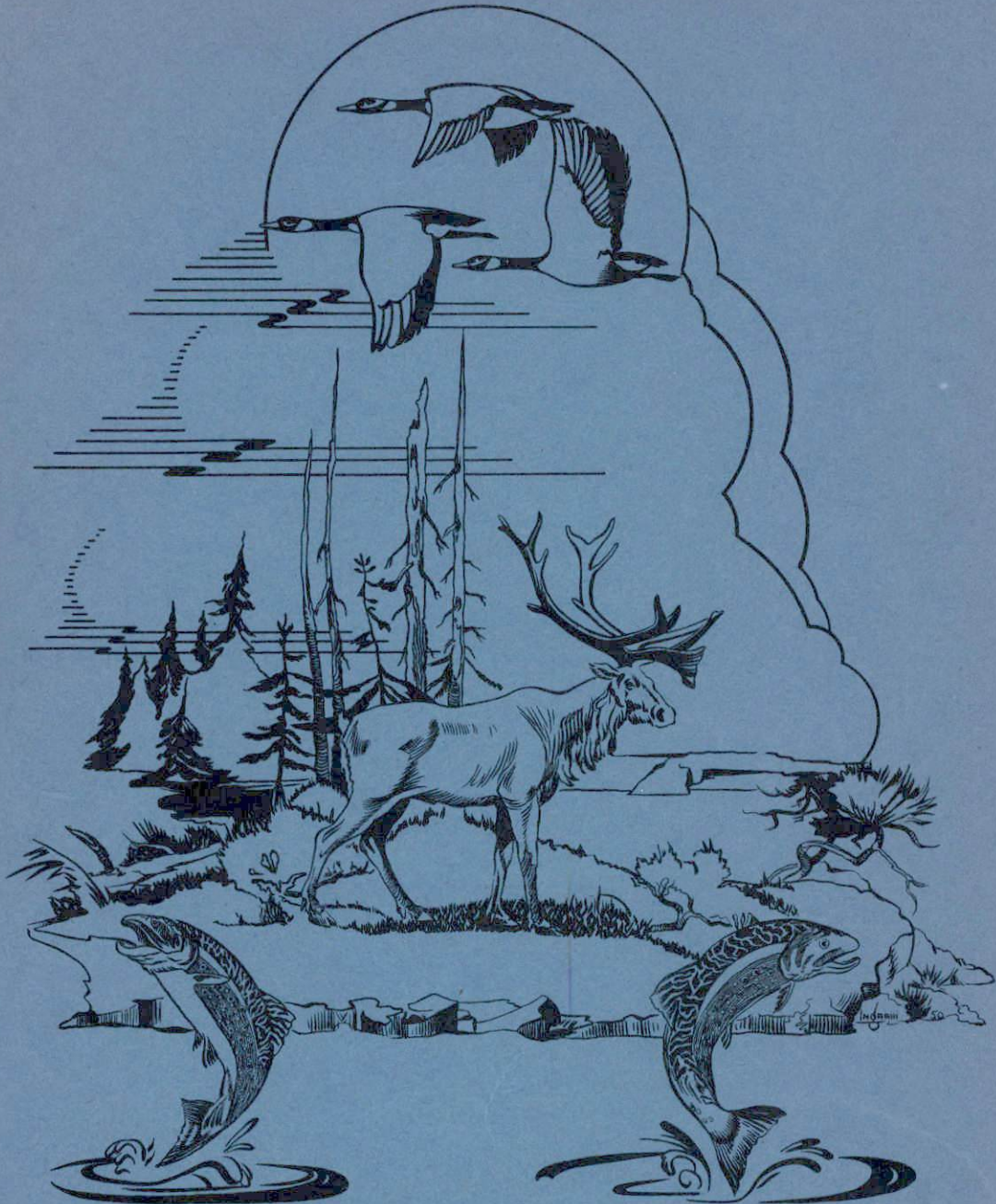


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A STUDY OF BIRD POPULATIONS IN THE
APPLE ORCHARDS OF THE
ANNAPOLIS VALLEY
NOVA SCOTIA

WITH PARTICULAR REFERENCE TO THE
EFFECTS OF ORCHARD SPRAYS UPON THEM

By

John P. Kelsall

1949.

CONTENTS

	<u>Page</u>
INTRODUCTION.....	
OBSERVATIONS ON BIRD POPULATIONS IN ORCHARDS AND OTHER HABITATS.....	1
Types of habitat investigated.....	2
General observations on orchards.....	3
Census methods.....	5
Results.....	8
Observations on nests.....	27
Discussion.....	33
THE SPRAY QUESTION.....	45
Nature and action of fruit sprays.....	46
Observations of orchardists and agriculturalists.....	51
Observations of the summer of 1946.....	52
Findings of other workers.....	53
Analyses of dead birds for arsenic content..	56
CONCLUSIONS.....	60
REFERENCES.....	63
Table Ifollowing page....	58
Table II.....following page....	37
Table III.....	40-41
Illustrations.....	64-69

INTRODUCTION

This study was conducted during the period May to September in 1946 for the National Parks Service of Canada. The primary purpose of the investigation was to determine whether or not there was poisoning among migratory birds in the commercial orchards of the Annapolis Valley, due to toxic materials in the sprays which are used for the control of insect pests and fungus infections. As the study progressed it became increasingly apparent that the orchard areas in question constituted a unique habitat, and that certain characteristics might be expected of the bird populations within them quite irrespective of any influence which spraying might have. Other characteristics were seen to be connected, at least indirectly, with spraying activities, and all seemed to follow a much more definite and limited pattern than had been expected.

This thesis deals primarily with the migratory bird populations and their composition, fluctuations and nesting activities in the commercial apple orchards of the Annapolis Valley. However, so much emphasis was placed on sprays and their toxic possibilities during the investigations and in the writer's original report on the subject, that it has become an integral part of the thesis as well.

Qualitative and quantitative data of a type desirable in a population study were frequently not recorded during this survey

because they were not pertinent to the major line of investigation. It is requested that this be borne in mind if an over-emphasis seems to be placed on sprays in various parts of the text, and if it seems that population studies were not made in strict accordance with the usual methods.

Thanks are extended to the many persons who were of assistance in this investigation. Arthur Kelsall, Superintendent of the Dominion Government Experimental Station, Kentville, Nova Scotia; A.D. Pickett, Chief of the Dominion Government Entomological Laboratory, Annapolis Royal, Nova Scotia, and members of their respective staffs were particularly helpful. Frank Herman, Chemist in Charge of the Division of Chemistry, Experimental Station, Kentville, Nova Scotia, analyzed birds for arsenic content during the summer, and permitted the use of the results of previous analyses. Robie Tufts, Wolfville, Nova Scotia, provided valuable advice and inspiration throughout the investigation. Many other persons were of assistance from time to time during the field investigations.

The writer wishes to express his appreciation to Prof. J.R. Dymond of the University of Toronto for supervising the preparation of this paper.

OBSERVATIONS ON BIRD POPULATIONS IN ORCHARDS
AND OTHER HABITATS.

As part of a study of the effects of orchard sprays on birds, censuses were made in different types of apple orchards and in other habitats in the Annapolis Valley. These data are presented as a contribution to the understanding of the effects of ecological conditions on the number and variety of birds found in different habitats.

It was hoped at the start of this project that the effect of spraying on bird populations might be indicated by taking censuses on wide areas of sprayed and unsprayed orchard. It was soon seen, however, that a comparison of this type would not serve at all. Bird populations were found to be not only greatly limited in number and species in both types of orchard, but subject to such variations depending on food supplies, that variations due to other causes would not be readily apparent. Moreover, unsprayed orchard plots that are suitable for comparison with sprayed plots are exceedingly scarce in the Annapolis Valley, and only two could be found that would serve during this survey.

Because of these factors, the idea of a random bird census over as wide an area as possible was abandoned early in the project, and observations were concentrated on eight sprayed and two unsprayed orchards. General observations were also made

occasionally in a dozen or so other orchards; but they were made largely after spray applications, with the express purpose of finding dead or sick birds, and as noted elsewhere in this paper they were unsuccessful from this standpoint.

Types of Habitat Investigated:

The apple orchards which were surveyed with regularity were chosen because they represented the major different types of orchard that might be found in the Annapolis Valley. They ranged from seedling plots with very young trees planted close together and not over eight to 12 feet high, to mature plots with old trees planted well apart. Ground cover included sod, sod strip and sod strip with cover crops. Some of the orchards were specifically chosen because they represented the majority of commercial orchards in that they had virtually no insect life in them, and others because they were heavily infected with insect pests of one kind or another.

A single census was made on each of two other habitat types for purposes of a general comparison with the orchard observations. The first of these was made on three acres of lawn, garden, shrubs and trees on the grounds of the Department of Agriculture Experimental Station, Kentville, immediately adjacent to commercial apple orchards. The second was made on three acres of field, bush and woodland in the Mill Brook valley, Kentville, and was well removed from agricultural or residential

areas. These particular areas were chosen because they included a wide range of habitat from open grassland through shrub thickets to tall, close tree growth within a limited area.

General Observations on Orchards:

It would appear that birds, as a whole, do not find a very suitable habitat in the orchards of the Annapolis Valley. In comparison with many meadows and woodlands in the same area, the average orchard offers poor shelter, poor nesting sites and poor feeding conditions. While no two orchards appear exactly alike with regard to suitability for birds, there are general characteristics which are common to most of them.

Trees in apple orchards are usually planted well apart in straight rows, and undergrowth in the form of grass and brush is usually kept at a minimum. In addition, apple trees as individuals are more open-growing than others. In well-kept commercial orchards the trees are pruned annually, and branches and foliage are kept comparatively thin. Shelter for birds from adverse weather and predatory birds and animals is poor. There are no sheltering thickets of close-growing twigs, small brush or tall grass in which to seek refuge.

Much the same factors apply with regard to nesting. Ground-nesting species which require thick cover usually can find little or none in an orchard. Tree-nesting species which

usually build in well-concealed spots would pay little attention to an apple tree. The branches and twigs of the trees are relatively thick and well separated and the foliage in general is not too effective in concealing the woody parts of the trees, particularly from beneath.

Human activity is a disturbing factor reducing the value of orchards as either shelter or nesting sites for birds. The spraying process, which is conducted every few weeks, is noisy and reaches every nook and corner. Sodded orchards are mowed, cultivated orchards are harrowed and seeded. While human activity is not continuous in an orchard, and in fact may be entirely absent for some weeks at a time, there is probably sufficient of it to convince some species of birds that it is time to move on to better habitat.

