

CANADIAN WILDLIFE SERVICE

*A preliminary report on the effects
of phosphamidon on bird populations
in central New Brunswick*

by C. DAVID FOWLE

OCCASIONAL PAPERS No. 7



A preliminary report on the effects of phosphamidon on bird populations in central New Brunswick

by C. DAVID FOWLE



Canadian Wildlife Service

Occasional Papers No. 7

Natural and Historic Resources Branch
Department of Northern Affairs and National Resources

Title page photograph

Budworm first appear in the spring in the light green new-growth tips (in this case balsam fir). To be effective, insecticides must be applied in the limited period when the larvae are exposed and vulnerable.

Issued under the authority of the
HONOURABLE ARTHUR LAING, P.C., M.P., B.S.A.,
Minister of
Northern Affairs and National Resources.

CONTENTS

INTRODUCTION, 17

ACKNOWLEDGEMENTS, 18

METHODS, 19

Study areas, 19

Population indices, 19

Application of spray, 20

Experiments with caged birds, 20

RESULTS, 21

Populations, 21

General conclusions, 21

Assessment of bird populations, 21

1. Control area, 22

2. Nashwaak area, 22

3. Bettsburg area, 23

4. Taxis River area, 23

5. Ludlow area, 24

6. Big Hole Brook area, 25

Interpretation of population data, 25

Laboratory and experimental investigations, 26

The "poisoned food" hypothesis, 26

The "starvation" hypothesis, 27

The "contact poison" hypothesis, 27

Experimental spraying, 28

DISCUSSION, 32

SUMMARY, 35

REFERENCES, 36

TABLES, 37

APPENDICES, 52

A Scientific names of birds mentioned in this paper, 53

B Scientific names of trees mentioned in this paper, 54

LIST OF TABLES

- 1 Percentage composition and mean DBH (inches) (\bar{X} D) for tree species over 1 inch DBH, 37
- 2 Census results (birds seen and heard), control area, 38
- 3 Population indices, control area, 39
- 4 Census results (birds seen and heard), Nashwaak area, 40
- 5 Population indices, Nashwaak area, 41
- 6 Census results (birds seen and heard), Bettsburg area, 42
- 7 Population indices, Bettsburg area, 43
- 8 Census results (birds seen and heard), Taxis River area, 44
- 9 Population indices, Taxis River area, 45
- 10 Census results (birds seen and heard), Ludlow area, 46
- 11 Population indices, Ludlow area, 47
- 12 Census results (birds seen and heard), Big Hole Brook area, 48
- 13 Population indices, Big Hole Brook area, 49
- 14 Census results (birds seen and heard), Big Hole Brook area, 50
- 15 Population indices, Big Hole Brook area, 51

LIST OF FIGURES

- 1 The high proportion of conifers in the Big Hole Brook area is evident in this photograph of a census route, 5
- 2 The author setting up a mirror trap on a drumming log to capture male ruffed grouse, 6
- 3 Captive ruffed grouse, 7
- 4 Holding pen for ruffed grouse, 8
- 5 Mixed forest stand similar to that on Nashwaak and Bettsburg sample areas, 9
- 6 View of west boundary of control area, 9
- 7 Portion of census route, control area, 10
- 8 Portion of census route, Nashwaak area, 10
- 9 Portion of census route, Bettsburg area, 11
- 10 Portion of census route, Bettsburg area, 11
- 11 View of Taxis River along north shore, 12
- 12 Portion of census route, Ludlow area, 12
- 13 Portion of census route, Big Hole area, 13
- 14 Alders along North Big Hole Brook. The census route ran along the north side of this area, 13
- 15 Portion of Big Hole Brook (East) area, 14
- 16 Searching for dead birds, Big Hole Brook area, 14
- 17 Frame shelter with plastic canopy used in experiments. The door has been raised to expose the cage and foliage in position for spraying, 15
- 18 Map of study areas. Numbered squares are spray areas, 16



Figure 1. The high proportion of conifers in the Big Hole Brook area is evident in this photograph of a census route.



Figure 2. The author setting up a mirror trap on a drumming log to capture male ruffed grouse.

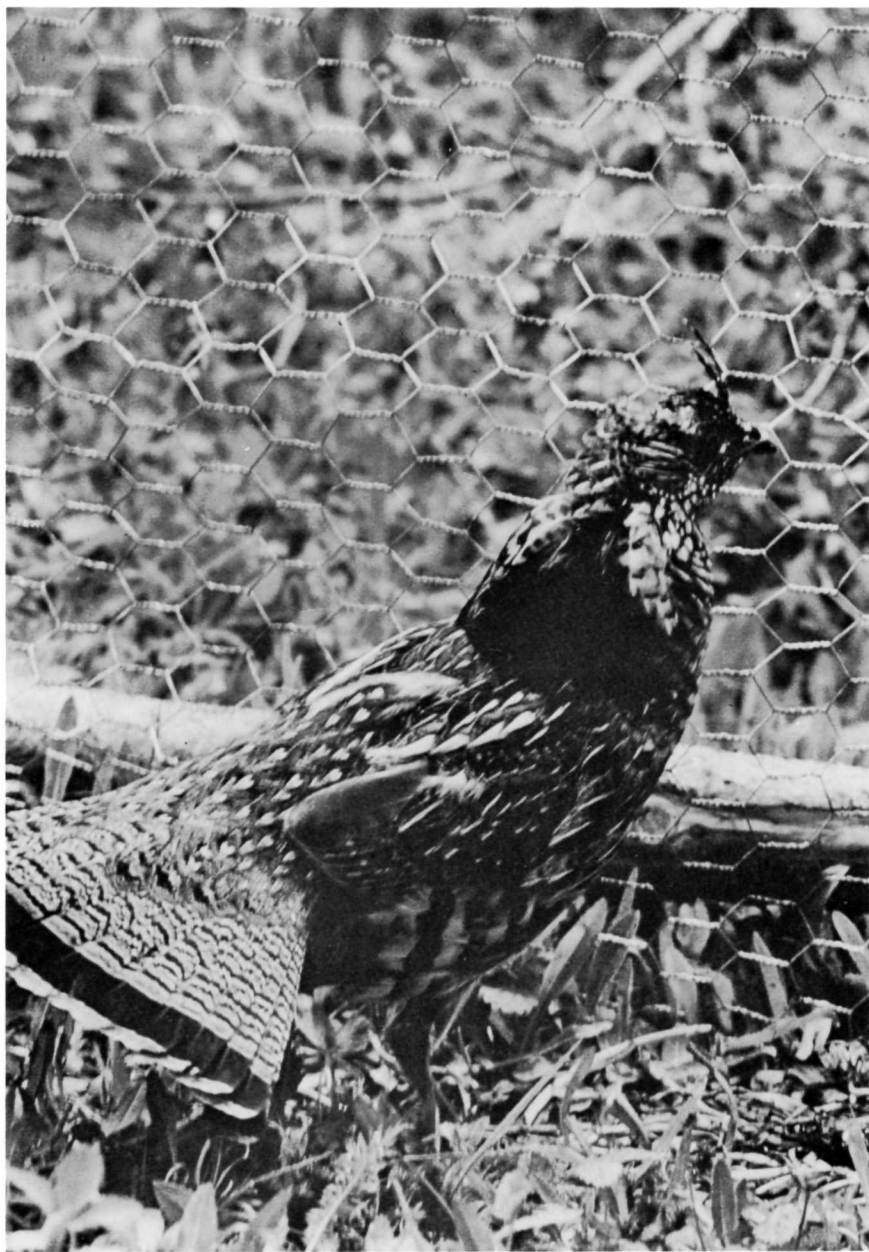


Figure 3. Captive ruffed grouse.

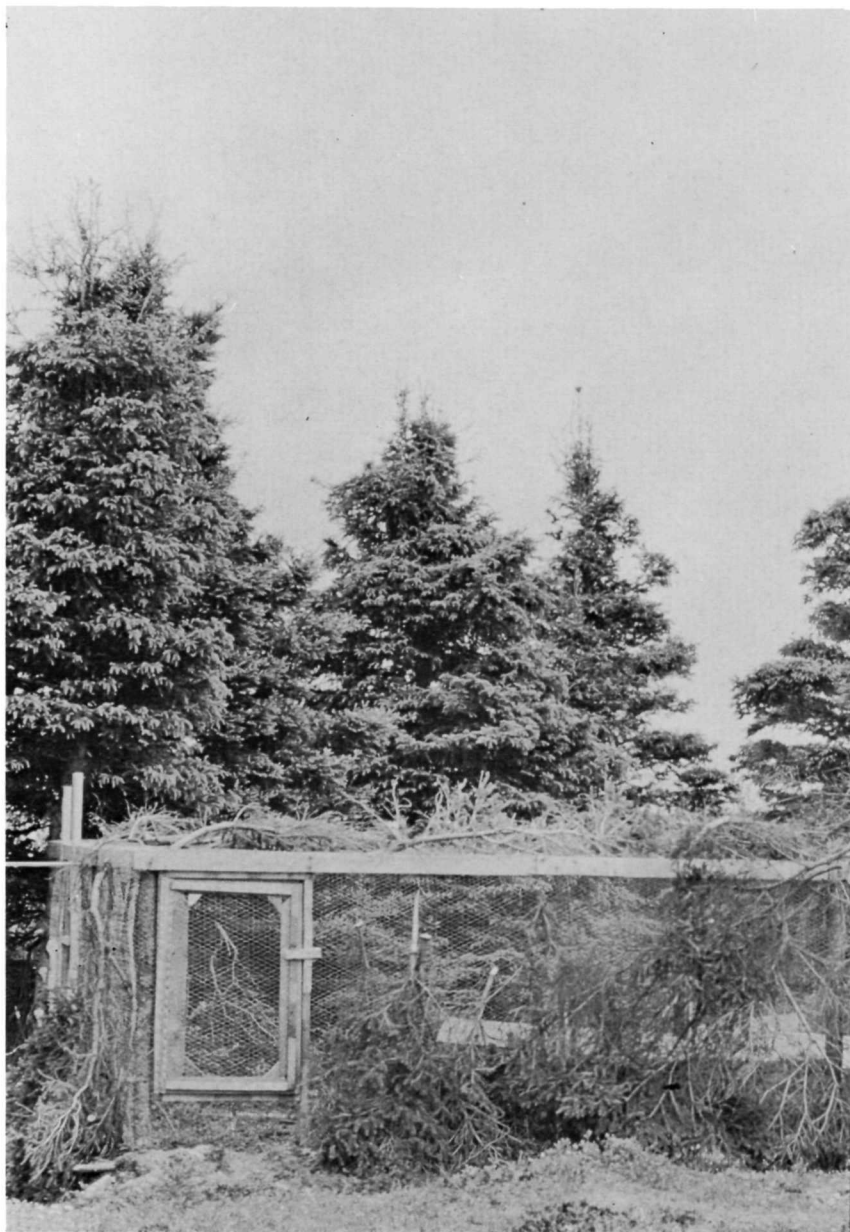


Figure 4. Holding pen for ruffed grouse.



Figure 5. Mixed forest stand similar to that on Nashwaak and Bettsburg sample areas.



Figure 6. View of west boundary of control area..



Figure 7. Portion of census route, control area.



Figure 8. Portion of census route, Nashwaak area.



Figure 9. Portion of census route, Bettsburg area.



Figure 10. Portion of census route, Bettsburg area.



Figure 11. View of Taxis River along north shore.



Figure 12. Portion of census route, Ludlow area.



Figure 13. Portion of census route, Big Hole area.



Figure 14. Alders along North Big Hole Brook. The census route ran along the north side of this area.



Figure 15. Portion of Big Hole Brook (East) area.



Figure 16. Searching for dead birds, Big Hole Brook area.

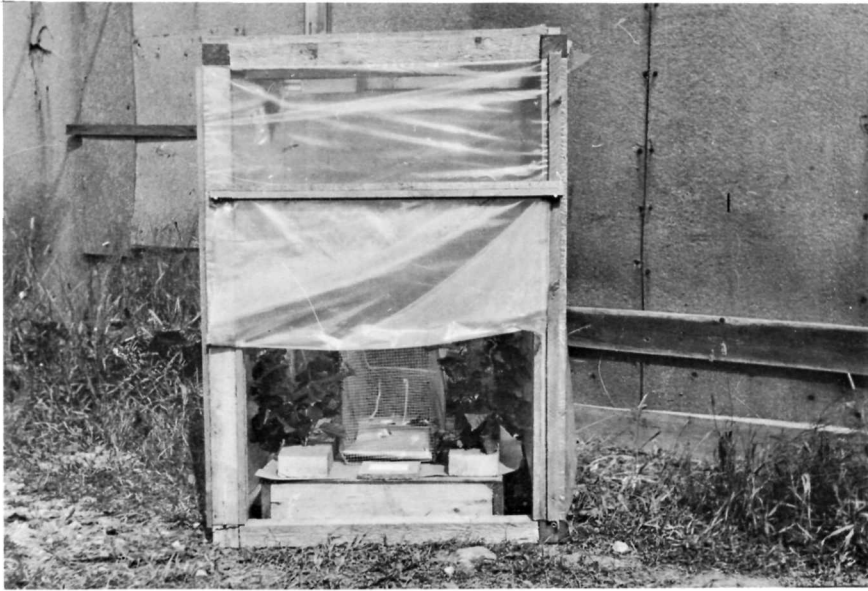


Figure 17. Frame shelter with plastic canopy used in experiments. The door has been raised to expose the cage and foliage in position for spraying.

