THE ENVIRONMENTAL IMPACT OF NONYL PHENOL AND THE MATACIL® FORMULATION

PART 2: TERRESTRIAL ECOSYSTEMS

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REPORT FPM-X-36

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

JANUARY 1981

Copies of this report may be obtained from:

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ACKNOWLEDGMENTS

A large number of people assisted in the planning and conduct of the spray trials reported. Special thanks are due to L.B. Pollock, B.F. Zylstra, A. Obarymskyj, J.W. Beveridge, L. Smith and B. Tomkins of the Forest Pest Management Institute for their assistance with aspects of the field application procedures. The study in Quebec could not have been carried out without the outstanding cooperation of Gilles Gaboury of the Quebec Ministère de l'Energie et Ressources and Raymond Sarrazin of the Quebec Ministère du Tourisme, de la Chasse et de la Pêche. Residue analyses were carried out by personnel of the Forest Pest Management Institute's chemistry section under the direction of K.M.S. Sundaram and S. Szeto and by the Quebec Services de Protection de l'Environnement's pesticide laboratory under the direction of G. Mamarbachi. K.L. Mortensen, W. Cameron, M. Dacey, S. Fast and D. McDonough assisted with aspects of the field and laboratory work.

ABSTRACT

Conventional double applications of MATACIL® and seasonal maximum applications of nonyl phenol and MATACIL® had no significant effects on forest songbird populations, and small mammal breeding activity was not affected by the seasonal maximum MATACIL® treatment. Nonyl phenol did not exhibit any apparent insecticidal effects on terrestrial invertebrates inhabiting trees or honey bee colonies, conventional MATACIL® applications caused a moderate knockdown of terrestrial arthropods over a two day period and a seasonal maximum application of MATACIL® resulted in a large knockdown of terrestrial arthropods persisting for a similar period. Field studies were conducted to assess the impact on terrestrial forest ecosystems of aerial applications of MATACIL® at conventional double application and seasonal maximum allowable dosage rates, and of nonyl phenol, an "inert" ingredient in MATACIL® formulations, at a rate equal to the amount of nonyl phenol that is contained in a seasonal maximum allowable dosage of MATACIL® formulation. A review of environmental monitoring of terrestrial organisms in MATACIL® treated forest areas in Eastern North America and of laboratory toxicity data towards honeybees, birds and mammals is included.

RÉSUMÉ

Des applications ordinaires doubles de MATACIL® et des applications saisonnières maximales de nonyl phénol et de MATACIL® n'ont eu aucun effet significatif sur les populations d'oiseaux chanteurs et un traitement saisonnier maximal au MATACIL® n'a pas affecté les activités de reproduction des petits mammifères. Le nonyl phénol n'a montré aucun effet insecticide apparent sur les invertébrés terrestres arboricoles ni sur les essaims d'abeilles; des applications ordinaires de MATACIL® ont causé un abattement modéré des arthropodes terrestres durant deux jours et une application saisonnière maximale de MATACIL® a provoqué un abattement important chex les arthropodes terrestres durant deux jours également. Des études de plein champ ont été effectuées pour évaluer l'impact sur les écosystèmes terrestres forestiers du MATACIL® en applications aériennes ordinaires doubles et à des doses maximales saisonnières a-nsi que du nonyl phénol, un ingrédient "inerte" des formules MATACIL® à une dose équivalente à la quantité de nonly phénol appliquée par un traitement saisonnier maximal au MATACIL®. Le lecteur trouvera un examen du contrôle environnemental des organismes terrestres dans les régions du nord-est de l'Amérique traitées au MATACIL® et des données de laboratoire sur la toxicité de cette formule pour les abeilles, oiseaux et mammifères.

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INTRODUCTION

Large scale aerial applications of insecticides have been used for many years to limit the destruction and damage caused to Eastern Canadian forests by the spruce budworm, *Choristoneura fumiferana* Clem. Aerial forest pest control operations have been continually evolving over this period in terms of the pest control products applied and the application procedures used to disperse them into the forest ecosystem. One of the commercial products used most extensively in spruce budworm control programs in recent years is MATACIL®, containing the carbamate insecticide aminocarb (4-dimethylamino-*m*-tolyl methylcarbamate).

Concerns over the toxicity of nonyl phenol, a component of commercial MATACIL® formulations, to fish, resulted in the Forest Pest Management Institute conducting a field evaluation in 1979 of the environmental impact of this material applied at a rate equivalent to the quantity of nonyl phenol present in the registered seasonal maximum dosage of MATACIL®. A companion study was carried out looking at the effects of a single aerial application of the seasonal maximum allowable dosage of MATACIL®. The aquatic studies carried out in these two programs have been reported by Holmes and Kingsbury (1980), along with reviews of the use of MATACIL® for forest pest control in Canada, its aquatic toxicity and previous aquatics monitoring programs carried out in MATACIL® treated areas. Terrestrial impact studies from these programs are contained in this report along with comparable studies carried out in an area receiving a conventional double application of MATACIL® at the application rate most widely used in spruce budworm control programs.

HISTORICAL PERSPECTIVE

Acute Toxicity Studies with MATACIL®

Laboratory studies indicate that MATACIL® is highly toxic to honeybees. The lethal dosage of MATACIL® in micrograms per bee causing 50 percent mortality has been reported as 1.160 µg/bee when applied to honeybees as a dust (Atkins et al. 1970) and 0.115 µg/bee when topically applied dissolved in acetone (Abdelwahab et al. 1973). In both studies the slope of the log dosage probit line was reported to be lower than 4, indicating a relatively homogeneous effect on the test insects. This suggests that moderate changes in the dosage of MATACIL® applied would only result in small changes in its toxic effects on honeybees (Atkins, 1975). MATACIL® was also found to be highly toxic to honeybees when sprayed on glass plates and placed in the bottom of wooden cages containing worker bees. A 0.195 w/v% concentration of MATACIL® dissolved in acetone sprayed on the plates killed 50% of the bees in 24 hours, showing it to be 11.7 times more potent than DDT when tested in the same way (Abdelwahab et al. 1973).

Acute oral toxicity values reported for MATACIL® technical (approximately 97% AI) tested against avian and mammalian wildlife species fall in the range between 7.5 and 50 mg/kg (Tucker and Crabtree 1970, FCH 1970, Kenaga and End 1974, Lamb and Jones 1975b, Nelson 1978a). MATACIL® formulations containing nonyl phenol exhibit acute oral toxicity to rats roughly proportional to their active ingredient content (Nelson 1978c). Reported LD_{50} values for nonyl phenol to rats are much higher than the values for technical MATACIL® (Jefferson Chemical Co. 1964, ITI 1978). Experiments carried out testing the concentration of technical MATACIL® in food required to cause mortality to ducks, pheasants and quail have shown that concentrations in excess of 1000-2000 parts per million must be ingested where the test organisms are allowed to feed *ad libitum* (Hill et al. 1975, Lamb and Jones 1975a). Experiments involving applying the MATACIL® formulation currently used in Canada to the shaved backs of rabbits (Nelson, 1978d) suggest that it presents a smaller hazard to small mammals through contact effects than through ingestion, as do dermal toxicity studies on nonyl phenol (Fairchild 1977). The acute inhalation toxicity of the MATACIL® formulation currently used in Canada (Nelson, 1978b) indicates that concentrations in air have to reach levels of greater than 2000 ppm of formulation and be present for an exposure period of one hour to exert lethal toxic effects on small mammals.

Toxicity data generated on birds and mammals for MATACIL®, some of its formulations and nonyl phenol is summarized in Table 1.

Monitoring of Experimental and Operational MATACIL® Applications

Field studies on the environmental impact of MATACIL® applied to Canadian forests were initiated in 1971, when semi-operational applications of both wettable powder and oil soluble concentrate formulations containing 0.105 kg AI/ha were monitored in New Brunswick. The Canadian Wildlife Service studied the effects of both formulations on forest songbirds and amphibians, while the Environmental Impact section of the Chemical Control Research Institute (CCRI) studied the small mammal complex within the area receiving the oil soluble concentrate formulation. The results of singing male counts along 4 km transects and observations on individual nests did not indicate any evidence of adverse effects on songbird populations or nestling survival (Pearce, 1971). Census counts and observations on behavior and calling activity indicated there were no apparent effects on adult frog populations (Rick and Gruchy, 1971). Small mammals collected by snapback trapping were mostly meadow voles, *Microtus pennsylvanicus* (Ord) and red-backed voles, *Clethrionomys gapperi* (Vigors), of which 40% were subadults and 89% of the females were in breeding condition, indicating that small mammal reproduction had not been affected by the treatment (Buckner et al. 1973).

Table 1

Toxicities of MATACIL® technical, MATACIL® formulations and nonyl phenol to birds and mammals.

Toxicity tested	Ingredient tested	Organism tested	LD_{50}*	Reference
Acute oral	MATACIL® technical (97%) AI)	Mallard duck	22.5 mg/kg (17.8 - 28.3)	Tucker and Crabtree, 1970
		Ring-necked pheasant	42.4 mg/kg (33.7 - 53.4)	Tucker and Crabtree, 1970
	MATACIL® technical (97.9% AI)	Mallard duck - males	15 mg/kg (8-28)	Lamb and Jones, 1975b
		Mallard duck - females	13 mg/kg (11-15)	Lamb and Jones, 1975b
		Bobwhite quail - males	31 mg/kg (28-34)	Lamb and Jones, 1975b
		Bobwhite quail - females	41 mg/kg (35-48)	Lamb and Jones, 1975b
Lethal dietary concentration**	MATACIL® technical	Mallard duck	2552 ppm	HILL et al. 1975
		Ring-necked pheasant	>2000 ppm	HILL et al. 1975
	MATACIL® technical (98% AI)	Mallard duck	>1000 ppm	Lamb and Jones, 1975a
		Bobwhite quail	>1000 ppm	Lamb and Jones, 1975a
Acute oral	MATACIL® technical?***	Rat	50 mg/kg	FCH, 1970
	MATACIL® technical?	Rat	30 mg/kg	Kenaga and End, 1974
	MATACIL® technical (96.3% AI)	Rat - females	27 mg/kg (23-31)	Nelson, 1978a
	MATACIL® analytical (99.6% AI)	Rat - females	22 mg/kg (19-25)	Nelson, 1978a
	MATACIL® 1.8-585 (19.5% AI)	Rat - females	101 mg/kg (83-127)	Nelson, 1978c
		Rat - males	170 mg/kg (146-200)	Nelson, 1978c
	Nonyl phenol	Rat - males	approx. 600 mg/kg	Jefferson Chemical Co., 1964
		Rat	1620 mg/kg	ITI, 1978
	MATACIL® technical (97% AI)	Mule deer	7.5 to 15 mg/kg	Tucker and Crabtree, 1970
Acute dermal	MATACIL® 1.8-585 (19.5% AI)	Rabbit - females	841 mg/kg (595-1190)	Nelson, 1978d
		Rabbit - males	1190 mg/kg (841-1682)	Nelson, 1978d
	Nonyl phenol	Rabbit	2140 mg/kg	Fairchild, 1977
Acute inhalation	MATACIL® 1.8-585 (19.5% AI)	Rat - females	2.21 mg formulation/ℓ air	Nelson, 1978b
		Rat - males	2.11 mg formulation/ℓ air	Nelson, 1978b

* 95% confidence limits given in parenthesis where available

** expressed as parts per million of compound in *ad libitum* diet calculated to produce 50% mortality in 8 days (5 days of toxic diet followed by 3 of untreated diet)

*** ingredient tested not stated, assumed to be technical material.

A semi-operational application of an oil soluble concentrate formulation of MATACIL® containing 0.052 kg AI/ha was studied by CCRI in 1972 near Maniwaki, Quebec, to determine effects on songbirds and small mammals (Buckner et al. 1973). Similar very low songbird populations were found on the MATACIL® plot before and after application. Small mammal trapping captured primarily red-backed voles and white-footed mice, *Peromyscus maniculatus* (Wagner), with age class structure and reproductive status of adult females indicating normal breeding populations. The following year (1973) studies were carried out in an operational spray block near Menjou Depot, Quebec receiving a 0.052 kg AI/ha application of MATACIL® after an initial application of fenitrothion (Buckner et al. 1975). Limited post-spray bird census data suggest that the treatments may have affected some species of birds, particularly the bay-breasted warbler, *Dendroica castanea* (Wilson). Very low populations of small mammals were found in both treatment and control areas, but the age class structure and breeding condition of the animals sampled from both areas were similar. Honeybee colonies moved into the area prior to the MATACIL® application suffered heavy but short lasting mortality of foraging bees, but all hives returned to normal activity within five days and hive strength and honey production appeared normal by the end of the season.

In 1974, the environmental impact section of CCRI studied the effects of MATACIL® applied experimentally at 0.070 kg AI/ha to a 930 ha block of the Larose County Forest near Ottawa, Ontario (Buckner et al. 1975) and applied operational at 0.052 kg AI/ha to large blocks near Parent, Quebec (Buckner and Sarrazin, 1975). Forest songbird populations remained relatively constant over the treatment periods in most of the bird plots censused, although some apparent reductions in populations of ruby-crowned kinglets, *Regulus calendula* (Linnaeus), and some warbler (Parulidae) species were noted. Very low small mammal populations were encountered in all the treated and untreated control areas studied. Caging studies, censuses and observations on adult frogs within the Larose Forest treatment area did not indicate any adverse effects. The early morning-late evening MATACIL® application to Larose Forest did not result in any observable effects on honeybee colonies, apparently because foraging bees were not actively flying during the period of greatest insecticide concentration in the environment.

The Canadian Wildlife Service studied the impact of a spray regime in New Brunswick in 1975 involving two applications of MATACIL® at 0.052 kg AI/ha with an intervening application of 0.175 kg fenitrothion/ha (Pearce et al. 1976). They found no effect following the first treatment, some after the fenitrothion application and a marked decrease in birds following the second MATACIL® spray based on counts of singing males along line transects. They suggested this indicated an impact due to accumulative effects from multiple spray applications. The same year MATACIL® was applied experimentally in Maine at an application rate of 0.170 kg AI/ha. Brain cholinesterase

measurements taken from birds, small mammals and frogs collected before and after the MATACIL® application showed a significant decrease after treatments among woodland jumping mice, *Napeozapus insignis* (Miller), and red squirrels, *Tamiasciurus hudsonicus* (Erxleben), but not for deer mice or any of the bird or frog species sampled (Peterson, 1976). The same applications were judged not to have had significant effects on spruce budworm parasites or other non-target arthropods based on examination of budworm larval collections, drop box catches and Malaise trap sampling (Simmons, 1976).

The Canadian Wildlife Service monitored forest songbirds by singing male counts along line transects in spray blocks in New Brunswick in 1976 where double applications of 0.090 kg AI/ha of MATACIL® followed prior applications of fenitrothion or phosphamidon. They concluded that the MATACIL® applications appeared to have little additional impact on birds beyond the effects of the initial organophosphate applications (Pearce et al. 1979). The same year, the Quebec Department of Tourism, Fish and Game carried out breeding bird census on a number of plots within spray blocks in Quebec receiving one or two applications of MATACIL® applied at 0.052 kg AI/ha and concluded that breeding bird populations were not affected (Sarrazin, 1976). A portion of a Quebec spray block inadvertently sprayed with this dosage of MATACIL® morning and evening of the same day was examined for indications of effects on the resident avian populations, but none were found even though MATACIL® residues found on spruce foliage indicated an above normal concentration of insecticide (McLeod et al. 1976).

MATACIL® was tested experimentally as an adult spruce budworm control agent in early July of 1976 in Acadia Forest, New Brunswick. Three successive applications of 0.070 kg AI/ha at two-day intervals did not result in noticeable reductions in bird populations, but a short lived decrease in activity was noted following the second application and a single bird exhibiting symptoms of pesticide intoxication was found (Buckner et al. 1976). The same adulticide trials caused a heavy knock-down of flying adult budworm parasites (Varty, 1976).

Extensive environmental monitoring of MATACIL® applications took place in Eastern Canada in 1977 in conjunction with spruce budworm control programs carried out in Quebec, New Brunswick and Newfoundland. Minor effects of MATACIL® applications of 0.075 kg AI/ha on certain forest canopy dwelling birds, particularly the ruby-crowned kinglet, were found on a small number of the plots monitored in Quebec, apparently because of the combined effects of severe early spring weather and the additional stress imposed by the insecticide (Sarrazin, 1977). No immediate bird mortality, influence on song frequency among various families of birds or rearing failures on approximately 100 nests located were found in areas of New Brunswick treated with single or double applications of MATACIL® at 0.052 to 0.070 kg AI/ha (Varty, 1978). In Newfoundland, forest songbirds were studied in areas treated with MATACIL® at the relatively high application rates of 2 x 0.087 and 3 x 0.070 kg AI/ha, but no damage to bird populations was found by breeding bird census (Buckner and McLeod, 1977) or mist-netting studies

(Environmental Monitoring Committee, 1979a). Small mammals collected by snap-trap from MATACIL® spray blocks in Quebec and New Brunswick included sizeable proportions of young of the year and adult females in breeding condition, suggesting that small mammal populations had not been affected (Sarrazin 1977, Varty 1978). Shrew populations, *Sorex cinereus* Kerr, were sampled from treatment and control areas in Newfoundland by pitfall traps. Smaller numbers of individuals and smaller proportions of juvenile were captured on treated plots than control plots, but the differences were not significant when tested statistically (Environmental Monitoring Committee, 1979a).

Extensive studies on a variety of non-target arthropod groups were carried out in MATACIL® treated areas of New Brunswick in 1977 (Varty, 1978). The first of two applications of 0.070 kg AI/ha caused light mortality to foraging honey bees and reduced pollen collection for two days, but no further effect was evident following the second application and overall colony vigor was not substantially reduced. MATACIL® sprays did not affect bumble bee queens held in exposure cages or worker longevity, caste production or reproductive success of established queens. It was concluded that conventional MATACIL® treatments pose no hazard to bumble bees and probably not to solitary bees. Spruce budworm parasitism was not detrimentally affected by various spray regimes, but MATACIL® sprays did inflict heavy mortality (60-70%) on populations of spiders and chalcid wasps and moderate mortality (40-50%) on beetles and ichneumonoid wasps, as determined by drop-tray and branch beating collections. It was concluded that these measurements indicated that the insecticide treatments had not produced drastic changes in either parasitism or predation processes within treated stands. Non-target arthropod collections made by sweeping shrubs and beating trees indicated average reductions in populations of approximately 15% in areas of Newfoundland treated with MATACIL® at 2 x 0.087 and 3 x 0.070 kg AI/ha, when compared to control areas (Environmental Monitoring Committee, 1979a). There was no evidence indicating any permanent or long-term impact on any of the arthropod populations studied.

Extensive areas of Eastern Canada were again sprayed with MATACIL® in 1978, and a great deal of environmental monitoring was conducted within these areas. Operational applications of MATACIL® in Quebec at dosages of 0.052 and 0.070 kg AI/ha were not found to cause any adverse effects on avifauna, including any impact on kinglets which were specifically looked at as an indicator species (Sarrazin, 1978). Intensive songbird census studies by FPMI on plots receiving 0.052 kg AI/ha of MATACIL® timed to different stages of budworm development did not indicate any effects on birds but did show that very few birds had migrated into the area prior to 50% emergence of second instar budworm (Kingsbury and McLeod, 1979). In similar studies, the same application rate of MATACIL® was found not to affect songbirds when delivered by either super constellation or DC-3 (Kingsbury and McLeod, 1980). Double applications

of 0.070 kg AI/ha MATACIL® were monitored in New Brunswick in 1978 by Avifauna Ltd., an environmental consulting firm with considerable expertise in songbird studies. Their report concluded that no evidence could be found showing a reduction in numbers of birds of any of the 20 species studied, which could be related to the insecticide applications (Germain and Morin, 1979). Songbird censuses in similar spray regimes in Newfoundland also failed to detect any adverse effects on populations, and mist netting studies indicated highly stable populations (Environmental Monitoring Committee, 1979b). They did, however, indicate a lower production of birds of the year from sprayed areas as compared to untreated areas, which was suggested as possibly resulting from a lack of insect food during a critical period of nestling growth. Forest songbirds were studied by a spot mapping method of censusing singing male songbirds within an area in Maine treated with 0.168 kg AI/ha of MATACIL® in 1978 (Brown, 1978). No effects on bird activity or populations were found and successful nesting and hatching activity was documented on a number of nests observed within the treated area.

Snap back trapping of small mammal populations in MATACIL® treated areas of Quebec in 1978 produced a very high (90%) proportion of young of the year and showed a healthy breeding status for the adult females captured (Sarrazin, 1978). Pitfall trapping of masked shrews within sprayed areas in Newfoundland did not show evidence of any impact on shrew populations resulting from the treatments (Environmental Monitoring Committee, 1979b). Snap back trapping within the relatively high dosage MATACIL® treated area in Maine produced identical numbers and similar sex and age ratios among small mammal populations as within the untreated control area (Brown 1978).

The incidence of parasites within spruce budworm 4th and 6th instars and pupae was studied in treated and untreated areas of Quebec in 1978 (Sarrazin, 1978). There were no significant differences in rates of parasitism within the areas studied except for a lower incidence of one pupal parasite (*Phaeogenes*) within one portion of treated area sampled. This same parasite was found in the same proportions in budworm pupae sampled from treated and untreated plots in other regions of Quebec receiving similar MATACIL® treatments, indicating the difference found was not a result of the insecticide treatments. MATACIL® applications in New Brunswick in 1978 did not kill caged adult bumble bees or affect reproduction of the insect-pollinated plant species studied, but a possible low level effect on solitary bees was suggested (Plowright and Rodd 1980). In another study Malaise trapping and counts of flower visitations did not indicate any reductions of solitary bees within MATACIL® treated areas, but fruit-set on rhodora and blueberry was low within these areas compared with that in an untreated control area (Varty, 1980). Malaise trap and sweep net catches within MATACIL® treated areas of Newfoundland in 1978 give no clear evidence of impact on any of the non-target arthropods sampled despite a major impact on budworm populations (Environmental Monitoring Committee, 1979b). It is suggested that the

reason for this may have been that under the conditions of application the MATACIL® acted primarily as a stomach poison and had relatively little contact effect. Extraction of soil arthropods from soil samples from treated and control sites did not indicate any significant effects of MATACIL® on this group of organisms during the 1978 Newfoundland spray program. Malaise trap catches within the plot in Maine treated with 0.168 kg AI/ha of MATACIL® indicated a temporary reduction in Ichneuman wasp populations after the treatment with recovery evident within a month (Brown, 1978). No effects on soil macroinvertebrates were apparent from pitfall trap catches within the treated area.

Some environmental monitoring studies carried out in MATACIL® treated areas of eastern Canada in 1979 have been reported to date. An extensive forest songbird monitoring program was carried out by Avifauna Ltd. in New Brunswick in which some 2,500 birds of 12 selected indicator species were identified in territories and monitored for singing activity over the period of spray application (Germain and Tingley, 1980). The general conclusion from this study was that MATACIL® applied at 0.070 and 0.085 kg AI/ha did not drastically alter the frequency of bird songs and did not affect the number of birds in treated areas. Forest songbird monitoring studies within MATACIL® treated areas in Northern Ontario did not reveal significant impacts on song bird communities with the exception of territorial abandonment by one species, the Tennessee warbler *Verivora peregrina* (Wilson), on one of the three treatment plots studied (MacCallum, 1980). Extensive mist netting studies carried out in Newfoundland in 1979 in areas treated with MATACIL® the previous year and in untreated areas suggested that even in the absence of spraying in 1979, there were lower rates of production of juvenile birds in previously sprayed areas than in unsprayed areas (Environmental Monitoring Committee, 1980). It is postulated that this may be due to reduced levels of budworm in these areas resulting in less available food for insectivorous bird species to utilize in producing young.

Non-target arthropod studies in New Brunswick in 1979 showed that bee activity and blueberry fruit set in fields closest to MATACIL® spray blocks were similar to or above the average of other years, indicating no serious effect on blueberry pollinators occurred (Varty, 1980). Spider densities in forest plots treated with MATACIL® three consecutive years were higher in 1979 than in 1977 or 1978, despite heavy knockdown of certain species caused by insecticide treatments. Studies of soil arthropod populations in Newfoundland in 1979 demonstrated lower population densities on sites treated with MATACIL® the previous year than at untreated sites, but the influence of inherent differences in the sites is suggested as a possible cause of the different populations found (Environmental Monitoring Committee 1980). No major impacts on non-target terrestrial plant-dwelling arthropods were observed the year after treatment with MATACIL®.

STUDY SITES AND APPLICATION PROCEDURES

Conventional Double Application of MATACIL®

A small (40 ha) forest plot in the vicinity of Wawa, Ontario received a double application of MATACIL® in the spring of 1979 as a standard treatment with which to compare the efficacy of experimental insect growth regulator treatments and the environmental impact of the MATACIL® solvent (nonyl phenol). The plot was located 33 km north of Wawa along the Trans Canada Highway 17 (Fig. 1), in a mixed forest stand of mainly black spruce, *Picea mariana* (Mill.) BSP., balsam fir, *Abies balsamea* (L.), and white birch, *Betula papyrifera* Marsh. Black spruce was the most prominent canopy species. The bird plot was situated in a low, wet area bordered on the east by the highway and on the west by a lake. Very little understory existed over most of the plot, except for a thick tangle of bushes and shrubs enclosing what was probably an intermittent stream. Honeybee (*Apis mellifera* Linnaeus) colonies were located approximately 200 meters east of the highway in a partially cut area of forest, where the surrounding vegetation provided considerable protection from the wind, but little overhead cover.

A control bird plot was set up on the east side of Highway 17, 9 km north of the spray block (Fig. 1). The forest type was very similar to that of the treatment plot but with less balsam fir and a larger proportion of white birch and jack pine, *Pinus banksiana* Lamb. The lower canopy was fairly scant, with few young trees or shrubs.