Food appears to be the major factor controlling bird populations in orchards -- as it frequently is elsewhere. In a well-kept orchard insect life is generally at minimum. Insect control measures not only eliminate harmful insect pests on the trees, but nearly all other insects, beneficial and neutral, which might be present in the trees or on the ground. Because of this, bee-keeping has not been found to be compatible with commercial orcharding, and also spraying often defeats its own end by destroying insect parasites which have been controlling certain insect pests which are not killed by spraying.

Vegetable bird foods may also be considered as scarce in orchards. The apple trees themselves supply none, except possibly for hummingbirds, and most seeding and fruiting ground plants are mowed before they reach maturity.

In general, therefore, commercial apple orchards may be considered as offering poor shelter, poor nesting sites and poor feeding conditions for birds.

Census Methods:

There are several approved methods for estimating bird populations in given areas. Strip censusing, random plot censusing and territorial counts of different types are among the more popular methods that have been used under various conditions. These have been described by Kendeigh (1944). All of these methods, as they are generally used, give an approximate, rather than an exact, bird population on the area involved.

In dealing with apple orchards during this study, exact information along the following lines was desired from each census.

- (a) The exact number and species of birds in the orchard at the time.
- (b) The exact number of nests in the orchard, and their status at the time.
- (c) Readily apparent general information relative to

bird populations at the time, (i.e. feeding conditions, dead birds, unusual activities, relation to surrounding habitats.)

The usual census techniques are not designed to give all this information, except possibly under unusual circumstances. The method used in this study did give this information in a very satisfactory manner.

During each census a standard procedure was used to give maximum coverage of the whole orchard involved in view of the requirements. The orchard was traversed in consecutive parallel strips with two rows of trees intervening between each traverse. A visual inspection was made of each individual tree, using binoculars where helpful, and the ground beneath and between the trees was also examined. In this way each tree was approached by the observer only once per inspection, birds which were present were disturbed as little as possible, and there was little likelihood of individuals being counted twice. The only modification to this procedure was made in the seedling orchards, where equally thorough coverage could be given with three or four rows of trees intervening between each traverse.

With regard to birds, it is felt that each census gave a very accurate count of number and species. None of the orchards chosen was so large that significant movements of

birds from censused to uncensused sections, or vice versa, would be likely to go undetected during the course of a census. A few birds might be expected to move into or out of the margins of an orchard during a census, but it is felt that such movements were mutually compensatory.

Bird populations were never so large that there was much danger of error due to individuals being counted twice. It was found that when startled birds flew into uncensused orchard ahead of the observer they almost invariably lighted close enough to the point of original observation so that they could be noted, and allowance made, on the next traverse.

The open nature of the orchards made it easy to spot the nests of tree-nesting species. The positions of nests were never marked, and they were always readily spotted during subsequent observations without specific searching. It is felt that some ground nests may have been missed. None were found and very few, if any, would be expected. However, on two occasions very young song sparrows were noted in orchards under circumstances which indicated that they might have been raised nearby.

In the two censuses made in non-orchard areas bird populations were counted as accurately as possible, again by making close parallel traverses. Due to the limited visibility found in shrubbery and bushes, in comparison with open orchards, this method cannot be expected to give an exact count except in

limited areas. For this reason only three acres were censused on each occasion. Both censuses were taken early in June on fine days when birds were nesting, and when populations might be considered as more or less permanent and normal for the particular areas.

Investigations of individual orchards were carried out from May to August, which included the period during which most migratory birds are establishing themselves for the season, nesting, rearing their young, and preparing for migration in the fall.

Observations on some individual orchards could not be made with the regularity which might be considered ideal in a project of this kind, largely because of the wide area over which the orchards were spread. However, the investigations which were made were done in a consistent, careful manner, and it is thought that the data accumulated demonstrate the type of bird activity which is to be expected in the various orchard types to be found in the Annapolis Valley.

Results:

The following data summarize in turn the observations made in each of the orchards and other areas on which work was concentrated.

SEEDLING ORCHARD, Experimental Station, Kentville, N.S. A

6.5-acre orchard of seedling apple trees, eight to twelve feet

high, planted extremely close together with a wide sod strip every six to ten rows to permit spraying equipment to move. This orchard was not pruned, and growth was so thick that a man would have difficulty in making his way laterally through the rows. There was a minimum of insect life present.

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 19	3 song sparrows 2 yellow-shafted flickers 1 chipping sparrow	0.9	Clear, windy 70°F.
July 3	6 song sparrows (2 young) 2 robins (2 nestlings)	1.5	Sunny, windy 80°F.
July 18	2 song sparrows 2 slate-colored juncos 1 robin	0.8	Sunny, hot 88°F.
Aug. 5	4 song sparrows 1 least flycatcher	0.8	Sunny, fine 80°F.

Only one robin's nest was found in this orchard, although cover could be considered as being far better than would be found in a mature orchard. It would seem that one pair of song sparrows also nested in the orchard, as very young birds were included in the observation of July 3.

Conditions in this young orchard duplicated closely the natural habitat of many small birds. The trees were small, in many places planted scarcely a foot apart, and the undergrowth was, for the most part, quite uncontrolled. Shelter could hardly be improved upon, and nesting possibilities both on the ground and in the trees were excellent. Insect life was at a

minimum and spray applications were made only to guard against any outbreak of special pests.

The bird population remained at about one bird per acre. The young song sparrows which were seen on July 3 were not seen in subsequent observations. Food supplies appeared to be the major factor controlling bird populations.

WILMOT ORCHARD, Wilmot, Annapolis County, N.S. An eight-acre orchard, with longitudinal sod strips and cultivated between the rows. (See figure 1). The trees are relatively small, though mature, and planted closer together than is average.

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
May 31	4 purple finches 3 chipping sparrows 2 song sparrows 1 robin	1.3	Sunny, warm 75°F.
June 21	2 robins	0.3	Dull, misty 70°F.
June 27	2 red-eyed vireos 2 robins 1 slate-colored junco 1 song sparrow	0.8	Sunny, windy 91°F.
July 11	4 robins 3 slate-colored juncos 1 chipping sparrow 1 woodcock	1.1	Sunny, warm 80°F.
July 25	5 slate-colored juncos 4 song sparrows 2 robins 1 sharp-shinned hawk	1.5	Overcast 75°F.
Aug. 2	5 slate-colored juncos (3 young) 2 robins 1 song sparrow	1.0	Sunny, warm 78°F.

Only one nest was found in this orchard, that being a robin's which was destroyed by predators shortly after the eggs were laid.

Throughout the season the regular spray schedule was followed in this orchard, calcium arsenate being the toxic agent used. Spraying was done in the most thorough manner possible, but no connection was noted between spraying and bird activities. When the inspection of June 21 was made the orchard had not been sprayed for two weeks or more, and the bird population was the lowest recorded.

This orchard was somewhat above average as far as shelter and nesting sites were concerned. The trees were small, thick and planted quite closely together. The longitudinal strips beneath the trees had grown up in thick grass, weeds and bushes, providing good shelter and even possible nesting sites. The whole orchard was largely surrounded with heavy, sheltering woods, and human activity was at a minimum.

In this orchard, as in others, the absence of any large quantity of desirable food supplies would seem to be the major controlling factor. Four purple finches were noted on May 31, but at that time of year some of these birds were still wandering in small flocks, not having paired off for the nesting season. Juncos became noticeable, particularly on and after July 11. This correlated with the appearance of young grasshoppers in the orchard, and all the juncos noted were feeding

on these insects. Casual observations in other orchards at about the same period showed that a few juncos were attracted wherever grasshoppers were developing.

WOOD'S ORCHARD, Kentville, N.S. A twelve-acre orchard, entirely sodded, and with mature well-cared-for trees. (See figure 2). Some sections of this orchard had been replaced with younger trees. (See figure 3).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
May 23	4 song sparrows 4 robins 1 least flycatcher 1 purple finch 1 yellow warbler	0.9	Sunny, windy 75°F.
May 30	4 yellow warblers 3 song sparrows 3 chipping sparrows 2 redstarts 1 robin 1 goshawk	1.2	Sunny, fine 78°F.
July 5	5 chipping sparrows (3 young) 3 song sparrows 2 goldfinches 1 least flycatcher 1 northern yellow-throat 1 yellow warbler 1 red-eyed vireo	1.2	Sunny, warm 75°F.
July 23	9 robins (5 young) 8 song sparrows (several young) 6 chipping sparrows (3 young) 4 purple finches 3 yellow-shafted flickers 1 English sparrow 1 goldfinch	2.7	Overcast 80°F.

This orchard could well be considered as typical of well-kept commercial sodded orchards. It was sprayed and pruned,

grass under the trees was kept mowed, and insect life was at a minimum. Two robins' nests were found in it, and both were abandoned for unknown reasons before any eggs were laid.

Bird populations on the checks from May 25 to July 5 were near the one per acre mark which would be expected. A fairly large variety of birds, 13 species, was noted, probably because adjacent hedgerows and fields had a large and varied bird population from which strays would be expected to enter the orchard from time to time. The check on July 23 showed over double the normal population, more than half of these birds being concentrated in one corner of the orchard. This was due to the ripening of some small choke-cherry trees, on which the majority of the birds were feeding. Many of these birds had brought their young or were independent juveniles.

BACK ORCHARD, Experimental Station, Kentville, N.S. A three-acre orchard with large trees planted well apart, and sodded between the rows. (See figure 4).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 11	3 robins (2 nestlings)	1.0	Overcast 60°F.
July 3	1 robin	0.3	Sunny, windy 80°F.
July 8	3 chipping sparrows 1 slate-colored junco	1.3	Overcast 70°F.
July 18	1 robin 1 song sparrow	0.7	Sunny, hot 88°F.
July 22	/-----	0.0	Overcast
Aug. 5	2 song sparrows 1 slate-colored junco	1.0	Fine 80°F.

One robin nested in this orchard and successfully reared three young.

This orchard is quite typical of the more mature sodded orchards in the Annapolis Valley. The trees are very large indeed and planted well apart. With the exception of the robin, which nested early in the year, all birds noted appeared to be stray visitors from surrounding fields and woodlands. The young robins which were raised in the orchard apparently left as soon as they could fly.

Again food appeared to be the controlling factor.