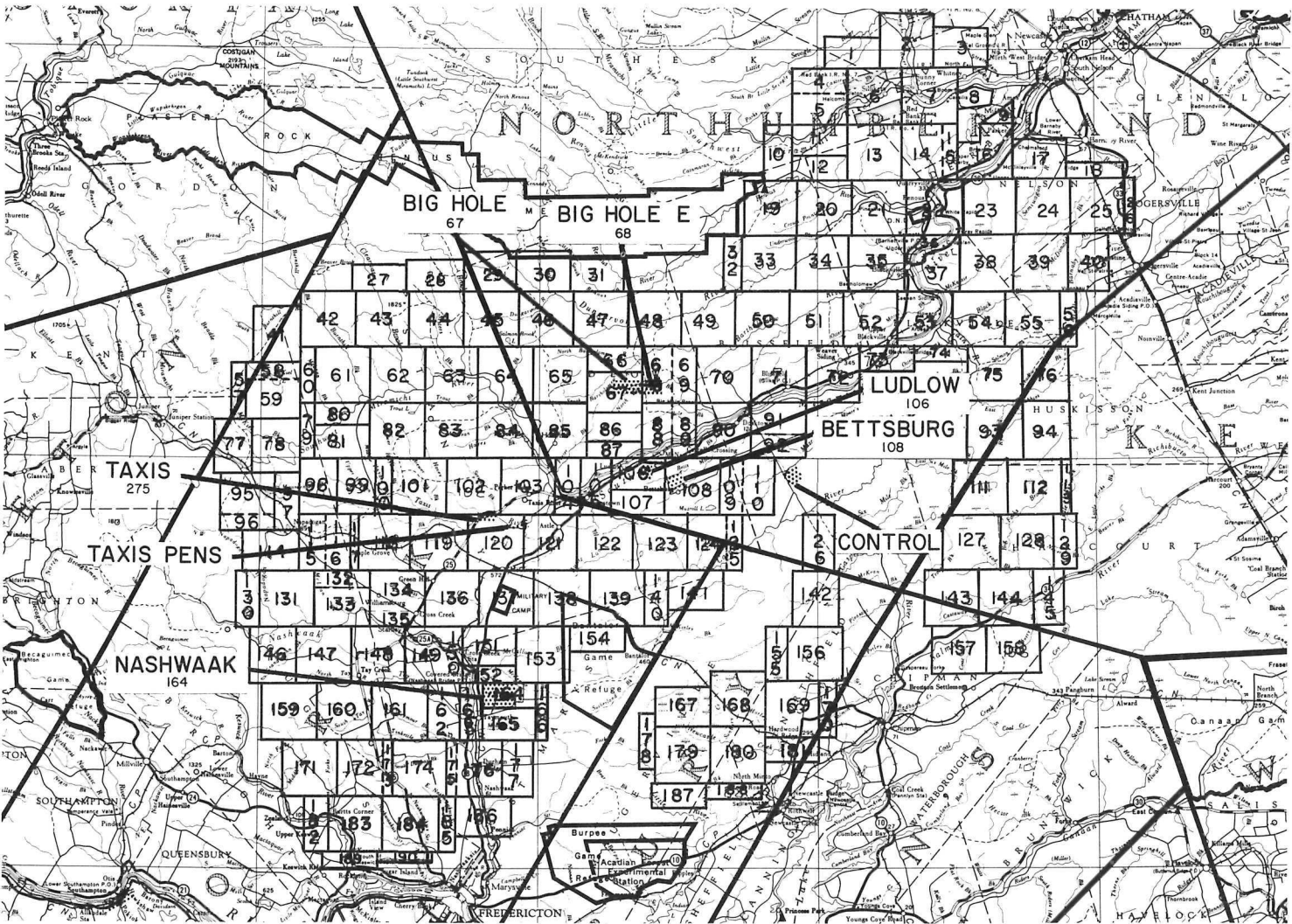


Figure 18. Map of study areas. Numbered squares are spray areas.

INTRODUCTION

During the summer of 1964 approximately 161,000 acres of forest in central New Brunswick were sprayed from the air with phosphamidon¹ (2-chloro-2-diethylcarbamoyl-1-methylvinyl-dimethyl phosphate) as part of the program to control spruce budworm (*Choristoneura fumiferana* (Clem.)) (Morris, 1963). Tests in 1962 by the Fisheries Research Board of Canada and the Canada Department of Forestry had shown that phosphamidon was less harmful to fish than DDT,² but still effective against budworm (Macdonald, 1964). In 1963 it was applied to 22,000 acres of stream bank, and in 1964 the program was expanded to include about 400 miles of streams (101,000 acres) and three upland areas (60,000 acres).

This paper is a preliminary report of an investigation of the effects of phosphamidon spraying on bird populations in some samples of forest in central New Brunswick.

¹ Trade name Dimecron, registered by CIBA Ltd.

² 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge the assistance of the many people and several agencies who contributed to this project.

The program was sponsored by the Canadian Wildlife Service, Department of Northern Affairs and National Resources. Plans were prepared in consultation with several officers of the Service, including Dr. David A. Munro, Chief; Dr. V. E. F. Solman, then Staff Specialist, Operations; and Mr. A. G. Loughrey, Superintendent, Eastern Region. Dr. Graham Cooch, then in charge of biocide investigations, was the officer principally concerned. He gave us enthusiastic support and assistance in planning, administration, and field work.

Generous assistance was provided by the New Brunswick Department of Lands and Mines. I especially thank Mr. Peter Pearce of the Timber Management Branch, who spent several weeks with us. Through his skill as a field ornithologist and his assistance with all phases of the program he made a major contribution to its success. Mr. Brian Carter of the Fish and Wildlife Branch was responsible for much of the advance preparation. Conservation Officer Brian Urquhart of Fredericton and Mr. E. Campbell, Fish and Wildlife Supervisor in Newcastle, helped us with the preliminary work, including the maintenance of captive woodcock and the erection of pens. The staffs of the Doaktown and Boisetown Ranger Stations volunteered observations on the effects of the spraying on birds and provided us with specimens and weather data.

Through the courtesy of Dr. R. M. Belyea, Officer-in-Charge of the Forest Entomology and Pathology Laboratory in Fredericton, we were able to borrow equipment and make use of the library and other facilities. Mr. Ross Macdonald and Mr. Donald Cameron of the Laboratory kept us informed of the progress of the entomological work and, from time to time, assisted with the field work.

I am particularly indebted to Messrs. B. W. Flieger and B. A. McDougall of Forest Protection Limited for the excellent facilities provided and for their interest and encouragement. Mr. Wayne Matthews, Supervisor of Operations at our headquarters at Taxis Airstrip, supported our work in every way and made our stay there very pleasant.

And finally, I thank Malcolm Jackson and Barry Cook, two students from York University, who worked hard at the variety of jobs that fall to student assistants in a project of this kind.

METHODS

Field work, which began May 20 and ended July 24, was carried out from a headquarters at the Taxis Airstrip near Boisetown where facilities were provided by Forest Protection Limited, the company carrying out the spray operation.

To assess the effects of phosphamidon we obtained indices to bird populations before and after spraying on five experimental and one control area and carried out experiments with caged birds.

STUDY AREAS

Figure 18 shows the location of the six sample areas. All are within Loucks' (1962) Maritime Lowlands Ecoregion and, within this region, in the Nashwaak-Miramichi and Bantalor Districts (Fig. 5). In Rowe's classification (1959) the study areas are in the Eastern Lowlands Section of the Acadian Forest. Both authors present general descriptions of the forest in this part of New Brunswick.

Estimates of forest composition were made by running several random transects across each sample area along compass lines. The diameter at breast height (DBH) of all trees over 1 inch in a 6-foot swath was tallied. No claim can be made for the adequacy of the sampling. The figures provide a rough basis for comparing major habitat features in the sample areas (Table 1).

POPULATION INDICES

Because we arrived in the field only shortly before operational spraying was to begin we had to proceed quickly to secure the pre-spray population indices. Since there was no time to establish surveyed sample plots from which to obtain data on population density and changes in territorial dispersal after spraying, we decided on a method designed to yield indices to changes in numbers and species composition.

In each sample area a "census route" was selected. These usually ran along logging or other access roads so that we could get into and return from the sample area on a roughly circular route. This was done to save time in marking routes and to permit us to move through the forest directly after spraying without contamination from shrubs and low branches of trees.

After a sample area had been selected and a route laid out, a series of counts were carried out as follows. An observer walked slowly along

the route, listening and watching for birds. All birds seen were identified and counted and, insofar as possible, individual singing birds which could not be seen were recorded. Doubtless errors were made, and there can be no claim that the count was precise. In addition, an estimate of the number of songs heard was made on a hand tally counter. It was, of course, impossible to count every song, especially when the frequency of singing was very high early in the morning, but the estimate obtained provided another index to the number of birds present.

Thus, at the conclusion of each count the following information was available:

- (a) time spent,
- (b) estimate of number of individual birds identified,
- (c) estimate of total number of songs,
- (d) estimate of number of species present.

From these data, indices to population — songs per minute and birds per minute — could be calculated. In addition, data on weather and special circumstances which might affect the observations were recorded.

Nearly all censuses were carried out early in the morning between 5:30 and 8:00 a.m. AST, or in the evening between 6:00 and 8:30 p.m. AST. On the whole, birds were more in evidence in the early morning than in the evening, except for some species, such as thrushes, which were more readily detected by song in the evening. Although we made as many censuses, both morning and evening, as weather permitted, final tabulations were based on early morning censuses only, except in cases where counts made at other times yielded particularly significant information.

Additional censuses were run after spraying. Early in July singing decreased as breeding activity declined and it became difficult to make counts comparable to those made earlier in the summer. Checking of sample areas was, therefore, abandoned except for counts made during timber cruises.

APPLICATION OF SPRAY

Spray was applied from modified Grumman Avenger (TBM) aircraft according to the procedure outlined by Flieger (1964). Except where otherwise noted, the dose rate was 0.45 pounds of phosphamidon in .75 U.S. gallons of water per acre. This is a concentration of about 7 per cent.

EXPERIMENTS WITH CAGED BIRDS

Two types of experiments were carried out. First, a small number of captive ruffed grouse and woodcock³ were exposed to operational spraying in large pens built in the forest. Second, a much larger number of songbirds were subjected to various experiments in more artificial conditions in a field laboratory. Most of the birds were captured in mist nets.

³ For scientific names of birds see Appendix A.

RESULTS

Populations

General conclusions

The results can be summarized briefly as follows. Phosphamidon applied as it was in the budworm control program is toxic to birds. The total effect of spraying cannot be established with certainty, but the following observations are suggestive:

1. Dead birds were found soon after spraying. They were sufficiently numerous to be found easily in fairly restricted areas, often by inexperienced observers. A number of people living in or near sprayed areas reported dead birds or gave us dead birds they had found.

2. The numbers of birds seen and heard soon after spraying were very strikingly reduced, and populations did not seem to have been restored to their original levels by the time censusing stopped. This observation could mean:

- (a) A substantial proportion of the bird population was killed, and the slow repopulation was due to immigration;

- or (b) A substantial number of birds left the sprayed areas and slowly returned or were replaced by immigrants.

3. A number of "sick" birds were found after spraying. These displayed the symptoms characteristic of poisoning with organophosphates, including lack of co-ordination, which rendered them flightless or nearly so (Holmstedt, 1959; Rudd, 1964). Many birds in this condition were easily collected by hand. Some recovered and were released.

4. Experiments with caged birds suggested that they might not be affected substantially by the spray falling from aircraft, but that they somehow accumulated an effective dose by contact over a few hours with sprayed vegetation.

Assessment of bird populations

Tables 2, 4, 6, 8, 10, 12, and 14 show the results of a selection of censuses on the six sample areas, and Tables 3, 5, 7, 9, 11, 13, and 15 contain the

pertinent statistics on the frequency of birds seen (birds per minute), song frequency (songs per minute), and numbers of species represented.⁴

For all areas except the control area, the tables show the same trends: before spraying, a large number of species and a relatively high frequency of birds and songs per minute, and after spraying a decline in these indices and a trend towards slow recovery.

1. CONTROL AREA

This was the only plot outside the Nashwaak–Miramichi District. It lay near the northern edge of the Bantalor District (Loucks, 1962) on flat land just south of Muzerol Brook, about a mile outside the DDT spray area and about 5.5 miles from the nearest phosphamidon area (Figs. 6, 7). It was not an entirely satisfactory control in that the composition of the forest was not as similar to the other areas as we might have wished (Table 1, Fig. 6). Moreover, our observations were disrupted by cutting operations which began towards the end of June and forced us to abandon the area sooner than intended. The census route was about 1.5 miles long.

Tables 2 and 3 show that the number of species, although smaller than on other areas, remained relatively stable and that song frequency and number of birds seen showed no changes similar to those observed on the experimental areas.

2. NASHWAAK AREA

This sample area lay east of the Nashwaak River about 2.5 miles north of Taymouth (Fig. 8). A census route of about 2.5 miles was used.

This was the first area to be sprayed with phosphamidon. Owing to an error in mixing the formulation, the concentration of insecticide was about 8 per cent instead of the usual 7 per cent. The southern half of the area was covered early on the morning of May 31 and the rest the next morning. A check on the afternoon of May 31 about 7 hours after the first spraying revealed that singing was very light even for mid-afternoon. Very few birds were seen. Four warblers (Tennessee, magnolia, Cape May, myrtle) and two rose-breasted grosbeaks were picked up, unable to fly. Nine other warblers (Tennessee, magnolia, Cape May, bay-breasted, Canada) and one junco were seen behaving as if they had been affected.