The control honeybee colonies were located approximately 7 km south of the treatment block in an old abandoned gravel pit, which lay adjacent to a small lake (Fig. 1). These colonies were only partially sheltered from winds and had no overhead cover. The forest type was similar to the treated area but with a greater abundance of shrubs in the immediate vicinity of the colonies.

MATACIL® (0.070 kg AI/ha) was applied to the plot at an emitted dosage rate of 4.7 ℓ/ha on the evenings of 15 and 18 June. Applications were made by Cessna Agwagon fitted with a Micronair spray emission system, contracted from General Air Spray. A small amount of automate B dye was added to both applications to facilitate deposit assessment. The formulation applied was the same for both applications:

MATACIL®[1]	15.78 ℓ	(8.3% by volume)
Insecticide diluent 585[2]	169.66 ℓ	(89.7% by volume)
Automate "B" dye[3]	3.79 ℓ	(2.0% by volume)

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[1]1.8-D oil soluble concentrate, Chemagro Ltd., Mississauga, Ontario.

[2]Shell Canada Ltd., Toronto, Ontario.

[3]Morton Williams Ltd., Ajax, Ontario.

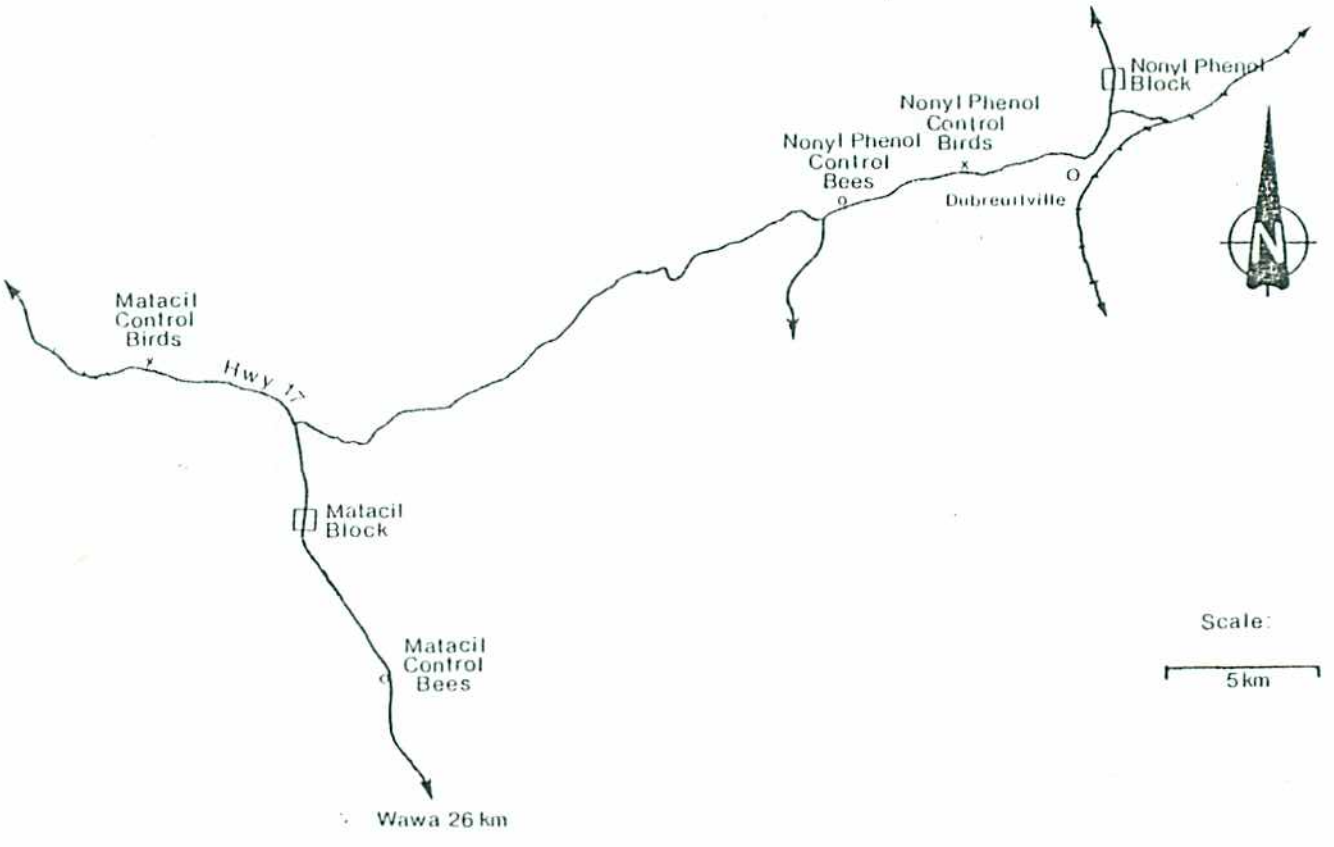

Figure 1: Location of terrestrial studies in Wawa-Dubreuilville area. Aerial view.

Both the 15 June and 18 June treatment began shortly after 21:00 hours, taking about 26 minutes to complete. The plane flew in an east-west direction across the highway, working from the north end of the block southwards. Mean weather conditions prevailing during the period of application were:

	Temperature (°C)	Relative Humidity (%)	Wind speed (m/sec)	Pressure (mb)	Stability Ratio
15 June	19.8	79.0	0.65	964.5	-2.45
18 June	20.0	43.6	2.32	1005.2	+7.07

Seasonal Maximum Application of Nonyl Phenol

The nonyl phenol studies were carried out in Algoma District, Ontario, just north of the Dubreuilville airstrip (Fig. 1). A 40 ha rectangular block centred on a small, unnamed stream flowing into the Magpie River 3 km north of the town of Dubreuilville was the site of terrestrial studies, while the stream itself was used for the aquatic studies reported in a companion report (Holmes and Kingsbury, 1980).

A 4-hectare bird census plot was set up within the nonyl phenol treatment block on the south side of the treatment stream between the Magpie River and the access road. The bird plot was located in a mixed stand of second growth jack pine and trembling aspen, *Populus tremuloides* Michx., with scattered white birch and black spruce. An untreated control bird census plot was set up about 6 km southwest of the treatment plot along the Dubreuilville road. The plot was located on uneven terrain, falling off to a stream on the north and west sides. The stand had been selectively cut; second growth species were white birch, black spruce, balsam fir, and speckled alder in order of predominance.

Two colonies of domestic honeybees, *Apis mellifera* L., were set up near the centre of the nonyl phenol treatment block and two colonies were set up along the Dubreuilville road about 10 km to the west to serve as untreated control.

The environmental impact studies carried out were designed to evaluate the effects on non-target fauna of exposure to the highest dosage of nonyl phenol that would be applied to forested areas under actual operational pest control programs. To this end, the dosage of nonyl phenol applied to the plot was 0.47 ℓ/ha, equivalent to the quantity of nonyl phenol applied to an area receiving the seasonal maximum allowable dosage (a total of 0.175 kg AI/ha applied in two 0.088 kg AI/ha applications) of aminocarb formulations containing this solvent. The conventional total emission rate of 1.46 ℓ/ha was duplicated by mixing the nonyl phenol in an appropriate quantity of

insecticide diluent 585. A small quantity of Automate "B" red dye was added to the spray mixture to facilitate deposit assessment.

The actual spray mixture consisted of:

Nonyl phenol[1]	30.28 ℓ	(32% by volume)
Insecticide diluent 585[2]	62.46 ℓ	(66% by volume)
Automate "B" dye[3]	1.89 ℓ	(2% by volume)

Spraying was carried out using a Cessna 185 Sky Wagon equipped with micronairs. The aircraft delivery system had been previously calibrated to emit 1.46 ℓ of spray liquid per hectare based on a swath width of 60 m; aircraft speed of 177 km/hr; spray pressure of 40 p.s.i.; and a variable restrictor unit (VRU) setting of 8.

Spraying commenced on 29 May, 1979 at 0710 hours on the south (down-wind) side of the block and then progressed at 60 m swaths to the north (upwind) side of the block. The spray application was made under complete cloud cover and cool, calm conditions. Mean weather prevailing at canopy height (12 m) over the period of spray application were a temperature of 8.5°C, relative humidity of 98%, wind speed of 0.72 m/sec and atmospheric pressure of 974.4 mb.

Seasonal Maximum Application of MATACIL®

The study of a seasonal maximum application of MATACIL® was conducted in a 400 ha spray block located in Tenebonne County, near St.-Donat-de-Montcalm, Quebec (Fig. 2). The treatment bird plot was situated in a low, flat area of the block, bordered by several small streams. Selective cutting over most of the area produced an open stand of mainly second growth. Predominant species of this mixed stand were balsam fir (L.) Mill., white spruce, *Picea glauca* (Moench) Voss., tamarack, *Larix laricina* (DuRoi) K. Koch, white birch, and speckled alder, *Alnus rugosa* (DuRoi) Spreng. The diversity of trees and shrubs within the plot was suitable for a variety of bird species.

The control bird plot was also situated in a mixed stand about 3 km west of the treatment block. However, this stand had not been disturbed and was therefore closed, with mature trees. Drainage over the plot was superior to that of the treatment plot. The predominant species were balsam fir, white spruce, white birch and red maple, *Acer rubrum* L.

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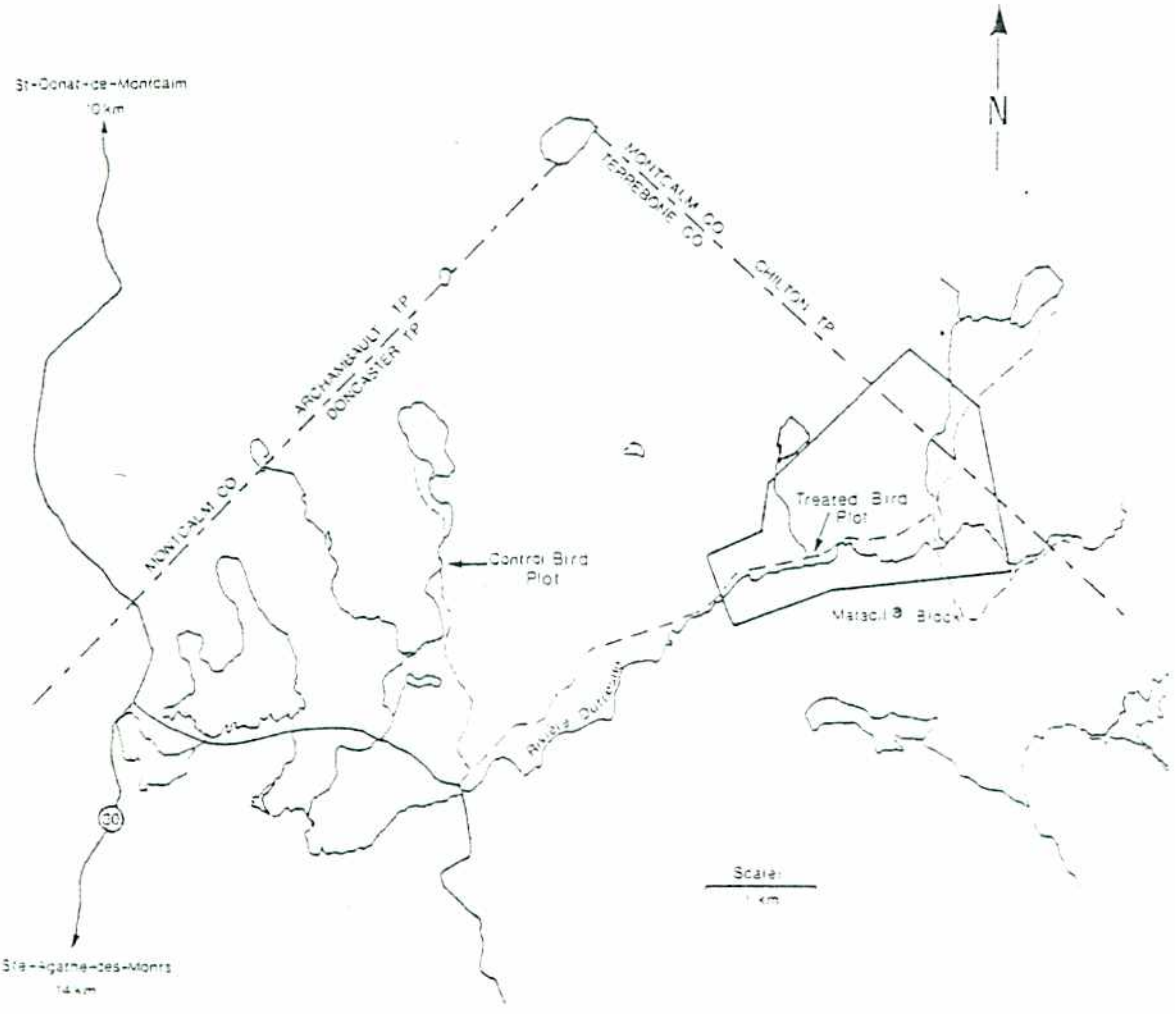
[1]Rohm and Haas Canada Ltd., West Hill, Ontario.

[2]Shell Canada Ltd., Toronto, Ontario.

[3]Morton Williams Ltd., Ajax, Ontario.

Fig. 2 MATACIL® BLOCK LOCATION

Aerial View



MATACIL® was applied to the treatment block on the evening of 28 June 1979 at the rate of 0.175 kg AI/ha in a total emitted volume of 2.19 ℓ/ha. Mixing and loading was carried out by personnel from the Quebec Ministére de l'Energie et Ressources with the proportions of ingredients in the spray formulation being:

MATACIL®[1]	47.5% by volume
Insecticide diluent 585[2]	52.0% by volume
Automate "B" dye[3]	0.5% by volume

The Forest Pest Management Institute's Cessna 185 spray aircraft was used for the application. The aircraft speed was approximately 160 kph at a height of 20 m above the tree tops, with a spray swath width of 50 m, a boom pressure of 40 p.s.i. and a VRU setting of 11. The spray was applied to the treatment block in two loads between 1935 and 2030 in the evening of 28 June 1979. Mean weather measurements at the airstrip over the period of application were a temperature of 17.6°C, relative humidity of 89% and a wind speed of 1.76 m/sec.

METHODS

Deposit Assessment Spray deposits within the conventional double application of MATACIL® block and nonyl phenol treatment block were assessed by setting out deposit sampling units consisting of a 10 cm x 10 cm Kromekote® card and either paired slides or a stainless steel plate. Spray droplets deposited on the Kromekote® cards were sized and counted using a NCR microcard reader. Droplet densities (drops/cm^2) were determined for each drop size class and then totalled to provide a drop density figure for the spray card. The glass slides and stainless steel plates were washed with toluene and the quantity of dye rinsed off them was measured using a Baush and Lomb Spectronic 100 spectrophometer. The equivalent deposit in ℓ/ha was calculated by comparison with the quantity of dye measured in a standard made up from the original dyed tank mix.

Kromekote® cards were set out in the seasonal maximum application of MATACIL® plot and sent to the National Aeronautical Establishment in Ottawa where deposit on them was assessed by a flying spot scanner (Slack, 1974).

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[1]1.4 oil soluble concentrate, Chemagro Ltd., Mississauga, Ont.

[2]Shell Canada Ltd., Toronto, Ontario.

[3]Morton Williams Ltd., Ajax, Ontario.

Residue Studies Nonyl phenol residues were measured in samples of white spruce foliage and soil collected from the seasonal maximum nonyl phenol treated plot. These substrates were sampled one day prior to treatment and 1 h, 3 h, 4 h, 6 h, 24 h, 2 days, 3, 4, 5, 9, 14, 30 and 62 days thereafter. White spruce foliage samples consisted of current year's foliage cut from branches taken from mid-crown portions of ten selected dominant trees to give an amalgamated sample from within the treatment block. A fully exposed plot (4 m x 4 m), about 10 m away from the nearest tree canopy, was selected for the sampling of forest soil. The acidity of the fine sand was about pH 6.4. At each sampling, 20 cores (2.5 cm in diameter) were taken from the top 5 cm layer randomly and wrapped in aluminum foil.

After collection samples were stored in clean glass containers and packed with ice in styrofoam coolers until transported to the Forest Pest Management Institute, where they were held at 0°C until analyzed by high performance liquid chromatographic analysis.

A complete description of the extraction, clean-up and analysis procedures used in the nonyl phenol residue analyses is presently in preparation by the Chemistry Section of the Forest Pest Management Institute (Sundaram, personal communication).

Three samples of balsam fir foliage and three soil samples were collected from the seasonal maximum MATACIL® treated block. The foliage samples represented amalgamated samples of terminal shoots collected from the lower portions of trees along a stretch of road running through the block. The three samples represent three different portions of the road, each about 0.6 km in length. Soil samples represent pooled soil cores taken from portions of the block with or without overhead forest canopy.

These samples were analyzed for MATACIL® residues by personnel of the Quebec Services de Protection de l'Environment's pesticide laboratory in Ste. Foy, Quebec.

Terrestrial Invertebrate Knockdown Normal and insecticide-induced "insect rain" from forest canopy to forest floor was measured by placing plastic containers (39 x 33 x 15 cm) under the canopy of various tree species within treated and untreated bird plots. Containers were placed under both coniferous and deciduous tree species, and separate data collected from each. Six to twelve knockdown buckets were placed on each plot, and the invertebrates collected removed daily, preserved and labelled and taken back to the laboratory for sorting and identification.

Knockdown from coniferous tree species was measured under white spruce in the conventional double application of MATACIL® study and under balsam fir in the other two studies. Knockdown from deciduous species were measured primarily under willow, *Salix* L. No samples were collected under deciduous tree species on the bird plot in the seasonal maximum MATACIL® treatment area.

Honeybees Domestic honeybee colonies were set out in the conventional double application of MATACIL® block, nonyl phenol treatment block, and untreated control areas in order to study the effects of these treatments on pollinating insects. The colonies were of overwintered stock from the apiary of the Forest Pest Management Institute, Sault Ste. Marie, Ontario. Those selected for the field trials were hived in a standard Langstroth single brood chamber. Once on site, all colonies were fitted with a dead bee box, an Ontario Agricultural College pollen trap and a photo-electric cell equipped activity counter. Hive weights were taken with a bathroom scale placed under the edge of the hive. The relative success and vigor of each hive was determined at intervals by taking measurements of the amount of capped brood present and by qualitative observations of honey production and the condition of the queen. Actual counts of the contents of the cells within specific portions of frames were made on two occasions in the case of the nonyl phenol treated and untreated control hives, in order to determine any effects on the development of a specific group of larvae.

Forest Songbirds Forest songbird populations were asseed on 4 hectare plots in the treated and untreated blocks employing the singing male-territory technique similar to that described by Kendeigh (1944). Pre-treatment surveys commenced 5 days prior to the application and were terminated five days after the completion of the treatment regime. Only three days prespray data were collected on the seasonal maximum application of MATACIL® block due to logistics problems.

Censuses were conducted daily shortly after dawn by recording on a plot map the species, sex, and type of activity of each bird encountered while walking set lines (40 meters apart) through the plot. Male birds vocally defending a territory are assumed to have a mate and are recorded as two birds, all others (slighted, calling, etc.) are recorded as one. The number of birds observed during each census indicate activity trends and relative abundance on that plot. Daily maps were later combined over the prespray and then postspray time periods, in order to delineate territorial boundaries for each species.

Each treated block and bird plot was searched extensively for dead or affected birds following spray applications. In the case of the seasonal maximum MATACIL® treated block these searches were carried out for a three day period.

Small Mammals Small mammal populations were trapped on the treated and untreated blocks during a 5-day pre-spray period immediately prior to the seasonal maximum application of MATACIL®, the 6-day period immediately following the treatment and during a 10-day period 23 days after the treatment. Factors such as age structure, survival of the "Young of the Year" and fecundity were examined to determine any immediate or short-term impact upon the small mammal complex.

Trapping was carried out using standard household snapback traps (Victor 4-way) baited with a mixture of rolled oats and peanut butter with a small amount of bacon fat added. Traps were placed at 22 m intervals along parallel lines (22 m apart) in the forest and at 22 m intervals along roadside shrubbery. Numbers of traps used varied at locations and trap periods according to the dictates of the operation.

The trapped specimens were collected early each morning, identified to species and sex, measured, weighed and recorded on field data sheets. All specimens were preserved in a 10 percent formalin solution and returned to the laboratory for dissection. All shrew spp. were dissected to determine sex and breeding condition and all adult female mice and voles were dissected to determine breeding condition. Females containing embryos, placental scars, or obviously lactating were recorded as "breeding".

RESULTS

Conventional Double Application of MATACIL®

Deposit Relatively good deposits of emitted spray products were measured following both spray applications on a deposit assessment line set out on a road running through the entire block perpendicular to the plane's flight lines (Table 2). Deposit measured on the ground within the bird plot was much lower, reflecting the thick overhead forest canopy. Deposit on the beehives located in a clearing on the upwind edge of the plot was similar to the deposit assessment line after the first application, but negligible after the second application when a moderate wind (2.32 m/sec) was blowing.

Table 2

Deposit measured in the MATACIL® treatment block,[A]
Wawa, Ontario, 15 and 18 June, 1979.

	No. of deposit Samplers	Mean drop density drops/cm^2	Mean volume deposited ℓ/ha	Mean % of emitted volume measured
1st application - 15 June				
Deposit assessment[AA] line across entire block	30	18.1	0.90	19.0
Bird plot	5	0.36	0.04	0.8
Bee hives	2	18.6	0.56	11.9
2nd application - 18 June				
Deposit assessment[AA] line across entire block	44	15.9	0.96	20.3
Bird plot	4	1.3	0.08	1.7
Bee hives	4	0.04	Not available	

[A] spray emission rate 4.7 ℓ/ha

[AA] data supplied by B.F. Zylstra, Forest Pest Management Institute

Terrestrial Invertebrate Knockdown Prior to the first MATACIL® application, the numbers of invertebrates collected in buckets under trees in the treatment plot were relatively low and fairly constant (3.0 ± 1.7 per bucket from spruce, 3.1 ± 1.9 from willow). On the untreated control plot, the catch per bucket over the entire sampling period was considerably higher and much more variable particularly under willow (6.7 ± 4.6 from spruce, 9.2 ± 12.5 from willow). These fluctuations on the control plot correspond to prevailing weather patterns, with localized rain or thunderstorms prior to sampling producing a large knockdown consisting mainly of Diptera:Sciaridae, but also of Hymenoptera and Collembola from willow (Fig. 3 and 4, Appendix I--Tables 1 to 4).

An immediate knockdown effect was observed on the treatment plot immediately following both applications, with the knockdown from the first application much more pronounced and involving a greater variety of invertebrate groups (Arachnida, Lepidoptera larvae, and various families of Diptera). The effects of the second application were much less noticeable. A prolonged effect on Lepidoptera larva was observed in the spruce samples where knockdown was still apparent five days after the second application. The knockdown, from willow was restricted to flying insects, mainly Hymenoptera. For both tree species, the peak overall knockdown was no greater than peaks in knockdown seen on the control plots attributable to natural causes, but different groups of insects were involved.

Honeybees Weather favourable to honeybee activity followed on the days after both evening applications, with temperatures rising to about 20°C on 16 and 19 June. Overcast conditions on 17 June were followed by rain on 20, 21, 22 June. The effect of weather was particularly evident on the amount of pollen collected, which was lowest on those four days for both the treatment block and control hives (Fig. 5). The average amount of pollen collected per colony on the treatment block did not decline below the amount collected by the control colonies, with the exception of the final day of monitoring. Pollen collected during the monitoring period was generally light green to pale yellow in colour, indicating it's source would probably be poplar, *Populus* sp., willow and birch, *Betula* sp. (Hodges, 1974), all of which occurred within the treatment block.

Activity at the front of the hive does not appear to have been affected by the treatment (Fig. 6). There were no significant differences in counts except on 21 June when excessive moisture may have been responsible for a counter malfunction on the control plot.

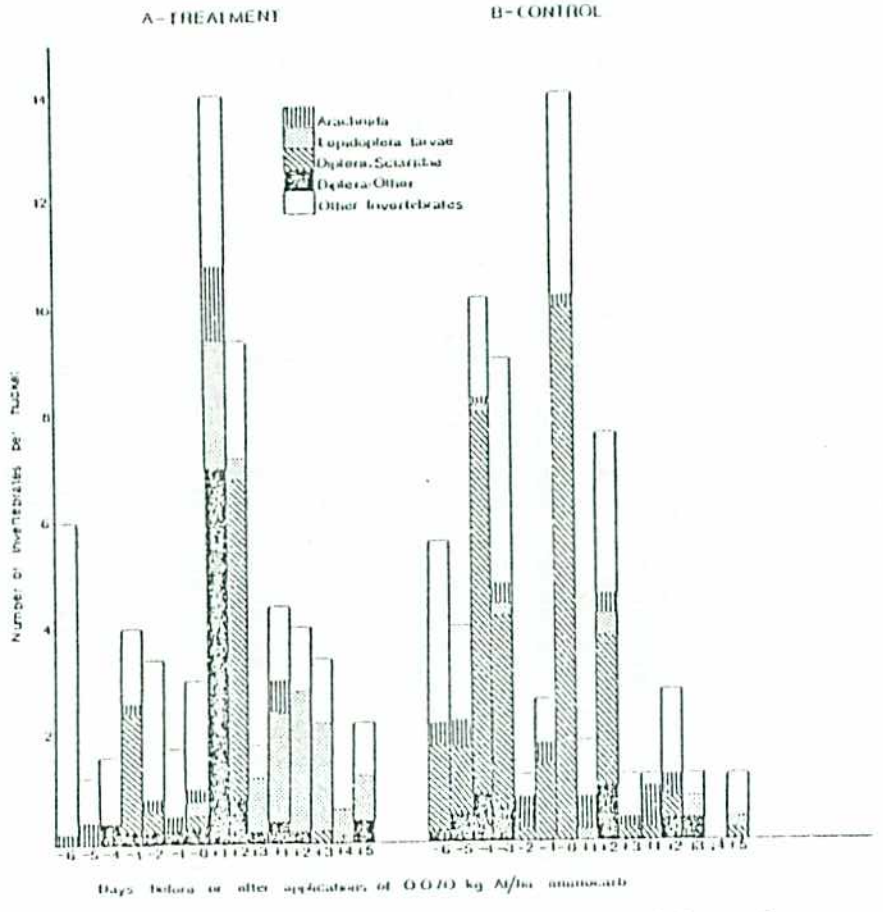


Fig. 3. Terrestrial invertebrate knockdown from spruce, MATACIL® treatment and untreated control plots, Wawa, Ontario. 9-23 June, 1979.