TRIANGLE ORCHARD, Experimental Station, Kentville, N.S. A 1.5-acre orchard, with very large trees planted well apart and cultivated between the longitudinal rows. (See figure 5).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
May 28	0	0	Cloudy, dull 55°F.
June 21	0	0	Dull, misty 70°F.
July 6	0	0	Sunny, windy
July 22	0	0	Overcast

No birds nested in this orchard and no birds were noted on any of four separate, careful inspections. This orchard plot is the extreme case of an orchard with no resident bird population. The relatively small size of the plot, 1.5 acres, probably had something to do with this for if the orchard had

been larger a few birds would surely stray into it. However, this orchard is typical of many in the area which have nothing to offer birds in the shape of shelter, food or nesting sites and which are surrounded with cultivated land also having no bird population.

OLD ORCHARD, Highbury, King's County, N.S. A 1.2-acre orchard, unsprayed, and with very large trees sodded between the rows. (See figure 6).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 19	2 song sparrows	1.7	Clear, windy 70°F.
July 8	2 song sparrows 1 yellow-shafted flicker	2.5	Overcast 70°F.
July 22	1 chipping sparrow	0.8	Overcast
July 30	1 song sparrow	0.8	Sunny, fine 70°F.

One robin's nest was noted in this orchard, but it was abandoned for unknown reasons before any eggs were laid, and the birds were not seen.

This was one of the only two unsprayed orchards which were found which could bear comparison with sprayed orchards. The orchard was well pruned and cared for, and while no injurious insects were damaging the trees there were more insects in evidence than would be found in the average sprayed orchard. Considering that this plot was surrounded with fields and woodlands which had apparently 6 to 8 birds per acre, it was thought

that the bird populations noted above were surprisingly consistent with those noted in sprayed orchards of similar character.

The above orchards were all ones in which insects and vegetable materials suitable for bird foods were at a minimum during most, or all, of the inspections made. As such they are considered typical of the great majority of commercial apple orchards in the Annapolis Valley. However, any given orchard may have outbreaks of insect pests from time to time, and the following orchards are ones which were specifically investigated because of such an occurrence.

MORTON ORCHARD, Pleasant Valley Road, Berwick, N.S. A 3.7-acre orchard, sodded, sprayed, and with large trees planted fairly close together. (See figure 7).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 12	12 song sparrows 2 least flycatchers 1 savannah sparrow 1 chipping sparrow	4.3	Sunny, breezy 80°F.
June 24	7 song sparrows 5 robins 4 chipping sparrows (3 nestlings) 2 savannah sparrows	4.9	Breezy 85°F.
June 27	10 song sparrows 4 chipping sparrows (3 nestlings) 2 savannah sparrows 1 robin	4.6	Sunny, windy 91°F.
July 9	7 song sparrows (4 young) 6 chipping sparrows (3 young) 5 redstarts (3 young) 2 savannah sparrows 2 robins 1 yellow warbler 1 pheasant	6.5	Sunny, fine 75°F.
July 16 2 acres only inspected	5 song sparrows 2 yellow-shafted flickers 1 savannah sparrow 1 chipping sparrow 1 robin	5.0	Sunny 85°F.
July 19	7 song sparrows 3 savannah sparrows 3 chipping sparrows 3 yellow-shafted flickers 1 robin	4.6	Sunny, breezy 90°F.
Aug. 7	5 savannah sparrows (2 young) 3 song sparrows	2.2	Overcast 80°F.

Two nests were found in this orchard; a robin's nest containing three eggs which were later destroyed by predators and a chipping sparrow's nest from which the young flew successfully.

This orchard was one of the most interesting in which work was done. It was a typical mature, sodded orchard, but was heavily infested with eye-spotted budmoth. (See figure 8). Budmoth larvae were present in quantity as food for birds until July 19, after which most of the larger ones had pupated and become moths. The regular spray schedule was followed in this orchard, using Bordeaux mixture and four pounds of lead arsenate per 100 gallons of water. All species of birds noted above, with the exception of the robins, flickers and pheasant were seen feeding on the budmoth larvae or the moths.

When first inspected on June 12, the orchard had been recently sprayed. Song, savannah and chipping sparrows were noted tearing apart the budmoth shelters to get at the larvae inside. From this inspection to the one made on July 19 it was apparent that the bulk of food of the birds in this orchard consisted of these larvae. Whether or not the birds picked up and ate dead larvae could not be determined, but certainly some of the live ones consumed must have had an arsenic content.

Chipping sparrows were raised in the orchard, as has been noted previously, and it is also suspected that at least one

nest of song sparrows was successfully raised here. The majority of the birds, however, appeared to be ones from adjacent fields and hedgerows which were entering the orchard regularly to feed. Young redstarts, song sparrows and savannah sparrows were all noted in the orchard from time to time, and most had been brought in by their parents for feeding purposes. The inspection of July 9 included three young redstarts, four young song sparrows and three young chipping sparrows all of which were being fed by parent birds. The redstarts were feeding on both moths and larvae, but the others were utilizing the larvae only.

When inspected on August 7 most of the budmoth larvae had pupated and food was not available in quantity. The bird population had dropped off appreciably as a consequence.

It was interesting to note that while the larger number of budmoth larvae undoubtedly accounted for the high bird population, the birds did not increase to the point where they were keeping the budmoths under control. In fact the birds seemed to be destroying only a small percentage of the larvae.

MEECHAN ORCHARD, Pleasant Valley Road, Berwick, N.S. A two-acre unsprayed orchard, sodded, and with large trees planted fairly close together. (See figure 10).

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 12	9 song sparrows 5 robins (3 nestlings) 4 savannah sparrows 1 chipping sparrow 1 blue-headed vireo	10.0	Sunny, breezy 80°F.
June 24	9 savannah sparrows 7 robins (3 young) 2 song sparrows 2 chipping sparrows 1 least flycatcher 1 yellow-shafted flicker	11.0	Breezy 85°F.
July 9	5 chipping sparrows (3 young) 2 savannah sparrows 1 song sparrow	4.0	Sunny, fine 75°F.
July 16	7 savannah sparrows 2 blue-headed vireos 1 song sparrow 1 robin	5.5	Sunny 85°F.
July 19	4 savannah sparrows 1 song sparrow 1 blue-headed vireo	3.0	Sunny, breezy 90°F.
Aug. 7	1 savannah sparrow	0.5	Overcast 80°F.

One nest was noted in this orchard, that belonging to a robin which successfully raised three young. Other young birds were noted here, but it is likely that they were raised elsewhere and came into the orchard to feed.

The observations in this unsprayed orchard are particularly

interesting in view of the fact that it compares in nearly every respect, except size, with the sprayed Morton orchard mentioned above, which was only 200 yards distant. It was also heavily infested with eye-spotted budmoth, and as no control measures were being taken more larvae were available as bird food than there were in the Morton orchard. This probably accounts for the higher relative populations on the first two inspections, June 12 and 24. All the species of birds noted, excepting the robins, flicker and least fly-catcher were feeding entirely on budmoths, and the larvae were at their peak during the first two inspections.

Unfortunately for this project, three quarters of this orchard was sprayed on July 17 with one quart of nicotine and eight pounds of lead arsenate per 200 gallons of water. Two inspections were made after this. On July 19 there were three birds per acre as compared with 4.6 in the Morton orchard, and on August 7 there were 0.5 birds per acre, as compared with 2.2 in the Morton orchard. This faster drop in bird population in this hitherto unsprayed orchard was credited to two factors:

- (a) The spray, when finally applied, contained nicotine, which is extremely lethal to budmoth larvae. Nicotine was not used in the Morton orchard.
- (b) The Morton orchard, being larger and having more nesting

birds, would be apt to hold its population longer in view of diminishing food supplies.

In this orchard also the birds ate many larvae, but certainly did not control the pest. It is even possible that the birds themselves did considerable damage by defoliating the trees when tearing at the larvae shelters to get at the insects.

It might be well to mention that the observations in this orchard and in the Morton orchard were made on the same days and in consecutive order, excepting for one extra inspection given the Morton orchard. Differences in bird activities or populations that could not be credited to factors other than toxic sprays were not noted.

GOULD ORCHARD, Long Island, King's County, N.S. A three-acre sprayed orchard of mature trees growing somewhat closer and thicker than is customary.

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
June 14	10 song sparrows 2 chipping sparrows 2 robins 1 yellow warbler 1 English sparrow 1 Kingbird	5.7	Sunny, clear 70°F.
June 28	11 song sparrows (5 young) 1 chipping sparrow 1 robin 1 yellow warbler	4.7	Sunny, hot 86°F.
July 12	15 song sparrows (8 young) 3 robins 3 flickers 1 chipping sparrow	7.3	Overcast

No nests were found in this orchard, although young birds were brought into it abundantly to feed. Like the Morton and Meechan orchards it was heavily infested with eye-spotted budmoth. It was sprayed regularly with lead arsenate, and the birds on all inspections seemed well and healthy. As in the other orchards bird populations were well above the average for uninfested orchards. Unfortunately it was not possible to arrange to visit this orchard during the period in which budmoth numbers declined.

NICTAUX ORCHARD, Nictaux, Annapolis County, N.S.

It was noted during the inspections of the above three orchards that the majority of birds noted were types well adapted for gathering and eating the large larvae of the eye-spotted budmoth. The question arose as to whether different food conditions might not attract a number of different species of birds. After much searching, a sprayed orchard in Nictaux, Annapolis County, answered this question in a fairly satisfactory manner. Unfortunately this orchard was visited only twice, and although the data are hardly sufficient to draw definite conclusions from, the observations are interesting.

<u>Visits</u>	<u>No. & Species of Birds</u>	<u>Birds Per Acre</u>	<u>Weather</u>
July 26	2 slate-colored juncos 2 chipping sparrows 2 myrtle warblers 2 yellow warblers 1 redstart 1 least flycatcher 1 robin	3.3	Overcast 78°F.
Aug. 16	3 slate-colored juncos 3 redstarts 2 chipping sparrows 2 northern yellow-throats 1 Nashville warbler	3.3	Overcast 78°F.

During each inspection 3.3 acres of orchard were covered. This orchard was a young sod strip plot, (see figure 11) and was heavily infested with green aphids (Aphis pomi DeG.) and rosy aphids (Anuraphis roseus Baker). These insects are relatively small, attack foliage and twigs, (see figure 12) and would provide food more suitable for the smaller insectivorous birds than for the larger sparrows. All the birds noted, with the exception of the robin, were feeding on the aphids.

EXPERIMENTAL STATION GROUNDS, Kentville, N.S.