The area was checked again in the evening on June 1 about 12 hours after the second spraying and about 36 hours after the first spraying. There

⁴ In interpreting the tables, the following points should be noted:

1. Some species have been grouped. Red and white-breasted nuthatches are listed as "Nuthatch sp." All vireos, probably solitary and red-eyed, are listed as "Vireo sp."
2. Evening grosbeaks are not included in "Total birds" because it was impossible to obtain more than rough estimates of numbers. They were nearly always seen or heard in flocks flying over the forest canopy. In the tables they are usually recorded by symbols such as 6F, meaning "six flocks". The flocks usually numbered from 2 to 10 birds. They are, of course, included in the figures for total species seen.

was virtually no song, and less than a quarter of the usual number of birds was seen and heard. In all, 30 birds displaying symptoms were observed. Thirteen were collected. The number of species seen fell from around 40 to less than 20. These data should be compared with those for May 27, which were also collected in the evening (Table 5).

Residents in the vicinity of the area reported finding a number of sick and dead birds.

Over the next 3 weeks the population seemed to recover slowly, but apparently it did not reach its former level (Tables 4 and 5).

3. BETTSBURG AREA

This area lay east of Boiestown about 1.2 miles south from New Bandon (Figs. 9, 10). The census route was about 3 miles long, passing through recently cutover forest. There were many openings and somewhat more shrub and young tree growth than on any of the other sample areas.

The area was sprayed early in the morning of June 13. Mr. Pearce stationed himself under a plastic canopy where he observed the birds during spraying. He saw no sign of altered behaviour. Singing continued at a high frequency even while the aircraft were directly overhead.

Population changes were similar to those in the Nashwaak area. Tables 6 and 7 show that the population apparently declined and began to recover slowly during the 3 weeks after spraying. Between June 13 and 27, 75 "sick" or dead birds representing 20 species were picked up.

4. TAXIS RIVER AREA

The census route was established along the north shore of the Taxis River about 4.5 miles east of Parker Ridge, as an example of stream bank sprayed with phosphamidon (Fig. 11). It was sprayed at 0550 AST on June 12. Before treatment, spray-detection cards were set out along the 1.25 miles of census route parallel to the river and along three other lines at right angles to the river. The intention was to measure the width of strip covered and to see if all the census route was sprayed.

Observers reported that there seemed to be sufficient wind to drift a good deal of the spray onto the south shore away from the census area. Inspection of the detection cards 4½ hours after spraying showed that a maximum width of about 900 feet from the river bank had been covered on the north shore and that all of the census route had been sprayed. In comparison with some other areas, however, the amount of spray reaching the cards seemed light.

A census made 4½ hours after spraying revealed a moderate reduction in total birds counted and a considerable reduction in singing. Three men failed to find any sick or dead birds. A census taken in the evening about 12 hours after spraying showed a considerable depression in population and

singing and a marked reduction in species seen (Tables 8 and 9). Nine sick birds were seen. Most songs tallied were those of a few persistently singing robins. In comparison, an evening census taken June 3, 9 days earlier, had yielded two and one-half times as many birds, more than three times the frequency of song, and 12 more species. On June 13, the day after spraying, four warblers were found in a weak condition. An evening census on June 14 yielded 28 species and a somewhat increased frequency of singing. Pressure of work on other areas and the weather prevented further census until June 24 when it appeared that the population had built up considerably.

Repopulation of this area was apparently more rapid than in other sample areas. Assuming immigration to be the main source of new birds, repopulation of this 900-foot-wide strip from the large adjacent areas (unbroken forest and the river) would probably be more rapid than repopulation of extensive areas such as Bettsburg, Nashwaak, and Big Hole Brook.

5. LUDLOW AREA

This census route of about 1.25 miles was located on the ridge immediately south of Ludlow (Fig. 12). The area was treated about 2040 hours AST on June 19 with a half-strength mixture (.25 lbs. in .75 U.S. gallons of water per acre). A census next morning showed no significant changes in bird population.

Three men searched the vicinity of the census route for about 1½ hours, but found no sick or dead birds. What appeared to be a sick ruffed grouse was reported on a woods road near the census route. On June 22 4 man-hours were spent in searching, but nothing was found. An evening census on June 23 suggested some reduction in song and number of species, but the population seemed to be fairly well recovered when the last census was taken on June 28 (Tables 10 and 11).

These results are inconclusive. There may have been some depression in population. There were striking reductions in Swainson's thrush, bay-breasted warblers, and lesser reductions in some other warblers, white-throats, and a few others. No dead or sick birds were found. Several interpretations are possible:

- (a) The half-strength spray is much less toxic than the full-strength.
- (b) Application in the late evening may be a factor. Most birds would be relatively inactive by the time the spray was applied. Much of it could have been absorbed by the plants before the birds became active in the morning. In all other areas the spray was applied in the morning.
- (c) Weather conditions could have been important. Drifting of spray by wind might have caused a light application of spray in the census area. Dilution by dew might also be a factor.

6. BIG HOLE BROOK AREA

This sample area lay north of the Southwest Miramichi River about 7 miles due north of Ludlow along the headwaters of North Big Hole Brook (Figs. 13, 14, 15). The census route of about 2.5 miles ran through a predominantly coniferous stand having a more "boreal" aspect than any of the other five areas. To obtain comparative data on population changes following spraying, a check area, Big Hole Brook (East), was selected nearby.

Big Hole Brook area was sprayed early in the morning of June 21 with the standard mix of phosphamidon to which the penetrating agent Invadine JFC (manufactured by CIBA) had been added. Tables 12 and 13 show that the typical decline and recovery in population occurred after spraying. No change was observed on the control area (Big Hole Brook (East)) until after June 23, when it was sprayed with DDT (Tables 14 and 15). The decline in birds noted (116 to 103) and in songs (19.6 to 12.2 songs per minute) may have been caused by DDT. However, population reduction on the Big Hole Brook area did not seem to be as drastic as on the Nashwaak or Bettsburg areas. Very few sick birds were seen and after considerable searching only four dead birds were found (Fig. 16). Several men who were cutting timber on the sprayed area reported seeing sick and dead birds.

The apparently limited effect of the spraying can be interpreted in various ways:

- (a) The wetting agent somehow reduced the toxic effect.
- (b) Only a light dose of spray fell in the sample area.
- (c) The spray was greatly diluted by the very heavy dew on the morning of the spraying. The block was sprayed between 0500 and 0530 AST and a census run from 0605 to 0710. At 0600 the vegetation was laden with water from a night shower and (or) an extremely heavy dew. The alders in the valley of North Big Hole Brook were laden with drops of water. All the vegetation on the census route was saturated to at least 15 feet and, as far as could be seen with binoculars, the taller trees were also wet with dew or rain. Hence, the spray falling on the vegetation would have been greatly diluted.
- (d) The very damp vegetation may have restricted the activity of many birds in some way that prevented extended contact with the spray.

Interpretation of population data

Observations on the six sample areas provide a measure of the effect of phosphamidon on bird populations with results which vary from an apparent considerable reduction to a slight reduction. These variations may be

accounted for by variations in application, moisture on the vegetation, concentration of phosphamidon, possible effect of Invadine, density of cover affecting ability to find dead or sick birds, time of application, and probably other factors. We are far from having a full understanding of the situation; the results must be regarded as preliminary.

The tables show that some species seem to be more affected than others. All the warblers, for example, were apparently considerably reduced as were a few other species, such as white-throated sparrow, Swainson's thrush, winter wren, and purple finch. On the other hand, sapsuckers, robins, and evening grosbeaks were apparently not so much affected. Data on grosbeaks are difficult to interpret. They were extremely abundant but were seldom seen perched in trees along the census routes; virtually all those tallied were in flocks flying over.

These observations prompted many questions, the main one being, "How are the birds affected?" Several hypotheses are possible:

- (a) The birds die or become ill as a result of eating insects and other food containing phosphamidon. (The "poisoned food" hypothesis.)
- (b) The birds are incapacitated by contact with the spray soon after it is applied. Those that die actually starve to death because they cannot move about sufficiently to get food. (The "starvation" hypothesis.)
- (c) The birds are affected by direct contact with the spray which somehow makes them ill or kills them. (The "contact poison" hypothesis.)

These ideas, arising from the field observations, were examined in more detail in a simple laboratory where captive birds and some equipment were available.

Laboratory and experimental investigations

1. THE "POISONED FOOD" HYPOTHESIS

It is unlikely that more than a small fraction of birds found dead were poisoned by their food. Ten birds found dead or disabled on June 1, on the Nashwaak area, were dissected and the entire intestinal tracts examined. All were virtually empty. Most contained only a few hard chitinous insect remains and some grit. Later, a number of other dead birds collected on the other areas were examined with the same result. In two experiments a captive purple finch and a chipping sparrow died, apparently from eating seed sprayed with 2.5 per cent and 5 per cent phosphamidon. The purple finch survived 20.5 hours and the chipping sparrow about 5 hours. Both

birds had fragments of contaminated seeds in their digestive tracts. A 3-week-old ruffed grouse became ill after eating contaminated food but soon recovered. While consumption of contaminated food may have been a factor in mortality, it was probably not a major one for reasons that will be discussed later.

2. THE "STARVATION" HYPOTHESIS

Some "sick" birds picked up in sprayed areas later recovered and were released. Some captive birds which were in contact with spray became ill but survived. It seems possible that phosphamidon incapacitated the birds in some way so that they were not able to move about to feed. If the incapacity lasted for several hours, especially early in the morning when the spray was usually applied, they might die of starvation.

To test this hypothesis, a number of birds representing 14 species⁵ were captured in mist nets and placed in cages without food or water. This experiment revealed birds could remain alive and active from 7 to 72 hours from the time they were placed in cages and most survived from 20 to 30 hours.

On the other hand, it seemed that all the birds that recovered from spraying did so within a few hours. No precise data are available, but most reports stated that the birds could fly within 5 or 6 hours after capture and usually sooner. Those which became ill in experiments and later recovered did so within a much shorter time.

Unfortunately, no warblers were available for this experiment, but it appears that other species can probably survive without food longer than the period of incapacity induced by phosphamidon. It seems that some birds become ill from the effects of phosphamidon and then recover, whereas others die. Starvation does not seem to be a factor, although it should be noted that nearly all the dead and dying birds from sprayed areas had empty intestinal tracts. These, however, were collected in a relatively short time after spraying, suggesting that they had been stricken soon after phosphamidon was applied.

3. THE "CONTACT POISON" HYPOTHESIS

Several experiments suggested that birds became ill or were killed through surface contact with or inhalation of spray. This is at present the most promising idea, but there is still a good deal that is unknown. When the size of the bird and its insulation are considered in relation to the amount of spray falling per unit area, it might reasonably be supposed that direct spraying of birds by aircraft would not be sufficient to disable or kill them. Experiments with caged ruffed grouse, woodcock, and some smaller birds suggest that this is true. To kill some birds directly with spray it was

⁵ Species: Black-billed cuckoo, yellow-shafted flicker, Traill's flycatcher, barn swallow, robin, olive-backed thrush, ovenbird, house sparrow, bobolink, purple finch, savannah sparrow, chipping sparrow, white-throated sparrow, song sparrow.

necessary to apply enough to make the feathers appear wet. It may also be necessary to apply it in the right places. It is unlikely that this happens often in operational spraying.

Experimental spraying

If contaminated food is regarded as a minor mortality factor and starvation seems not to be important, the question remains of how birds acquire a lethal dose. Time or facilities were not available in the field to examine this question fully, but a few preliminary experiments have suggested a fruitful approach.

During July, 44 simple experiments were run involving about 50 individual birds representing 13 species. It was impossible to approach the problem systematically, because the birds had to be used as they came to hand from the mist nets. This phase of the work is, therefore, deficient in replications and representation of species. Very few warblers were available, for example. Moreover, the equipment and facilities were makeshift, as they must be in any preliminary trials in the field.

The first series of tests involved spraying captive birds by hand or exposing them in pens to operational spraying. The results are summarized as follows:

Ruffed grouse. — (a) An adult female whose head was sprayed with a 5 per cent mixture until the feathers were moist showed no ill effects. (b) On June 11, four birds were placed in a large holding pen along the Taxis River in an area sprayed from the air in the morning and again in the evening of June 12 because the spray detection cards showed that only a light dose had fallen in the morning. On the evening of June 13, one bird was very weak and was sacrificed. On June 14 another was weak, and one was dead. On June 16, a fourth bird appeared ill.

It is important to note that these birds were not in good health at the beginning of the experiment. They had been held in pens at headquarters for some time, had suffered the shock of recapture and transfer to pens by the river before spraying, and were underweight when placed in the new pens. They lost considerable weight between the time of transfer and the time they were sacrificed. The results of this experiment then, while suggestive, cannot be regarded as conclusive. Several factors could have contributed to their weakness and death. We do not know how healthy, wild birds would have responded. Stickel *et al.* (1965) report that response to pesticides in woodcock varies with the well-being of the birds.

Woodcock. — (a) The upper breast and one leg and foot of a woodcock were sprayed with about 0.5 cc. of 5 per cent phosphamidon. The bird showed no ill effects. (b) Two woodcock were exposed in the pens on the Taxis River as described above for ruffed grouse. One, removed from the pen directly after the spray operation, died in a holding pen at headquarters on June 14, 2 days after spraying. A second bird, left in the pen by the

river was found on June 15 too weak to escape capture by hand. Again, however, those birds were not in good health and consequently we cannot be certain that they died of phosphamidon poisoning. (See Stickel *et al.*, 1965.)

Wood thrush. — A wood thrush sprayed lightly from 3 feet showed no ill effects.