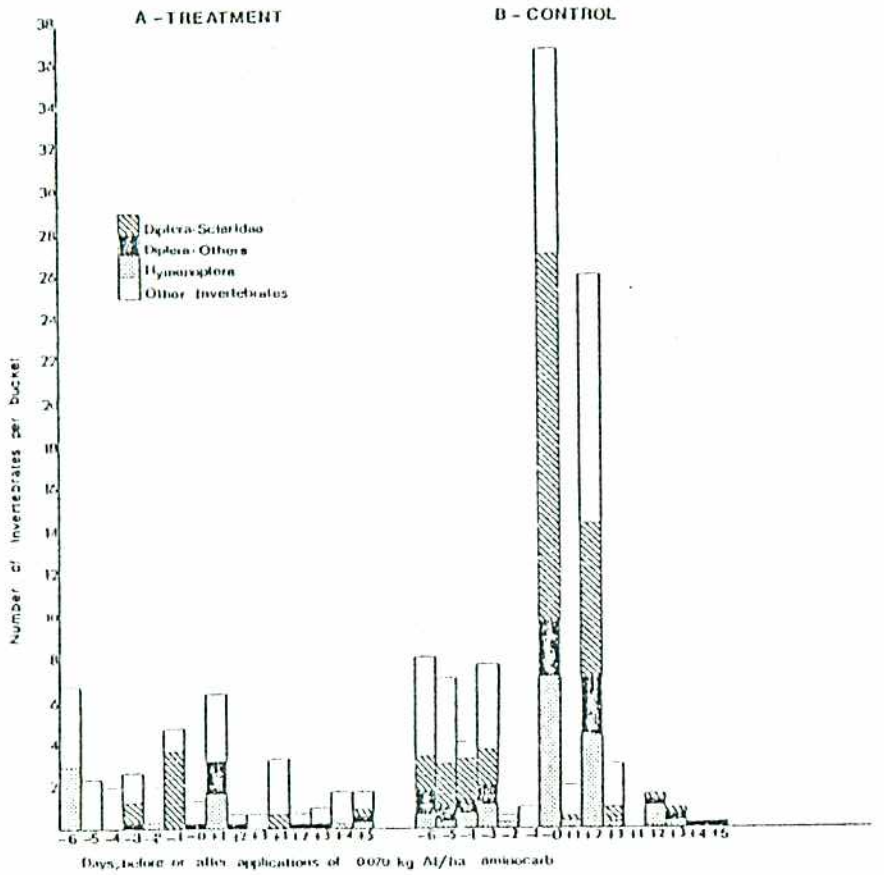


Fig. 4. Terrestrial invertebrate knockdown from willow, MATACIL® treatment and untreated control plots, Wawa, Ontario. 9-23 June, 1979.

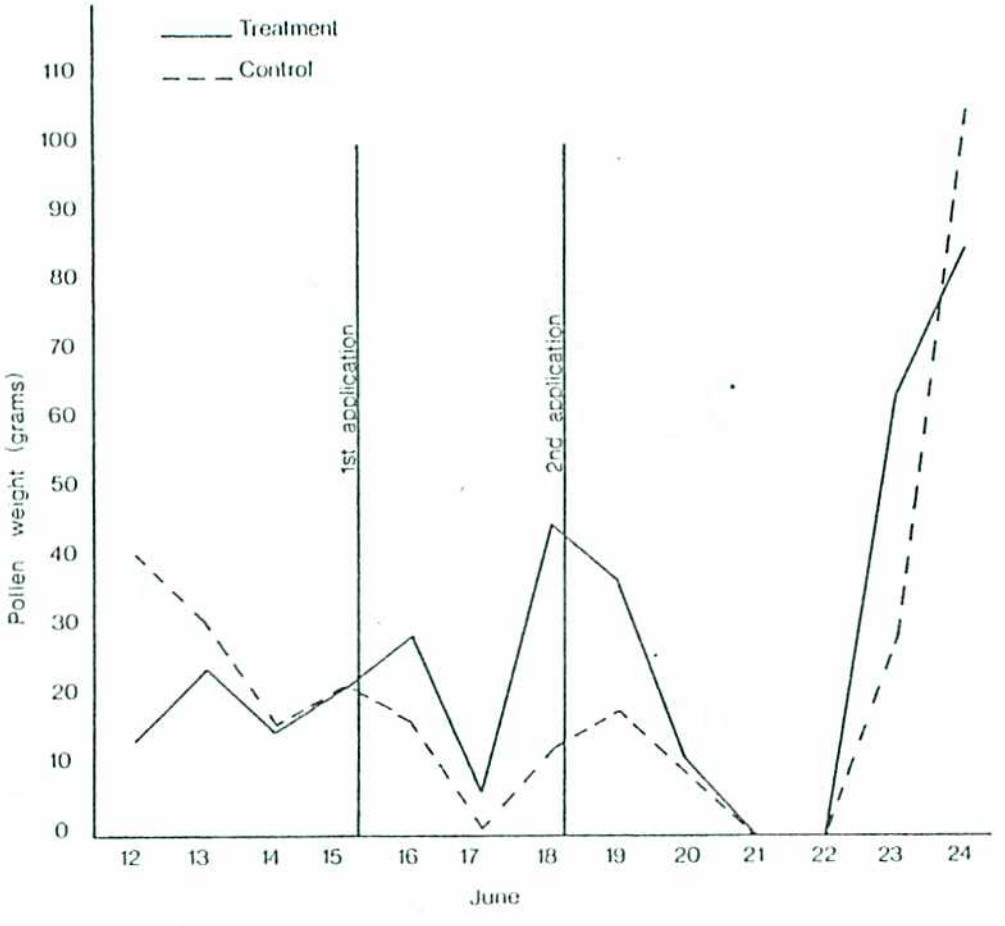


Fig. 5. Pollen collected by honeybee colonies on the MATACIL® treatment and untreated control plots, Wawa, Ontario. 12-24 June, 1979.

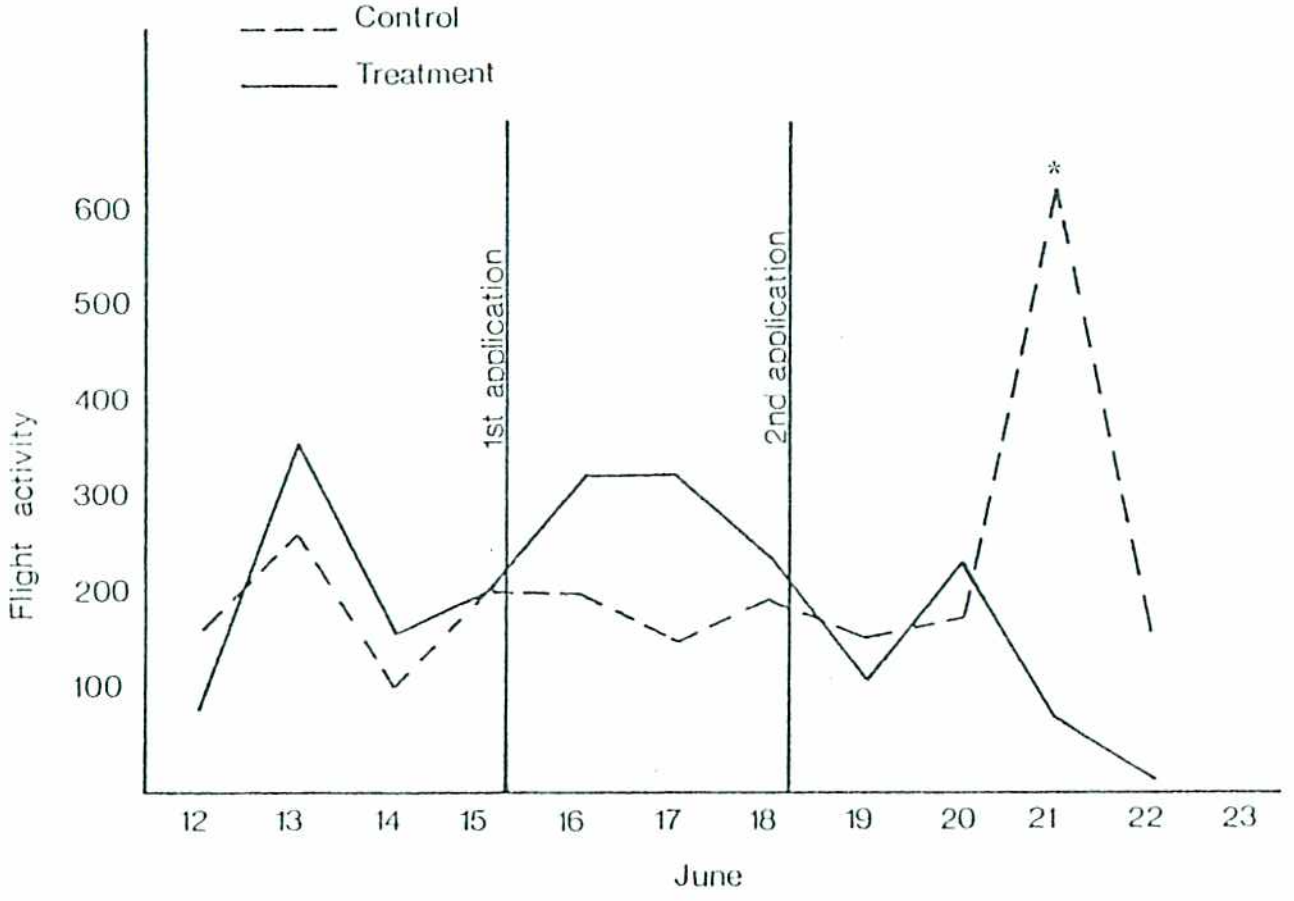


Fig. 6. Flight activity counts for honeybee colonies on the MATACIL® treatment and untreated control plots, Wawa, Ontario, 12-22 June, 1979.

* suspected counter malfunction.

The dead bee count (Fig. 7) was slightly higher on the treatment block on the day following the first application, although both numbers were very low. Some bees were observed having difficulty becoming airborne. Following the second application, the dead bee count remained very low for both groups, and no symptoms of pesticide poisoning were observed.

The average weight gain over a ten-day period on the treatment block was 1.3 kilograms, while the average colony weight remained static on the control group.

Capped brood measurements (Fig. 8) expressed in square centimeters, were quite similar, with a total gain of 11.2% for the treatment colonies, and 13.4% for control. These figures would probably have been closer had one of the treatment colonies not swarmed prior to the final measurement.

Forest Songbirds The MATACIL® treatment plot was productive in terms of bird populations, offering a dense forest cover for such species as the hermit thrush, *Catharus quattatus* (Pallas), the veery, *Catharus fuscescens* (Stephens), and the ovenbird, *Seiurus aurocapillus* (Linnaeus), and varying canopy levels to fulfill the niche requirements of many other species. An average of 28 species were present throughout the study period. Insectivores were a major component of the bird complex; Parulidae, Turdidae and Tyrannidae comprised roughly 47%, 15% and 7% respectively, of the total population censused. Seed eating fringillids were the third-most predominant, making up 14% of the total population.

Fewer shrubs and a scant understory on the control plot, may account for the low population average of 43 birds (of 12 species) as compared to the 87 birds on treatment (Appendix II, Tables 1 and 2). Warblers, flycatchers and thrushes were again prominent members of the community (65%, 7%, and 6% of the total censused population, respectively). However, vireos represented an unusually high proportion of the control population (13%) and fringillids were extremely low (4%); perhaps due to a less diversified habitat.

Avifauna populations remained fairly stable over the study, with no observed reduction in activity as a result of either application (Fig. 9). There was a general lull in activity over both plots on 17 and 23 June, primarily of the families Turdidae, Vireonidae and Fringillidae (Tables 3 and 4); but this was due to adverse weather conditions, and there was no observed territorial abandonment by species within these families (Fig. 10 to 19).

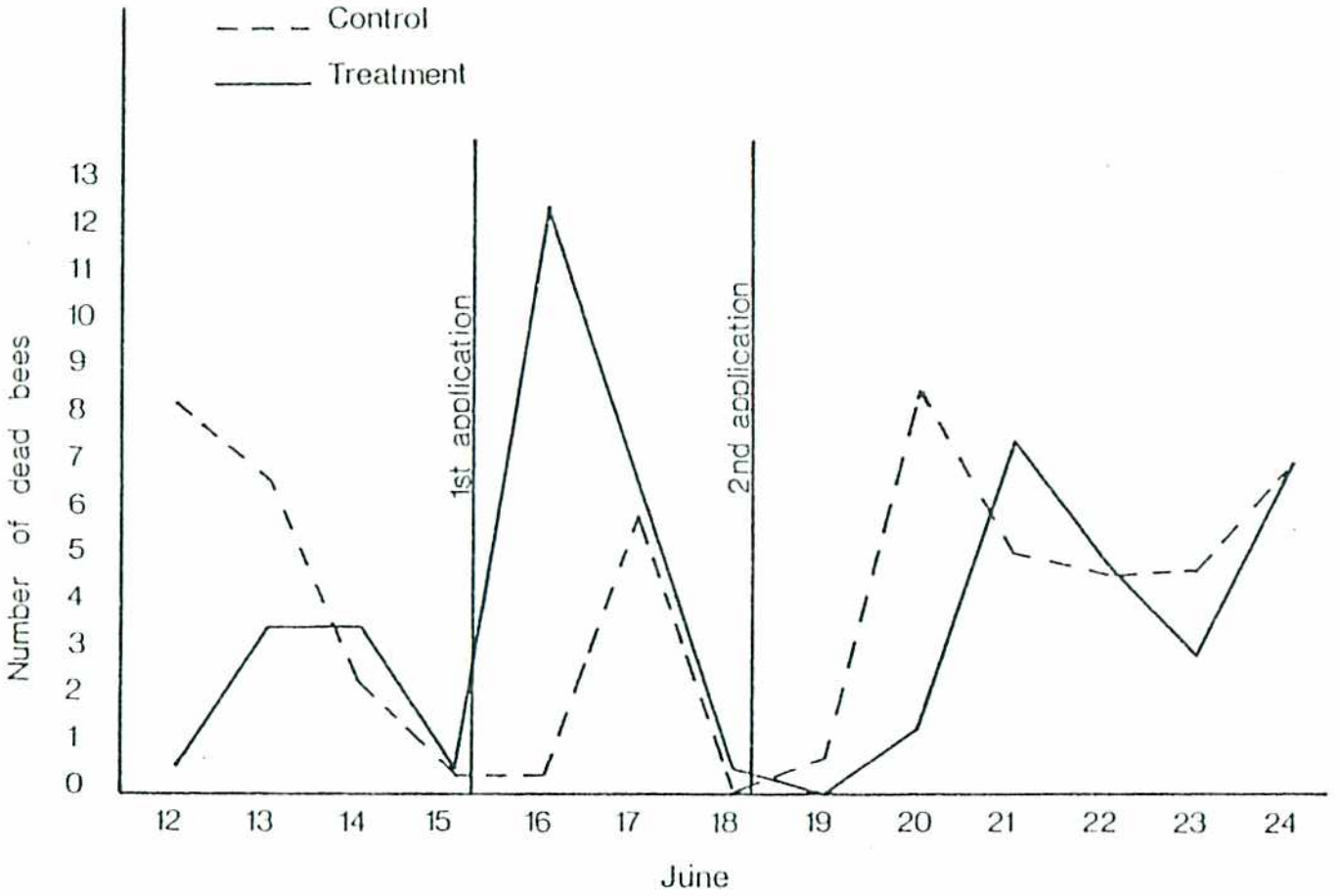


Fig. 7. Dead bees collected from honeybee colonies on the MATACIL® treatment and untreated control plots, Wawa, Ontario, 12-24 June, 1979.

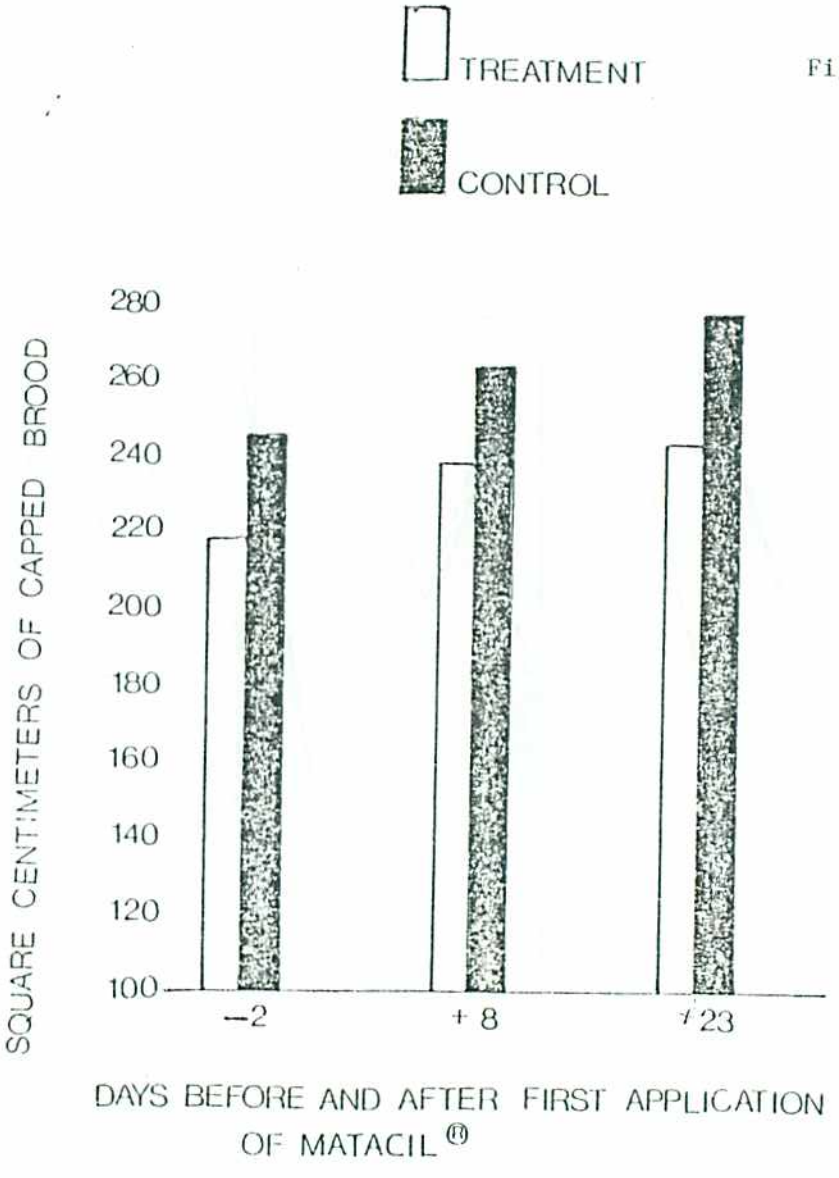


Fig. 8. Capped brood measurements from honeybee colonies on the MATACIL® treatment and untreated control plots, Wawa, Ontario, 13 June - 8 July, 1979.

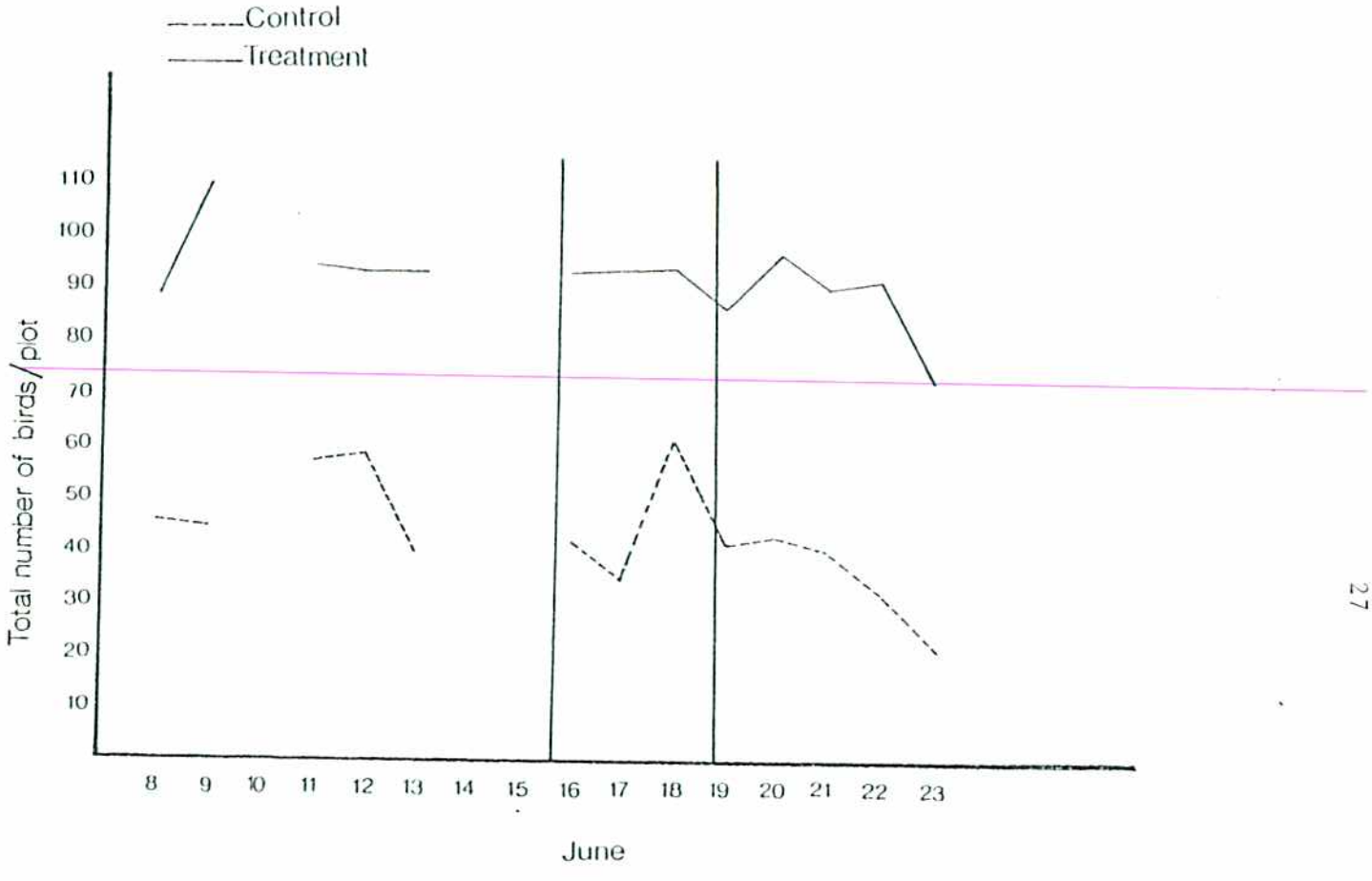


Fig. 9. Forest songbird activity on the MATACIL® treatment and untreated control plots, Wawa, Ontario, 8-23 June, 1979.

Table 3

Forest Bird Population Census
MATACIL® Treatment Plot
Wawa, Ontario
8-23 June, 1979.

(MATACIL® applied on 15 June and 18 June at the emitted dosage of 0.070 kg AI/ha)

Family	Pre-spray treatment 1						Post-spray treatment 1				Post-spray treatment 2					
	June 8	June 9	June 11	June 12	June 13	Daily	June 16	June 17	June 18	Daily	June 19	June 20	June 21	June 22	June 23	Daily
	-7	-6	-4	-3	-2	ave.	1	2	3	ave.	1	2	3	4	5	ave.
Tetraonidae	2	2	2	2	2	2.0	2	0	2	1.3	2	2	0	2	2	1.6
Picidae	0	0	0	2	0	0.4	2	0	0	0.7	0	2	0	4	0	1.2
Tyrannidae	8	8	6	8	6	7.2	6	4	6	5.4	8	8	6	6	6	6.8
Corvidae	0	0	0	1	2	0.6	0	0	0	0.0	0	0	0	0	0	0.0
Paridae	0	2	4	4	3	2.6	3	0	1	1.3	0	2	0	1	0	0.6
Sittidae	2	2	2	2	2	2.0	0	0	2	0.7	2	2	0	2	2	1.6
Troglodytidae	2	2	2	2	2	2.0	2	0	2	1.3	2	2	2	2	2	2.0
Turdidae	13	16	16	7	14	13.2	14	6	13	11.0	13	15	16	15	9	13.6
Sylviidae	4	4	4	4	4	4.0	4	2	4	3.3	4	2	4	4	4	3.6
Vireonidae	6	4	4	4	4	4.4	4	0	4	2.7	6	6	6	2	6	5.2
Parulidae	41	53	41	42	42	43.8	40	32	44	38.8	36	42	44	40	34	39.2
Fringillidae	10	16	13	15	12	13.2	16	2	16	11.3	13	13	12	14	8	12.0
Total Birds	88	109	94	93	93	95.4	93	46	94	77.8	86	96	90	92	73	87.4

Table 4

Forest Bird Population Census
MATACIL® Untreated Control Plot
Wawa, Ontario
8-23 June, 1979.