Throughout this study it was noted that while bird populations averaged about one bird per acre in commercial orchards, the woodlands and fields immediately adjacent to such orchards generally seemed to have much higher populations. Several species of birds, the ruby-throated hummingbird and the black-throated green warbler for example, were seen quite frequently immediately adjacent to orchards, but never actually

in them. Numerous other species which were never seen in orchards may be seen almost any summer day in the meadows and woodlands and along roads and streams in the Annapolis Valley.

In order to get some concrete idea of how these bird populations would compare in number and species with those in orchard areas two censuses were taken. The birds observed in these areas are felt to be quite representative of those to be found in any similar areas which might occur in the Annapolis Valley.

The first census was taken on the grounds of the Experimental Station, Kentville, on June 4, immediately adjacent to sprayed orchards which were averaging less than one bird per acre. Judging from numerous general observations throughout the summer, the bird population found might be typical of the grounds of any other farm in the Annapolis Valley where birds are protected and where similar ground conditions exist.

The result of this census, made on three acres of lawns, garden, shrubs and trees is as follows:

10 starlings	2 redstarts
6 robins	2 catbirds
4 yellow warblers	2 slate-colored juncos
4 chipping sparrows	1 least flycatcher

3 song sparrows	1 tree swallow
3 cedar waxwings	1 ruby-throated hummingbird
2 goldfinches	

At the same time four robins' nests, two chipping sparrows' nests, a yellow warbler's nest and a catbird's nest, all in current use, were noted on the same area. Other nests were undoubtedly present.

This gives a population of 13.7 birds per acre, comprising 13 species, which is quite normal for this area.

FIELD, BRUSH AND WOODLAND, Kentville, N.S.

The second census was made on an area of field, brush and woodland bordering the Mill Brook valley in Kentville, which was well removed from cultivated land or residential areas. No effort was made to find nests on this three acre area. The census was taken on June 17, and the following birds were noted:

19 starlings	1 flicker
5 robins	1 goldfinch
2 cliff swallows	1 chipping sparrow
2 kingfishers	1 spotted sandpiper
2 song sparrows	1 yellow warbler
2 slate-colored juncos	1 black-capped chickadee

This gives a population of 12.7 birds per acre, comprising 12 different species.

It will be noted that in these two censuses alone nine different species of birds were noted that were not recorded at all in the orchard observations. This in itself constitutes some proof that bird populations in commercial orchards are well below those in other valley areas, and that the number and species of birds which find suitable habitat in commercial orchards is limited.

This, of course, should not be taken to mean that all valley areas other than orchards average 12 to 13 birds per acre. Pastures and cultivated fields, particularly those growing crops and hay, would have relatively low bird populations. But in marginal areas everywhere, where varied types of cover and food may be found under more or less natural conditions, bird populations would certainly approximate those above. Certainly even an amateur observer should be able to see upwards of 100 different bird species in non-cultivated areas in the Annapolis Valley in the same length of time that this observer spent working in orchards.

OBSERVATIONS ON NESTS:

Primarily in order to learn if there might be mortality among nestling birds through the eating of poisoned foods, or through direct contact with sprays, a careful check was kept on nests found in or near sprayed orchards. Only nests that could be visited with some regularity were recorded in non-orchard areas, and for this reason most of them were on the

Dominion Government Experimental Station at Kentville.

The following nine nests were found in current use in sprayed orchards:

- Robin May 23 Found in Wood's Orchard, Kentville.
Abandoned for unknown reasons before eggs were laid.
- Robin May 23 Found in Wood's Orchard, Kentville.
Abandoned for unknown reasons before eggs were laid.
- Robin May 22 Back Orchard, Experimental Station. Freshly built when found; 3 eggs laid and hatched. Young matured and flew June 23.
- Robin June 12 Morton Orchard, Berwick. Three eggs when found, later destroyed by predator.
- Chipping sparrow
June 12 Morton Orchard, Berwick. Three eggs when found. Young matured, flew July 3.
- Robin June 19 Seedling Orchard, Experimental Station.
Three eggs when found. Young matured, flew July 7.
- Robin June 21 Wilmot Orchard, Wilmot. Three eggs when found, later destroyed by predator.
- Robin July 8 Seedling Orchard, Experimental Station. Four eggs when found, later destroyed by predators.
- Robin July 8 Seedling Orchard, Experimental Station. Three eggs when found; two were infertile. One young matured, flew July 30.

In both orchard and non-orchard areas all nests found were in trees or shrubs. It is almost certain that song sparrows nested on the ground in some of the orchards under observation, probably building close to the trunks of trees in thick grass where spraying, cultivating and mowing activities would not affect them. In cases where song sparrows were seen under circumstances which might indicate nesting, attempts were made to locate ground nests without success. However, observations on young birds in orchards and on adults in the nesting season would indicate that song sparrow nests are infrequent in sprayed orchards.

This paucity of nests in orchard areas is surprising when one considers that well over 100 acres of orchard were minutely examined for birds and nests, plots totalling 38 acres having been examined four to six times each. Nests of only the two species noted above were found.

Searches for nests in non-orchard areas were conducted systematically only twice during the summer, both times in an area of no more than six acres in total on the grounds of the Experimental Station, Kentville. In those two searches, in which only about four hours were spent, 17 occupied nests were found in gardens, shrubbery and trees within 200 yards of sprayed commercial orchards. Nests of eight different species were included, and there was no good reason for believing that all nests in the area had been found either time.

Of the 17 nests which were found 14 were observed with considerable care until the young had matured sufficiently to leave the nest, or until the nests were destroyed. Some of the nests were not found until the eggs had hatched. The nests of a catbird, a redstart and a least flycatcher were not included because they were not readily accessible for frequent checks.

Chipping sparrow	June 4	Four eggs when found. Three young matured, flew June 19. Fourth egg hatched but the bird disappeared.
Chipping sparrow	June 4	Three eggs when found, later destroyed by crows.
Robin	June 4	Four eggs when found, later destroyed by crows.
Yellow warbler	June 4	Four eggs when found. Three young hatched, matured, flew on July 1.
Myrtle warbler	June 4	Three young when found. Matured, flew June 20.
Chipping sparrow	June 25	Three young when found. Matured, flew July 2.
Chipping sparrow	June 25	Four eggs when found. Nest later destroyed by rain.
Robin	June 25	Three young when found. Matured, flew July 20.
Robin	June 25	Three young when found. Later

		destroyed by predators.
Robin	June 25	Three young when found. Matured, flew July 1.
Yellow warbler	June 25	Three young when found. Matured, flew June 30.
Song sparrow	June 25	Two eggs when found. Later abandoned for unknown reasons.
Song sparrow	June 25	Three young when found. Matured, flew July 3.
Robin	July 3	Three eggs when found. Two young hatched, matured, flew July 25.

It will be noted that there was a higher percentage of success among the nests under observation in non-orchard areas than there was among those in orchards, although the data are certainly not sufficient to make conclusive statements.

In none of these 23 nests, all of which were either in or adjacent to sprayed orchards, was there any indication that either young or adult birds were adversely affected either directly or indirectly by sprays or spraying.

In the cases where young matured and flew from nests found in sprayed orchards there is little doubt that a large percentage of their food was taken directly from the orchard.

This is particularly true of the chipping sparrow's nest found in the Morton Orchard in Berwick. It was found on

June 12, at which time the female was sitting on three eggs. The orchard had been heavily, and recently, sprayed with Bordeaux mixture containing 4 pounds of lead arsenate per 100 gallons, and the nest and eggs themselves had been heavily spotted with the mixture. On June 24 a second check was made, and at this time the nest contained three healthy young birds. The orchard was being sprayed with the same mixture as before, and the young birds and nest were heavily spattered. On June 27 a third check was made. The young birds still appeared normal and healthy in every way, and observations showed that the female was feeding the young on the larvae of the eye-spotted budmoth (Spilonota ocellana Schiff.) from the orchard - the very insect against which spray control measures were being directed. Whether any of the larvae were dead when the female picked them up could not be determined, but it is nearly certain that they must have contained some amount of arsenic. As nearly as could be determined the young chipping sparrows left the nest July 3, as at least two of them were being fed nearby when checked on that date. A check on July 9 revealed that three young chipping sparrows were still being fed on budmoth larvae in the orchard, and it is reasonably certain that they were the same birds.

A similar case was that of the robin's nest found in the back orchard plot on the Experimental Station in May. On June 3

the nest contained three eggs, and both nest and eggs had been recently spattered with arsenic and Bordeaux mixture. On June 11 the orchard was sprayed again. When checked later the same day the nest contained two freshly hatched young and one egg, and both nest and surroundings had again been spattered with spray. On June 20 the young appeared normal and healthy in every way. Earthworms appeared to be making up the bulk of their food, and they were being gathered largely in the orchard by the female. The young birds flew successfully on June 23 and were not seen again.

The two bird families noted above certainly had every chance that might occur in a normally sprayed orchard to receive arsenic poisoning. These opportunities were much better than average in fact in the case of the chipping sparrows, which were being fed the very insect against which spray control measures were being taken. Robins, which were seen to raise young successfully in orchards several times during the summer, would not of course have the same opportunities since earthworms, their major food, would probably not contain a high concentration of arsenic at any time.

DISCUSSION:

From the observations recorded above certain trends in bird populations in orchards stand out clearly. Other trends

are suggested in less certain fashion.

Possibly the most striking point is that song sparrows, robins, chipping sparrows, savannah sparrows and slate-colored juncos were by far the most abundant species. Together they made up over 80 per cent of the total birds observed in all orchards (see table II). Only four of these species were seen in uninfested orchards, where they made up over 75 per cent of the birds observed. These were song sparrows, robins, chipping sparrows and slate-colored juncos. Only four species were also seen in budmoth-infested orchards where they made up over 75 per cent of the birds observed. These were song sparrows, robins, chipping sparrows and savannah sparrows.

Song sparrows were the most numerous single species, but robins and chipping sparrows were also observed regularly in both types of orchards.

Savannah sparrows are seen to make up 18.6 per cent of the birds observed in budmoth-infested orchards, but they were not noted in other orchards at all. The reason for this is clear. Savannah sparrows in the Annapolis Valley are essentially birds of the meadowlands.

They appear to enter orchards regularly only when insect food, such as budmoth larvae, is present in attractive quantity, and when they find suitable open habitat for nesting immediately adjacent to such orchards. This combination is

not frequently encountered in the Annapolis Valley, and it was found only in the Morton and Meechan orchards during this study.