Olive-backed thrush. — An olive-backed thrush was placed in a ¼-inch mesh cage under a plastic canopy. Spray was introduced through the top of the canopy and allowed to settle in the still air inside. In about 70 minutes the bird was staggering and exhibiting what seemed to be initial symptoms of poisoning. However, it soon recovered and was active about 2 hours later.

Robin. — A lightly sprayed robin survived for about 32 hours. It showed no symptoms of poisoning but was very weak, probably from lack of food.

Blackburnian warbler. — The head of a Blackburnian warbler was sprayed with 2.5 per cent phosphamidon until its feathers were damp. No ill effects were evident during the 10 hours of observation. The bird died during the night, but there was no symptom of poisoning. This may be significant in the light of observations on the Ludlow area, where a dose of approximately 3.5 per cent was used and only moderate changes in bird populations were noted.

Ovenbird. — (a) An ovenbird sprayed from 3 feet with a 10 per cent solution of phosphamidon at 8 a.m. remained active all day but was dead by 6 a.m. next morning. The five ovenbirds tested in the starvation experiments lasted about the same length of time or less. It seemed likely that this bird starved. (b) The heads of two birds were sprayed with a 10 per cent solution until damp. They were both dead in 20 minutes. (c) A bird whose head was sprayed with a 10 per cent solution died in 11 minutes.

Bobolink. — An adult male was sprayed lightly from 3 feet with a 5 per cent solution. It survived 24 hours and was transferred to another experiment, apparently in good health.

Purple finch. — About 5 p.m. the head of a purple finch was sprayed with 10 per cent phosphamidon until it appeared "wet". In the following 35 minutes the bird remained quite still except for three drinks from the water pan. Fifteen minutes after treatment it appeared to disgorge a few fragments of seed or other food and a few drops of water. It survived overnight in a cage with food and water. By 8:30 the next morning, it was trembling and was holding its head tilted up. It died at 10:30 a.m. It showed some symptoms of poisoning but the evidence is inconclusive.

Savannah sparrow. — At 12:30 p.m. a 10 per cent solution of phosphamidon was applied with a swab to the crown, nape, and side of the bird's head. The bird remained active all day, but was dead by 7 a.m. next morning. Again, an inconclusive result.

Chipping sparrow. — A chipping sparrow whose head was sprayed with 5 per cent solution until wet died in 11 minutes.

White-throated sparrow. — An adult male whose head was sprayed until wet with a 5 per cent solution died in 18 minutes.

These experiments suggest that a light spray of phosphamidon falling from an aircraft is insufficient to kill a bird. On the other hand, a dose concentrated on the head in sufficient quantity to wet the feathers will kill some birds very quickly. When the head is sprayed the eyes, nostrils, and oral cavity may be the vulnerable areas. Whereas ovenbirds whose heads were sprayed at close range died in 10 to 20 minutes, the savannah sparrow whose head except for eyes and bill was swabbed with phosphamidon lived for several hours. Some experiments with phosphamidon carrying a radioactive label would be valuable in determining the way the material enters the bird's system.

The ideas developed for the foregoing experiments were tested further in a somewhat more elaborate procedure. A polyethylene canopy stretched over a wooden frame was constructed to provide a shelter free from air currents in which spray could be applied to birds and vegetation. The frame was about 4 feet high, 2 feet wide, and 4 feet long with a glass window fitted in the top to permit observation of the spray and responses of the birds (Fig. 17). A number of small branches with foliage were fastened upright into racks inside the canopy near the floor. A bird in a cage made of ¼-inch hardware cloth was placed under the canopy between the foliage racks. Several spray-detection cards were placed on the floor near the cage and around the vegetation to give a measure of the spray dosage. The canopy was then closed and a few jets of spray were introduced from a hand atomizer through a hole in the top of the canopy about 3 feet above the vegetation and cage. By watching the spray cards through the glass window in the top of the canopy the amount of spray could be roughly regulated. In every experiment the vegetation and bird probably received more spray than would have been the case in operational spraying.

In the second step of the experiment the caged bird was removed from the canopy and set aside for observation. The sprayed foliage was removed and put into a second cage together with an unsprayed bird of the same species. Thus in one cage there was a bird that had been sprayed directly, and in another an unsprayed bird in contact with freshly sprayed foliage. This design required two birds of the same species, which were not always available. In supplemental experiments a few single birds were exposed to sprayed foliage.

As might be expected from a series of preliminary experiments using rather crude apparatus and measurements, the results were not entirely consistent, but they are indicative.

There is good evidence that birds may be poisoned by contact with sprayed foliage. For example, a magnolia warbler was placed in a cage containing sprayed balsam branches. In about 1 hour the typical trembling symptoms began to develop and progressed to the stage of loss of equilibrium in slightly less than 4 hours. A Tennessee warbler put into a cage of

sprayed foliage in the evening went to roost almost at once, but was trembling and staggering by 6:15 the next morning and was dead at 6:40. A young junco placed in a cage with sprayed aspen foliage died in 11 hours. An ovenbird exposed to sprayed foliage was dead in about 4 hours. A 3-week-old grouse chick died about 5 hours after exposure to sprayed foliage.

Some other birds, including a robin, thrush, woodcock, and several grouse survived experiments of this kind.

In the experiment in which two birds were used as described above, the bird in the cage with the foliage usually showed symptoms of poisoning first. In an experiment with two blue jays, the bird in the foliage died and the other survived an additional 10 hours and was liberated. In an experiment with two juncos the bird in the foliage died about 3 hours before the other bird. In the case of two olive-backed thrushes the bird in the foliage showed symptoms after about 19 hours, but the other bird showed no sign of distress.

DISCUSSION

Like most initial attacks on a problem, these preliminary results raise more questions than they answer. Certain important conclusions may be drawn and this is the reason for publishing a report now before the completion of more work.

This seems to be the first report of a substantial avian mortality following application of phosphamidon. In the light of the findings of this study, the reports of other experiments are puzzling. Dever and Davis (1960), for example, report no effect on caged canaries exposed during spraying and kept under observation for approximately 5 weeks. Moreover, no effect was noted on free-living robins, blue jays, verios, thrushes, "sparrows", and "hawks" observed before, during, and after spraying operations. No toxic symptoms or dead birds were observed. The results with the canaries may now be interpreted in the light of the fact that they were not in contact with sprayed vegetation.

Oliver (1964) reports on an experimental study to control forest tent caterpillar (*Malacosoma disstria*) in Louisiana in which phosphamidon was applied at the rate of .5 to 1 pound per acre. He says that the insecticide was applied "without apparent detrimental effects to wildlife" (p. 160) but does not define the criteria for determining detrimental effects. He implies that birds were present before and after spraying, but makes no reference to possible changes in population levels. Finley and Richmond (Crabtree, 1964) report some bird mortality and apparent depression in population in a small area where phosphamidon was used at the rate of 1 pound per acre in Montana. Feeding tests by DeWitt *et al.* (1962, 1963) showed variations in toxicity of phosphamidon in various game birds.

No bird mortality was reported in 1962 when phosphamidon was tested in New Brunswick by the Fisheries Research Board and the Department of Forestry. From discussions with some of the men who carried out the tests I have concluded that there were probably no observers in the plots at times when mortality might have been apparent.

In 1963, however, when the insecticide was used on 22,000 acres of stream bank, two members of the Canada Department of Fisheries, J. R. MacDonald and Robert Dunfield, observed some evidence of bird mortality along the Salmon River in Kent County. The stream and its banks were sprayed on June 12. On June 14 a sick robin was picked up.

Dead birds of various species were found on June 17, 19, 20, and 21. All were in or immediately adjacent to the sprayed areas.

Population changes following spraying can be accounted for by mortality and emigration. If some of the original population left the areas as a result of spraying, some birds would have to move a considerable distance; for example, at least 1.5 miles in the case of Big Hole Brook area. In most cases movement out of an area treated with phosphamidon would simply place birds in an adjacent area treated with DDT. Here they would also have to deal with a changed food supply.

The extent of mortality cannot be fully assessed. Some sick and dead birds were found. In the Bettsburg area, where the most manpower was available for searching, 75 specimens were picked up. More manpower on the other areas might have produced more specimens. Stickel (1964) reports on some experiments at the Patuxent Wildlife Research Center in Maryland which show considerable variation among observers in the ability to find dead birds in natural vegetation.

There is also the question of how long it is profitable to search. Dead animals are soon picked up by scavengers or decompose and break up. Rosene and Lay (1963) report the fairly rapid disappearance of carcasses of bobwhite quail. Stickel (1964), however, cites experiments which show a good deal of variation. In some, over 50 per cent of the specimens set out remained after 5 weeks, while in another 90 per cent were gone in 4 days. We put a number of fresh bird specimens on the Taxis River area, on the Bettsburg area, and at a third location along Stewart Brook. None of the nine specimens disappeared from the Taxis area in 7 days, none in 10 days on the Bettsburg area, and none in 5 days along the brook. This suggests that if searching is carried out immediately after spraying and continues for a few days, few specimens will be lost to scavengers.

Although the reduction of population may be reasonably accounted for, it is more difficult to explain the build-up after spraying. Some build-ups may be due to recovery of birds temporarily incapacitated by spray. If some birds emigrate they may return. It seems likely, however, that most of the build-up is due to newcomers. Territories vacated as a consequence of mortality or emigration may be filled by birds moving in from adjacent areas. The work in Maine of Stewart and Aldrich (1951) and Hensley and Cope (1951) showed that there seems to be a huge reserve of birds ready to move in and occupy recently vacated space in the forest. In their study they removed from a 40-acre block of forest most of what they believed to be the resident population of males and some females. In the first year they estimated a population of territorial males of 148. In the second year it was 152. In the first year 420 adult birds were removed by shooting, nearly all of them immigrants. In the second year 528 birds were removed. Note that most of the birds collected were

males. If there is a large reserve of non-breeding birds in the forest available to fill vacated territories this is an important idea to be taken into account in assessing mortality caused by application of pesticides in small areas. A study to investigate this hypothesis is required.

The need for efficient pesticides, having limited or negligible side effects on animals other than the target organisms, should encourage further research on promising compounds. The fact that phosphamidon appears to have no ill effects on aquatic organisms and, as far as we know, breaks down rapidly without leaving undesirable residues suggests that it may be very useful.

There are, however, practical problems relating to potential toxicity to birds and perhaps other animals, to cost, and to problems of handling the highly toxic compound. If continued research on biological and ecological effects points the way to application methods that will not harm birds, and if economic and technological problems can be overcome, phosphamidon may well prove to be a valuable tool of forest management.

The continuing investigations planned for 1965 may well take us closer to our objective.

SUMMARY

The primary purpose of this project was to assess the effects of phosphamidon on bird populations. It has been shown that:

1. Phosphamidon applied as it was in 1964 in the budworm control program is toxic to birds;

2. Birds are apparently incapacitated or killed mainly as a result of accumulating phosphamidon from sprayed vegetation in the first few hours after spraying.

These results should not be used to condemn phosphamidon outright. Under the operational conditions in 1964 phosphamidon killed some birds. We know nothing of what might happen if the dosage were altered, if it were applied earlier in the year, or sprayed in the evening instead of in the morning. We do not really understand how the birds pick up the poison. Certainly the results suggest that the compound should be used with extreme caution until we know more about it, but at the same time, we should recognize that by no means all the possibilities have been explored.

REFERENCES

- Crabtree, D. G. 1964. Wildlife studies, Denver Wildlife Research Center. *In* Pesticide-Wildlife studies 1963: A review of Fish and Wildlife Service studies during the calendar year. U.S. Dept. Interior, Fish Wildl. Serv. Circ. 199:44-76.
- Dever, D. A., and D. L. Davis. 1960. Aerial application of phosphamidon to forested areas—Maine, 1960. Calif. Chem. Co., Ortho Division, Res. Develop. Dept., Res. Rept. File No. 721:110.
- Dewitt, J. B., D. G. Crabtree, R. B. Finley, and J. L. George. 1962. Effects on wildlife. *In* Effects of pesticides on fish and wildlife: A review of investigations during 1960. U.S. Dept. Interior, Fish Wildl. Serv. Circ. 143:4-15.
- DeWitt, J. B., W. H. Stickel, and P. F. Springer. 1963. Wildlife studies, Patuxent Wildlife Research Center. *In* Pesticide-wildlife studies: A review of Fish and Wildlife Service investigations during 1961 and 1962. U.S. Dept. Interior, Fish Wildl. Serv. Circ. 167:74-96.
- Flieger, B. W. 1964. A new method for guiding spray aircraft. Canada Dept. Forestry. Bi-monthly Prog. Rept. 20(1):2-4.
- Hensley, M. M., and J. B. Cope. 1951. Further data on the removal and repopulation of the breeding birds in a spruce-fir forest community. *Auk* 68:483-493.
- Holmstedt, B. 1959. Pharmacology of organophosphorous cholinesterase inhibitors. *Pharm. Rev.* 11(33):567-688.
- Loucks, O. L. 1960. A forest classification for the Maritime Provinces. *Proc. Nova Scotia Inst. Science*, 25 (Part 2) 1959-60:85-167. (Reprinted: Canada Dept. Forestry, 1962.)
- Macdonald, D. R. 1964. Aerial spraying against the spruce budworm in New Brunswick, 1960 to 1963. Canada Dept. Forestry. Bi-monthly Prog. Rept. 20(1):1-2.
- Morris, R. F., *ed.* 1963. The dynamics of epidemic spruce budworm populations. *Mem. Entomol. Soc. Canada*, No. 31.
- Oliver, A. D. 1964. Control studies of the forest tent caterpillar, *Malacosoma disstria*, in Louisiana. *J. Econ. Entomol.* 57:157-160.
- Rosene, W., and D. W. Lay. 1963. Disappearance and visibility of quail remains. *J. Wildl. Mgmt.* 27:134-142.
- Rowe, J. S. 1959. Forest regions of Canada. Canada Dept. Northern Affairs and Natl. Resources, Forestry Branch Bull. 123.
- Rudd, R. L. 1964. Pesticides and the living landscape. University of Wisconsin Press, Madison, Wisc.
- Stewart, R. E., and J. W. Aldrich. 1951. Removal and repopulation of breeding birds in a spruce-fir forest community. *Auk* 68:471-482.
- Stickel, L. 1964. Wildlife studies, Patuxent Wildlife Research Center. *In* Pesticide-wildlife studies 1963: A review of Fish and Wildlife Service investigations during the calendar year. U.S. Dept. Interior, Fish Wildl. Serv. Circ. 199:77-115.
- Stickel, W. H., W. E. Dodge, W. G. Sheldon, J. B. DeWitt, and L. F. Stickel. 1965. Body condition and response to pesticides in woodcock. *J. Wildl. Mgmt.* 29:147-155.