Family	Pre-spray treatment 1						Post-spray treatment 1				Post-spray treatment 2					
	June 8	June 9	June 11	June 12	June 13	Daily	June 16	June 17	June 18	Daily	June 19	June 20	June 21	June 22	June 23	Daily
	-7	-6	-4	-3	-2	ave.	+1	+2	+3	ave.	+1	+2	+3	+4	+5	ave.
Tetraonidae	0	0	1	1	0	0.4	0	0	0	0.0	0	0	0	0	0	0.0
Picidae	0	1	0	1	0	0.4	0	0	0	0.0	0	0	0	0	0	0.0
Tyrannidae	2	4	6	4	6	4.4	2	2	4	2.7	2	4	4	2	0	2.4
Sittidae	2	0	0	2	0	0.8	0	0	0	0.0	0	0	0	0	0	0.0
Turdidae	3	1	6	2	5	3.4	4	0	6	3.4	3	1	0	2	0	1.2
Sylviidae	0	4	2	4	0	2.0	0	4	2	2.0	0	2	0	2	0	0.8
Vireonidae	4	6	8	8	2	5.6	8	2	8	6.0	6	8	6	2	2	4.8
Parulidae	30	26	34	36	26	30.4	26	24	36	28.6	30	26	30	20	20	25.2
Fringillidae	4	2	0	0	0	1.2	2	2	5	3.0	0	2	0	4	0	1.2
Total Birds	45	44	57	58	39	48.6	42	34	61	45.7	41	43	40	32	22	35.6

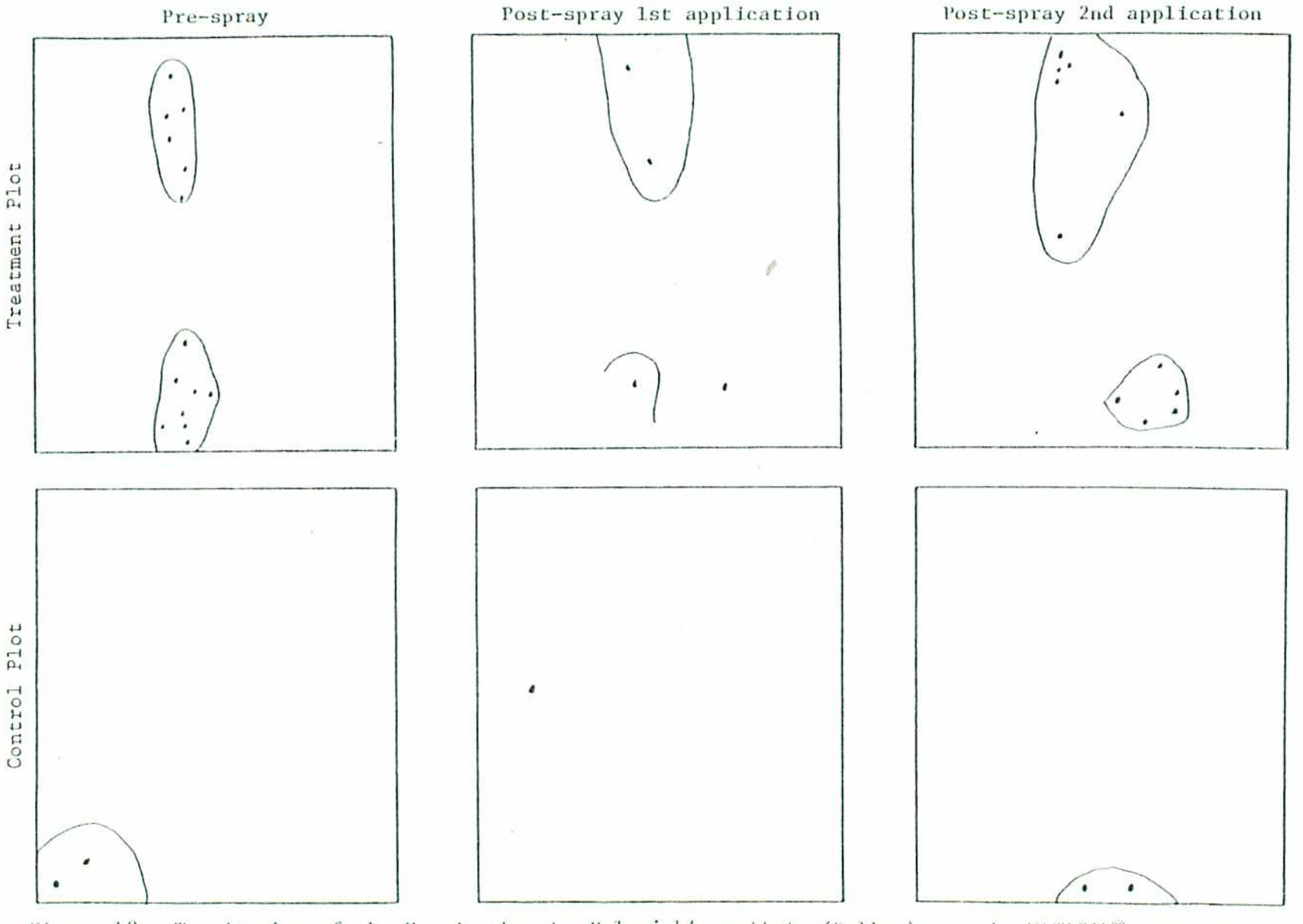


Figure 10. Territories of the Hermit thrush, *Hylocichla guttata* (Pallas), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

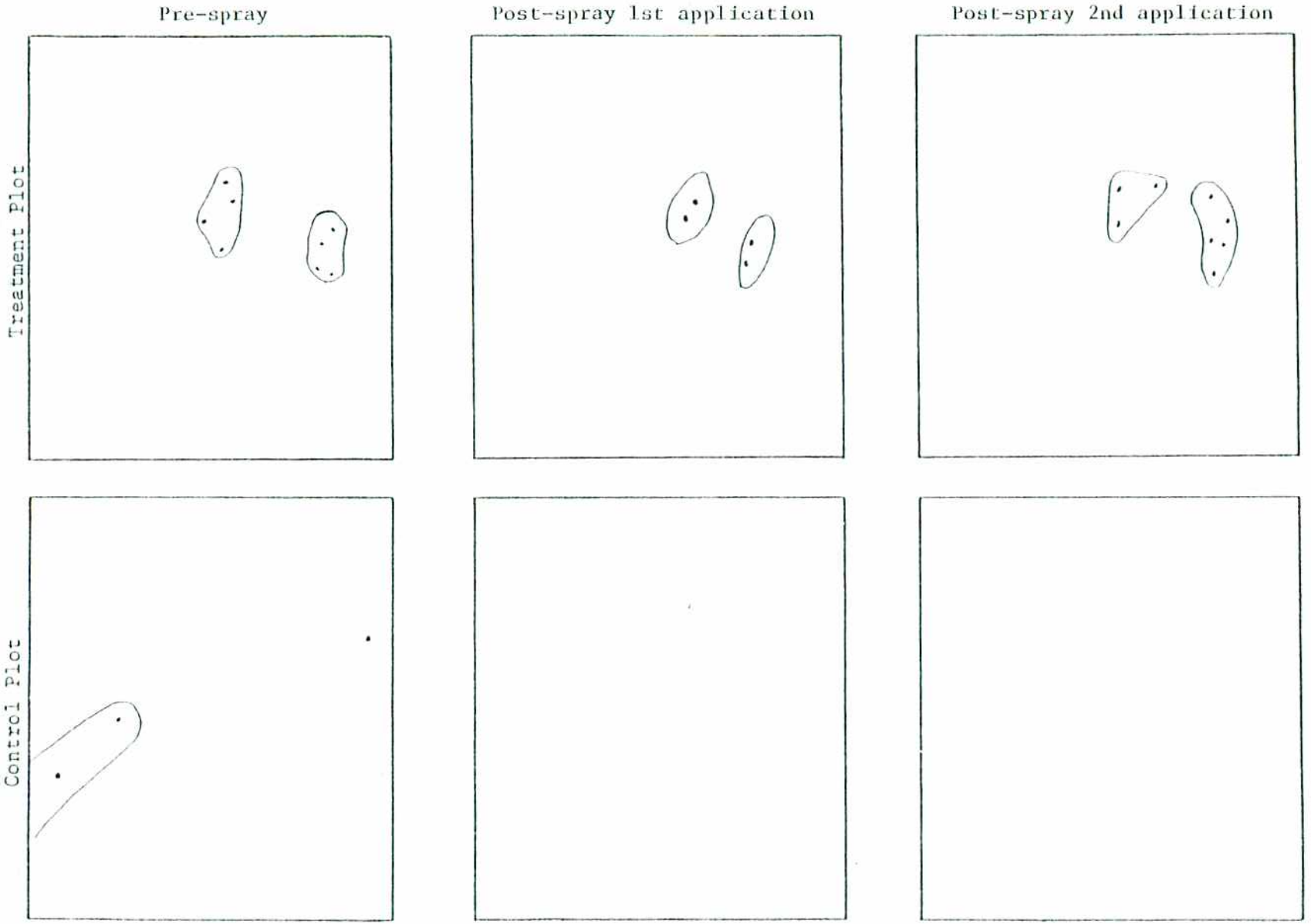


Figure 11. Territories of the Veery, *Hylocichla fuscescens* (Stephens), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario June 1979.

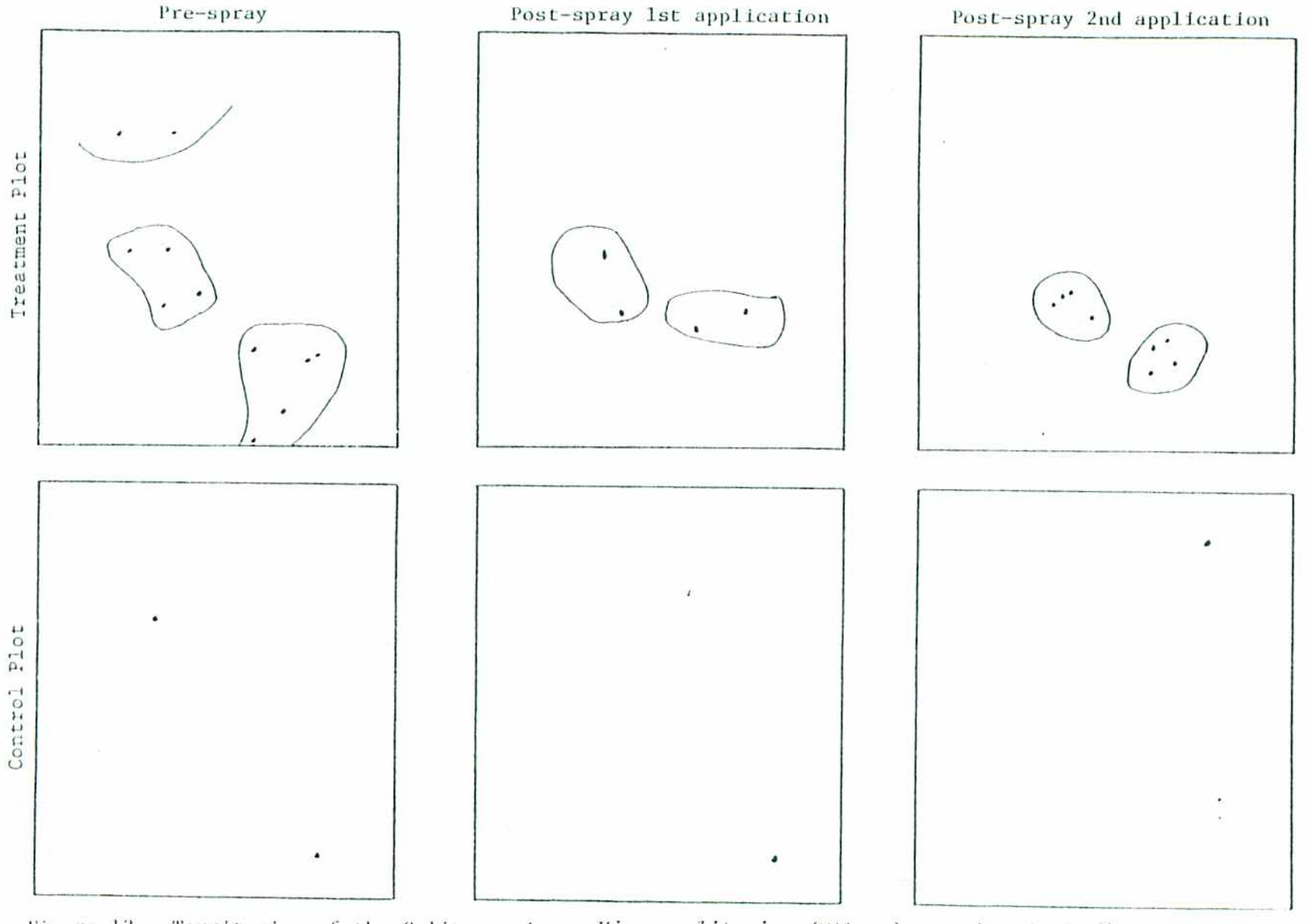


Figure 12. Territories of the Solitary vireo, *Vireo solitarius* (Wilson), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

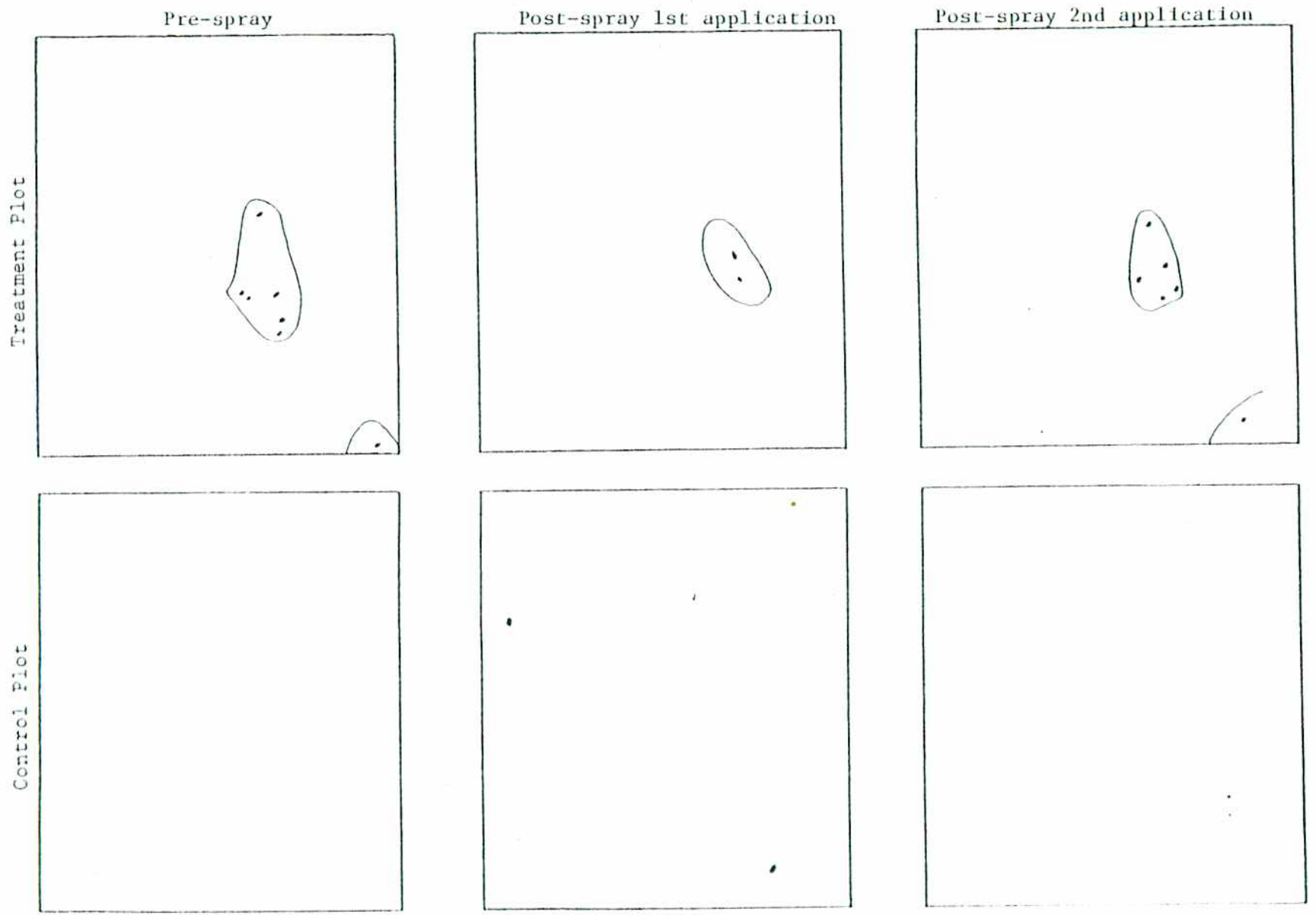


Figure 13. Territories of the Purple finch, *Carpodacus purpureus* (Gmelin), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

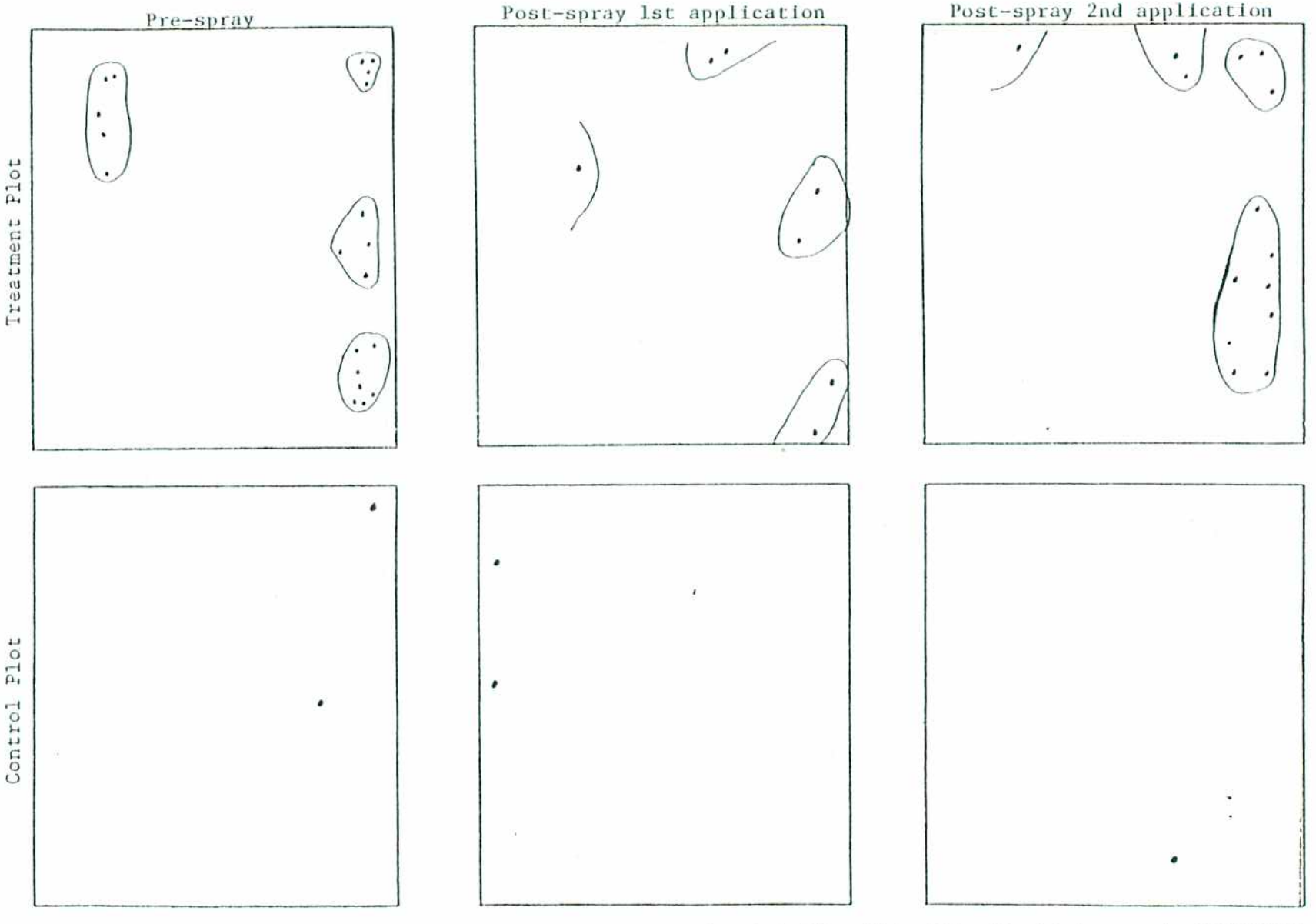


Figure 14. Territories of the White-throated sparrow, *Zonotrichia albicollis* (Gmelin), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

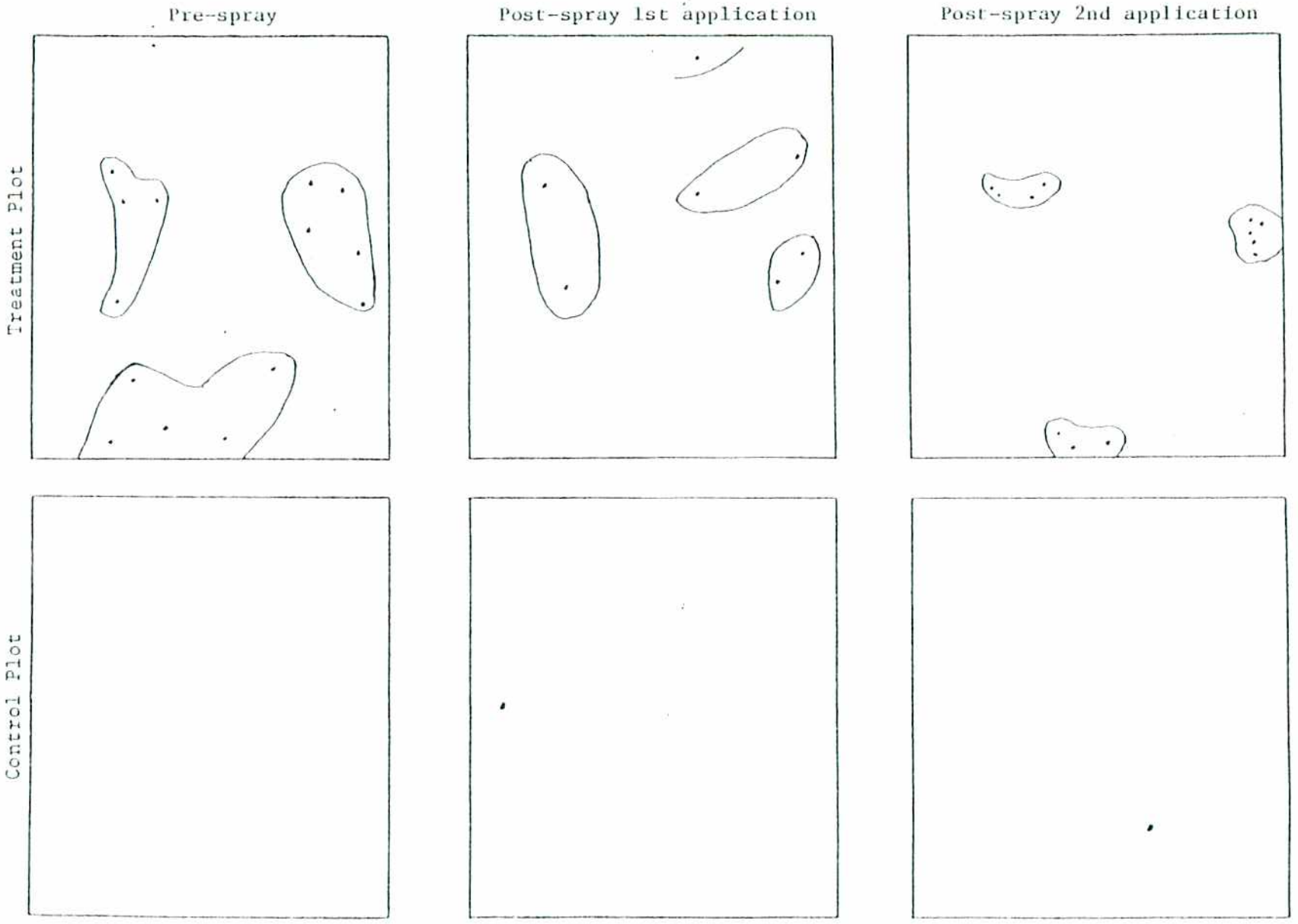


Figure 15. Territories of the Black-throated green warbler, *Dendroica virens* (Gmelin), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