It is less clear why slate-colored juncos, which make up 13.4 per cent of observations in uninfested orchards, should not be found in budmoth-infested orchards. However, these birds appear to prefer insect foods somewhat smaller than the average large budmoth larvae and appear to be essentially ground feeders, although they were noted feeding on aphids in the trees of the Nictaux orchard.

One junco was shot in the Nictaux orchard and its stomach was found to contain only aphids. Where juncos were noted in other orchards, however, they appeared to have been attracted by, and were feeding on, either young grasshoppers or ripening cover crops of buckwheat. Neither grasshoppers in quantity nor buckwheat cover crops were to be found in the budmoth-infested orchards.

Eleven other species of birds were noted in normal orchards and eight others in budmoth-infested orchards. In neither case did these additional species make up quite 25 per cent of the total observations, although they made up two thirds or more of the total number of species observed. Reference to Table II will show that in no case did any of these other species make up a significant proportion of the total birds observed in either type of orchard under present consideration.

Most of these other species were recorded in one or two instances only, and many of the observations could be explained in terms of occasional strays from surrounding habitats. Thus while yellow warblers, least flycatchers, pheasants and woodcock, to mention a few species, were certainly not nesting in any of the orchards under observation, they must have been nesting in some number in suitable habitat such as woodlands, hedgerows and fields immediately adjacent.

Some of the infrequent observations on various species can be explained in more specific terms.

Thus hawks were noted only on two occasions. Both species noted are wide ranging hunters which might be expected to be seen occasionally over any habitat in the Annapolis Valley in the course of their feeding activities.

Five redstarts were seen in budmoth-infested orchard. These were three flying young which were being fed by two adult birds in the Morton orchard on July 9. They were doubtless attracted by the large number of adult budmoths which had recently begun to appear.

Blue-headed vireos were seen fairly regularly in the Meehan orchard, and while they did not nest in the orchard, it appeared that at least one pair of birds included the area in its feeding territory in view of the excellent feeding conditions present. Their continued presence in this orchard was considered a rather remarkable condition. Blue-headed

vireos are normally found in the Annapolis Valley only in infrequent stands of large hemlock and fir, and there were no such stands in the vicinity.

Yellow-shafted flickers were seen occasionally in various orchards. Flickers are known to feed to a large extent on ants, and ants are frequently found on the ground in orchards even when other types of insects are virtually absent.

With regard to the aphid-infested Nictaux orchard, observations were hardly taken frequently enough, or over a sufficiently wide area to support definite statements in comparison with the other types of orchard investigated. However, it is interesting to note the possibilities indicated. Aphids would supply suitable food for the smallest insectivorous birds, and these were the major types noted. Reference to table II will show that yellow warblers, redstarts, northern yellow-throats, myrtle warblers and a Nashville warbler made up 50 per cent of the birds observed. Nashville warblers and myrtle warblers were not noted in other orchards at all. A least flycatcher, chipping sparrows and slate-colored juncos made up an additional 45 per cent of the birds observed. All the species mentioned were feeding on aphids.

The censuses made on non-orchard areas are also hardly sufficient, or suitable, for statistical comparison with those made in orchards. However they do show some interesting generalities. Thus in only two short censuses, on a total of

BIRDS	ALL ORCHARDS		NORMAL ORCHARDS		BUDMOTH ORCHARDS		APHID ORCHARD		MISCELLANEOUS
	TOTAL	% OF TOTAL	TOTAL	% OF TOTAL	TOTAL	% OF TOTAL	TOTAL	% OF TOTAL	
Song sparrows	150	35.8	41	30.6	101	43.7		8	
Robins	67	16.2	28	20.9	29	12.6	1	9	
Chipping sparrows	60	14.3	19	14.2	31	13.4	4	6	
Savannah sparrows	43	10.3			43	18.6			
Slate-colored juncos	23	5.5	18	13.4	9	3.9	5	22	
Yellow-shafted flickers	15	3.6	3	2.3	3	1.3	2	9	
Yellow warblers	11	2.6	6	4.5	5	2.2	4	18	
Redstarts	11	2.6	2	1.5	3	1.3			
Purple finchs	9	2.1	5	3.7	3	1.3	1	5	
Least flycatchers	7	1.7	3	2.3	4	1.8		4	
Blue-headed vireos	4	1.0							
Red-eyed vireos	3	0.7	3	2.3			2	9	
Northern yellow throat	3	0.7	1	0.7			2	9	
Goldfinch	3	0.7	2	1.5				1	
Myrtle warbler	2	0.5							
English sparrow	2	0.5			1	0.4			
Mashville warbler	1	0.2			1	0.4	1	5	
Kingbird	1	0.2							
Woodcock	1	0.2	1	0.7					
Sharp-shinned hawk	1	0.2	1	0.7					
Goshawk	1	0.2							
Pheasant	1	0.2			1	0.4			
	419	100.0	134	100.0	231	100.0	22	100	32

TABLE II: Species and numbers of birds observed in different types of orchards.

The MISCELLANEOUS column above refers to the observation of July 23 for Wood's orchard when the bird population increased beyond normal by the attraction of ripe choke-cherries. This observation is not comparable with the others.

only six acres of ground, 18 different species of birds were noted; only four fewer species than were noted during 46 censuses on a total of 202.6 acres of orchard. Thirteen of these species were noted during a census made within 200 yards of commercial orchard.

Of the 18 species noted in these non-orchard areas half were not seen at all in orchards during the summer. Some of these species, such as the kingfisher and the spotted sandpiper, would obviously not find suitable ecological niches in orchards. Others such as the starling, which is particularly abundant throughout most cultivated areas in the Annapolis Valley, are not present in orchards for more obscure reasons.

It is thought that these two censuses on non-orchard areas demonstrate the limited appeal which many orchards must have for many types of birds.

Not only were bird populations in orchards found to be decidedly limited as to number of species present, but they were also limited as to number per acre. Table III shows that in normal orchards, that is in those having no particular infestation of insects suitable for bird food, populations averaged between zero and 1.5 birds per acre for individual orchards. The mean was one bird per acre on a total of 138.8 censused acres.

In budmoth-infested orchards the average number per acre

ranged from 4.6 to 5.9 for individual orchards, with the mean at 5.4 on a total of 45.2 censused acres.

In normal orchards, with no particular insect or vegetable food present in quantity, the evidence indicates that the bird population to be expected is about one per acre. Birds which might be considered as resident or nesting in such orchards are very few. In fact many orchards appear to have no such birds, the majority appearing to be stray or occasional visitors from surrounding habitats. The number of species in such orchards appears to depend largely on the number found in surrounding habitats, and not on any particular attribute of the orchards. Very possibly many of these occasional visitors are actually birds which have established nesting territories immediately adjacent to the orchards in which they are seen and which may include a small bit of orchard in their territory.

<u>HABITAT</u>	<u>NO. OF VISITS & TIME</u>	<u>AVERAGE BIRDS PER ACRE</u>	<u>TOTAL NO. OF SPECIES.</u>
<u>Seedling orchard</u> : small trees close together with uncontrolled tree growth and ground cover-sprayed - 6.5 acres.	4 (June 19-Aug. 5)	1.0	6
<u>Wilmot orchard</u> : small, mature trees planted closer together than is average-sod strip-sprayed- 8 acres.	6 (May 31-Aug. 2)	1.0	8
<u>Wood's orchard</u> : mature open-growing trees-sodded-sprayed- 12 acres.	4 (May 23-July 23)	1.5	13
<u>Back orchard</u> : large, mature trees-sodded-sprayed- 3 acres.	6 (June 11-Aug. 5)	0.7	4
<u>Triangle orchard</u> : large, mature trees sod strip-sprayed- 1.5 acres.	4 (May 28-July 22)	0.0	0
<u>Old orchard</u> : large, mature trees-sodded-unsprayed- 1.2 acres.	4 (June 19-July 30)	1.5	3
<u>Morton orchard</u> : mature trees fairly close together-sodded-sprayed-budmoth infested- 3.7 acres.	7 (June 12-Aug. 7)	4.6	9
<u>Meechan orchard</u> : mature trees fairly close together-sodded-unsprayed-budmoth infested- 2 acres.	6 (June 12-Aug. 7)	5.7	7

(Table continued on next page)

<u>HABITAT</u>	<u>NO. OF VISITS & TIME</u>	<u>AVERAGE BIRDS PER ACRE</u>	<u>TOTAL NO. OF SPECIES.</u>
<u>Gould orchard</u> : mature trees very close together-sodded-sprayed- budmoth infested - 3 acres.	3 (June 14- July 12)	5.9	7
<u>Nictaux orchard</u> : young thick trees fairly close together-sod strip-sprayed-aphid infested - 3.3 acres.	2 (July 26- Aug. 16)	3.3	9
<u>Experimental Station grounds</u> : lawn, shrubs, garden, trees - 3 acres.	1 (June 4)	13.7	13
<u>Mill Brook Valley</u> : field, brush and woodland - 3 acres.	1 (June 17)	12.7	12

TABLE III: NUMBER OF SPECIES AND AVERAGE NUMBER OF BIRDS PER ACRE IN DIFFERENT HABITATS.

In orchards infested with insect pests, however, the picture is somewhat different. In these orchards bird populations were seen to rise to 11 per acre on at least one occasion while food insects were present in quantity. They were also seen to fluctuate in number depending on the food supply. While evidence is incomplete, it would also appear that different types of insect pests will attract different types of birds. Thus warblers were seen to dominate in the aphid-infested Nictaux orchard rather than the larger song sparrows and robins which were present in budmoth-infested orchards. Chipping sparrows seemed to be an "in between" type which could utilize either type of insect to good advantage.

It is interesting to speculate on the origin of the numerous birds which were found in budmoth-infested orchards. That they were attracted by the excellent feeding conditions is beyond question. It is almost equally certain that if these orchards had not been infested with budmoth, or with some other insect pest, the bird populations within them would have run no higher than the general average of one per acre.

There was no real indication that more birds were establishing nesting territories in budmoth-infested orchards than there were in uninfested orchards, even though populations were much greater. There is no doubt that many of the birds

in these orchards were ones which had nesting habitats in nearby areas. Possibly they had forsaken their regular feeding grounds in fields and hedges to take advantage of the superior food in the orchards.

Some of the birds, notably song sparrows, appeared to be at least temporary residents in the orchards although they were not nesting. This applies to censuses taken early in the season as well as to ones taken later in the year. The conclusion appears to be that a certain number of individuals among the song sparrows, and possibly among other species as well, do not necessarily nest each year.