TABLES

TABLE 1 Percentage composition and mean DBH (inches) (\bar{X} D) for tree species over 1 inch DBH

| Species* | Control | | | Nashwaak | | | Bettsburg | | | Taxis River | | | Ludlow | | | Big Hole Brook | | | Big Hole Brook East | | |
|------------------------|---------|----|-------------|----------|----|-------------|-----------|----|-------------|-------------|----|-------------|--------|----|-------------|----------------|-----|-------------|---------------------|-----|-------------|
| | Total | % | \bar{X} D | Total | % | \bar{X} D | Total | % | \bar{X} D | Total | % | \bar{X} D | Total | % | \bar{X} D | Total | % | \bar{X} D | Total | % | \bar{X} D |
| Balsam | 110 | 21 | 3.3 | 276 | 71 | 3.4 | 201 | 28 | 3.0 | 491 | 64 | 5.5 | 162 | 41 | 3.2 | 120 | 46 | 4.0 | 198 | 51 | 3.1 |
| Hemlock | — | — | — | — | — | — | — | — | — | — | — | — | 15 | 5 | 7.5 | — | — | — | — | — | — |
| White spruce | 14 | 3 | 4.0 | — | — | — | — | — | — | 25 | 3 | 5.8 | — | — | — | 1 | T‡ | 9.0 | — | — | — |
| Red spruce | 42 | 8 | 5.2 | 31 | 8 | 5.1 | 134 | 19 | 5.8 | 95 | 12 | 6.3 | 123 | 31 | 4.4 | 23 | 9 | 6.3 | — | — | — |
| Black spruce | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 62 | 24 | 6.2 | — | — | — |
| "Spruce"† | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 164 | 42 | 5.5 |
| White pine | 74 | 14 | 7.2 | 2 | T | 15.5 | — | — | — | — | — | — | — | — | 14 | 5 | 4.0 | 7 | 2 | 8.4 | |
| White cedar | — | — | — | — | — | — | — | — | — | 14 | 2 | 8.0 | — | — | — | 1 | T | 10.0 | — | — | — |
| Trembling aspen | 4 | 1 | 7.0 | — | — | — | 11 | 2 | 4.1 | 1 | T | 2.0 | — | — | — | 3 | 1 | 14.6 | 8 | 2 | 8.2 |
| Largetooth aspen | 8 | 2 | 7.5 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Ironwood | — | — | — | 1 | T | 8.0 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Yellow birch | — | — | — | — | — | — | — | — | — | 10 | 1 | 7.6 | 2 | T | 7.5 | — | — | — | — | — | — |
| White birch | 95 | 18 | 5.6 | 3 | 1 | 7.0 | 6 | 1 | 4.7 | — | — | — | 2 | T | 8.0 | 7 | 3 | 9.0 | 2 | T | 10.0 |
| Beech | — | — | — | 11 | 3 | 5.0 | 2 | T | 2.0 | — | — | — | 26 | 7 | 7.2 | — | — | — | — | — | — |
| Pin cherry | — | — | — | — | — | — | 1 | T | 2.0 | — | — | — | — | — | — | — | — | — | — | — | — |
| Black cherry | — | — | — | — | — | — | — | — | — | — | — | — | 1 | T | 3.0 | — | — | — | — | — | — |
| Choke cherry | — | — | — | — | — | — | 2 | T | 3.5 | 1 | T | 2.0 | — | — | — | — | — | — | — | — | — |
| Striped maple | — | — | — | — | — | — | — | — | — | 1 | T | 2.0 | 5 | T | 1.0 | — | — | — | — | — | — |
| Sugar maple | — | — | — | 4 | 1 | 5.5 | 1 | T | 3.0 | 35 | 5 | 4.1 | — | — | — | — | — | — | — | — | — |
| Red maple | 186 | 35 | 2.7 | 58 | 15 | 4.9 | 350 | 50 | 4.5 | 85 | 11 | 4.3 | 65 | 16 | 4.4 | 30 | 11 | 3.7 | 11 | 3 | 4.1 |
| Black ash | — | — | — | — | — | — | — | — | — | 7 | T | 6.0 | — | — | — | — | — | — | — | — | — |
| | 533 | — | — | 386 | — | — | 707 | — | — | 764 | — | — | 401 | — | — | 261 | — | — | 390 | — | — |

* For scientific names of plants, see Appendix B.

† Red, black, and a few white together.

‡ Trace.

TABLE 2 Census results (birds seen and heard), control area

| | June 3 | June 5 | June 15 | June 28 |
|------------------------------------|--------|--------|---------|---------|
| Broad-winged hawk | | | | |
| Ruffed grouse | 1 | 1 | | |
| American woodcock | | | | |
| Spotted sandpiper | | | | |
| Chimney swift | | | | |
| Ruby-throated hummingbird | 1 | | | |
| Belted kingfisher | | | | |
| Woodpecker sp. | 4 | | | 5 |
| Yellow-shafted flicker | | | 1 | |
| Pileated woodpecker | | | | |
| Yellow-bellied sapsucker | 4 | 6 | 2 | 4 |
| Hairy woodpecker | | | | |
| Black-backed three-toed woodpecker | | | | |
| Yellow-bellied flycatcher | | | | |
| Traill's flycatcher | | | | |
| Least flycatcher | 4 | 5 | 15? | 7 |
| Eastern wood pewee | 1 | 1 | 2 | 3 |
| Olive-sided flycatcher | | | | |
| Swallow sp. | | | | |
| Tree swallow | | | | |
| Bank swallow | | | | |
| Barn swallow | | | | |
| Gray jay | | | | |
| Blue jay | | 1 | 1 | |
| Common raven | | | | |
| Common crow | | | | |
| Black-capped chickadee | | 4 | | |
| Boreal chickadee | | | | |
| Nuthatch sp. | 1 | 1 | 2 | 2 |
| Brown creeper | | | | |
| Winter wren | 1 | 3 | | |
| Catbird | | 1 | | |
| Thrush sp. | 2 | | | |
| Robin | 4 | 5 | | 2 |
| Hermit thrush | | 4 | 2 | 3 |
| Swainson's thrush | 7 | 4 | 17 | 9 |
| Veery | 1 | | | |
| Ruby-crowned kinglet | 3 | 5 | | |
| Starling | | | | |
| Vireo sp. | 5 | 5 | 11 | 7 |
| Black-and-white warbler | 1 | | | |
| Tennessee warbler | 12 | 16 | 23 | 4 |
| Nashville warbler | | 1 | 2 | |
| Parula warbler | | | 3 | 1 |
| Magnolia warbler | 5 | 8 | 6 | 6 |
| Cape May warbler | | 1 | 2 | 4 |
| Black-throated blue warbler | 5 | 4 | 2 | 1 |
| Myrtle warbler | | | | |
| Black-throated green warbler | 2 | 5 | 5 | 4 |
| Blackburnian warbler | | | 1 | 2 |
| Bay-breasted warbler | 3 | 4 | 7 | 5 |
| Blackpoll warbler | | | | |

TABLE 2 (continued)

| | June 3 | June 5 | June 15 | June 28 |
|------------------------|------------|------------|------------|------------|
| Warbler sp. | 3 | 2 | | |
| Ovenbird | 25 | 36 | 47 | 23 |
| Northern waterthrush | | | | |
| Mourning warbler | 1 | | | |
| Yellowthroat | | | | |
| Canada warbler | | | | |
| American redstart | | | 2 | |
| House sparrow | | | | |
| Redwinged blackbird | | | | |
| Common grackle | | | | |
| Brown-headed cowbird | 4 | 2 | 1 | 2 |
| Scarlet tanager | | | | |
| Rose-breasted grosbeak | | | | 1 |
| Evening grosbeak | | 8F | 1F | 4+5F |
| Purple finch | 1 | 4 | | 4 |
| Pine grosbeak | | | | |
| Pine siskin | | 1 | | |
| American goldfinch | | | | |
| Crossbill sp. | | | | |
| Savannah sparrow | | | | |
| Slate-colored junco | 7 | 5 | 4 | 8 |
| Chipping sparrow | 1 | | | |
| White-throated sparrow | 11 | 18 | 10 | 18 |
| Swamp sparrow | | | | |
| Song sparrow | | | | |
| "Bird sp." | 6 | 4 | | |
| TOTALS | 126 | 157 | 168 | 125 |

TABLE 3 Population indices, control area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|---------------|-------------|-------------|------|------------|------------|---------------|
| June 3 | 126 | 479 | 70 | 6.8 | 1.8 | 26 |
| June 5 | 157 | 913 | 110 | 8.3 | 1.4 | 28 |
| June 15 | 168 | 1,083 | 65 | 16.2 | 2.6 | 26 |
| June 28 | 125 | 814 | 57 | 14.2 | 2.2 | 23 |

TABLE 4 Census results (birds seen and heard), Nashwaak area

| | May 25 | May 29 | June 1 (p.m.) | June 4 | June 6 | June 16 | June 25 |
|---------------------------------------|-----------|-----------|------------------|-----------|-----------|------------|------------|
| Broad-winged hawk | 1 | | | | | | 1 |
| Ruffed grouse | 1 | 1 | | | | | 1 |
| American woodcock | | | | | | | |
| Spotted sandpiper | | | | | | | |
| Chimney swift | | | | | | | |
| Ruby-throated hummingbird | | 1 | | 1 | | | |
| Belted kingfisher | | | | | | | |
| Woodpecker sp. | | 4 | 2 | | | | 1 |
| Yellow-shafted flicker | 2 | 1 | | | | | |
| Pileated woodpecker | | | | 1 | | | |
| Yellow-bellied sapsucker | 5 | 3 | 5 | 2 | 6 | 7 | 6 |
| Hairy woodpecker | | | | | | | |
| Black-backed three-toed woodpecker | | | | | | | |
| Yellow-bellied flycatcher | | 1 | | (1)* | | | |
| Traill's flycatcher | | | | | | | |
| Least flycatcher | 7 | 6 | | 2 | 2 | 8 | 1 |
| Eastern wood pewee | 2 | 1 | | | | 1 | 2 |
| Olive-sided flycatcher | | | | | | | 1 |
| Swallow sp. | | | | | | | |
| Tree swallow | 2 | | | | | | |
| Bank swallow | | | | | | | |
| Barn swallow | 3 | | | | | | |
| Gray jay | | | | | | | |
| Blue jay | 6 | 7 | | | 4 | 4 | 3 |
| Common raven | 1 | | | | | | |
| Common crow | 2 | | 1 | | | | 1 |
| Black-capped chickadee | 1 | 1 | | 1 | 3 | | |
| Boreal chickadee | 4 | 3 | | | | 5 | |
| Nuthatch sp. | 1 | 3 | 1 | 1 | | | |
| Brown creeper | 1 | | | | | | |
| Winter wren | 4 | 8 | 2 | | 1 | 1 | 3 |
| Catbird | | | | | 1 | | |
| Thrush sp. | | | | | | | |
| Robin | 10 | 10 | 5 | 8 | 10 | 18 | 10 |
| Hermit thrush | 2 | 2 | 1 | (1)* | (1)* | 1 | 2 |
| Swainson's thrush | 12 | 11 | 5 | 2 | 3 | | 10 |
| Veery | 1 | 2 | | | | 1 | 1 |
| Ruby-crowned kinglet | 8 | 8 | | 1 | | 14 | |
| Starling | | | | | | | |
| Vireo sp. | | | | | | 5 | |
| Black-and-white warbler | 1 | 1 | | | | | |
| Tennessee warbler | 45 | 79 | 1 | 8 | 17 | 26 | 7 |
| Nashville warbler | | 1 | | | | 1 | 1 |
| Parula warbler | 2 | 1 | | | | | 2 |
| Magnolia warbler | 3 | 11 | | | 2 | 2 | 3 |
| Cape May warbler | 12 | 16 | | | 2 | 1 | 3 |
| Black-throated blue warbler | 1 | 2 | | | | 1 | |
| Myrtle warbler | 2 | 5 | | 1 | | | |
| Black-throated green warbler | 6 | 4 | | | | | |
| Blackburnian warbler | 3 | 4 | 1 | 1 | 2 | 6 | 4 |
| Bay-breasted warbler | 9 | 25 | 2 | 4 | 12 | 13 | 8 |
| Blackpoll warbler | | | | | | | |

TABLE 4 (continued)

| | May 25 | May 29 | June 1 (p.m.) | June 4 | June 6 | June 16 | June 25 |
|------------------------|------------|------------|------------------|-----------|------------|------------|------------|
| Warbler sp. | 9 | 6 | | | 4 | 15 | 2 |
| Ovenbird | 35 | 45 | 10 | 13 | 27 | 31 | 13 |
| Northern waterthrush | | | | | | | |
| Mourning warbler | | | | | | | |
| Yellowthroat | 1 | | | | | | |
| Canada warbler | | | | | | | |
| American redstart | 1 | | | | | | |
| House sparrow | | | | | | | |
| Redwinged blackbird | | | | | | | 1 |
| Common grackle | | | | | | | |
| Brown-headed cowbird | 7 | 9 | | 2 | 5 | | 5 |
| Scarlet tanager | 2 | 1 | | | | | 1 |
| Rose-breasted grosbeak | 6 | 5 | (2)* | 3 | 1 | | 4 |
| Evening grosbeak | 10+ | 16+ | F+ | 15+ | 6+ | 18+ | 5 |
| Purple finch | 11 | 11 | 2 | 4 | 6 | 8 | 6 |
| Pine grosbeak | | | | | | | |
| Pine siskin | | 6 | | | | | |
| American goldfinch | 1 | 2 | | | | | |
| Crossbill sp. | | | | | | | |
| Savannah sparrow | | | | | | | |
| Slate-colored junco | 6 | 12 | 8 | 5 | 10 | | 6 |
| Chipping sparrow | 2 | | 1 | 3 | | | 3 |
| White-throated sparrow | 17 | 22 | 2 | 1 | 3 | 7 | 10 |
| Swamp sparrow | | | | | | | |
| Song sparrow | 1 | 2 | | | | | 2 |
| "Bird sp." | | 4 | 4 | 2 | 4 | 4 | 5 |
| TOTALS | 264 | 351 | 53 | 66 | 125 | 180 | 129 |

* Seen after census.