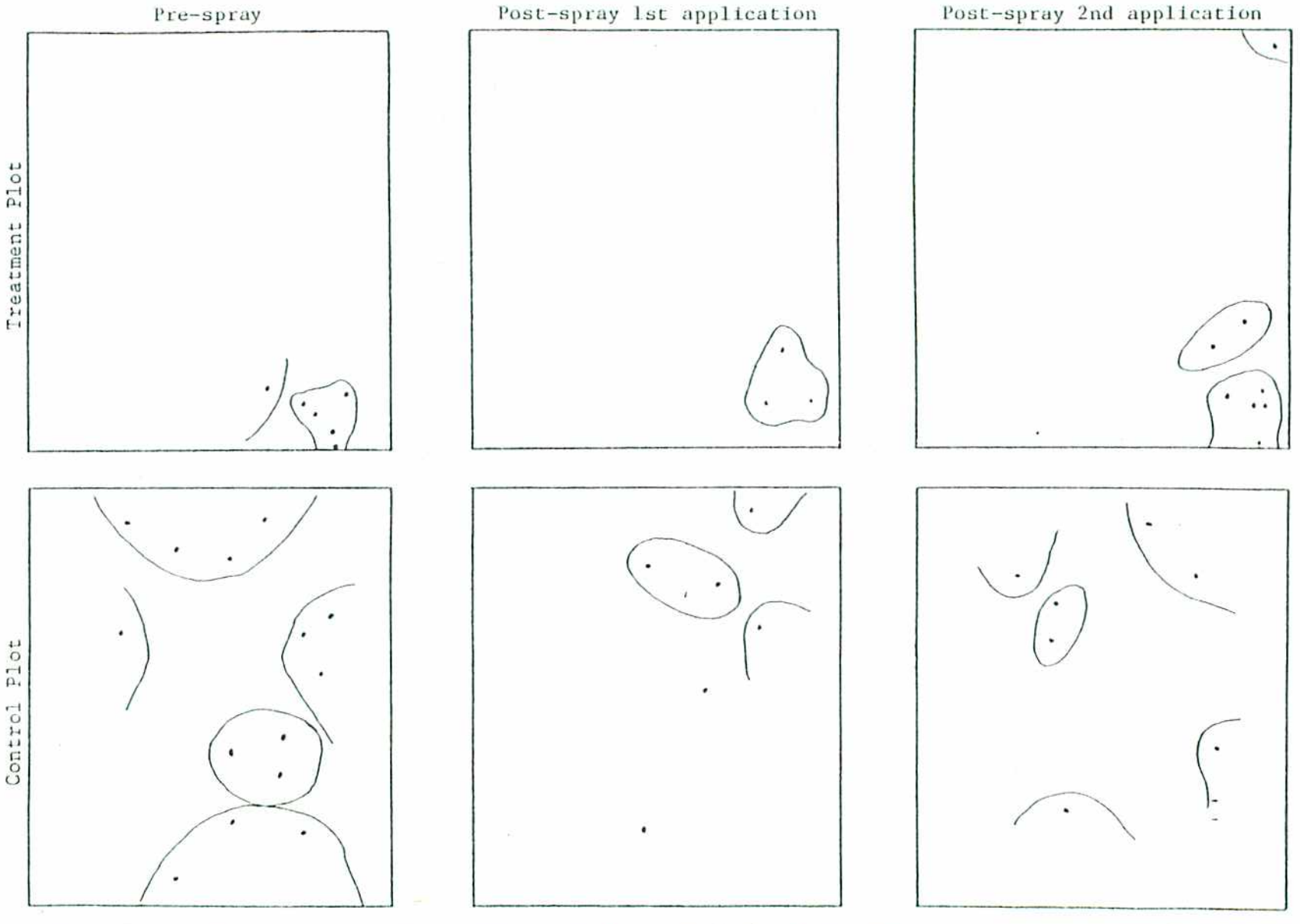


Figure 16. Territories of the Blackburnian warbler, *Dendroica fusca* (Muller), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

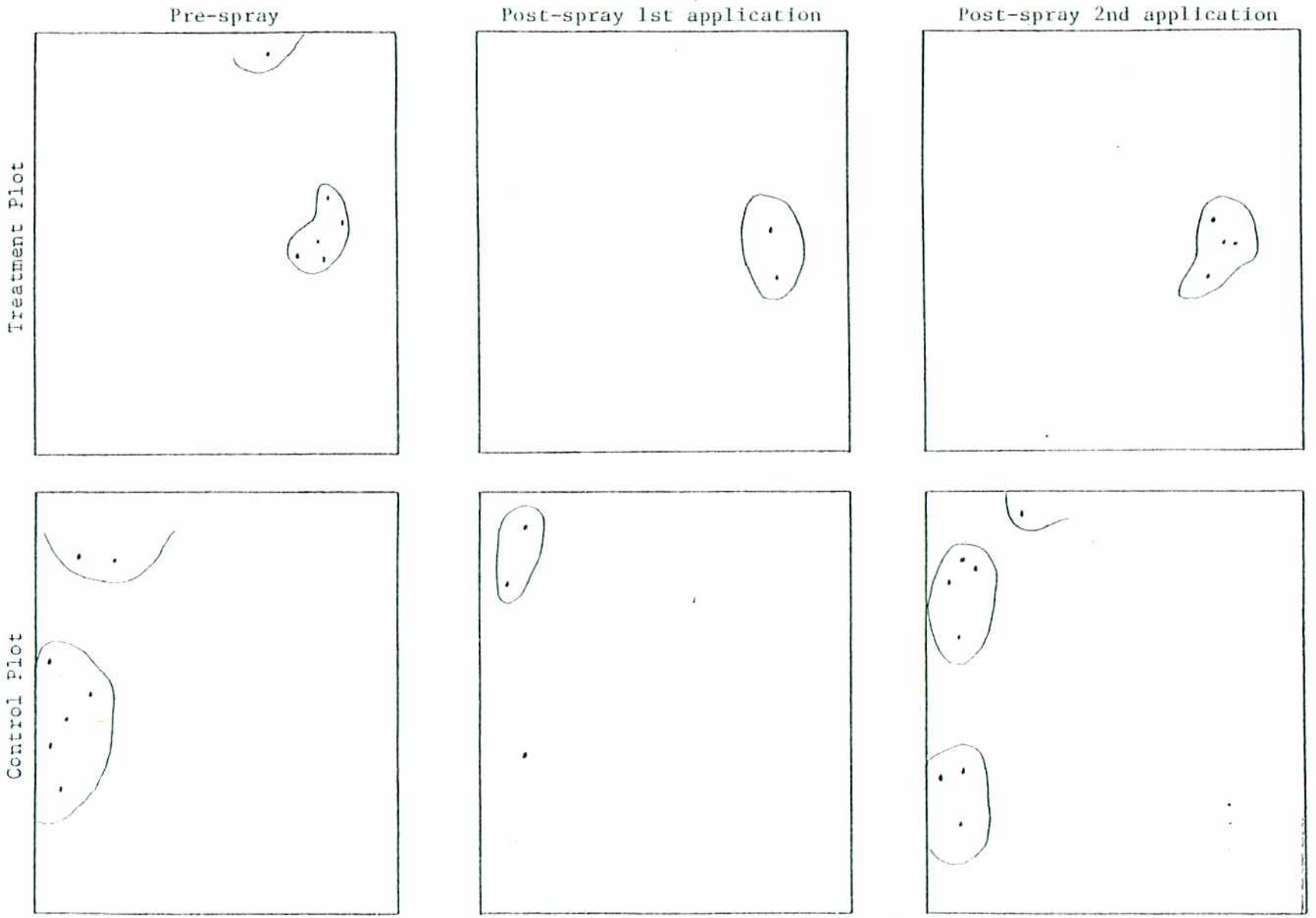


Figure 17. Territories of the Chestnut-sided warbler, *Dendroica pensylvanica* (Linnaeus), on the MATACIL® treatment and control plots, over the study area, Wawa, Ontario, June 1979.

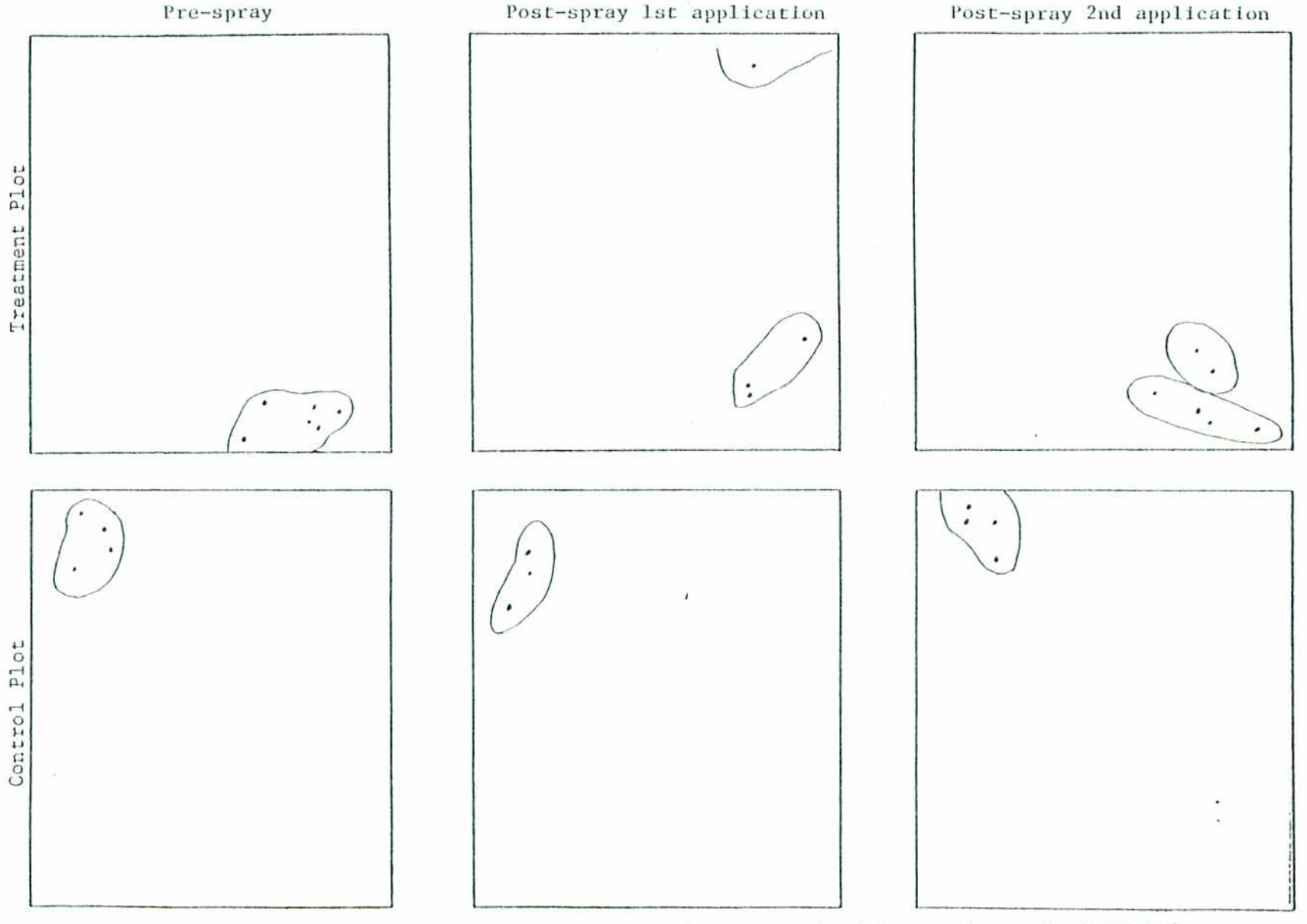


Figure 18. Territories of the Canada warbler, *Wilsonia canadensis* (Linnaeus), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

Figure 19. Territories of the Ovenbird, *Seiurus aurocapillus* (Linnaeus), on the MATACIL® treatment and control plots, over the study period, Wawa, Ontario, June 1979.

Small insectivorous species, such as the Black-throated green warbler, *Dendroica virens* (Gmelin), the Blackburnian warbler, *Dendroica pensylvanica* (Linnaeus); and the Canada warbler, *Wilsonia canadensis* (Linnaeus), actively forage throughout the canopy and are potentially vulnerable to pesticide poisoning due to their size and behaviour. Illustrations of their territories throughout the season indicate that no disruption had occurred (Fig. 15 to 18).

The ovenbird, a ground dwelling warbler, is fairly removed from direct exposure to the chemical spray. Territories for this species remained occupied as well (Fig. 19).

Many species of birds sang throughout both spray applications, seemingly undisturbed by the operation. Thorough plot searches for sick or dead birds failed to reveal adverse effects of either application.

Seasonal Maximum Application of Nonyl Phenol

Deposit Relatively high levels of emitted spray products were measured on deposit samplers set out in various areas within the nonyl phenol treatment block (Table 5).

The high level of deposit recorded within the bird plot reflects the open nature of the forest stand and the high degree of coverage of the south portion of the block reported elsewhere (Armstrong and Kingsbury, 1979).

Nonyl Phenol Residues Nonyl phenol residues persisted in white spruce foliage for about 30 days. The highest concentration was 18.9 ppm detected one hour after spraying. It declined to 0.54 ppm in 30 days and was no longer detected 62 days after treatment (Table 6). Levels of nonyl phenol in soil never exceeded the limit of detection (0.1 ppm).

Terrestrial Invertebrate Knockdown Relatively small numbers of terrestrial invertebrates were collected in buckets set out under trees in the nonyl phenol treated and untreated control plots (Fig. 20, Appendix I--Tables 5 to 8). Catches in all areas sampled showed very similar patterns of increase and decrease, both between different tree species sampled in each plot and between treatment and control plots. There was a very slight increase in the catch of spiders (Arachnida) and flies (Diptera) under deciduous trees in the nonyl phenol plot after the treatment, however, the increases in total catch were no larger than similar increases seen in the untreated control area within the next few days. Catches on both plots were relatively high on 1 June as a result of heavy rains which fell throughout the day.

Table 5

Deposit measured in the nonyl phenol treatment block,*
Dubreuilville, Ontario, 29 May, 1979.

	No. of deposit Samplers	Mean drop density drops/cm^2	Mean volume deposited ℓ/ha	Mean % of emitted volume measured
Deposit assessment line across entire block	34	13.3	0.41	27.9
Bird plot	6	19.7	0.60	40.7
Bee hives	2	10.7	0.38	25.8

* spray emission rate 1.46 ℓ/ha

TABLE 6

Nonyl phenol residues in white spruce foliage and forest soil from the treatment plot*, Dubreuilville, Ont.

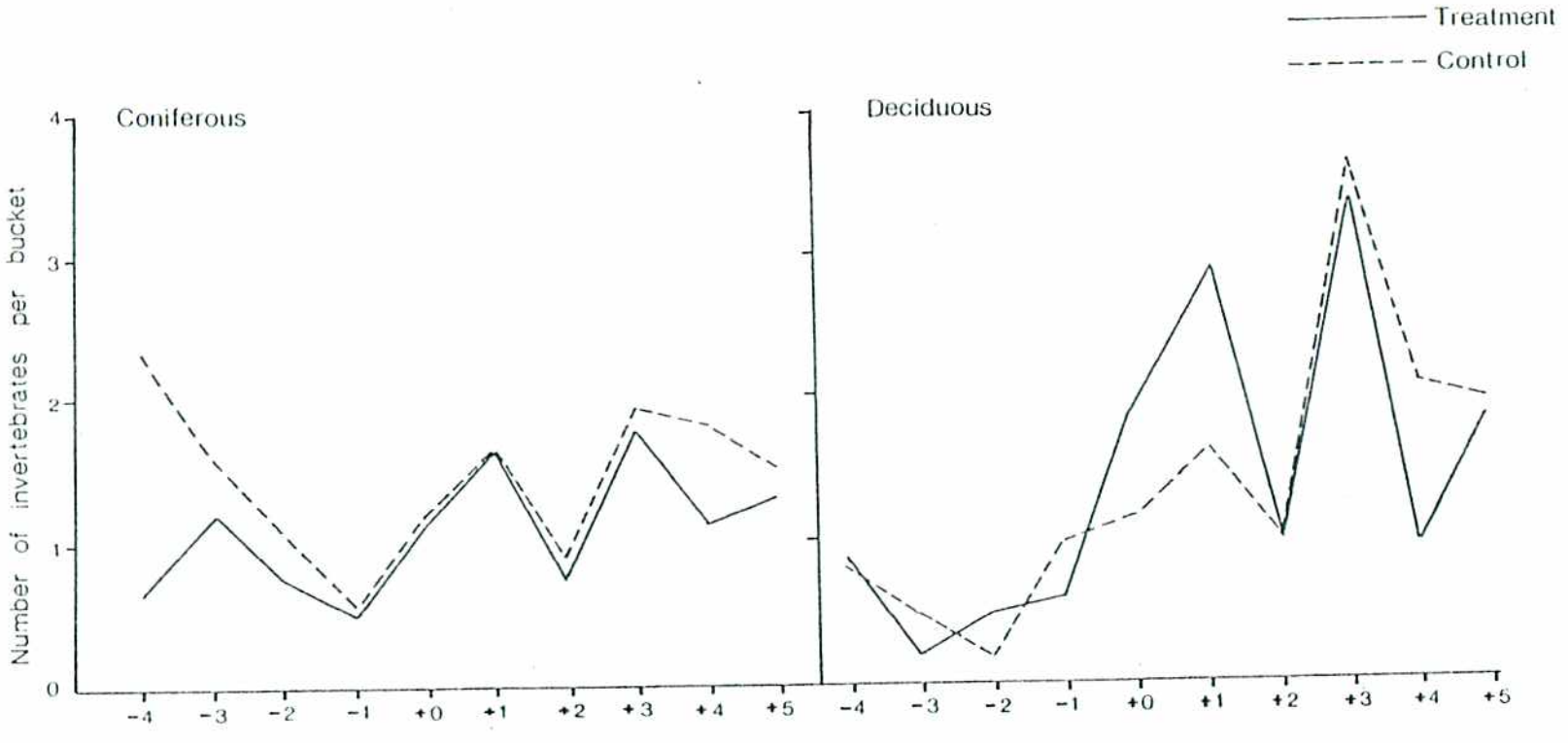
Time after spraying	Nonyl phenol residue (ppm)	
	Foliage	Forest soil
1 hour	18.90	N.D.
3 hours	7.70	N.D.
4 hours	4.86	-
6 hours	4.44	N.D.
24 hours	4.06	N.D.
2 days	3.54	N.D.
3 days	2.06	N.D.
4 days	1.49	N.D.
5 days	1.70	N.D.
9 days	1.23	N.D.
14 days	1.43	N.D.
30 days	0.54	N.D.
62 days	N.D.	N.D.

N.D. = not detectable (detection limits were 0.20 ppm for foliage and 0.10 ppm for forest soil).

*treated with 0.47 ℓ/ha nonyl phenol on 29 May 1979.

Fig. 20

Terrestrial invertebrate knockdown into buckets set under trees in the nonyl phenol treatment* and control bird plots, Dubreuilville, Ontario. 25 May-3 June, 1979.



*treated at 0707 on 29 May 1979

Honeybees The application of nonyl phenol had relatively little impact upon populations or activity of domestic honeybees. A slight increase in the numbers of dead foraging bees was recorded from the treated hives on the day following the day of treatment, but subsided quickly to "normal" levels in subsequent days (Table 7). Activity patterns (flights to and from the hive) were relatively constant on the treated site but somewhat more variable on the untreated control site, probably reflecting local conditions such as hive location, shelter, microclimatic conditions, etc. Pollen collections reflect weather patterns throughout the experimental period. Very little pollen was recorded at the treated site and the discovery of a virgin queen in one of the treated hives would indicate that the colony had superceded an old failing queen which would account for the reduction in pollen collecting for brood rearing.

Hive weights remained relatively constant throughout the experimental period. The area of capped brood was slightly affected by the requeening as the area of brood declined slightly over a period of 9 days in the treated hives while a slight increase was recorded on the untreated hives. Measurements taken later in the season show a substantial increase of capped brood in hives from both treated and untreated sites. Of 340 cells counted in a marked portion of brood in the untreated hives, 295 contained eggs of which 292, or approximately 99%, reached the capped brood stage, while 400 cells out of 490, or 81%, reached the capped brood stage in the treated hives (Table 8).

Forest Songbirds Avian activity on both the nonyl phenol treated and untreated plots follow a similar pattern except for a noticeable decline in singing activity on the treatment plot during the spray operations when large numbers of people were engaged in various activities on or near the bird plot (Fig. 21). None of the major family groups were affected by the treatment and a recorded decline in the family Fringillidae on the treated plot also occurred on the untreated control plot (Tables 9 and 10).

Populations of the ruby crowned kinglet, *Regulus calendula* (Linnaeus), a small insectivorous bird known to be quite pesticide sensitive, were not affected. Activity of such species as the Nashville warbler, *Vermivora ruficapilla* (Wilson) and the yellow-rumped warbler, *Dendroica coronata* (Linnaeus) decreased following treatment while others like the Cape May warbler, *Dendroica tigrina* (Gmelin) and Tennessee warbler, *Vermivora peregrina* (Wilson) increased. White-throated sparrow, *Zonotrichia albicollis* (Gmelin) acitivty declined on both plots following treatment (Appendix II, Tables 3 and 4).

Table 7

Honeybee activity on nonyl phenol treated and untreated control plots

Dubreuilville, Ontario
27 May - 6 June
1979

(average of two colonies on each site)

Date	Untreated control beehives					Nonyl phenol treated beehives				
	Mortality (adult bees)	Activity bee/trips	Pollen (gm)	Hive weight (kg)	Brood (cm^2)	Mortality (adult bees)	Activity bee/trips	Pollen (gm)	Hive weight (kg)	Brood (cm^2)
27 May	4.5	-	-	-		18.0	-	-	-	
28 May	2.0	35520	-	-		3.5	2880	-	-	
29 May	2.0	7296	4.12	12.2	928	3.0	11776	0	12.2	1016
30 May	6.5	18688	21.85	12.4		23.5	23552	4.04	12.4	
31 May	4.0	10624	7.01	12.2		8.5	23552	0	12.4	
1 June	3.0	47232	4.91	12.2		5.0	23872	1.45	12.7	
2 June	1.0	8448	8.14	12.2		2.0	20416	1.80	12.4	
3 June	1.5	11648	16.24	12.2		3.5	20864	0	12.4	
4 June	0.5	8640	22.80	11.9		6.5	38976	1.91	12.4	
6 June	-	-	-	-	1168	-	-			944
30 July	-	-	-	-	2688	-	-			2296

Table 8

Honeybee brood development within Nonyl phenol treatment and untreated control hives

Dubreuilville, Ontario
30 May - 6 June, 1976

Untreated control hives			Treated hives		
	30 May	6 June		30 May	6 June
no. of cells examined	340	340	no. of cells examined	500	500
no. of cells containing eggs	295	0	no. of cells containing eggs	490	10
no. of cells containing larvae	0	0	no. of cells containing larvae	0	10
no. of cells containing capped brood	0	295	no. of cells containing capped brood	0	400
no. of empty cells	45	48	no. of empty cells	10	80

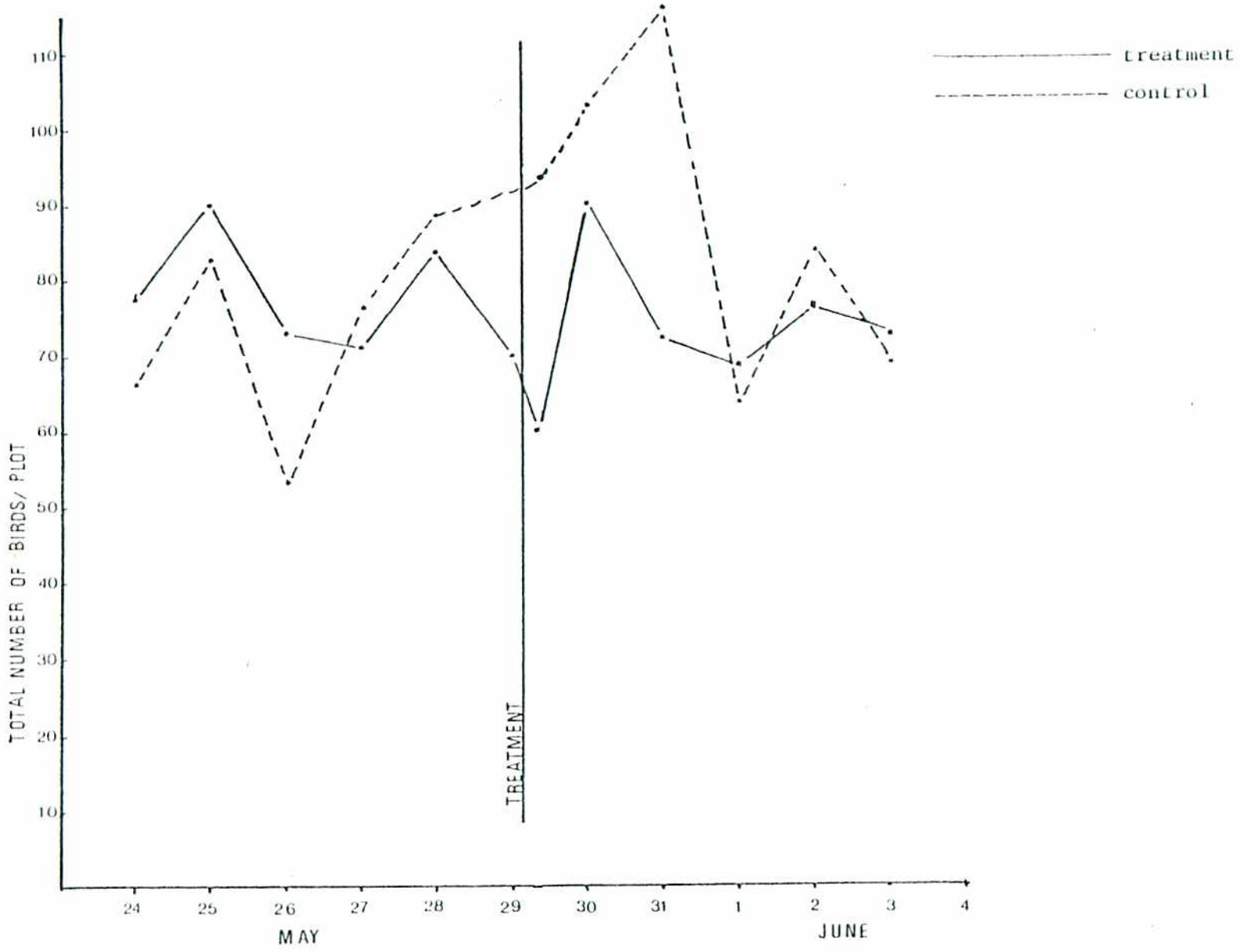


Figure 21. Forest songbird activity on the nonyl phenol treated and control bird plots, Dubreuilville, Ontario, 24 May - 3 June, 1979.