The relatively high population of warblers in the Nictaux orchard is not so surprising. By the time this orchard was first censused most young warblers of the year were independent and the birds were beginning to show wandering tendencies in view of the advent of fall. Stray warblers which entered the orchard would be apt to remain for a time in view of the excellent feeding conditions.

In the censuses taken on non-orchard areas a graphic illustration is seen with regard to a diversified habitat providing room for a wide variety and large number of birds on even a limited area. It is a reasonable assumption that the majority of the 13 species noted on the Experimental Station Grounds, and the 12 species noted on the field, brush and wood-

land area, were resident, nesting birds. Many of these species are specialized for particular feeding or nesting conditions which could be found in these areas.

No such illustration is seen in the orchards. Robins, and in a single instance chipping sparrows, were the only species actually seen to take up nesting territories within orchards. Possibly the major reason for this is that few, if any, of the species in the Annapolis Valley are specialized for living in the type of habitat afforded by apple orchards. Even though food supplies may be abundant at times, shelter and nesting sites for these species are still poor.

Robins are specialized for feeding on earthworms and they can find suitable feeding conditions in most orchards. The other predominant birds in most orchards, however, are not specialized species. Chipping sparrows, song sparrows and slate-colored juncos are species which can, and do, utilize whatever type of food is most available, within reasonable limits. They will utilize many kinds of insect and vegetable food, both on the ground and in trees. This lack of specialization in feeding habits is apparently the reason why individuals from these species were found even in orchards having no apparent food resources. Even in thoroughly sprayed and well cared for orchards there must be some number of miscellaneous insects and plant seeds which

can support a few omnivorous birds.

THE SPRAY QUESTION

The original motive in making this investigation was to determine, for the administrative purposes of the National Parks Service, whether or not there was serious poisoning of migratory birds in the Annapolis Valley, due to toxic materials used in commercial orchard sprays.

For years bird-lovers have been making all kinds of accusations in this connection. Commercial sprays have been held responsible for everything from isolated bird deaths to the virtual elimination of certain species. Various persons have held these views, usually without any qualifying evidence to back up such assertions.

Few of the persons who make such claims are commercial orchardists. Field men of the Department of Agriculture, some of whom have worked for as long as thirty years on spray problems in the Annapolis Valley, have noted no such occurrence, but the possibility is there. Some of the materials used in sprays in commercial orchards are toxic, in sufficient quantity, to warm blooded animals, and in most orchards are applied regularly five or six times a year.

Therefore, before any bird population observations in the Annapolis Valley can be considered as representative of certain trends it is first necessary to consider the toxic

possibilities of the various sprays, and to determine whether they are of major, minor or negligible importance.

All the evidence accumulated during this investigation would indicate that the possibility of actual bird mortality due to commercial spraying activities is remote. Even without actual observation a good case against such a possibility can be built up.

Five general lines of evidence will be considered below, and additional remarks will be found where applicable in the general text.

1. Nature and action of fruit sprays.

The spraying of fruit trees in the Annapolis Valley is a most necessary operation. Just how necessary it is may be better appreciated if one considers Bulletin No. 12, Injurious Insects of Nova Scotia, issued by the provincial Department of Agriculture. Fifty-two insects are listed which do commercial damage in apple orchards. Of course regular spray control measures taken against a few of these pests usually keep the rest under control at the same time.

In many cases a fungus - apple scab (Venturia inequalis)- is even more important as a pest than the insects.

The following is a brief survey of the spray schedule which is followed, materials used, and some conjectures as to the possibility of their poisoning birds.

(a) In the dormant season (late March) oil sprays are used, generally mineral oil, sometimes containing dinitro compounds. These sprays control several types of insects such as scale insects, aphids, and red mite.

(b) The first regular spray is applied in early May. It is generally composed of Bordeaux mixture plus nicotine sulphate.

(c) Other regular sprays follow successively, usually five in addition to those mentioned above, and on dates ranging from May 15 to late July.

The regular sprays are dual-purpose; that is, they contain both a fungicide and an insecticide, and the same basic substances have been used in sprays in the Annapolis Valley for the past thirty years. These are copper or sulphur in one form or another as fungicides, arsenic as a biting insecticide and nicotine as a contact insecticide.

Other spray materials are occasionally used commercially, but their use is the exception rather than the rule, and such birds as they might affect would be relatively small in number. D.D.T. for example is in use only experimentally in small plots, and cryolite, in which the killing agent is fluorine, is used occasionally as a late spray as it leaves no residue on the apples. Since materials such as the above have limited use, and since observations on

their use could not be made, no assessment of their effects on birds can be made in this report.

The fungicides in common use in the Annapolis Valley are as follows:

(a) Bordeaux mixture - usually 5 pounds of copper sulphate, 15 pounds of hydrated lime, 100 gallons of water. Sometimes a 5 - 10 - 100 mixture is used and varying amounts of oil.

(b) Lime sulphur - 2 gallons in 100 gallons of water.

(c) Flotation sulphur - 15 pounds in 100 gallons of water.

(d) Wettable sulphur - 5 to 8 pounds per 100 gallons of water.

(e) Fermate (ferric dimethyldithiocarbamate) - a new organic fungicide - usually $1\frac{1}{2}$ to 2 pounds per 100 gallons of water.

With the possible, but not probable, exception of Fermate, it seems scarcely possible that any of the above could be toxic to birds as used in fruit sprays. Once applied to the trees these materials dry rapidly and circumstances under which a bird would consume enough of these materials to have a toxic effect do not present themselves in commercial spraying.

The insecticides used may be of two types - namely, biting insecticides and contact insecticides. The biting insecticides

in common use in the Annapolis Valley are either lead or calcium arsenate, applied at the rate of three or four pounds per 100 gallons of water in conjunction with a fungicide. If there is any poisoning of birds due to commercial spraying, the toxic agent is most likely to be one of these. However, both are relatively insoluble in water, the highest solubility tolerated being about 16 milligrams of arsenic per litre of water. In other words the clear filtrate of spray applied to fruit trees is non-toxic, except to forms of life which might be extremely susceptible to arsenical compounds. These sprays generally dry on the trees within two or three minutes of being applied and thereafter flake off slowly. They are quite resistant to rain. The possibility of birds becoming poisoned owing to drip from the trees at the time of application or afterward should be negligible. However, some species, such as humming-birds, might conceivably get water containing enough arsenic to be toxic from the leaves and branches immediately after the spray has been applied by direct drinking.

These insecticides kill insects because they are soluble in the digestive juices of insects and are absorbed. While of course toxic to mammals and birds, they are not as toxic as one unfamiliar with them might expect. For example, a

given amount of arsenic in the form of sodium arsenite or sodium arsenate is many times more toxic to mammals than the same amount of arsenic in the form of lead arsenate. This is largely due to the difference in solubility. Lead and calcium arsenate are toxic in minute doses to biting insects; but much larger doses of these compounds than of the soluble arsenical salts are required in order to produce a toxic effect on mammals and birds.

Nicotine is the common contact insecticide used in the Annapolis Valley. Pyrethrum is used to some extent. The latter is non-toxic to warm-blooded animals.

Sprays of nicotine are used in the Annapolis Valley when required, usually as one pint of nicotine sulphate per 100 gallons of water, but these nicotine sprays are not used regularly or universally. The effect of nicotine is immediate in most cases, and approximately 90 per cent of it is quickly volatilized and lost. There does remain, however, a small persistent residue of toxic material which is sufficient to control some newly hatched insects - the eye-spotted budmoth in particular. The bodies of insects killed by nicotine spray are generally pretty well destroyed by its contact action, and it is extremely doubtful if birds would use them for food. It is difficult to conceive of nicotine poisoning adult birds directly either by contact or by residual toxicity.

It is possible that nicotine sprays might be directly toxic to young birds in the nest. This is only a possibility and no evidence to suggest such an occurrence was found during this investigation.

2. Observations of orchardists and agriculturalists:

In connection with this investigation many commercial orchardists and agricultural scientists of long experience were questioned. Some of the Department of Agriculture scientists in particular are men of long experience, of keen and quick perception for the unusual, and of excellent scientific training.

None of the men questioned could recall ever having seen sick, dead or dying birds in apple orchards in circumstances which might suggest toxicity following spray applications. In fact only a few could recall ever having seen any dead birds in orchards at all, and all were sceptical as to the possibility of poisoning under normal spraying conditions.

The case of poultry in orchards was frequently cited to add weight to this scepticism. Poultry are often raised commercially in the sprayed orchards of the Annapolis Valley.

An excellent case in illustration was that of W.C. Oulton, Windsor, Nova Scotia. During the summer of 1946 he raised ten thousand chickens in a fenced-in commercial apple orchard. The chickens were put in the orchard when eight weeks old, and

they were still there at the close of the regular spray schedule. During this time no special allowance was made for the presence of the chickens when spraying, the chickens matured normally, and no losses could be credited to arsenical poisoning. The chickens kept the grass in the orchard cropped short and must have consumed the considerable amount of arsenic which invariably gets on the grass.

This raising of poultry under the trees in sprayed commercial orchard is a very common practice, and numerous other instances, similar to the above, could be cited. Several men who follow this practice on a large scale were questioned, and none could recall trouble which could be attributed to poisoning by orchard spray.

3. Observations of the summer of 1946:

During the period over which this investigation was made approximately 300 acres of orchard were examined minutely both during spraying operations and at various times between applications. Some of these examinations were made with the express purpose of finding poisoned birds, and all were made with this thought in mind.

It is possible that individual specimens of small birds, which might have been lying dead between the trees in heavily-sodded orchards, were overlooked, but any significant number of dead birds would certainly not have escaped observation.

In addition, several farmers with large orchards and about a dozen men of the Department of Agriculture's field personnel co-operated by watching for dead or sick birds during the course of their duties, and reported on their observations. Many other orchardists were requested to notify the observer if they noted anything suggesting bird poisoning.

All of these sources of information agreed in stating that no sick or dying birds had been discovered in or near commercial orchards. An elderly lady, anxious to co-operate, sent in two dead robins. Both of these, however, were so badly decomposed that it was impossible to determine the cause of death; and neither of them had been found in sprayed orchard.

Observations of birds's nests both in and adjacent to sprayed orchards have a bearing on the spray question. Nests have been the subject of a separate section in this report, and to avoid repetition only the general conclusion arrived at is stated here, namely, that during the summer of 1946 no observations on nests or nestling birds in or adjacent to sprayed orchards indicated that they are any more affected by the toxic properties of sprays than are adult birds.