TABLE 5 Population indices, Nashwaak area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|---------------------|----------------|----------------|------|------------|------------|------------------|
| May 25 | 264 | — | 130 | — | 2.0 | 45 |
| May 27 (p.m.) | 243 | 281* | 155 | 4.3* | 1.6 | 41 |
| May 29 | 351 | 1,902 | 170 | 11.2 | 2.1 | 41† |
| June 1 (p.m.) | 53 | 18 | 100 | 0.2 | 0.5 | 16‡ |
| June 4 | 66 | 240 | 95 | 2.5 | 0.7 | 21‡ |
| June 6 | 125 | 588 | 115 | 5.0 | 1.1 | 20† |
| June 16 | 180 | 935 | 120 | 7.8 | 1.5 | 22 |
| June 25 | 129 | 931 | 96 | 9.7 | 1.3 | 31 |

* Song tally made on about two-thirds of route only.

† One more species seen just after census concluded.

‡ Two more species seen just after census concluded.

TABLE 6 Census results (birds seen and heard), Bettsburg area

| | May 28 | June 1 | June 9 | June 13 | June 14 | June 17 | June 21 | June 27 | July 3 |
|---------------------------------------|-----------|-----------|-----------|------------|------------|------------|------------|------------|-----------|
| Broad-winged hawk | 1 | | | | | | | | |
| Ruffed grouse | 3 | 2 | | | | | | | |
| American woodcock | | | | | | | | | |
| Spotted sandpiper | | | | | | | | | |
| Chimney swift | | | | | | | | | |
| Ruby-throated hummingbird | | 2 | 3 | | | | | | |
| Belted kingfisher | | | | | | | | | |
| Woodpecker sp. | 11 | 8 | | | | | | 8 | 10 |
| Yellow-shafted flicker | 1 | 1 | 1 | 1 | | | 1 | 1 | 3 |
| Pileated woodpecker | | | 1 | | | 1 | 1 | | |
| Yellow-bellied sapsucker | 7 | 14 | 14 | 13 | 4 | 2 | 6 | 8 | 4 |
| Hairy woodpecker | | | | | | | | | |
| Black-backed three-toed woodpecker | | | | | | | | | |
| Yellow-bellied flycatcher | | | | | | | 1 | | |
| Traill's flycatcher | | | | | | | | | |
| Least flycatcher | 13 | 18 | 19 | 20 | | 1 | 1 | 2 | 1 |
| Eastern wood pewee | | 5 | 7 | 3 | | | 2 | 3 | 2 |
| Olive-sided flycatcher | | 1 | 2 | 2 | | 1 | | | |
| Swallow sp. | | 1 | | 1 | | | | 2 | |
| Tree swallow | | 1 | | | | | | | |
| Bank swallow | | | | | | | | | |
| Barn swallow | | 1 | | | | 2 | | | 3 |
| Gray jay | | | | | | | | 1 | |
| Blue jay | 4 | 5 | 1 | 5 | | 1 | 3 | 1 | 1 |
| Common raven | | 1 | 1 | 1 | | | 1 | | 1 |
| Common crow | | | 2 | 2 | 1 | 1 | 2 | 1 | |
| Black-capped chickadee | 1 | | | 1 | | | 1 | | |
| Boreal chickadee | 1 | 2 | | | | | | | |
| Nuthatch sp. | 1 | 5 | 3 | 4 | 1 | | 2 | 1 | |
| Brown creeper | | | | | | | | | |
| Winter wren | 3 | 6 | 6 | 3 | 1 | 1 | 1 | 3 | 1 |
| Catbird | | | | | | | | | |
| Thrush sp. | 1 | 2 | | | | | | | |
| Robin | 6 | 4 | 10 | 7 | 5 | 3 | 5 | 4 | 2 |
| Hermit thrush | | 4 | 9 | 6 | 5 | 1 | 3 | 2 | 3 |
| Swainson's thrush | 6 | 8 | 12 | 20 | | 4 | 5 | 6 | 14 |
| Veery | | | | | | | | | |
| Ruby-crowned kinglet | 9 | 10 | 9 | | | 1 | | 2 | 2 |
| Starling | | | 3 | | | | | 4 | |
| Vireo sp. | 5 | 10 | 5 | 2 | 1 | 1 | | | 1 |
| Black-and-white warbler | | | | | | | | | |
| Tennessee warbler | 78 | 56 | 57 | 22 | 5 | 8 | 18 | 24 | 20 |
| Nashville warbler | | 2 | 1 | 2 | 1 | | | | |
| Parula warbler | | 5 | 4 | 1 | | | 2 | | |
| Magnolia warbler | 13 | 9 | 15 | 13 | | 3 | 3 | 5 | 6 |
| Cape May warbler | 11 | 3 | 7 | 8 | | | 1 | 5 | 6 |
| Black-throated blue warbler | 5 | 6 | 8 | 2 | | | 2 | 2 | 1 |
| Myrtle warbler | 1 | 1 | | | | | | | |
| Black-throated green warbler | 1 | 6 | 3 | 2 | | | 1 | 2 | 1 |
| Blackburnian warbler | 2 | | 2 | 3 | | 1 | | | |
| Bay-breasted warbler | 8 | 8 | 17 | 24 | 3 | 3 | 6 | 4 | 4 |
| Blackpoll warbler | | | | | | | | | |
| Warbler sp. | | 5 | | 1 | | | 1 | 3 | 1 |

TABLE 6 (continued)

| | May 25 | May 29 | June 1 (p.m.) | June 4 | June 6 | June 16 | June 25 |
|------------------------|-----------|-----------|------------------|-----------|-----------|------------|------------|
| Ovenbird | 35 | 26 | 31 | 31 | 3 | 5 | 10 |
| Northern waterthrush | | | | | | | |
| Mourning warbler | | 2 | 2 | 1 | | | |
| Yellowthroat | 3 | 1 | 1 | | 1 | | 1 |
| Canada warbler | | | | 1 | | 1 | |
| American redstart | 3 | 3 | 3 | | 1 | | |
| House sparrow | | | | | | | 1 |
| Redwinged blackbird | | 1 | 1 | 1 | | | |
| Common grackle | 3 | | 1 | 1 | 1 | 1 | 1 |
| Brown-headed cowbird | 8 | 12 | 3 | 5 | 2 | 1 | 3 |
| Scarlet tanager | | 1 | 2 | | | | |
| Rose-breasted grosbeak | 12 | 6 | 7 | | 2 | | 2 |
| Evening grosbeak | 11F | 8F+ | 10F | 9F | 4F | 4F | 12F |
| Purple finch | 15 | 18 | 8 | 10 | 2 | 3 | 5 |
| Pine grosbeak | 1 | | | 1 | | | 1 |
| Pine siskin | | | 1 | | | | |
| American goldfinch | | 1 | | | | | |
| Crossbill sp. | | | | | | | |
| Savannah sparrow | | | | | | | |
| Slate-colored junco | 8 | 14 | 5 | 2 | | 3 | 5 |
| Chipping sparrow | 8 | 1 | 2 | 2 | 1 | 1 | 1 |
| White-throated sparrow | 58 | 31 | 36 | 24 | 8 | 4 | 10 |
| Swamp sparrow | | | | | | | |
| Song sparrow | 1 | | 2 | 1 | | 1 | 2 |
| "Bird sp." | 11 | 3 | 7 | | 4 | | 1 |
| TOTALS | 358 | 332 | 334 | 249 | 47 | 53 | 102 |
| | | | | | | | 142 |
| | | | | | | | 146 |

TABLE 7 Population indices, Bettsburg area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|---------------|----------------|----------------|------|------------|------------|------------------|
| May 28 | 358 | 1,382 | 135 | 10.2 | 2.6 | 37 |
| June 1 | 332 | 1,442 | 145 | 9.9 | 2.3 | 46 |
| June 9 | 334 | 1,716 | 140 | 12.2 | 2.4 | 44 |
| June 13 | 249 | 2,417 | 135 | 17.9 | 1.8 | 40 |
| June 14 | 47 | 184 | 80 | 2.3 | 0.6 | 18 |
| June 17 | 53 | 275 | 80 | 3.4 | 0.7 | 25 |
| June 21 | 102 | 775 | 85 | 9.1 | 1.2 | 33 |
| June 27 | 142 | 726 | 78 | 9.3 | 1.8 | 31 |
| July 3 | 146 | 991 | 83 | 12.0 | 1.8 | 30 |

TABLE 8 Census results (birds seen and heard), Taxis River area

| | May 23 | May 26 | May 28 | June 11 | June 12 a.m. | June 12 p.m. | June 24 | June 29 |
|---------------------------------------|-----------|-----------|-----------|------------|-----------------|-----------------|------------|------------|
| Broad-winged hawk | | | | | | | | |
| Ruffed grouse | 1 | | 1 | | 1 | | | |
| American woodcock | | 1 | | | | | | 4 |
| Spotted sandpiper | 3 | 3 | | 1 | | | | |
| Chimney swift | | | 2 | 2 | | 1 | 8 | |
| Ruby-throated hummingbird | 1 | | | | | | 1 | |
| Belted kingfisher | 2 | 2 | 2 | 1 | | 1 | 2 | |
| Woodpecker sp. | 2 | | | | | | | 5 |
| Yellow-shafted flicker | | | 1 | | | | 1 | |
| Pileated woodpecker | | 1 | 1 | | | | | |
| Yellow-bellied sapsucker | 7 | 6 | 4 | 5 | | 2 | 4 | 1 |
| Hairy woodpecker | | | | | 2 | | | |
| Black-backed three-toed woodpecker | | | | | | | | |
| Yellow-bellied flycatcher | | | | | | | | |
| Traill's flycatcher | | | | | 1 | | 3 | |
| Least flycatcher | 2 | 3 | 10 | 8 | 3 | | 10 | 1 |
| Eastern wood pewee | | 1 | | | | | 1 | |
| Olive-sided flycatcher | 1 | | | 1 | 3 | 1 | 2 | |
| Swallow sp. | | | | | | | 2 | |
| Tree swallow | 5 | | 4 | | | | | |
| Bank swallow | | | | | 3 | | | |
| Barn swallow | 1 | | 1 | 2 | 1 | 2 | 1 | |
| Gray jay | | | | | | | | |
| Blue jay | 4 | 4 | 1 | | 1 | | 1 | 1 |
| Common raven | | | 1 | 1 | | | | 1 |
| Common crow | 1 | | | 1 | | | | |
| Black-capped chickadee | 1 | | | | | | | |
| Boreal chickadee | 1 | | | 1 | | | | |
| Nuthatch sp. | 2 | 1 | | 2 | 1 | 2 | 1 | 1 |
| Brown creeper | | | | | | | | |
| Winter wren | 8 | 2 | 4 | | 3 | 1 | 5 | 4 |
| Catbird | | | 1 | 1 | | | | |
| Thrush sp. | | | | | | | | |
| Robin | 12 | 5 | 14 | 10 | 7 | 13 | 12 | 6 |
| Wood thrush | | | | | 1 | | | |
| Hermit thrush | | | | | | | | |
| Swainson's thrush | 4 | 4 | 2 | 5 | 3 | 3 | 11 | 7 |
| Veery | 7 | 4 | 4 | 5 | 3 | 2 | 8 | 5 |
| Ruby-crowned kinglet | 10 | 3 | 5 | 4 | 1 | 1 | 1 | |
| Starling | | | | | | | | |
| Vireo sp. | 4 | 5 | 9 | 3 | 1 | | | |
| Black-and-white warbler | | | | | | | | |
| Tennessee warbler | 4 | 6 | 31 | 23 | 12 | 3 | 8 | 5 |
| Nashville warbler | | | | | | | | |
| Parula warbler | 14 | | 5 | 2 | 1 | | 2 | 1 |
| Magnolia warbler | 6 | 1 | 7 | 4 | 4 | | 6 | 5 |
| Cape May warbler | 2 | 4 | 8 | 11 | 9 | | 4 | 6 |
| Black-throated blue warbler | | | | | | | | |
| Myrtle warbler | 1 | | 3 | | | | | |
| Black-throated green warbler | | | | | | | 1 | |
| Blackburnian warbler | | | 3 | | 1 | | 3 | |
| Chestnut-sided warbler | 1 | | 1 | | | | | |
| Bay-breasted warbler | 8 | 8 | 21 | 16 | 11 | 3 | 9 | 9 |