Table 9

Forest Bird Population Census
Nonyl phenol treatment plot
Dubreuilville, Ontario
24 May - 3 June 1979

Family	Prespray							Postspray						
	May 24 -5	May 25 -4	May 26 -3	May 27 -2	May 28 -1	May 29 -0	Daily ave.	May 29 +0	May 30 +1	May 31 +2	June 1 +3	June 2 +4	June 3 +5	Daily ave.
Tetraonidae	0	0	1	0	0	0	0.2	0	0	0	0	1	1	0.3
Alcedinidae	1	0	0	0	1	0	0.3	0	1	1	0	1	0	0.5
Picidae	1	3	3	4	0	0	1.8	0	0	0	2	0	0	0.3
Tyrannidae	0	0	0	2	0	0	0.3	2	2	4	0	4	2	2.3
Corvidae	4	2	2	2	2	0	2.0	0	1	0	0	1	0	0.7
Paridae	0	0	2	1	0	0	0.5	0	3	1	0	0	2	1.0
Sittidae	2	0	0	0	0	0	0.3	0	0	0	0	0	0	0.0
Troglodytidae	2	0	0	2	2	2	1.3	0	0	0	0	0	2	0.3
Turdidae	1	3	3	0	9	6	3.7	2	8	6	8	6	11	6.8
Sylvidae	7	8	6	8	4	6	6.3	6	8	4	2	2	2	4.0
Vireonidae	2	0	0	4	0	2	1.3	0	2	2	0	0	0	0.7
Parulidae	41	51	24	39	47	33	39.2	40	50	32	37	40	42	40.2
Icteridae	0	0	2	0	0	0	0.3	0	0	0	0	0	0	0.0
Fringillidae	17	21	30	9	18	21	19.7	10	15	22	19	19	11	16.0
Total Birds	77	90	73	71	83	70	77.3	60	90	72	68	76	73	73.2

Table 10

Forest Bird Population Census
Nonyl phenol untreated control plot
Dubreuilville, Ontario
24 May - 3 June 1979

Family	Prespray						Postspray						
	May 24	May 25	May 26	May 27	May 28	Daily	May 29	May 30	May 31	June 1	June 2	June 3	Daily
	-5	-4	-3	-2	-1	Ave	+0	+1	+2	+3	+4	+5	Ave
Tetraonidae	0	1	0	0	1	0.4	2	0	1	0	0	1	0.7
Picidae	2	1	2	0	2	1.4	5	1	2	0	1	0	1.5
Tyrannidae	2	0	0	0	0	0.4	0	4	2	0	6	4	2.7
Corvidae	2	0	0	1	0	0.6	1	4	2	0	0	0	1.2
Paridae	2	0	0	1	2	1.0	0	0	0	0	1	0	0.2
Troglodytidae	2	2	4	4	2	2.8	2	0	0	2	2	2	1.3
Turidae	4	4	0	6	4	3.6	2	9	6	3	6	5	5.2
Sylviidae	6	6	4	4	10	6.0	8	10	2	3	2	6	5.2
Vireonidae	0	0	0	0	0	0.0	0	4	4	2	2	2	2.3
Parulidae	42	51	38	49	54	46.8	69	59	68	51	53	40	56.7
Icteridae	0	0	0	0	0	0.0	0	2	0	0	2	0	0.7
Fringillidae	5	18	6	12	13	10.8	5	10	24	2	9	9	9.8
TOTAL	67	83	54	77	88	73.8	94	103	111	63	84	69	87.3

While the activity of some species were affected by human acitivity following treatment, breeding territories remained occupied. The breeding territories of six species of wood warblers (family Parulidae), Fig. 22, as well as territories for the white-throated sparrow, ruby-crowned kinglet and the hermit thrush, *Hylocichla gutata* (Pallus), Fig. 23, are illustrated and show that the experimental application of nonyl phenol did not force abandonment of territories.

Intensive plot searches were carried out for two days following the experimental treatment but no dead birds were recovered and no birds were observed exhibiting the typical symptoms of pesticide stress.

Seasonal Maximum Application of MATACIL®

Deposit The results of deposit assessment conducted with the NAE flying spot scanner indicate that a relatively uniform and substantial deposit of the emitted spray products occurred over the entire block treated at the seasonal maximum MATACIL® rate. Mean deposit recorded on 54 Kromecote® cards laid out along a road traversing the block was 0.29 ℓ/ha (13.4% of the emitted volume) with an average drop density of 9.0 drops/cm^2. A substantially higher deposit of 0.74 ℓ/ha (33.7% of the emitted volume) and 42.6 drops/cm^2 was recorded on nine cards set out within the bird census plot.

MATACIL® Residues Relatively high quantities of MATACIL® were measured in balsam fir foliage and forest soil collected shortly after treatment. Three foliage samples from different portions of the block contained 28.9, 25.0 and 17.0 µg/g (parts per million) of MATACIL®. Residues in forest soil were much lower and more variable with 0.184 µg/g being measured from an open area and 0.255 and 0.050 µg/g measured in soil from two different areas with forest cover overhead.

Terrestrial Invertebrate Knockdown A dramatic but short-lived knockdown of terrestrial insect fauna was recorded within 12 hours of the MATACIL® application (Fig. 24, Appendix I, Table 9). Peak knockdown from balsam fir was recorded on the morning following the application. Collections made 36 hours after the application (30 June) indicate a definite decline in knockdown and daily collections from 1 to 4 July are similar to pre-treatment levels. A small increase in the knockdown sample was recorded on 2 July on the untreated plot, but the reason is unclear.

The composition of the insecticide induced knockdown was very diverse and included substantial numbers of Diptera, Arachnida, Collembola Hymenoptera, Psocoptera, Trichoptera, Hemiptera and Lepidoptera.

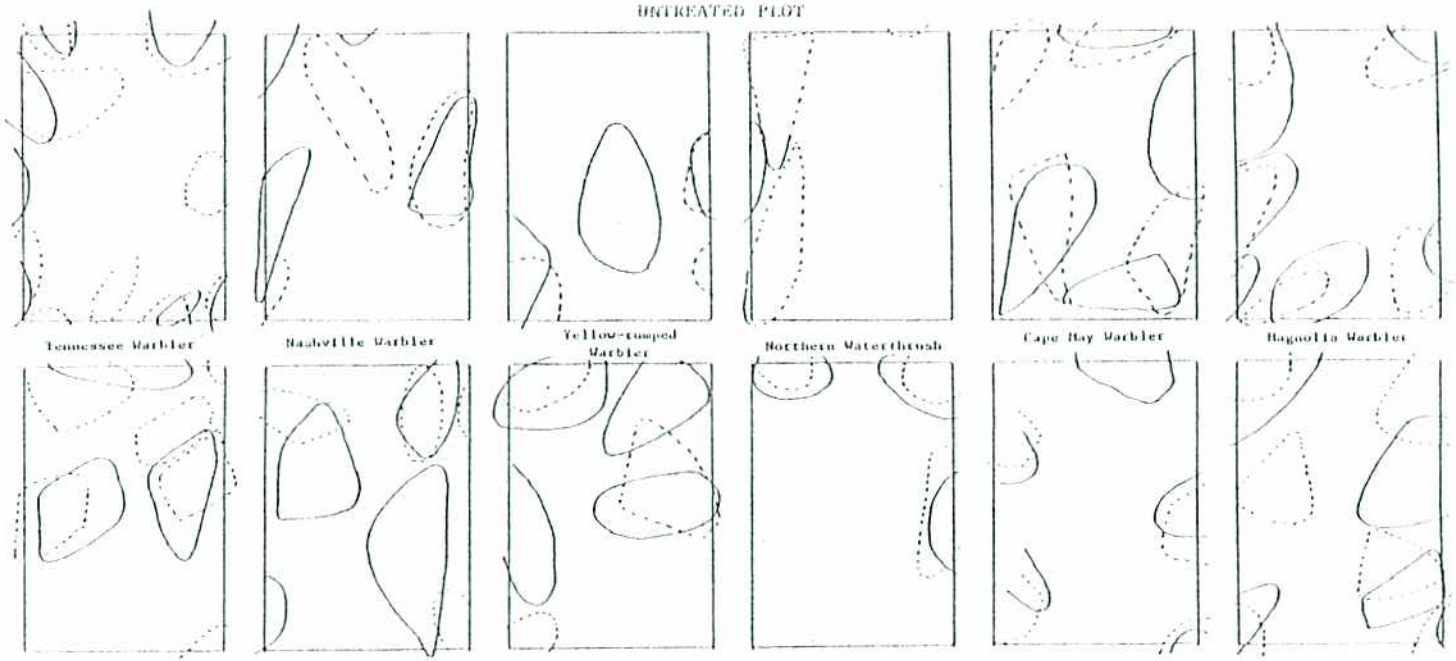


Figure 22

Pre and post-spray territories of warblers (Parulidae) on nonyl phenol treatment and control plots, Dubreuilville, Ontario, 24 May-3 June, 1979.

– – – – – prespray territorial boundary

——————— postspray territorial boundary

plots are 4 ha. in area.

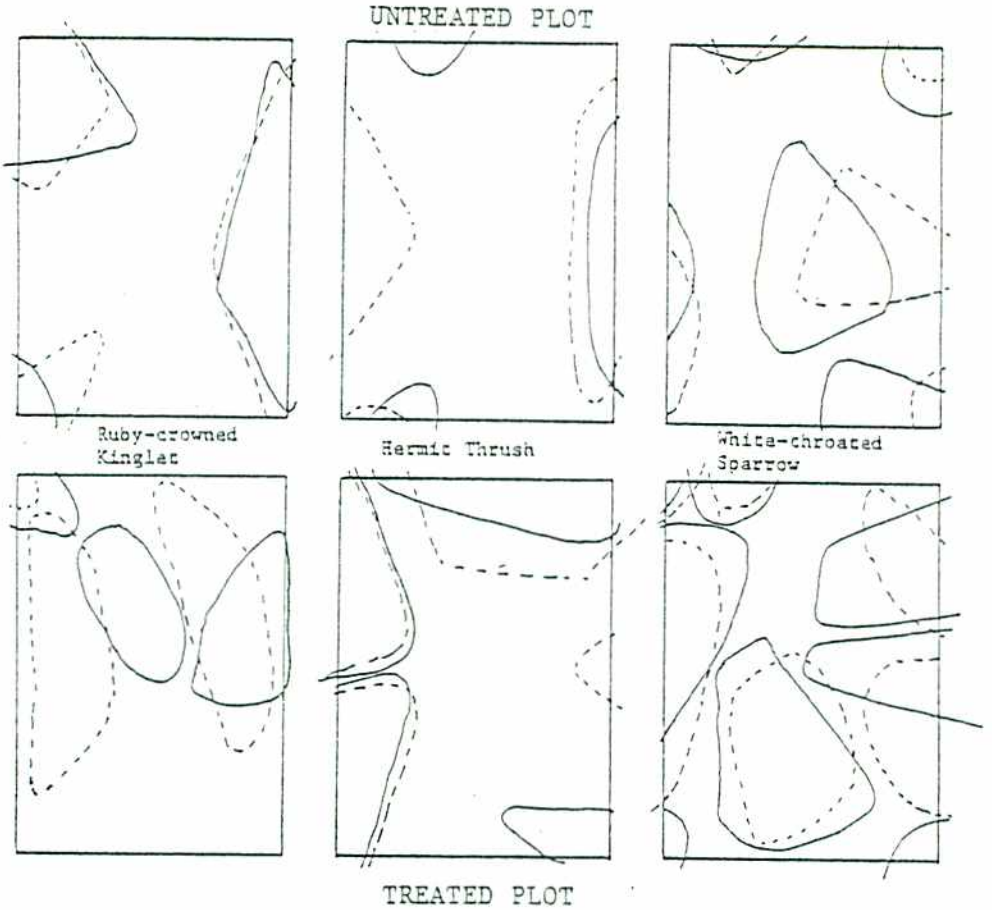


Figure 23

Pre and post-spray territories of ruby-crowned kinglet, *Regulus calendula* (Linnaeus), hermit thrush, *Hylocichla guttata* (Pallas), and white-throated sparrow, *Zonotrichia albicollis* (Gmelin), on Nonyl phenol treatment and control plots, Dubreuilville, Ontario, 24 May-3 June, 1979.

———— prespray territorial boundaries

-------- postspray territorial boundaries

plots are 4 ha. in area.

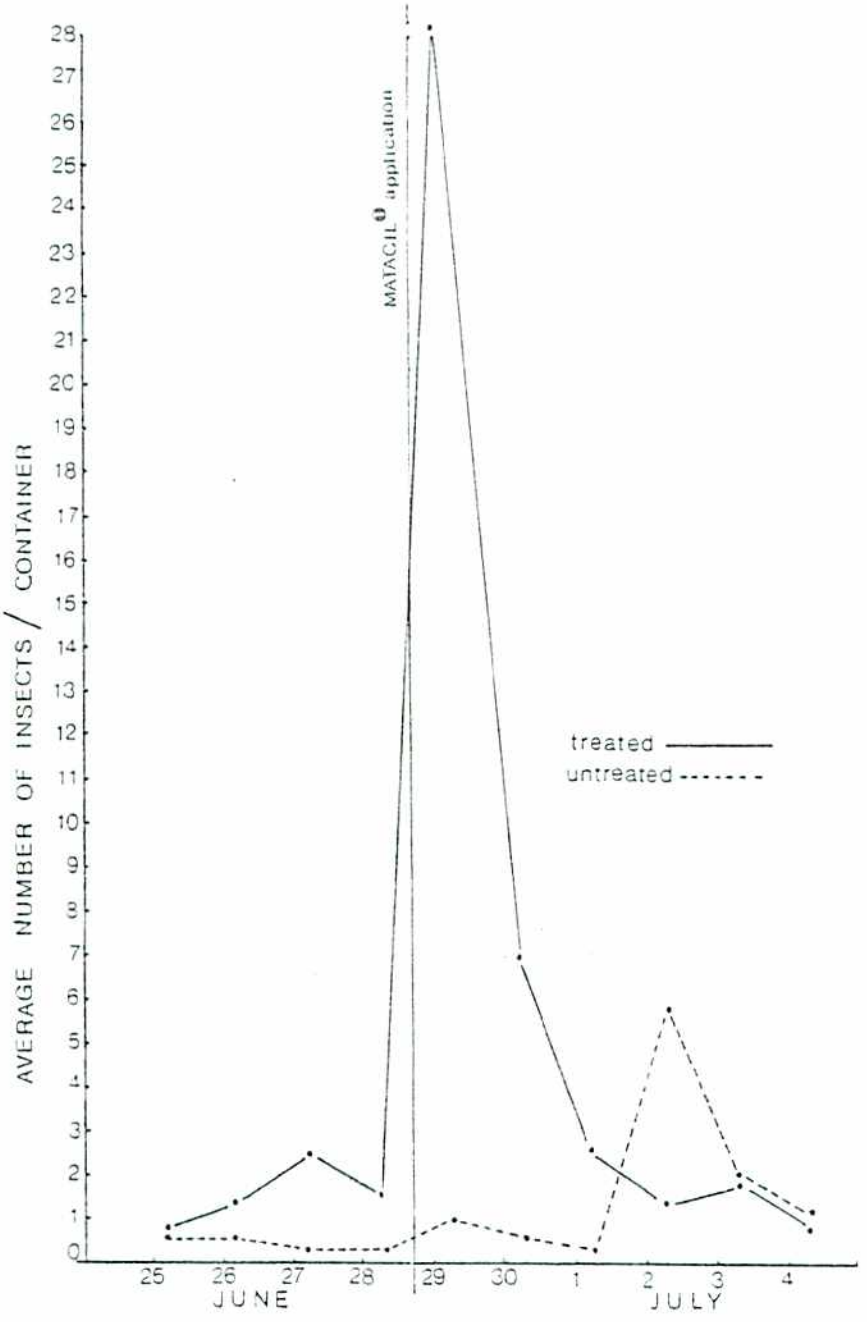


Figure 24. Terrestrial insect knockdown from balsam fir on MATACIL® treated and untreated plots, St. Donat de Montcalm, Quebec 1979.

Uglynest caterpillar (*Archips cerasivoranus* Fitch) tents on chokecherry (*Prunus virginiana* L.) were common throughout the experimental area. Caterpillars feeding outside the nest were observed to be killed within minutes of the treatment but insects remaining within the tent were not affected throughout the course of the experiment. Ants (Formicidae), spiders (Arachnidae) and beetles (Coleoptera) in open areas such as roadways, paths or cut-overs were also immediately killed. Ants inhabiting areas not directly exposed to the spray were observed on the day after the evening treatment foraging on dead insects which had fallen to the ground.

Forest Songbirds A total of 39 avian species representing 12 families were recorded on the aminocarb treated plot and 37 species representing 12 families recorded on the untreated control plot. The wood warblers (family Parulidae) and the sparrow-finch group (family Fringillidae) were the two most dominant families encountered in the study areas (Tables 11 and 12).

Avian activity patterns recorded throughout the experimental period were quite similar (Fig. 25) with a general decline of activity being recorded on both plots following the treatment as breeding territories started to break down for the season. Small flocks of some individual species (Swainson's thrushes, veerys, white-throated sparrows and common yellowthroats) were observed foraging through the plots causing minor fluctuations of activity (Appendix II, Table 5 and 6). No immediate (30-hour) or short-term (5-day) impact on populations or activity resulting from the treatment was observed or recroded. Breeding territories generally remained occupied following the application but seasonal breakdown is indicated as boundary areas were found to be quite flexible (Fig. 26).

Intensive searches throughout the treated area were carried out during the three days following the application of aminocarb but no avian mortality was recovered and no symptoms of pesticide stress (bill wiping, irratic flight or perching, wing droop, etc.) were observed.

Small Mammals A total of 374 trap nights yielded a total of only 13 small mammal specimens (.034 animals per trap night) during the immediate pre-spray trap period of 5 days on the treatment block while 375 trap nights yielded 18 specimens (.048 animals per trap night) on the untreated control block during the same period (Tables 13 and 14). The red-backed vole, *C. gapperi*, was the dominant animal trapped, followed by the masked shrew, *S. cinereus*. Few "young of the year" animals were taken during this trap period (8% on the treatment block and 33% in the untreated block).

Table 11

Forest Bird Population Census
MATACIL® Treatment Plot
St. Donat de Montcalm, Quebec
26 June - 4 July 1979

(MATACIL® applied 28 June at the emitted dosage rate of 175 g AI/ha)

Family	Pre-spray				Post-spray					
	June 26	June 27	June 28	Daily	June 29	June 30	July 1	July 3	July 4	Daily
	-2	-1	-0	Ave	+1	+2	+3	+5	+6	Ave
Tyrannidae	2	4	4	3.3	4	2	0	2	0	1.6
Corvidae	1	0	0	0.3	0	0	1	1	1	0.6
Paridae	0	1	1	0.7	0	0	0	0	0	0.0
Sittidae	0	2	0	0.7	0	2	0	2	2	1.2
Troglodytidae	0	2	2	1.3	6	4	6	2	4	4.4
Turdidae	7	13	13	11.0	7	7	5	3	7	5.8
Sylviidae	4	4	6	4.7	9	8	4	2	2	5.0
Bombycillidae	1	2	2	1.7	2	1	4	1	5	2.6
Vireonidae	2	4	4	3.3	2	2	0	0	0	0.8
Parulidae	40	71	37	49.3	54	37	25	20	16	30.4
Icteridae	1	0	1	0.7	0	0	1	0	0	0.2
Fringillidae	13	26	22	20.3	18	11	13	11	8	12.2
Unidentified Birds	8	4	3	5.0	1	0	0	0	0	0.2
Total Birds	79	133	95	102.3	103	74	59	44	45	65.0

Table 12

Forest Bird Population Census
MATACIL® Untreated Control Plot
St. Donat de Montcalm, Quebec
24 June - 4 July 1979

Family	Pre-spray						Post-spray					
	June 24 -4	June 25 -3	June 26 -2	June 27 -1	June 28 -0	Daily Ave	June 29 +1	June 30 +2	July 1 +3	July 3 +5	July 4 +6	Daily Ave
Tetraonidae	0	0	0	0	0	0.0	0	0	0	5	0	1.0
Tyrannidae	0	0	0	4	0	0.8	2	0	0	0	0	0.4
Corvidae	2	0	0	0	0	0.4	0	2	0	0	0	0.4
Paridae	0	0	0	1	2	0.6	0	0	0	2	0	0.4
Sittidae	0	0	0	0	2	0.4	0	0	0	0	0	0.0
Mimidae	0	0	0	0	0	0.0	0	0	2	0	4	1.2
Turdidae	0	15	3	10	6	6.8	13	15	9	7	4	9.6
Sylviidae	0	2	0	4	2	1.6	2	0	0	1	0	0.6
Bombycillidae	0	3	0	0	3	1.2	0	0	2	2	0	0.8
Vireonidae	2	4	0	0	4	2.0	2	4	2	0	0	1.6
Parulidae	24	46	26	30	31	31.4	32	22	14	16	18	20.4
Fringillidae	6	9	2	5	4	5.2	6	5	6	2	5	4.8
Unidentified Birds	2	2	0	0	0	0.8	0	0	2	0	0	0.4
Total Birds	36	81	31	54	54	51.2	57	48	37	35	31	41.6

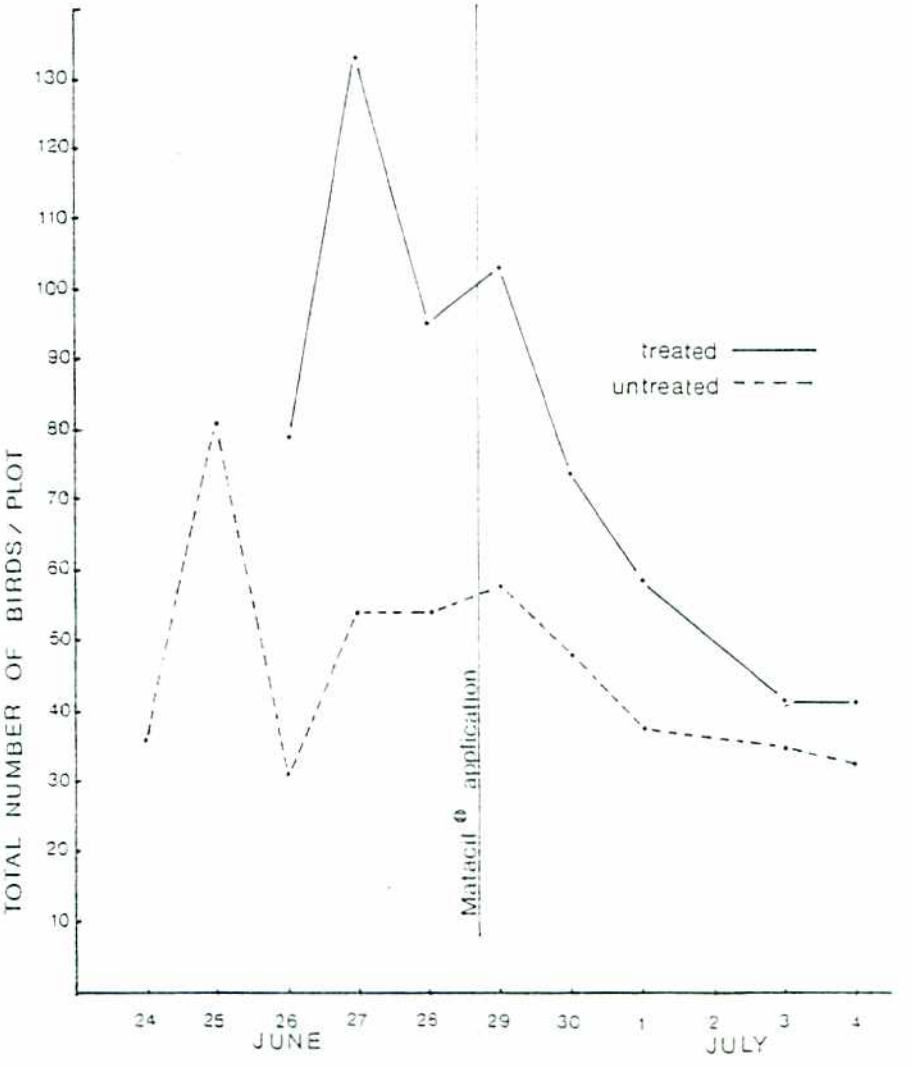


Figure 25. Activity trends of bird populations on MATACIL® treated and untreated plots, St. Donat de Montcalm, Quebec 1979.

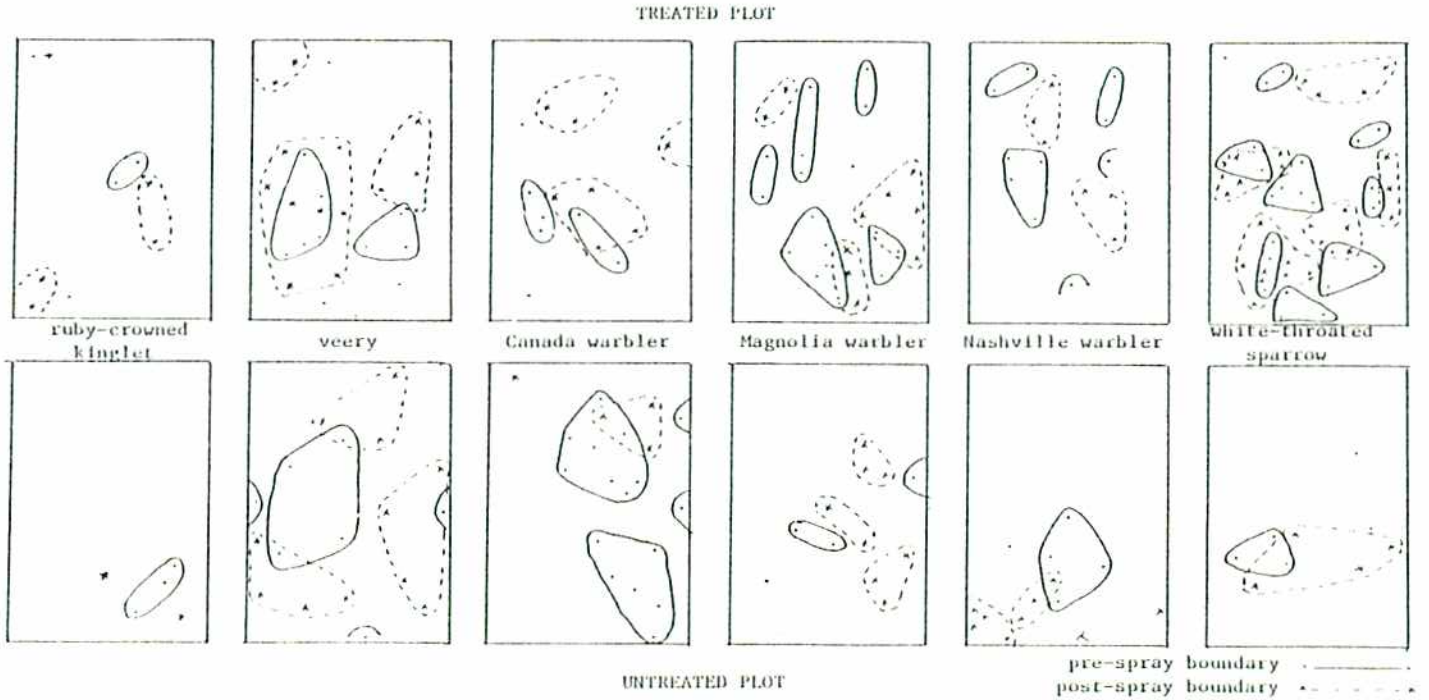


Figure 26. Breeding territories of six small forest birds on MATACIL® treated and untreated control plots, St. Donat du Montcalm, Quebec, 1979.