4. Findings of other workers:

There is a paucity of material in the literature concerning the toxicity of most commercial sprays with regard to

wild birds. However, controlled experiments have been performed with poultry as subjects, using insoluble lead and calcium arsenate. Thomas and Shealy (1932) reported that though lead arsenate will produce death in chickens when fed in large quantities, chickens showed no ill effects from the consumption of feed and water which had been deliberately contaminated with spray solution containing 4 pounds of lead arsenate in each 100 gallons of water for a period of 60 days. As much as 13 grains of lead arsenate daily for 60 days did not cause any apparent ill effects on chickens of two to three pounds of weight.

A considerable amount of work has been done in connection with the use of soluble and highly toxic arsenious oxide (As_2O_3) as used in poison bait for grasshoppers. Van Zyle (1929) has written about this work and its effect on poultry in South Africa. He found that meal prepared from poisoned locusts was quite harmless to poultry when fed over an extended period of time in as large quantities as the fowls would consume, and he concluded that poisoning of poultry from the feeding of locust meal made from poisoned locusts is practically negligible.

Whitehead (1934), Barber and Hubster (1933), and others, have all worked with soluble arsenical compounds and their effects on poultry. Whitehead has progressed in this work further than the others, and his findings are substantiated

by the others except in minor instances. He worked with domestic fowls, quail and - to a limited extent - wild birds. His experiments were conducted to determine whether or not poisoned bran bait for grasshoppers, or the dead grasshoppers themselves, were a menace. Arsenious oxide was the toxic agent used. His conclusions are interesting and have a definite bearing on this study; the following are his conclusions in part:

"From the experiments, the following conclusions were drawn concerning domestic fowls;

1. They readily recognize the fact that poisoned grasshoppers are not as desirable food as unpoisoned grasshoppers.
2. They will eat less than half the number of poisoned grasshoppers that they will of unpoisoned grasshoppers.
3. The amount of arsenic consumed through feeding on poisoned grasshoppers averages much less than half a toxic dose.
4. Even though no other food is available for a period of ten days, the fowls will not eat a sufficient number of poisoned grasshoppers to obtain a toxic dose.
5. The arsenic obtained through eating poisoned grasshoppers does not have a cumulative effect even though the fowls were fed for a period of sixty-six days.
6. Feeding on poisoned grasshoppers does not materially

affect the weight or growth of the fowls.

Concerning quail the following conclusions were drawn:

1. Even if quail were to eat the maximum number of grasshoppers that they have ever been recorded as having eaten, they will not be noticeably injured though each of the grasshoppers was killed by feeding on poisoned bran.

2. Quail eating the number of grasshoppers normally eaten probably receive only from one to seven per cent of a toxic dose.

Concerning wild birds, it was concluded:

1. Nestling robins, and presumably other species of similar size, can consume as many as one hundred and thirty-four poisoned grasshoppers containing 39.986 mg. of As_2O_3 and still mature normally.

2. Poisoned grasshoppers may be somewhat injurious to nestling birds although the evidence is incomplete.

3. There is very little danger, if any, to adult wild birds.

4. It must be shown that the parent birds pick up dead grasshoppers and feed them to nestlings before any danger to nestlings can be claimed. The few observations made do not indicate that such is the case."

Lead and calcium arsenate being relatively insoluble would probably be considerably less toxic than the white

arsenic used in Whitehead's work.

With regard to nicotine, Parker (1929), showed that a three per cent nicotine solution administered in 0.2 c.c. doses did not kill baby chicks. The normal concentration of nicotine sulphate as applied in fruit sprays in the Annapolis Valley is one part in 800 of water or a 0.05 per cent nicotine solution. If the susceptibility of wild birds is at all analogous to that of baby chicks, which would appear to be a reasonable assumption, it is difficult to conceive how they could either obtain or contain enough spray solution containing nicotine to constitute a toxic dose.

5. Analyses of dead birds for arsenic content:

As stated previously it is not difficult to find persons in the Annapolis Valley who claim to have seen or heard of birds being killed through the use of arsenic poisoned spray. At the beginning of this project it was hoped that birds, suspected of having been killed by such poisoning, could be collected and their stomach contents analyzed. Numerous farmers and other persons who frequent orchards were requested to save any dead birds which they might find in orchards, and similar general requests were made through advertisements in local papers.

The only birds found were two robins, both so badly decomposed that nothing could be done with them, neither of

affect the weight or growth of the fowls.

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The only birds found were two robins, both so badly decomposed that nothing could be done with them, neither of

which came from sprayed orchards. The observer found neither sick nor dead birds in any of the orchards covered during the summer.

However, over a period of years, F.A. Herman of the Kentville Experimental Station has analyzed eleven birds, presumably killed by spray, which were brought into the laboratory by various persons. The results of these analyses are as follows:

<u>BIRD</u>	<u>ARSENIC as mgs. of arsenious oxide in the internal organs</u>
Cedar waxwing	0.007
Humming-bird	nil
Female purple finch	"
Yellow-shafted flicker	"
Yellow flycatcher (misidentified?)	"
Least flycatcher	0.02
Purple finch	nil
Humming-birds (3)	0.39
Black-billed cuckoo	0.095

These results are interesting in that they show that some bird deaths credited to arsenic spray are not the result of arsenic at all. No definite indication of how much arsenic it would actually take to kill any of the above birds could be found in the literature. It seems doubtful if any of them, with the possible exception of the humming-birds and the least flycatcher were killed by it. It should be pointed out that the humming-birds in question were found, not in commercially sprayed orchard, but on a private property where arsenic

spraying had been done using spray concentrations considerably higher than those used commercially, and under conditions suggesting that the birds might have taken actual liquid spray from the blossoms. Commercial spraying is not done in a manner which would allow this latter possibility much chance of being realized.

When blossoms are out in commercial orchards sprays are withheld to give insects a better chance to carry on pollination.

Many forms of life will develop a considerable tolerance to a poison if they are more or less continuously exposed to it, and the possibility that this is the case with birds feeding in sprayed orchards should not be overlooked. It was thought that possibly the arsenic content noted in Herman's above analyses might be no greater than might normally be found in birds feeding in sprayed orchards. In order to learn if this might be the case, six normal birds were shot in sprayed orchards and their stomach contents analyzed. The results are given in Table I.

All the birds shot were feeding, and were presumed resident, in the orchard from which they were taken. All of the birds contained arsenic and those taken from the Wilmot orchard contained more arsenic in proportion to body weight than any of the birds in Herman's original analyses, with

SPECIES OF BIRDS	DATE SHOT	ORCHARD	WEIGHT OF BIRD IN GRAMS	WEIGHT OF INTERNAL ORGANS IN GRAMS	ARSENIC AS METALLIC ARSENIC IN PARTS PER MILLION	ARSENIC AS AS ₂ O ₃ IN MILLIGRAMS
Song sparrow	July 26	Avery	20.1	3.6	2.0	.0096
Redstart	July 26	Avery	7.7	1.5	2.4	.0048
Song sparrow	July 26	Morton	20.3	3.4	1.6	.0073
Savannah sparrow	July 26	Morton	16.1	3.0	1.8	.0072
Slate-colored junco	July 25	Wilmot	16.6	3.6	10.8	.0515
Song sparrow	July 25	Wilmot	25.9	7.7	4.1	.0421

TABLE I: The penultimate column above shows the number of parts of metallic arsenic by weight per million parts of the internal organs of each bird examined.

The final column above shows the total amount of arsenious oxide in milligrams found in the internal organs of each bird examined.

the exception of the humming-birds and the least flycatcher. Care was taken that all birds shot appeared normal and healthy. It can be seen therefore that birds can normally tolerate some amount of arsenic in their bodies.

An interesting sidelight on the above analyses is that the arsenic content, as expressed in parts per million, shows three definite concentration groupings. Furthermore, the varied arsenic concentrations noted in the three groups of birds would correspond, as nearly as could be ascertained by visual inspection alone, with the arsenic concentrations in the orchards from which they came.

The Wilmot orchard, in which the birds showed the highest concentration of arsenic, had been last sprayed early in July, but in an exceedingly thorough manner, and the foliage, branches and undergrowth were heavily coated with arsenious residue at the time the specimens were taken. The Avery orchard, in which birds showed the next highest arsenic content, had not been sprayed since late June, but at that time lead arsenate had been applied at the concentration (twice normal) of eight pounds per 100 gallons of water. The Morton orchard was sprayed July 16, but the spray was comparatively light, and visible residue was less than in the other two orchards.

It would be interesting to learn if birds resident in

unsprayed areas would show a normal arsenic content, and how high the arsenic content in birds resident in sprayed orchards might rise without a toxic effect. A study to throw light on these questions would be a relatively simple matter, but the analytical technique for determining arsenic content in small birds is a very delicate one which necessitates the co-operation of a skilled chemist.

CONCLUSIONS

1. Commercial orchards in general offer poor shelter, feeding conditions and nesting sites for birds.
2. Bird populations average about one per acre in average commercial orchards where insect life is at a minimum.
3. Bird populations will rise to at least 11 per acre, while food is abundant, in orchards where outbreaks of insects occur.
4. Bird populations in average commercial orchards, with regard to both number and species, are only a fraction of those which may be found in more suitable habitat in the Annapolis Valley. This is because non-orchard areas may include a diversified habitat suitable for a large number and variety of birds on even a limited area. Orchards do not appear to provide a habitat suited to the exact needs of any of the bird species in the Annapolis Valley, with the exception of robins.

5. Birds with specialized feeding habits, other than robins, rarely find suitable feeding conditions, or are seen in orchards. The birds which are most frequently encountered in orchards are those which lack specialized feeding habits and which may be classed as omnivorous. Excepting robins, the most generally distributed of these were seen to be song sparrows, chipping sparrows and slate-colored juncos, in that order.

6. Song sparrows, robins, chipping sparrows and savannah sparrows were seen to make up more than 75 per cent of the total birds observed in budmoth infested orchards.

7. Song sparrows, robins, chipping sparrows and slate-colored juncos were seen to make up more than 75 per cent of the total birds observed in normal orchards.

8. Food supply is the major factor controlling bird populations in commercial orchards.

9. There is some indication that specific types of birds will be attracted by specific types of food, if the latter is present in quantity, even though they would not normally enter orchards. This was seen when warblers were found to predominate in an aphid-infested orchard and when savannah sparrows were found in numbers in budmoth-infested orchards.