TABLE 8 (continued)

| | May 23 | May 26 | May 28 | June 11 | June 12 a.m. | June 12 p.m. | June 24 | June 29 |
|------------------------|------------|------------|------------|------------|-----------------|-----------------|------------|------------|
| Blackpoll warbler | | | 1 | | | | | |
| Warbler sp. | 13 | 2 | | 1 | 3 | | | 3 |
| Ovenbird | 24 | 10 | 17 | 14 | 10 | 2 | 17 | 10 |
| Northern waterthrush | 5 | 3 | 11 | 3 | 3 | 1 | 3 | |
| Mourning warbler | | | | | | | | |
| Yellowthroat | 5 | 1 | 3 | 4 | 3 | 1 | 3 | 2 |
| Canada warbler | | | 1 | 1 | | | | |
| American redstart | 2 | | 2 | 1 | | 1 | | 1 |
| House sparrow | | | | | | | | |
| Redwinged blackbird | 8 | | 4 | 2 | 1 | 1 | 2 | 1 |
| Rusty blackbird | | | | 1 | | | | |
| Common grackle | 3 | 4 | 2 | 1 | 1 | 1 | 2 | |
| Brown-headed cowbird | 2 | 2 | 5 | 4 | 3 | | 4 | 3 |
| Scarlet tanager | | | | | | | | |
| Rose-breasted grosbeak | 1 | 1 | 2 | 1 | | | 3 | 2 |
| Evening grosbeak | 35 | 8 | 25 | 9 | 6 | 4 | 8F | 7F |
| Purple finch | 9 | 5 | 10 | 9 | 9 | 4 | 7 | 5 |
| Pine grosbeak | | 1 | 1 | 1 | | | 1 | |
| Pine siskin | | | | 3 | 2 | 2 | 1 | |
| American goldfinch | | | 3 | | | | | |
| Crossbill sp. | | | | | | | | |
| Savannah sparrow | 1 | | | | | | | |
| Slate-colored junco | 4 | | 4 | 3 | 2 | 2 | 4 | 5 |
| Chipping sparrow | 2 | | 4 | 1 | 1 | 1 | 2 | 1 |
| White-throated sparrow | 13 | 11 | 15 | 10 | 4 | 3 | 9 | 11 |
| Swamp sparrow | | | | | | | | |
| Song sparrow | 1 | 2 | 4 | 3 | 1 | 1 | 1 | |
| "Bird sp." | | 7 | | 4 | | 3 | 5 | 3 |
| TOTALS | 208 | 113 | 235 | 185 | 122 | 60 | 171 | 109 |

TABLE 9 Population indices, Taxis River area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|----------------------|----------------|----------------|------|------------|------------|------------------|
| May 23 | 208 | — | 125 | — | 1.7 | 42 |
| May 26 | 113 | 318 | 120 | 2.7 | 0.9 | 30 |
| May 28 | 235 | 1,376 | 125 | 11.0 | 1.9 | 44 |
| June 11 | 185 | 1,345 | 90 | 14.9 | 2.0 | 40 |
| June 12 | 122 | 656 | 75 | 8.7 | 1.6 | 35 |
| June 12 (p.m.) | 60 | 205 | 70 | 2.9 | 0.9 | 26 |
| June 24 | 171 | 1,395 | 86 | 16.1 | 1.9 | 40 |
| June 29* | 109 | 944 | 85 | 11.1 | 1.3 | 27 |

* Efficiency of census may have been reduced in that two observers took a census and made observations at the same time.

TABLE 10 Census results (birds seen and heard), Ludlow area

| | June 17 | June 18 | June 19 | June 20 | June 28 |
|---------------------------------------|------------|------------|------------|------------|------------|
| Broad-winged hawk | 1 | 1 | | | |
| Ruffed grouse | | | | | |
| American woodcock | | | | | |
| Spotted sandpiper | | | | | |
| Chimney swift | | | | | |
| Ruby-throated hummingbird | | 1 | 1 | | |
| Belted kingfisher | | | | | |
| Woodpecker sp. | 2 | | 2 | | 2 |
| Yellow-shafted flicker | | | | 1 | 1 |
| Pileated woodpecker | | | | | |
| Yellow-bellied sapsucker | 1 | 7 | 4 | 3 | 1 |
| Hairy woodpecker | 1 | 2 | 1 | 1 | |
| Black-backed three-toed woodpecker | | | | | |
| Yellow-bellied flycatcher | | | | | |
| Traill's flycatcher | 1 | | | | |
| Least flycatcher | 8 | 11 | 13 | 8 | 2 |
| Eastern wood pewee | 3 | 2 | 1 | | |
| Olive-sided flycatcher | | | | | |
| Swallow sp. | | | | | |
| Tree swallow | | | | | |
| Bank swallow | | | | | |
| Barn swallow | | | | | |
| Gray jay | | | | | |
| Blue jay | 3 | 1 | 1 | 2 | 2 |
| Common raven | | 2 | 1 | 2 | |
| Common crow | | 1 | 1 | | |
| Black-capped chickadee | 4 | 1 | 2 | 1 | 2 |
| Boreal chickadee | | | 1 | | 1 |
| Nuthatch sp. | 1 | | | | 1 |
| Brown creeper | | | | | |
| Winter wren | 2 | 2 | 4 | 2 | 1 |
| Catbird | | | | | |
| Thrush sp. | | | | | |
| Robin | 3 | 7 | 5 | 9 | 1 |
| Hermit thrush | 2 | 1 | 2 | | 1 |
| Swainson's thrush | 5 | 7 | 15 | 9 | 5 |
| Veery | 1 | 1 | 1 | 1 | 2 |
| Ruby-crowned kinglet | 3 | | | | |
| Starling | 1 | 1 | | | |
| Vireo sp. | 1 | 3 | 3 | 4 | 1 |
| Black-and-white warbler | | | | | |
| Tennessee warbler | 7 | 9 | 12 | 12 | 2 |
| Nashville warbler | 1 | | | | |
| Parula warbler | 5 | 5 | 6 | 3 | 3 |
| Magnolia warbler | 7 | 2 | 4 | 3 | 1 |
| Cape May warbler | 3 | 1 | 3 | 4 | 2 |
| Black-throated blue warbler | 1 | | 1 | 1 | 1 |
| Myrtle warbler | | | | | |
| Black-throated green warbler | 1 | 3 | 4 | 2 | 2 |
| Blackburnian warbler | 4 | 2 | | | 1 |
| Bay-breasted warbler | 7 | 13 | 12 | 6 | 1 |
| Blackpoll warbler | | | | | |
| Warbler sp. | 2 | | | 2 | |

TABLE 10 (continued)

| | June 17 | June 18 | June 19 | June 20 | June 28 |
|------------------------|------------|------------|------------|------------|------------|
| Ovenbird | 18 | 17 | 24 | 17 | 10 |
| Northern waterthrush | | | | | |
| Mourning warbler | 1 | 1 | 1 | 1 | |
| Yellowthroat | | | | | |
| Canada warbler | 1 | 2 | 2 | 1 | |
| American redstart | | 1 | 2 | 1 | |
| House sparrow | | | | | |
| Redwinged blackbird | 1 | 1 | 1 | 1 | |
| Common grackle | 7 | 3 | 3 | 3 | 1 |
| Brown-headed cowbird | | 1 | 1 | 1 | |
| Scarlet tanager | 2 | 2 | 2 | | |
| Rose-breasted grosbeak | 3 | 5 | 5 | 5 | |
| Evening grosbeak | 6 | 3 | 3F | 2 | 2F |
| Purple finch | 4 | 5 | 3 | 4 | |
| Pine grosbeak | | 2 | 1 | 1 | |
| Pine siskin | | | 2 | | |
| American goldfinch | | | | | 1 |
| Crossbill sp. | | | | | |
| Savannah sparrow | | | | | |
| Slate-colored junco | 2 | 1 | 3 | 3 | 1 |
| Chipping sparrow | 1 | 1 | 1 | 1 | |
| White-throated sparrow | 8 | 7 | 10 | 7 | 5 |
| Swamp sparrow | | | | | |
| Song sparrow | 2 | 2 | 2 | 2 | 1 |
| "Bird sp." | 2 | | | 4 | |
| TOTALS | 133 | 137 | 163 | 128 | 55 |

TABLE 11 Population indices, Ludlow area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|---------------|----------------|----------------|------|------------|------------|------------------|
| June 17 | 133 | 700 | 65 | 10.7 | 2.0 | 39 |
| June 18 | 137 | 837 | 60 | 13.9 | 2.3 | 40 |
| June 19 | 163 | 1,077 | 60 | 17.9 | 2.7 | 40 |
| June 20 | 128 | 800 | 42 | 19.0 | 3.0 | 35 |
| June 28 | 55 | 410 | 30 | 13.6 | 1.8 | 28* |

* Five additional species seen just after census concluded.

TABLE 12 Census results (birds seen and heard), Big Hole Brook area

| | June 7 | June 8 | June 19 | June 21 | June 22 | June 23 | June 26 | July 2 |
|---------------------------------------|-----------|-----------|------------|------------|------------|------------|------------|-----------|
| Broad-winged hawk | | 1 | 1 | | 1 | | | |
| Ruffed grouse | | | | B* | | | | 1 |
| American woodcock | | | | | | | | |
| Spotted sandpiper | | | | | | | | |
| Chimney swift | | | | | 1 | | | |
| Ruby-throated hummingbird | 1 | 4 | 1 | (1)† | | | | (1)† |
| Belted kingfisher | | | | | | | | |
| Woodpecker sp. | | 5 | | | | | 2 | 8 |
| Yellow-shafted flicker | | | | 1 | 2 | | 1 | |
| Pileated woodpecker | 1 | | 1 | | | | | |
| Yellow-bellied sapsucker | 12 | 6 | 11 | 14 | 12 | 20 | 12 | 6 |
| Hairy woodpecker | | 1 | 1 | 3 | | 3 | | |
| Black-backed three-toed woodpecker | | | | | 1 | | | |
| Yellow-bellied flycatcher | | | | | | | 1 | |
| Traill's flycatcher | | 1 | 2 | 1 | | | 5 | |
| Least flycatcher | 7 | 4 | 8 | 5 | 2 | 3 | | 3 |
| Eastern wood pewee | 3 | | | | | | | 1 |
| Olive-sided flycatcher | | 4 | 2 | 2 | | 4 | 1 | |
| Swallow sp. | | | | | | | | |
| Tree swallow | | | | | | | | |
| Bank swallow | | | | | | | | |
| Barn swallow | 2 | | | | | | | |
| Gray jay | | 4 | 3 | 2 | | 1 | 1 | 1 |
| Blue jay | 2 | 2 | 4 | 1 | | 1 | 2 | 1 |
| Common raven | | 1 | | | | | | |
| Common crow | | | | | | | | |
| Black-capped chickadee | | | | | | | | |
| Boreal chickadee | 1 | | | | | | | |
| Nuthatch sp. | 2 | 2 | 5 | 1 | | | 2 | 1 |
| Brown creeper | | | | | | | | |
| Winter wren | 4 | 2 | 3 | 2 | 1 | 1 | 2 | 3 |
| Catbird | | | | | | | | |
| Thrush sp. | | | | | | | | |
| Robin | | 2 | 1 | 1 | | 1 | 2 | 1 |
| Hermit thrush | 1 | | 2 | | | | | 3 |
| Swainson's thrush | 3 | 4 | 12 | 10 | 5 | 6 | 10 | 7 |
| Veery | | | | 1 | | | | |
| Ruby-crowned kinglet | 5 | 7 | | 2 | | 1 | 2 | 1 |
| Starling | | | | | | | | |
| Vireo sp. | 2 | 1 | 1 | | | | 1 | |
| Black-and-white warbler | | | | | | | | |
| Tennessee warbler | 37 | 66 | 65 | 53 | 22 | 27 | 35 | 17 |
| Nashville warbler | | 2 | | | | | 2 | 1 |
| Parula warbler | | | | | | | | |
| Magnolia warbler | 7 | 4 | 4 | 3 | 1 | 3 | 2 | 3 |
| Cape May warbler | 4 | 6 | 14 | 3 | | 4 | 3 | 1 |
| Black-throated blue warbler | | | | | | | | |
| Myrtle warbler | 1 | 2 | | | | | | |
| Black-throated green warbler | | | | | | | | |
| Blackburnian warbler | 1 | | 2 | | | | | |
| Bay-breasted warbler | 8 | 14 | 9 | 5 | 4 | 1 | 5 | 4 |
| Blackpoll warbler | | | | | | | | |
| Warbler sp. | | | | | 1 | 1 | | |

TABLE 12 (continued)

| | June 7 | June 8 | June 19 | June 21 | June 22 | June 23 | June 26 | July 2 |
|------------------------|-----------|-----------|------------|------------|------------|------------|------------|-----------|
| Ovenbird | 13 | 11 | 9 | 9 | 8 | 11 | 10 | 8 |
| Northern waterthrush | | | | | | | | |
| Mourning warbler | | | | | | | | |
| Yellowthroat | 4 | 2 | 1 | | | 1 | 1 | |
| Canada warbler | | | | | | | | |
| American redstart | 1 | | | | | | | |
| House sparrow | | | | | | | | |
| Redwinged blackbird | 2 | 2 | 2 | 1 | 2 | | | |
| Rusty blackbird | 4 | 2 | | 4 | | 3 | | |
| Common grackle | | | | | | | | |
| Brown-headed cowbird | 2 | | 1 | | | 1 | | 1 |
| Scarlet tanager | | | | | | | | |
| Rose-breasted grosbeak | | 1 | | | | | 1 | |
| Evening grosbeak | 3F | 6F | 9 | 7F | 9F | 8F | 9F | 7F |
| Purple finch | 10 | 10 | 5 | 5 | 3 | 3 | 4 | 8 |
| Pine grosbeak | | 1 | | 5 | | | | 1 |
| Pine siskin | | | 1 | | (1)† | | 4 | |
| American goldfinch | | | | | | | | 1 |
| Crossbill sp. | | | 1 | | | | | |
| Savannah sparrow | | | | | | | | |
| Slate-colored junco | 2 | 3 | 2 | 5 | 1 | 5 | | 4 |
| Chipping sparrow | | | | | | | 1 | |
| White-throated sparrow | 15 | 22 | 14 | 26 | 8 | 20 | 17 | 17 |
| Swamp sparrow | 1 | 2 | 1 | 1 | 1 | 1 | | 1 |
| Song sparrow | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 |
| "Bird sp." | | | | 3 | 2 | | 1 | |
| TOTALS | 160 | 202 | 191 | 170 | 79 | 123 | 132 | 105 |

* Brood.