Table 13

Small mammal population census
MATACIL® treated and untreated plots
St. Donat de Montcalm, Quebec
1979

pre-spray trap period

	treated block						untreated control block					
	males		females				males		females			
	sub-adult	adult	sub-adult	adult breeding	adult not breeding	totals	sub-adult	adult	sub-adult	adult breeding	adult not breeding	totals
Clethrionomys gapperi	0	7	0	1	0	8	0	5	2	1	1	9
Sorex cinereus	1	0	0	1	2	4	1	1	1	1	0	4
Blarina brevicauda	0	0	0	0	0	0	0	0	2	0	1	3
Napaozapus insignis	0	0	0	0	0	0	0	0	0	1	0	1
Zapus hudsonius	0	1	0	0	0	1	0	0	0	0	1	1
Totals	1	8	0	2	2	13	1	6	5	3	3	18

first post-spray period (immediate)

Clethrionomys gapperi	0	4	3	4	2	13	0	4	0	1	0	5
Sorex cinereus	0	2	0	2	1	5	9	16	3	10	8	46
Blarina brevicauda	0	2	0	0	0	2	0	0	0	0	1	1
Napaozapus insignis	0	0	0	1	0	1	1	1	0	1	0	3
Zapus hudsonius	0	0	0	2	0	2	0	0	0	0	0	0
Peromyscus maniculatus	1	0	0	0	0	1	0	0	0	0	0	0
Tamias striatus	0	0	0	0	0	0	0	0	0	1	0	1
Totals	1	8	3	9	3	24	10	21	3	15	9	58

second post-spray period (3 - 4 weeks)

Clethrionomys gapperi	0	25	1	6	0	34	0	18	2	7	1	28
Sorex cinereus	30	30	24	22	6	112	19	17	12	17	8	73
Blarina brevicauda	6	7	3	3	2	21	0	1	1	2	4	8
Napaozapus insignis	0	3	1	4	0	8	2	6	3	8	1	20
Zapus hudsonius	3	2	1	0	0	6	0	1	0	0	0	1
Peromyscus maniculatus	0	13	1	5	1	20	0	13	0	6	0	19
Microtus pennsylvanicus	0	1	0	0	0	1	0	1	0	0	0	1
Condylura cristata	0	0	0	1	0	1	0	0	0	0	0	0
Tamias striatus	0	0	0	0	0	0	0	1	0	1	1	3
Totals	39	81	33	51	9	203	21	58	18	41	15	153

TABLE 14

Summary of small mammal populations on
MATACIL® treated and untreated control plots
St. Donat de Montcalm, Quebec
1979

trap period	treated block: portion of total catch (percent)	treated block: young of the year (percent)	treated block: adult females breeding (percent)	treated block: trap success (animal/trap night ratio)	untreated block: portion of total catch (percent)	untreated block: young of the year (percent)	untreated block: adult females breeding (percent)	untreated block: trap success (animal/trap night ratio)
all mammals								
immediate pre-spray	100.0	7.6	50.0	0.034	-	33.3	50.0	0.048
immediate post-spray	100.0	16.6	50.0	0.038	-	22.4	62.5	0.128
23 day post-spray	100.0	35.4	82.0	0.088	-	25.4	73.2	0.085
red-backed vole								
immediate pre-spray	61.5	0.0	100.0	0.021	50.0	22.2	50.0	0.024
immediate post-spray	54.1	23.0	66.6	0.021	8.6	0.0	100.0	0.011
23 day post-spray	16.7	8.8	100.0	0.014	18.3	7.1	87.5	0.015
shrew spp.								
immediate pre-spray	30.7	25.0	33.3	0.010	38.8	57.1	50.0	0.018
immediate post-spray	29.1	0.0	66.6	0.011	81.0	25.5	52.6	0.104
23 day post-spray	65.4	47.3	75.7	0.057	52.9	39.5	61.2	0.045
others								
immediate pre-spray	7.6	0.0	0.0	0.002	11.1	0.0	50.0	0.005
immediate post-spray	16.6	25.0	100.0	0.006	10.3	16.6	100.0	0.013
23 day post-spray	17.1	17.1	90.9	0.015	28.7	11.3	93.7	0.024

Slightly higher numbers were taken during the 6-day immediate post-spray trapping period in the treatment block (24 animals in 618 trap nights, yielding the same animal-trap night success ratio of .03 animals per trap night). Fifty-eight animals were trapped in 450 trap nights during the same period on the untreated block (.12 animals per trap night success ratio). An increase in the numbers of "young of the year" was recorded on the treatment block (16%) while a slight decrease was recorded on the untreated block (22%). A dramatic increase in the numbers of masked shrews taken on the untreated block was not recorded in the treated block sample. Numerous sightings of weasels (*Mustela erminea*, Linnaeus or *Mustela nivalis*, Linnaeus) on the treated block during this period suggests that predation by them depressed small mammal populations in this area.

During the 10-day second post-spray trap period (3-4 weeks post-treatment) a total of 203 animals were trapped in 2300 trap nights (0.088 animals per trap night) on the treated block and 153 animals taken in 1800 trap nights (0.085 animals per trap night) on the untreated block. The percent of "young of the year" in the treated block sample, which had increased from 7.6 percent in the pre-spray sample to 16.6 percent in the immediate post-spray sample, further increased to 35.4 percent in this late season sample. This increase was not reflected in the untreated population sample where 33.3 percent was recorded prior to treatment, 22.4 percent immediately after treatment and 25.4 percent in the final sample.

The portion of the adult female population recorded as being in "breeding condition" (containing embryos, placental scars or obviously lactating) increased on both plots over the experimental period. Fifty percent of the adult females trapped during the pre- and immediate post-spray periods and 82 percent of the later sample from the treated block were recorded as being in "breeding condition". This trend is also present in the untreated block sample where 50 percent of the pre-spray sample, 62.5 percent of the immediate post-spray sample and 73.2 percent of the late sample were in "breeding condition".

DISCUSSION

Review of terrestrial monitoring studies carried out in forest areas in Eastern North America treated with MATACIL® to control spruce budworm, indicates that this material has been found not to have any serious side-effects on the organisms and ecological processes studied. Various federal and provincial monitoring groups and research agencies have reached this same conclusion (e.g., Environmental Monitoring Committee 1979 a and b, Kingsbury and McLeod 1978, Varty 1980). In light of the extensive widespread monitoring of forest songbirds carried out without the detection of any significant effects, it has been suggested that further extensive monitoring of forest songbirds exposed to MATACIL® treatments applied under current use patterns would be of little value (Germain and Tingley, 1980). MATACIL® treatments also seem to have negligible effects on

pollination processes, although this field of study has not been as extensively studied (Varty, 1980).

The present study examining the effects of a seasonal maximum application of nonyl phenol is the first direct field evaluation of the impact of this material on non-target organisms in forest ecosystems. Nonyl phenol has, however, been present in all MATACIL® formulations applied in Canada since 1975, so that vast majority of monitoring studies carried out to date have indirectly examined the effects of this material in its actual use pattern. In the present experiment nonyl phenol was applied at a rate equivalent to the quantity of nonyl phenol applied in allowable maximum seasonal applications of MATACIL® (2 to 3 1/2 times suggested single application rates), and a very substantial deposit of the emitted dosage was recorded on the terrestrial impact study plot. Studies of terrestrial invertebrate knockdown, honeybee colonies and forest songbird populations indicate that nonyl phenol does not have any significant insecticidal effects in terrestrial ecosystems and has no effect on forest songbird populations or their ability to defend breeding territories. The evidence of nonyl phenol's relative low-persistence in foliage and non-persistence in soil under "worst case" application conditions indicates that environmental contamination from nonyl phenol present in insecticide formulations used in pest control operations would be minimal. The relatively rapid initial decline of nonyl phenol residue in foliage may be primarily due to volatilization, but other environmental and biological factors may be important for its subsequent degradation in foliage. The failure to detect nonyl phenol in soil samples collected from an open plot well exposed to the sky suggests that this chemical disappears very rapidly from soil through physical, chemical or biological processes.

A very high level of contamination with MATACIL® was recorded from the area treated with a seasonal maximum application of this material, judging from the results of deposit assessment and residue analysis, and from observations of insect knockdown. The MATACIL® residues measured in balsam fir foliage in the treated area were approximately 5 times greater than the maximum level (5.5 µg/g) and 20 times greater than the mean level of MATACIL® measured in large numbers of foliage samples collected shortly after operational MATACIL® treatments from forest areas in Quebec in 1979 (G. Gaboury, personal communication). Despite this, there were no measurable effects recorded on forest songbird or small mammal populations. A large percentage of the adult female small mammal population were found to be breeding after the treatment and many young of the year were present, indicating normal breeding activity had continued over the treatment period. Knockdown of terrestrial invertebrates from conifers was increased by a far greater extent over prespray levels in the area receiving the seasonal maximum MATACIL® application than

in the area receiving conventional applications of MATACIL®, but in both cases total knockdown significantly greater than prespray levels only persisted for a period of less than 48 hours. The overall lack of significant effects of the seasonal maximum MATACIL® application on terrestrial vertebrates, the short duration of its knockdown effects of terrestrial invertebrates and the relatively minor effects it had on aquatic ceosystems (Holmes and Kingsbury, 1980) all suggest that there is a substantial safety margin built into the conventional dosages of MATACIL® currently applied to control spruce budworm in terms of the hazard they present to non-target fauna of forest ecosystems.

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APPENDIX I

TERRESTRIAL INVERTEBRATE

KNOCKDOWN DATA

Table I-1
Terrestrial invertebrate knockdown from spruce
MATACIL® treatment plot
Wawa, Ontario
9 June to 23 June 1979

Date		June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23
Days before or after application		-6	-5	-4	-3	-2	-1	-0	+1	+2	+3	+1	+2	+3	+4	+5
Oligochaeta										0.20						
Arachnida																
Acari									0.20			0.20				
Araneida		0.20	0.40		0.20	0.20	0.25	0.25	1.20			0.40				
Collembola												0.40				
Odonata																
Anisoptera				0.20												
Hemiptera						0.20			0.20							
Coleoptera																
Carabidae									0.20	0.20						
Staphylinidae		1.40				0.60		0.50	1.20		0.40	0.60	0.60			
Elateridae								0.25			0.20					
Psephenidae					0.20											
Other										0.20						
Trichoptera													0.20			
Lepidoptera	larvae							0.25	2.40	0.40	1.00	2.00	2.60	2.00	0.60	0.80
Diptera																
Tipulidae						0.20								0.20		
Culcidae			0.20									0.20				
Chironomidae		0.20	0.20	0.20	0.40	1.20	0.50		1.00	0.20						
Simuliidae		0.40	0.40	0.20	0.40	0.40	0.50	1.00	0.20					0.20		0.80
Sciaridae					2.20	0.40		0.25		6.00				0.20		
Muscoidae										0.60						
Other				0.40	0.20	0.20	0.25	0.25	7.00	0.80	0.20	0.40	0.20			0.40
Hymenoptera																
Formicidae		0.20			0.20		0.25									
Other	adults	3.60		0.60	0.20			0.25	0.40	0.80		0.20	0.40			0.20
Other	larvae													0.80		
Total number of invertebrates/bucket		6.00	1.20	1.60	4.00	3.40	1.75	3.00	14.00	9.40	1.80	4.40	4.00	3.40	0.60	2.20

Table I-2
Terrestrial invertebrate knockdown from willow
MATACIL® treatment plot
Wawa, Ontario
9 June to 23 June 1979

Date		June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23
Days before or after application		-6	-5	-4	-3	-2	-1	-0	+1	+2	+3	+1	+2	+3	+4	+5
Gastropoda								0.33	0.33		0.33					
Arachnida																
Araneida		0.33	1.00	2.00	0.67	1.00	0.33		0.67			0.67			0.33	0.33
Hemiptera		0.33													0.33	
Homoptera										0.33				0.33		
Coleoptera																
Carabidae					0.33							0.33				
Staphylinidae		1.00			0.33	0.67	0.33	0.33	0.33			1.00	0.33			
Other									0.67							0.33
Lepidoptera	larvae										0.33			0.33		
Diptera																
Culicidae		0.33							0.33							
Chironomidae		1.33	0.67				0.33		0.33			0.33				
Simuliidae		0.33	0.67					0.33				0.33			0.67	
Sciaridae					1.00		3.67					0.67				0.33
Muscoidae									0.33							
Other					0.33			0.33	1.67	0.33			0.33	0.33		0.33
Hymenoptera																
Formicidae						0.33										
Other	adults	3.00							1.67						0.33	
Other	larvae															0.33
Total number of invertebrates/bucket		6.62	2.34	2.00	2.66	2.00	4.66	1.32	6.33	0.66	0.66	3.33	0.66	0.99	1.66	1.65

Table I-3
Terrestrial invertebrate knockdown from spruce
MATACIL® untreated control plot
Wawa, Ontario
9 June to 23 June 1979

Date	June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23
Days before or after application	-6	-5	-4	-3	-2	-1	-0	+1	+2	+3	+1	+2	+3	+4	+5
Gastropoda													0.20		
Arachnida															
Acari	0.40			0.20											
Araneida		0.50	0.17	0.20	0.60	0.40	0.20	0.60	0.40	0.20	0.80	0.40			
Collembola	1.00			2.80	0.20	0.60	0.60		0.20	0.40	0.20	0.20			
Homoptera															
Cicadellidae							0.20								
Coleoptera															
Carabidae			0.17												0.40
Staphylinidae	0.20			0.20	0.20		0.40	0.60							
Elateridae							0.20		0.20	0.20		0.20			
Other	0.40						0.20								
Lepidoptera larvae			0.17	0.20				0.20	0.40				0.40		0.20
Diptera															
Chironomidae	0.40	0.50	0.17	0.40					0.80			0.40			
Simulidae	0.20	0.75	0.50	0.40			0.40	0.40	0.20						0.20
Sciaridae	2.60	1.25	7.30	3.60	0.20	1.40	10.00		2.80	0.20	0.20	0.40			0.20
Muscoidae		0.25	0.17										0.20		0.20
Other	0.20	0.50	0.83	0.60					1.00			0.40	0.40		
Hymenoptera															
Formicidae	0.20	0.25		0.40		0.20	0.80		0.20	0.20					
Other			0.67				1.00		1.40			0.80			
Total number of invertebrates/bucket	5.60	4.00	10.15	9.00	1.20	2.60	14.00	1.80	7.60	1.20	1.20	2.80	1.20	0.00	1.20

Table I-4
Terrestrial invertebrate knockdown from willow
MATACIL® untreated control plot,
Wawa, Ontario
9 June to 23 June 1979

Date		June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23
Days before or after application		-6	-5	-4	-3	-2	-1	-0	+1	+2	+3	+1	+2	+3	+4	+5
Arachnida																
Acari								0.33								
Araneida		0.67			0.33		0.33	0.33		0.67						
Other										0.33						
Collembola		2.67	3.67	0.67	3.00			3.33	0.33	5.33	1.67	0.33				0.33
Orthoptera																
Acrididae							0.33									
Hemiptera								0.33								
Homoptera																
Cicadellidae			0.33													
Coleoptera																
Carabidae		0.33							0.33							
Staphylinidae		0.33						1.67								
Other										0.33						
Lepidoptera	larvae						0.33								0.33	
Diptera																
Chironomidae		0.67			0.67			1.33	0.33	2.67			0.33			
Simuliidae								2.33	0.33	2.33	0.33					
Sciaridae		1.67	2.00	2.00	1.67			17.33	0.33	7.33	0.67		0.33	0.33		
Other		1.00	0.67	0.67	1.00			2.67		2.67			0.33	0.33	0.33	0.33
Hymenoptera																
Formicidae		0.67			1.00	0.33		1.67	0.33	1.00			0.33			
Other	adults		0.33	0.67				5.33		3.00	0.33		0.67	0.33		
Other	larvae									0.33						
Total number of invertebrates/bucket		8.01	7.00	4.01	7.67	0.33	0.99	36.65	1.98	25.99	3.00	0.33	1.99	0.99	0.66	0.66

Table I-5

Terrestrial invertebrate knockdown from coniferous trees
Nonyl phenol treatment plot
Dubreuilville, Ontario
25 May to 3 June, 1979.

Date	May 25	May 26	May 27	May 28	May 29	May 30	May 31	June 1	June 2	June 3
Days before or after application	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5
Arachnida										
Phalangida									0.08	
Araneida	0.13	0.25	0.25			0.17	0.17	0.08	0.08	0.08
Acari									0.08	
Collembola	0.13							0.08		
Hemiptera										0.08
Coleoptera										
Staphylinidae					0.08	0.17	0.25	0.17	0.33	0.17
Other		0.38			0.25	0.08	0.08	0.08		
Diptera										
Chironomidae						0.08				
Other	0.38	0.63	0.50	0.50	0.83	1.08	0.25	1.17	0.42	0.92
Hymenoptera										
Formicidae										0.08
Other						0.08		0.17	0.17	
Number of Invertebrates/Bucket	0.64	1.26	0.75	0.50	1.16	1.66	0.75	1.75	1.16	1.33

Table I-6

Terrestrial invertebrate knockdown from deciduous trees
Nonyl phenol treatment plot
Dubreuilville, Ontario
25 May to 3 June, 1979.

Date	May 25	May 26	May 27	May 28	May 29	May 30	May 31	June 1	June 2	June 3
Days before or after application	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5
Arachnida										
Araneida	0.13	0.13	0.13	0.08	0.58	0.50	0.25	0.08	0.08	0.25
Acari								0.08		
Collembola							0.08			
Hemiptera			0.13			0.17		0.08		
Coleoptera										
Staphylinidae					0.08	0.17		0.08	0.08	0.17
Other					0.08	0.17		0.33		
Lepidoptera larvae			0.13					0.08		
Diptera	0.50	0.13		0.25	1.17	1.50	0.42	2.08	0.75	1.33
Hymenoptera										
Formicidae				0.08			0.08			
Other	0.25		0.13	0.17		0.42	0.17	0.58	0.08	0.08
Number of Invertebrates/Bucket	0.88	0.26	0.52	0.58	1.91	2.93	1.00	3.39	0.99	1.83

Table I-7

Terrestrial invertebrate knockdown from coniferous trees
Nonyl phenol untreated control plot
Dubreuilville, Ontario
25 May to 3 June, 1979.

Date	May 25	May 26	May 27	May 28	May 29	May 30	May 31	June 1	June 2	June 3
Days before or after application	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5
Arachnida										
Araneida	0.13		0.13			0.17		0.17	0.08	0.08
Collembola			0.25			0.08		0.08		
Hemiptera					0.08					
Homoptera										0.08
Coleoptera										
Staphylinidae	0.13					0.08	0.08	0.17		0.08
Other							0.17			
Lepidoptera larvae	0.13		0.38							
Diptera										
Chironomidae					0.08				0.17	0.17
Other	1.50	1.50	0.38	0.42	1.00	1.17	0.67	1.33	0.50	1.00
Hymenoptera	0.50	0.13		0.17	0.08	0.17		0.17	0.08	0.17
Number of Invertebrates/Bucket	2.39	1.63	1.14	0.59	1.24	1.67	0.92	1.92	0.83	1.58

Table I-8

Terrestrial invertebrate knockdown from deciduous trees
Nonyl phenol untreated control plot
Dubreuilville, Ontario
25 May to 3 June, 1979.

Date	May 25	May 26	May 27	May 28	May 29	May 30	May 31	June 1	June 2	June 3
Days before or after application	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5
Gastropoda									0.08	
Arachnida										
Araneida	0.25			0.08	0.08	0.08	0.08			0.08
Collembola			0.13	0.42				0.08		
Coleoptera										
Staphylinidae	0.25				0.08	0.25			0.08	0.08
Other					0.25	0.08		0.17		
Lepidoptera larvae					0.08					
Diptera										
Chironomidae						0.08		0.17		0.17
Other	0.13	0.50	0.13	0.42	0.50	1.08	0.92	2.92	1.83	1.50
Hymenoptera										
Formicidae									0.08	0.17
Other	0.13			0.08	0.25	0.08		0.33	0.08	
Number of Invertebrates/Bucket	0.76	0.50	0.26	1.00	1.24	1.65	1.00	3.67	2.15	2.00

Table I-9

Terrestrial insect knockdown from balsam fir
MATACIL® treated and untreated control plots
St. Donat de Montcalm, Quebec
1979

Order	Family	treated										untreated control									
		June						July				June						July			
		25	26	27	28	29	30	1	2	3	4	25	26	27	28	29	30	1	2	3	4
Archnida	Phalangida	0	3	2	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
	Acari	0	0	0	0	5	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	Araneida	1	2	6	0	42	16	2	2	2	1	1	0	0	0	1	0	1	0	0	1
Diploda		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Collembola		0	0	0	0	33	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0
Plecoptera		0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psocoptera		0	0	0	0	15	0	2	0	2	0	2	0	0	0	1	0	0	5	6	1
Hemiptera		0	0	5	2	11	6	0	0	3	0	0	0	0	0	0	1	0	3	0	0
Homoptera	Cicadellidae	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	1	0	0	2	3	7	2	3	2	0	1	0	1	0	1	0	0	1	0	0
Neuroptera		0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Coleoptera	Carabidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	1	1	0	1
	Staphylinidae	0	0	0	0	1	0	2	2	1	0	0	1	0	0	0	0	0	0	0	0
	Elateridae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	0	1	0	0	5	11	2	0	0	1	0	1	0	1	0	0	0	3	0	0
Trichoptera		0	0	0	0	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidoptera		1	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tipulidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Culicidae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomidae	0	0	0	0	10	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	Simuliidae	1	1	0	0	14	6	1	2	0	0	0	0	0	0	0	0	0	0	0	0
	Sciaridae	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Muscoidae	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Other	3	1	4	7	30	4	3	1	1	0	0	1	1	1	1	1	0	11	3	4
Hymenoptera	Formicidae	0	0	2	0	0	0	1	0	1	4	0	0	0	0	0	0	0	0	0	0
	Other	0	1	2	1	18	2	3	1	1	0	0	1	0	0	1	0	0	10	2	0
Totals		7	11	21	13	228	56	21	12	15	7	5	4	2	2	6	4	2	35	17	8

APPENDIX II

FOREST SONGBIRD

CENSUSES

Table II-1

Forest Bird Population Census
MATACIL® Treatment Plot
Wawa, Ontario
8-23 June 1979

(MATACIL® applied on 15 June and 18 June at the emitted dosage rate of 0.070 kg AI/ha)

Family	Species	Prespray treatment 1						Post-spray treatment 1				Post-spray treatment 2					
		June 8	June 9	June 11	June 12	June 13	Daily	June 16	June 17	June 18	Daily	June 19	June 20	June 21	June 22	June 23	Daily
		-7	-6	-4	-3	-2	Ave	+1	+2	+3	Ave	+1	+2	+3	+4	+5	Ave
Tetraonidae	Ruffed Grouse	2	2	2	2	2	2.0	2	0	2	1.3	2	2	0	2	2	1.6
Picidae	Common Flicker	0	0	0	0	0	0.0	0	0	0	0.0	0	0	0	2	0	0.4
	Yellow-bellied Sapsucker	0	0	0	2	0	0.4	2	0	0	0.7	0	2	0	2	0	0.8
Tyrannidae	Yellow-bellied Flycatcher	0	0	0	0	0	0.0	0	2	0	0.7	0	2	0	2	0	0.8
	Least Flycatcher	6	6	4	6	4	5.2	6	2	6	4.7	6	4	4	4	4	4.4
	Olive-sided Flycatcher	2	2	2	2	2	2.0	0	0	0	0.0	2	2	2	0	2	1.6
Corvidae	Gray Jay	0	0	0	1	2	0.6	0	0	0	0.0	0	0	0	0	0	0.0
Paridae	Boreal Chickadee	0	2	4	4	3	2.6	3	0	1	1.3	0	2	0	1	0	0.6
Sittidae	Red-breasted Nuthatch	2	2	2	2	2	2.0	0	0	2	0.7	2	2	0	2	2	1.6
Troglodytidae	Winter Wren	2	2	2	2	2	2.0	2	0	2	1.3	2	2	2	2	2	2.0
Turdidae	American Robin	2	2	2	0	2	1.6	1	0	2	1.0	0	2	4	2	2	2.0
	Hermit Thrush	3	4	5	3	4	3.8	4	0	3	2.3	3	5	3	1	2	3.2
	Swainson's Thrush	6	7	6	3	5	5.4	5	6	4	5.0	8	4	5	6	5	5.6
	Veery	2	3	3	1	3	2.4	4	0	4	2.7	2	4	4	4	0	2.8
Sylviidae	Ruby-crowned Kinglet	4	4	4	4	4	4.0	4	2	4	3.3	4	2	4	4	4	3.6
Vireonidae	Solitary Vireo	6	4	4	4	4	4.4	4	0	4	2.7	4	4	4	0	4	3.2
	Philadelphia Vireo	0	0	0	0	0	0.0	0	0	0	0.0	2	2	2	2	2	2.0
Parulidae	Black-and-white Warbler	2	4	4	2	2	2.8	6	0	2	2.7	2	4	4	2	2	2.8

