu'un seul qui a permis d'atteindre le niveau de protection visé. Il s'agit de pulvérisations de methoxychlore (2.5 lb de substance active mélangée à du fuel-oil N^{O} 2) à raison de 4 gallons de mélange par âcre. Ces applications ont réduit de 87% les dommages causés par la charançon en 1972 (infestation par le charançon: 0.6%) et de 91% en 1972 (infestation par le charançon: 1%).

(3) Parmi les plus importants facteurs de succès pour le traitement des peuplements de pin par pulvérisation aérienne figuraient à notre avis: la grosseur des goutelettes de la substance pulvérisée, la mesure où la surface de la région à traiter est rec ouverte par la pulvérisation et le choix de la période propice aux applications. Au cours de l'étude, nous avons évalué deux dispositifs de pulvérisation: (1) la lance d'arrosage classique (2) le Micronair AU2000. Ce dernier a permis d'obtenir la meilleure distribution de grosseur des goutelettes (100 à 125 μ) mais des phénomènes de dérive et d'évaporation ayant réduit le volume de la substance pulvérisée, il a été impossible de recouvrir la surface dans la mesure voulue (150 goutelettes/cm^2). Pour obtenir le dépôt requis tout en utilisant les dispositifs Micronair, des intervalles plus étroites de variation des conditions météorologiques (par ex., vent de 3 à 4 mi/h, facteur de stabilité élevé, humidité relative de 80%) pourraient être nécessaires.

(4) Des études connexes sur la rémanence des résidus du méthoxychlore et du Gardona pulvérisés ont démontré que l'action des dépôts laissés par la pulvérisation aérienne ne peut durer qu'une semaine, soit environ le tiers de la durée déterminée pour des quantités équivalentes appliquées par application au sol, la différence constatée étant liée aux propriétés chimiques et physiques des petites goutelettes de la substance pulvérisée.

(5) L'étude de cinq espèces de petits mammifères capturés à l'aide de pièges dans la plantation traitée a révélé que ni les pulvérisations de méthoxychlore ni celles de Gardona n'ont affecté ces populations de façon mesurable.

Il est recommandé de poursuivre les expériences en 1974 afin d'atteindre, finalement, le niveau de protection désiré contre les attaques du charançon du pin blanc.

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Mr. R. Young, Midair (Canada) Ltd., Norwich, once again piloted the ancient Stearman with great skill; Mr. R. Khan of the same firm arranged for the allocation of the aircraft.

Quantities of spray ingredients were provided by DuPont Canada Ltd. (methoxychlor), Niagara Chemicals (Methoxychlor), Shell Canada Ltd. (Gardona®), Agway Inc. (Target E®).

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