10. Robins appear to be the only species which regularly take up nesting territories within orchards. All other species may be classed as:

- (a) Birds which enter orchards in the course of their daily activities because they have nesting territories, or find suitable habitat, immediately adjacent.
- (b) Non-nesting birds which will visit and remain in orchards provided suitable feeding conditions are to be found.
- (c) Stray or occasional visitors.
- (d) Nesting birds from nearby habitats which will visit orchards for feeding purposes provided suitable food is present in unusual abundance.

11. All sources of information indicate that the use of poisoned sprays, as normally applied in the commercial orchards of the Annapolis Valley, have no readily observable direct effect on the migratory bird populations nesting or feeding in the orchards.

REFERENCES

- Barber, P.G., and E.B. Hubster, 1933; Arsenic poisoning in poultry. *Vet. Med.*, 28: 500-502.
- Brittain, W.H., and A.D. Pickett, 1933; Injurious insects of Nova Scotia. *Bul. No. 12, N.S. Dept. of Agr.*
- Kendeigh, S.C., 1944; Measurement of Bird Populations. *Ecol. Monog.* 14: 67-106.
- Parker, S.L., 1929; Effects of early handicaps on chickens as measured by yolk absorption and body weight to twenty weeks of age. *Hilgardia*, 4: 1-56.
- Traverner, P.A., 1934; Birds of Canada. *Nat. Mus. of Can. Bul. No. 72, Biol. Ser. No. 19.*
- Thomas, E.F., and A.L. Shealy, 1932; Lead arsenate poisoning in chickens. *Journ. Agr. Res.*, 45: 317-319.
- Van Zyle, J.P., 1929; On the toxicity of arsenic to fowls. *Ann. Rept. Dir. Vet. Ed. and Res. Union of So. Africa*, 15: 1189-1202.
- Whitehead, F.E., 1934; The effect of arsenic, as used in poisoning grasshoppers, upon birds. *Oklahoma Agr. Exp. Sta. Bul.*, 218: 1-54.



Figure 1. Wilmot orchard. These trees, though mature, are relatively small and are planted closer together than is average. Note the cultivated strip between the rows and the unmowed sod strip beneath the trees.

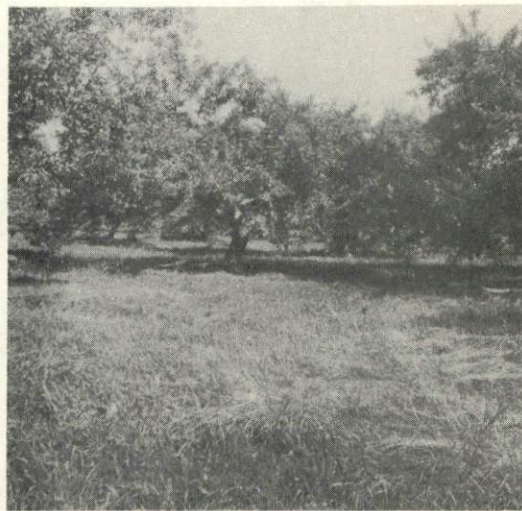


Figure 2. Wood's orchard. Note the wide spacing of the mature trees and the sod ground cover.



Figure 3. Wood's orchard. Relatively young trees in one section of the orchard. Note the typical open-growing nature of the young tree in the foreground.



Figure 4. Back orchard. Note the wide spacing of the mature trees and the sod ground cover.



Figure 5. Triangle orchard. Note the large trees, the cultivated, seeded strip between the rows and the sod strip under the trees.

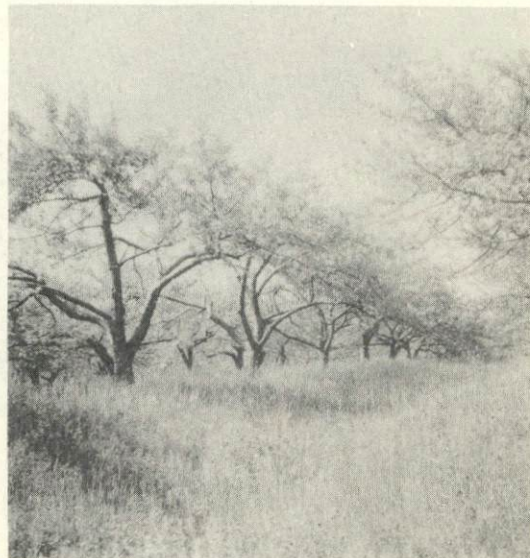


Figure 6. Old orchard. Note the large over-mature trees and the unmowed, sod ground cover.

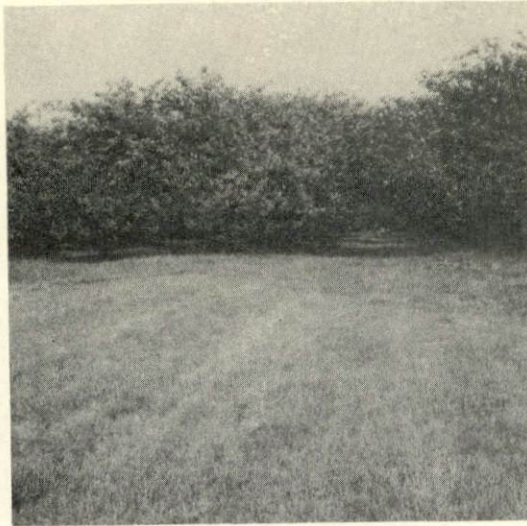


Figure 7. Morton orchard. Note the relatively close growth of the trees and the sod ground cover.

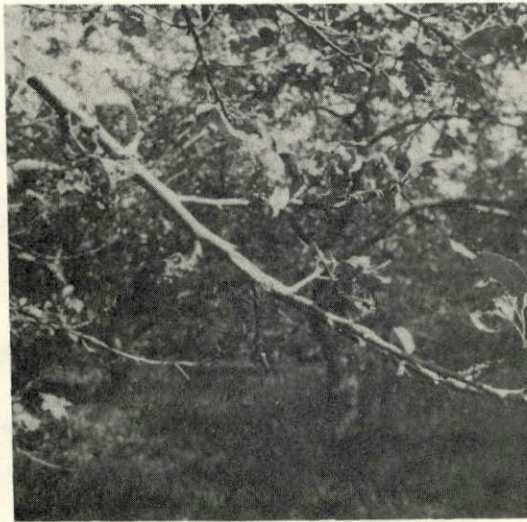


Figure 8. Budmoth infested apple twig. Many of the leaves have been eaten away by the larvae and most of the remainder have been incorporated into shelters. For comparison with a normal twig see Figure 9.

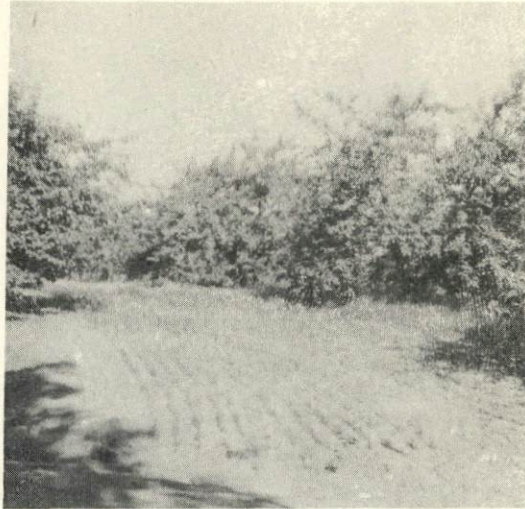


Figure 5. Triangle orchard. Note the large trees, the cultivated, seeded strip between the rows and the sod strip under the trees.

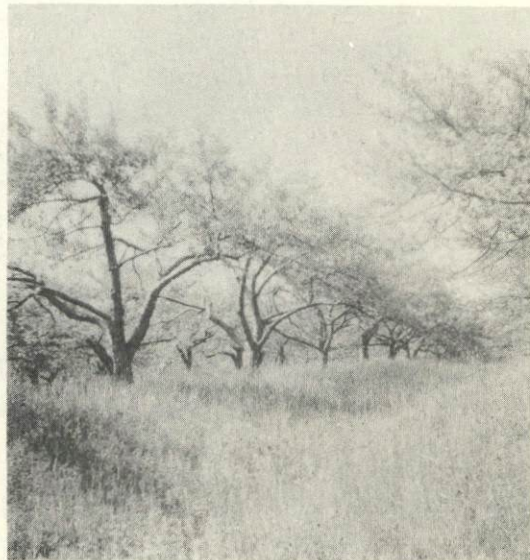


Figure 6. Old orchard. Note the large over-mature trees and the unmowed, sod ground cover.

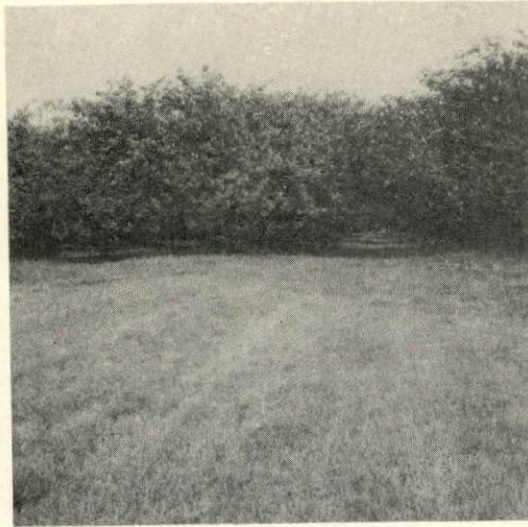


Figure 7. Morton orchard. Note the relatively close growth of the trees and the sod ground cover.

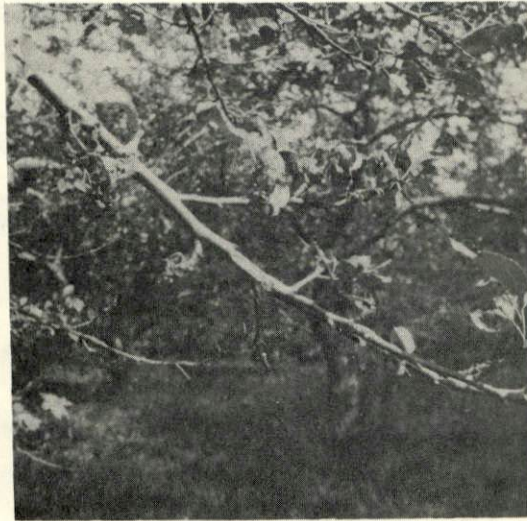


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