Table II-1 (cont'd)

Family	Species	Prespray treatment 1						Post-spray treatment 1				Post-spray treatment 2					
		June 8	June 9	June 11	June 12	June 13	Daily Ave	June 16	June 17	June 18	Daily Ave	June 19	June 20	June 21	June 22	June 23	Daily Ave
		-7	-6	-4	-3	-2		+1	+2	+3		+1	+2	+3	+4	+5	
Parulidae cont'd	Tennessee Warbler	5	4	4	4	4	4.2	4	2	4	3.3	2	2	4	4	4	3.2
	Nashville Warbler	2	2	2	2	2	2.0	2	2	4	2.7	2	2	2	2	2	2.0
	Magnolia Warbler	2	3	2	2	2	2.2	0	0	2	0.7	0	2	2	2	2	1.6
	Cape May Warbler	4	2	1	2	2	2.2	0	4	2	2.0	0	2	2	2	2	1.6
	Yellow-rumped Warbler	4	8	0	4	4	4.0	4	2	4	3.3	4	4	4	4	2	3.6
	Black-throated Green Warbler	4	6	6	6	6	5.6	6	4	4	4.7	6	6	6	6	2	5.2
	Blackburnian Warbler	2	4	4	2	2	2.8	2	2	2	2.0	4	2	4	4	2	3.2
	Chestnut-sided Warbler	2	2	4	2	2	2.4	0	2	2	1.3	2	2	0	2	2	1.6
	Bay-breasted Warbler	2	4	2	2	4	2.8	2	2	2	2.0	2	4	0	2	2	2.0
	Ovenbird	4	6	4	6	4	4.8	6	4	4	4.7	6	2	6	6	4	4.8
	Mourning Warbler	2	2	2	2	2	2.0	2	2	2	2.0	2	2	2	0	2	1.6
	Canada Warbler	2	2	2	2	2	2.0	2	2	4	2.7	2	4	4	0	2	2.4
	American Redstart	4	4	4	4	4	4.0	4	4	6	4.7	2	4	4	4	4	3.6
Fringillidae	Evening Grosbeak	0	0	0	0	0	0.0	2	0	2	1.3	0	2	2	1	0	1.0
	Purple Finch	2	4	2	4	2	2.8	2	0	2	1.3	4	2	2	2	2	2.4
	Dark-eyed Junco	2	2	0	2	2	1.6	4	0	4	2.7	4	2	0	4	0	2.0
	White-throated Sparrow	4	8	9	7	6	6.8	8	2	6	5.3	5	5	6	5	4	5.0
	Swamp Sparrow	2	2	2	2	2	2.0	0	0	2	0.7	0	2	2	2	2	1.6
TOTAL BIRDS		88	109	94	93	93	95.4	93	46	94	77.8	86	96	90	92	73	87.4
Total Species		29	30	28	31	31	29.8	26	17	30	24.3	26	34	26	31	28	29.0

Table II-2

Forest Bird Population Census
HATACH[90] Untreated Control Plot
Wawa Ontario
8-23 June 1979

Family	Species	Prespray treatment 1						Post-spray treatment 1				Post-spray treatment 2					
		June 8	June 9	June 11	June 12	June 13	Daily	June 16	June 17	June 18	Daily	June 19	June 20	June 21	June 22	June 23	Daily
		-7	-6	-4	-3	-2	Ave	+1	+2	+3	Ave	+1	+2	+3	+4	+5	Ave
Tetraonidae	Ruffed Grouse	0	0	1	1	0	0.4	0	0	0	0.0	0	0	0	0	0	0.0
Picidae	Yellow-bellied Sapsucker	0	1	0	1	0	0.4	0	0	0	0.0	0	0	0	0	0	0.0
Tyrannidae	Yellow-bellied Flycatcher	2	4	6	2	2	3.2	0	0	2	0.7	0	2	2	2	0	1.2
	Least Flycatcher	0	0	0	2	4	1.2	2	2	2	2.0	2	2	2	0	0	1.2
Sittidae	Red-breasted Nuthatch	2	0	0	2	0	0.8	0	0	0	0.0	0	0	0	0	0	0.0
Turdidae	Hermit Thrush	0	0	0	2	2	0.8	0	0	2	0.7	2	0	0	2	0	0.8
	Swainson's Thrush	1	1	3	0	3	1.6	4	0	4	2.7	1	1	0	0	0	0.4
	Veery	2	0	3	0	0	1.0	0	0	0	0.0	0	0	0	0	0	0.0
Sylviidae	Golden-crowned Kinglet	0	4	2	4	0	2.0	0	4	2	2.0	0	2	0	2	0	0.8
Vireonidae	Solitary Vireo	0	0	2	2	0	0.8	0	0	2	0.7	0	0	2	0	0	0.4
	Red-eyed Vireo	4	6	6	6	2	4.8	8	2	6	5.3	6	8	4	2	2	4.4
Parulidae	Black-and-white Warbler	2	0	2	0	2	1.2	0	0	0	0.0	2	0	0	0	0	0.4
	Tennessee Warbler	0	0	0	0	0	0.0	0	0	0	0.0	2	2	2	0	0	1.2
	Nashville Warbler	0	0	2	2	0	0.8	0	0	0	0.0	0	0	0	0	0	0.0
	Magnolia Warbler	2	4	6	0	2	2.8	8	4	4	5.3	4	4	4	2	4	3.6
	Cape May Warbler	0	2	0	0	0	0.4	0	2	8	3.3	2	2	2	0	0	1.2
	Yellow-rumped Warbler	0	0	4	2	2	1.6	2	6	4	4.0	2	2	4	4	0	2.4
	Black-throated Green Warbler	0	0	0	0	0	0.0	2	0	0	0.7	0	2	0	0	0	0.4
	Blackburnian Warbler	10	6	4	6	2	5.6	4	4	4	4.0	2	2	2	2	4	2.4
	Chestnut-sided Warbler	4	0	4	2	2	2.4	2	2	2	2.0	2	2	4	6	2	3.2
	Ovenbird	12	14	10	18	14	13.6	6	6	12	8.0	14	8	10	6	8	9.2
	Canada Warbler	0	0	2	6	2	2.0	2	0	2	1.3	0	2	2	0	2	1.2
Fringillidae	Rose-breasted Grosbeak	0	0	0	0	0	0.0	0	2	4	2.0	0	0	0	0	0	0.0
	Purple Finch	2	0	0	0	0	0.4	0	0	0	0.0	0	2	0	2	0	0.8
	White-throated Sparrow	2	2	0	0	0	0.8	2	0	1	1.0	0	0	0	2	0	0.4
TOTAL BIRDS		45	44	57	58	39	48.6	42	34	61	45.7	41	43	40	32	22	35.6
Total Species		12	10	15	15	12	12.8	11	10	16	12.3	12	15	12	11	6	11.2

Table II-3

Forest Bird Population Census
Nonyl phenol treatment plot
Dubreuilville, Ontario
24 May - 3 June 1979

		Prespray							Postspray						
		May 24	May 25	May 26	May 27	May 28	May 29	Daily	May 29	May 30	May 31	June 1	June 2	June 3	Daily
Family	Species	-5	-4	-3	-2	-1	-0	ave.	+0	+1	+2	+3	+4	+5	ave.
Tetraonidae	Spruce Grouse	0	0	1	0	0	0	0.2	0	0	0	0	1	1	0.3
Alcedinidae	Belted Kingfisher	1	0	0	0	1	0	0.3	0	1	1	0	1	0	0.5
Picidae	Common Flicker	0	0	3	0	0	0	0.5	0	0	0	1	0	0	0.2
	Yellow-bellied Sapsucker	1	3	0	4	0	0	1.3	0	0	0	1	0	0	0.2
Tyrannidae	Great Crested Flycatcher	0	0	0	2	0	0	0.3	0	0	2	0	0	0	0.3
	Least Flycatcher	0	0	0	0	0	0	0.0	0	2	2	0	2	2	1.3
	Olive-sided Flycatcher	0	0	0	0	0	0	0.0	2	0	0	0	2	0	0.7
Corvidae	Gray Jay	0	0	1	0	1	0	0.3	0	0	0	0	0	0	0.0
	Blue Jay	2	2	1	1	1	0	1.2	0	0	0	0	0	0	0.0
	Raven	2	0	0	1	0	0	0.5	0	1	0	0	1	0	0.7
Paridae	Black-capped Chickadee	0	0	1	0	0	0	0.2	0	0	0	0	0	0	0.0
	Boreal Chickadee	0	0	1	1	0	0	0.3	0	3	1	0	0	2	1.0
Sittidae	Red-breasted Nuthatch	2	0	0	0	0	0	0.3	0	0	0	0	0	0	0.0
Troglodytidae	Winter Wren	2	0	0	2	2	2	1.3	0	0	0	0	0	2	0.3
Turdidae	American Robin	0	1	0	0	0	0	0.2	0	0	0	0	0	2	0.3
	Hermit Thrush	1	2	3	0	9	6	3.5	2	7	6	8	6	7	6.0
	Veery	0	0	0	0	0	0	0.0	0	1	0	0	0	2	0.5
Sylviidae	Ruby-crowned Kinglet	6	8	6	8	4	6	6.3	6	8	4	2	2	2	4.0
Vireonidae	Solitary Vireo	2	0	0	0	0	2	0.7	0	0	2	0	0	0	0.3
	Red-eyed Vireo	0	0	0	4	0	0	0.7	0	2	0	0	0	0	0.3
Parulidae	Black and White Warbler	0	1	0	1	3	0	0.8	0	0	0	0	0	0	0.0
	Tennessee Warbler	2	0	2	2	9	6	3.5	8	12	10	8	6	8	8.7
	Nashville Warbler	6	10	6	6	7	10	7.5	3	8	2	2	2	2	3.2
	Magnolia Warbler	8	15	4	5	6	6	7.3	8	6	8	9	8	12	8.5
	Cape May Warbler	6	8	2	10	4	2	5.3	7	6	4	4	8	4	5.5
	Yellow-rumped Warbler	13	13	8	9	0	7	8.3	4	2	0	2	4	6	3.0
	Black-throated Green Warbler	0	0	0	0	0	0	0.0	0	4	0	0	0	2	1.0
	Chestnut-sided Warbler	0	0	0	1	0	0	0.2	4	2	0	2	4	0	2.0
	Bay-breasted Warbler	2	2	0	0	2	0	1.0	0	4	0	6	2	4	2.7
	Ovenbird	0	0	0	0	4	0	0.7	0	0	0	0	0	2	0.3
	Northern Waterthrush	2	2	2	4	4	2	2.7	4	6	6	4	4	2	4.3
	Wilson's Warbler	2	0	0	0	2	0	0.7	0	0	0	0	0	0	0.0
	Canada Warbler	0	0	0	0	2	0	0.3	2	0	2	0	0	0	0.7
	American Redstart	0	0	0	1	4	0	0.8	0	0	0	0	2	0	0.3
Icteridae	Brown-headed Cowbird	0	0	2	0	0	0	0.3	0	0	0	0	0	0	0.0
Fringillidae	Rose-breasted Grosbeak	0	0	2	0	0	0	0.3	2	4	0	0	4	0	1.6
	Evening Grosbeak	1	1	9	0	0	0	1.8	1	3	0	0	1	0	0.8
	Purple Finch	0	0	0	0	0	0	0.0	0	0	2	0	0	0	0.3
	Dark-eyed Junco	0	0	1	0	0	0	0.2	0	2	1	4	4	2	2.2
	Chipping Sparrow	0	4	0	0	2	2	1.3	0	2	0	0	0	0	0.3
	White-throated Sparrow	16	18	18	9	16	19	16.0	7	4	19	15	10	9	10.7
TOTALS:		77	90	73	71	83	70	77.1	60	90	72	68	76	71	73.2

Table II-4

Forest Bird Population Census
Nonyl phenol untreated control plot
Dubreuilville, Ontario
24 May - 3 June 1979

		Prespray						Postspray						
Family	Species	May 24 -5	May 25 -4	May 26 -3	May 27 -2	May 28 -1	Daily ave.	May 29 +0	May 30 +1	May 31 +2	June 1 +3	June 2 +4	June 3 +5	Daily ave.
Tetraonidae	Ruffed Grouse	0	1	0	0	1	0.4	2	0	1	0	0	1	0.7
Picidae	Yellow-bellied Sapsucker	2	1	2	0	2	1.4	5	1	2	0	1	0	1.5
Tyrannidae	Least Flycatcher	0	0	0	0	0	0.0	0	2	0	0	2	2	1.0
	Olive-sided Flycatcher	2	0	0	0	0	0.4	0	2	2	0	4	2	1.7
Corvidae	Gray Jay	0	0	0	1	0	0.2	0	0	0	0	0	0	0.0
	Blue Jay	1	0	0	0	0	0.2	0	4	1	0	0	0	0.8
	Raven	1	0	0	0	0	0.2	1	0	1	0	0	0	0.3
Paridae	Black-capped Chickadee	2	0	0	0	2	0.8	0	0	0	0	0	0	0.0
	Boreal Chickadee	0	0	0	1	0	0.2	0	0	0	0	1	0	0.2
Troglodytidae	Winter Wren	2	2	4	4	2	2.8	2	0	0	2	2	2	1.3
Turdidae	American Robin	0	2	0	2	0	0.8	0	3	0	0	2	0	0.8
	Hermit Thrush	3	2	0	2	4	2.2	2	6	6	0	4	5	3.8
	Swainson's Thrush	1	0	0	2	0	0.6	0	0	0	3	0	0	0.5
Sylviidae	Golden-crowned Kinglet	0	0	0	0	2	0.4	0	0	0	0	0	0	0.0
	Ruby-crowned Kinglet	6	6	4	4	8	5.6	8	10	2	3	2	6	5.2
Vireonidae	Solitary Vireo	0	0	0	0	0	0.0	0	2	2	2	0	2	1.3
	Red-eyed Vireo	0	0	0	0	0	0.0	0	2	2	0	2	0	1.0
Parulidae	Black-and-White Warbler	4	0	2	4	2	2.4	0	0	0	1	0	0	0.1
	Tennessee Warbler	8	4	4	6	16	7.6	20	14	18	10	12	8	13.7
	Nashville Warbler	4	13	2	4	3	5.2	4	2	3	2	0	2	2.2
	Magnolia Warbler	10	6	10	6	10	8.4	6	4	6	8	4	6	5.7
	Cape May Warbler	6	4	8	4	6	5.6	10	8	6	4	8	0	6.0
	Yellow-rumped Warbler	2	6	2	11	4	5.0	6	2	8	4	4	4	4.7
	Black-throated Green Warbler	0	2	0	0	0	0.4	0	0	4	0	2	0	1.0
	Blackburnian Warbler	2	0	0	2	0	0.8	0	0	2	6	6	4	3.0
	Chestnut-sided Warbler	2	4	0	0	0	1.2	2	4	4	0	2	4	2.7
	Bay-breasted Warbler	0	8	8	6	5	5.4	10	15	4	4	4	6	7.2
	Ovenbird	4	4	2	4	6	4.0	7	4	4	4	4	2	4.2
	Northern Waterthrush	0	0	0	2	2	0.8	2	2	4	4	4	4	3.3
	Canada Warbler	0	0	0	0	0	0.0	2	4	5	4	3	0	3.0
Icteridae	Red Winged Blackbird	0	0	0	0	0	0.0	0	0	0	0	2	0	0.3
	Brown-headed Cowbird	0	0	0	0	0	0.0	0	2	0	0	0	0	0.3
Fringillidae	Rose-breasted Grosbeak	2	4	2	0	2	2.0	0	3	4	0	2	0	1.5
	Evening Grosbeak	1	1	2	1	2	1.4	1	0	2	0	2	1	1.0
	Purple Finch	2	0	0	0	0	0.4	0	4	6	0	0	2	2.0
	Pine Siskin	0	0	0	2	0	0.4	0	0	0	0	0	0	0.0
	Dark-eyed Junco	0	1	0	0	2	0.6	0	0	0	0	0	2	0.3
	Chipping Sparrow	0	0	0	1	0	0.2	2	0	0	0	0	0	0.3
	White-throated Sparrow	0	12	2	8	7	5.8	2	3	12	2	5	4	4.7
TOTALS:		67	83	54	77	88	73.8	94	103	111	63	84	69	87.3

Table 11-5

Forest Bird Population Census
Aminocarb Treatment Plot
St. Donat de Montcalm, Quebec
26 June - 4 July 1979

(Aminocarb applied 28 June at the emitted dosage rate of 175 g AI/ha)

Family	Species	Pre-spray				Post-spray					
		June 26 -2	June 27 -1	June 28 -0	Daily Ave	June 29 +1	June 30 +2	July 1 +3	July 3 +5	July 4 +6	Daily Ave
Tyrannidae	Alder Flycatcher	0	4	4	2.7	0	0	0	0	0	0.0
	Least Flycatcher	2	0	0	0.7	2	2	0	2	0	1.2
	Olive-sided Flycatcher	0	0	0	0.0	2	0	0	0	0	0.4
Corvidae	Blue Jay	1	0	0	0.3	0	0	1	1	1	0.6
Paridae	Black-capped Chickadee	0	1	1	0.7	0	0	0	0	0	0.0
Sittidae	Red-breasted Nuthatch	0	2	0	0.7	0	2	0	2	2	1.2
Troglodytidae	Winter Wren	0	2	2	1.3	6	4	6	2	4	4.4
Turdidae	American Robin	0	0	1	0.3	0	0	0	1	4	1.0
	Swainson's Thrush	5	10	1	5.3	0	4	2	0	1	1.4
	Veery	2	3	11	5.3	7	1	3	2	2	3.4
Sylviidae	Golden-crowned Kinglet	2	2	4	2.7	4	4	4	2	2	3.2
	Ruby-crowned Kinglet	2	2	2	2.0	5	4	0	0	0	1.8
Bombycillidae	Cedar Waxwing	1	2	2	1.7	2	1	4	1	5	2.6
Vireonidae	Solitary Vireo	2	0	2	1.3	0	2	0	0	0	0.4
	Red-eyed Vireo	0	0	2	0.7	2	0	0	0	0	0.4
	Philadelphia Vireo	0	4	0	1.3	0	0	0	0	0	0.0
Parulidae	Black-and-white Warbler	2	0	6	2.7	2	0	4	0	0	1.2
	Tennessee Warbler	0	2	0	0.7	0	0	0	2	0	0.4
	Nashville Warbler	2	12	4	6.0	4	0	3	2	0	1.8
	Magnolia Warbler	9	14	4	9.0	2	4	4	4	6	4.0
	Black-throated Blue Warbler	0	2	0	0.7	0	0	0	0	0	0.0

Table II-5 cont'd

Family	Species	Pre-spray				Post-spray					
		June 26 -2	June 27 -1	June 28 -0	Daily Ave	June 29 +1	June 30 +2	July 1 +3	July 3 +5	July 4 +6	Daily Ave
Parulidae cont'd	Yellow-rumped Warbler	0	2	2	1.3	5	4	2	0	0	2.2
	Black-throated Green Warbler	2	0	0	0.7	2	0	0	0	0	0.4
	Blackburnfan Warbler	4	0	4	2.7	6	0	2	4	2	2.8
	Chestnut-sided Warbler	2	6	2	3.3	0	6	2	2	2	2.4
	Ovenbird	0	2	0	0.7	2	2	0	2	0	1.2
	Northern Waterthrush	6	6	0	4.0	7	2	2	2	0	2.6
	Mourning Warbler	0	0	0	0.0	2	2	0	0	0	0.8
	Common Yellowthroat	9	13	5	9.0	12	10	6	2	4	6.8
	Wilson's Warbler	0	0	0	0.0	0	2	0	0	0	0.4
	Canada Warbler	2	6	6	4.7	6	4	0	0	2	2.4
	American Redstart	2	6	4	4.0	4	1	0	0	0	1.0
Icteridae	Common Grackle	1	0	1	0.7	0	0	1	0	0	0.2
Fringillidae	Rose-breasted Grosbeak	2	0	0	0.7	0	0	0	0	0	0.0
	Purple Finch	0	2	2	1.3	0	0	0	2	0	0.4
	White-winged Crossbill	0	0	0	0.0	0	0	0	0	2	0.4
	Dark-eyed Junco	2	4	2	2.7	2	2	4	0	0	1.6
	Chipping Sparrow	2	2	4	2.7	6	2	1	4	0	2.6
	White-throated Sparrow	7	18	14	13.0	10	7	8	5	6	7.2
Unidentified Birds		8	4	3	5.0	1	0	0	0	0	0.2
TOTAL BIRDS		79	133	95	102.3	103	74	59	44	45	65.0

Table II-6

Forest Bird Population Census
Aminocarb Untreated Control Plot
St. Donat de Montcalm, Quebec
24 June - 4 July 1979

Family	Species	Pre-spray						Post-spray					
		June 24	June 25	June 26	June 27	June 28	Daily	June 29	June 30	July 1	July 3	July 4	Daily
		-4	-3	-2	-1	-0	Ave	+1	+2	+3	+5	+6	Ave
Tetraonidae	Ruffed Grouse	0	0	0	0	0	0.0	0	0	0	5	0	1.0
Tyrannidae	Least Flycatcher	0	0	0	4	0	0.8	2	0	0	0	0	0.4
Corvidae	Blue Jay	2	0	0	0	0	0.4	0	2	0	0	0	0.4
Paridae	Black-capped Chickadee	0	0	0	1	2	0.6	0	0	0	2	0	0.4
Sittidae	Red-breasted Nuthatch	0	0	0	0	2	0.4	0	0	0	0	0	0.0
Mimidae	Catbird	0	0	0	0	0	0.0	0	0	2	0	4	1.2
Turdidae	Hermit Thrush	0	0	2	6	2	2.0	1	4	0	0	3	2.8
	Swainson's Thrush	0	12	0	1	0	2.6	3	1	5	3	0	1.6
	Veery	0	3	1	3	4	2.2	3	4	4	4	1	3.2
Sylviidae	Golden-crowned Kinglet	0	2	0	0	0	0.4	0	0	0	0	0	0.0
	Ruby-crowned Kinglet	0	0	0	4	2	1.2	2	0	0	1	0	0.6
Bombycillidae	Cedar Waxwing	0	0	0	0	0	0.0	0	0	2	2	0	0.8
	Bohemian Waxwing	0	3	0	0	3	1.2	0	0	0	0	0	0.0
Vireonidae	Solitary Vireo	0	2	0	0	0	0.4	0	0	0	0	0	0.0
	Red-eyed Vireo	2	2	0	0	4	1.6	2	4	2	0	0	1.6
Parulidae	Black-and-white Warbler	2	4	2	2	3	2.6	0	0	0	0	0	0.0
	Tennessee Warbler	4	0	0	0	0	0.8	0	0	0	0	0	0.0
	Nashville Warbler	0	0	4	4	4	2.8	0	10	2	4	4	4.0
	Parula Warbler	0	2	0	0	0	0.4	0	0	0	0	0	0.0
	Magnolia Warbler	0	0	0	6	2	1.6	4	2	4	4	4	3.6

Table II-6 cont'd

Family	Species	Pre-spray June 24 -4	June 25 -3	June 26 -2	June 27 -1	June 28 -0	Daily Ave	Post-spray June 29 +1	June 30 +2	July 1 +3	July 3 +5	July 4 +6	Daily
Parulidae cont'd	Black-throated Blue Warbler	4	6	4	8	8	6.0	4	0	2	0	0	1.2
	Yellow-rumped Warbler	0	2	0	0	6	1.6	4	0	0	4	6	2.8
	Black-throated Green Warbler	0	4	0	0	0	0.8	2	0	0	0	2	0.8
	Blackburnian Warbler	0	8	0	0	0	1.6	4	0	0	2	2	1.6
	Chestnut-sided Warbler	0	0	0	0	0	0.0	0	2	2	0	0	0.8
	Bay-breasted Warbler	0	0	6	0	0	1.2	2	2	0	0	0	0.8
	Ovenbird	2	6	4	4	6	4.4	8	6	2	2	0	3.6
	Mourning Warbler	2	2	0	0	0	0.8	0	0	0	0	0	0.0
	Canada Warbler	10	12	6	4	0	6.4	4	0	2	0	0	1.2
	American Redstart	0	0	0	2	0	0.4	0	0	0	0	0	0.0
Fringillidae	Rose-breasted Grosbeak	0	1	0	0	0	0.2	0	0	0	0	0	0.0
	Evening Grosbeak	0	0	0	0	0	0.0	0	0	0	0	3	0.6
	Purple Finch	0	0	0	0	0	0.0	0	0	2	0	0	0.4
	Dark-eyed Junco	2	0	0	0	0	0.4	0	2	0	0	0	0.4
	Chipping Sparrow	0	0	0	0	2	0.4	2	0	0	2	0	0.8
	White-throated Sparrow	4	4	0	1	2	2.2	2	1	2	0	2	1.4
	Swamp Sparrow	0	4	2	4	0	2.0	2	2	2	0	0	1.2
Unidentified Birds		2	2	0	0	0	0.8	0	0	2	0	0	0.4
TOTAL BIRDS		36	81	31	54	54	51.2	57	48	37	35	31	41.6