† Seen after census completed.

TABLE 13 Population indices, Big Hole Brook area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|---------------|----------------|----------------|------|------------|------------|------------------|
| June 7 | 160 | 910 | 85 | 10.7 | 1.6 | 32 |
| June 8 | 202 | 930 | 70 | 13.2 | 2.8 | 34* |
| June 19 | 191 | 1,650 | 73 | 22.6 | 2.6 | 33 |
| June 21 | 170 | 1,053 | 65 | 16.1 | 2.6 | 29 |
| June 22 | 79 | 444 | 67 | 6.6 | 1.2 | 21 |
| June 23 | 123 | 755 | 70 | 10.7 | 1.8 | 24 |
| June 26 | 132 | 1,169 | 70 | 16.7 | 1.9 | 27 |
| July 2 | 105 | 765 | 67 | 11.4 | 1.5 | 27 |

* A quick survey earlier the same morning added four more species for a total of 38.

TABLE 14 Census results (birds seen and heard), Big Hole Brook (East) area

| | June 19 | June 22 | June 23 | June 26 | July 2 |
|---------------------------------------|------------|------------|------------|------------|-----------|
| Broad-winged hawk | | 1 | | | |
| Ruffed grouse | | | | | |
| American woodcock | | | | | |
| Common snipe | | 1 | 1 | | |
| Spotted sandpiper | | | | | |
| Chimney swift | | 1 | 1 | | |
| Ruby-throated hummingbird | | | | | |
| Belted kingfisher | | | | | |
| Woodpecker sp. | | | 1 | 7 | 4 |
| Yellow-shafted flicker | | 1 | 1 | | |
| Pileated woodpecker | | | | | |
| Yellow-bellied sapsucker | 3 | 5 | 6 | 3 | 4 |
| Hairy woodpecker | | | | | |
| Black-backed three-toed woodpecker | | | | | |
| Yellow-bellied flycatcher | | 1 | 1 | | |
| Least flycatcher | 3 | 3 | 4 | 2 | 2 |
| Trail's flycatcher | 3 | 3 | 2 | 1 | 1 |
| Eastern wood pewee | | | | 1 | |
| Olive-sided flycatcher | | 1 | 2 | | |
| Swallow sp. | | | | | |
| Tree swallow | | | 1 | 1 | |
| Bank swallow | | | | | |
| Barn swallow | | | | | |
| Gray jay | 2 | | | | 1 |
| Blue jay | 1 | 1 | | 2 | 3 |
| Common raven | | | | | |
| Common crow | | | | | |
| Black-capped chickadee | | | | | |
| Boreal chickadee | | | | | |
| Nuthatch sp. | 1 | | 1 | | |
| Brown creeper | | | | | |
| Winter wren | | 2 | 1 | 1 | 1 |
| Catbird | | | | | |
| Thrush sp. | | | | | |
| Robin | | 2 | | 2 | 1 |
| Hermit thrush | | | 1 | 2 | 1 |
| Swainson's thrush | 3 | 5 | 11 | 8 | 3 |
| Veery | | | | 1 | |
| Ruby-crowned kinglet | 5 | 4 | 4 | 4 | 1 |
| Starling | | | | | |
| Vireo sp. | 1 | | | | 2 |
| Black-and-white warbler | | | | | |
| Tennessee warbler | 27 | 22 | 18 | 18 | 7 |
| Nashville warbler | | | | | |
| Parula warbler | | | | | |
| Magnolia warbler | 2 | 3 | 2 | 4 | 1 |
| Cape May warbler | 7 | 8 | 11 | 6 | 3 |
| Black-throated blue warbler | | | | | |
| Myrtle warbler | | | 1 | | |
| Black-throated green warbler | | | | | |
| Blackburnian warbler | | | | 1 | |
| Bay-breasted warbler | 5 | 7 | 4 | 7 | 5 |
| Blackpoll warbler | | | | | |

TABLE 14 (Continued)

| | June 19 | June 22 | June 23 | June 26 | July 2 |
|------------------------|------------|------------|------------|------------|-----------|
| Warbler sp. | 3 | 2 | | 1 | |
| Ovenbird | 5 | 6 | 8 | 6 | 4 |
| Northern waterthrush | | | | | |
| Mourning warbler | | | | | |
| Yellowthroat | | 1 | | | 1 |
| Canada warbler | | | | | |
| American redstart | | | | | |
| House sparrow | | | | | |
| Redwinged blackbird | 4 | 5 | 13 | 4 | 3 |
| Rusty blackbird | 2 | | | | |
| Common grackle | | 1 | | | |
| Brown-headed cowbird | | 1 | 1 | 1 | 1 |
| Scarlet tanager | | | | | |
| Rose-breasted grosbeak | | | 1 | | |
| Evening grosbeak | | 2F | 5 | 6F | 7F |
| Purple finch | 3 | 2 | 4 | 3 | 4 |
| Pine grosbeak | | | | 1 | 1 |
| Pine siskin | | | | | |
| American goldfinch | | | | | |
| Crossbill sp. | | | | | |
| Savannah sparrow | | | | | |
| Slate-colored junco | 1 | | 1 | 1 | 5 |
| Chipping sparrow | | | | | |
| White-throated sparrow | 6 | 9 | 8 | 8 | 12 |
| Swamp sparrow | | | 1 | 3 | 3 |
| Song sparrow | | | | | |
| "Bird sp." | | | | 4 | 3 |
| TOTALS | 87 | 98 | 116 | 103 | 77 |

TABLE 15 Population indices, Big Hole Brook (East) area

| | Total birds | Total songs | Time | Songs/min. | Birds/min. | Total species |
|----------------|----------------|----------------|------|------------|------------|------------------|
| June 19 | 87 | 564 | 30 | 18.8 | 2.9 | 19 |
| June 22 | 98 | 883 | 40 | 22.0 | 2.4 | 26 |
| June 23* | 116 | 783 | 40 | 19.6 | 2.9 | 28 |
| June 26 | 103 | 595 | 48 | 12.2 | 2.1 | 27 |
| July 2 | 77 | 339 | 41 | 8.2 | 1.8 | 26 |

* Sprayed with DDT early in the morning.

APPENDICES

APPENDIX A SCIENTIFIC NAMES OF BIRDS MENTIONED IN THIS PAPER

| | |
|------------------------------------|--|
| Broad-winged hawk | <i>Buteo platypterus</i> (Vieillot) |
| Bobwhite | <i>Colinus virginianus</i> (L.) |
| Ruffed grouse | <i>Bonasa umbellus</i> (L.) |
| American woodcock | <i>Philohela minor</i> (Gmelin) |
| Spotted sandpiper | <i>Actitis macularia</i> (L.) |
| Black-billed cuckoo | <i>Coccyzus erythrophthalmus</i> (Wilson) |
| Chimney swift | <i>Chaetura pelagica</i> (L.) |
| Ruby-throated hummingbird | <i>Archilochus colubris</i> (L.) |
| Belted kingfisher | <i>Megaceryle alcyon</i> (L.) |
| Yellow-shafted flicker | <i>Colaptes auratus</i> (L.) |
| Pileated woodpecker | <i>Dryocopus pileatus</i> (L.) |
| Yellow-bellied sapsucker | <i>Sphyrapicus varius</i> (L.) |
| Hairy woodpecker | <i>Dendrocopos villosus</i> (L.) |
| Black-backed three-toed woodpecker | <i>Picoïdes arcticus</i> (Swainson) |
| Yellow-bellied flycatcher | <i>Empidonax flaviventris</i> (Baird and Baird) |
| Traill's flycatcher | <i>Empidonax traillii</i> (Audubon) |
| Least flycatcher | <i>Empidonax minimus</i> (Baird and Baird) |
| Eastern wood pewee | <i>Contopus virens</i> (L.) |
| Olive-sided flycatcher | <i>Nuttallornis borealis</i> (Swainson) |
| Tree swallow | <i>Iridoprocne bicolor</i> (Vieillot) |
| Bank swallow | <i>Riparia riparia</i> (L.) |
| Barn swallow | <i>Hirundo rustica</i> (L.) |
| Gray jay | <i>Perisoreus canadensis</i> (L.) |
| Blue jay | <i>Cyanocitta cristata</i> (L.) |
| Common raven | <i>Corvus corax</i> L. |
| Common crow | <i>Corvus brachyrhynchos</i> Brehm |
| Black-capped chickadee | <i>Parus atricapillus</i> L. |
| Boreal chickadee | <i>Parus hudsonicus</i> Forster |
| Nuthatch sp. | <i>Sitta carolinensis</i> Latham and <i>Sitta canadensis</i> L. |
| Brown creeper | <i>Certhia familiaris</i> L. |
| Winter wren | <i>Troglodytes troglodytes</i> (L.) |

| | |
|------------------------------|---|
| Catbird | <i>Dumetella carolinensis</i> (L.) |
| Robin | <i>Turdus migratorius</i> L. |
| Wood thrush | <i>Hylocichla mustelina</i> (Gmelin) |
| Hermit thrush | <i>Hylocichla guttata</i> (Pallas) |
| Swainson's thrush | <i>Hylocichla ustulata</i> (Nuttall) |
| Veery | <i>Hylocichla fuscescens</i> (Stephens) |
| Ruby-crowned kinglet | <i>Regulus calendula</i> (L.) |
| Starling | <i>Sturnus vulgaris</i> L. |
| Vireo sp. | <i>Vireo olivaceus</i> (L.) and <i>Vireo solitarius</i> (Wilson) |
| Black-and-white warbler | <i>Mniotilta varia</i> (L.) |
| Tennessee warbler | <i>Vermivora peregrina</i> (Wilson) |
| Nashville warbler | <i>Vermivora ruficapilla</i> (Wilson) |
| Parula warbler | <i>Parula americana</i> (L.) |
| Magnolia warbler | <i>Dendroica magnolia</i> (Wilson) |
| Cape May warbler | <i>Dendroica tigrina</i> (Gmelin) |
| Black-throated blue warbler | <i>Dendroica caerulescens</i> (Gmelin) |
| Myrtle warbler | <i>Dendroica coronata</i> (L.) |
| Black-throated green warbler | <i>Dendroica virens</i> (Gmelin) |
| Blackburnian warbler | <i>Dendroica fusca</i> (Müller) |
| Chestnut-sided warbler | <i>Dendroica pensylvanica</i> (L.) |
| Bay-breasted warbler | <i>Dendroica castanea</i> (Wilson) |
| Blackpoll warbler | <i>Dendroica striata</i> (Forster) |
| Ovenbird | <i>Seiurus aurocapillus</i> (L.) |
| Northern waterthrush | <i>Seiurus noveboracensis</i> (Gmelin) |
| Mourning warbler | <i>Oporornis philadelphia</i> (Wilson) |
| Yellowthroat | <i>Geothlypis trichas</i> (L.) |
| Canada warbler | <i>Wilsonia canadensis</i> (L.) |
| American redstart | <i>Setophaga ruticilla</i> (L.) |
| House sparrow | <i>Passer domesticus</i> (L.) |
| Bobolink | <i>Dolichonyx oryzivorus</i> (L.) |
| Redwinged blackbird | <i>Agelaius phoeniceus</i> (L.) |
| Rusty blackbird | <i>Euphagus carolinus</i> (Müller) |
| Common grackle | <i>Quiscalus quiscula</i> (L.) |
| Brown-headed cowbird | <i>Molothrus ater</i> (Boddaert) |
| Scarlet tanager | <i>Piranga olivacea</i> (Gmelin) |
| Rose-breasted grosbeak | <i>Pheucticus ludovicianus</i> (L.) |
| Evening grosbeak | <i>Hesperiphona vespertina</i> (Cooper) |
| Purple finch | <i>Carpodacus purpureus</i> (Gmelin) |
| Pine grosbeak | <i>Pinicola enucleator</i> (L.) |
| Pine siskin | <i>Spinus pinus</i> (Wilson) |
| American goldfinch | <i>Spinus tristis</i> (L.) |
| Crossbill sp. | <i>Loxia</i> sp. |
| Savannah sparrow | <i>Passerculus sandwichensis</i> (Gmelin) |

| | |
|------------------------|--|
| Slate-colored junco | <i>Junco hyemalis</i> (L.) |
| Chipping sparrow | <i>Spizella passerina</i> (Bechstein) |
| White-throated sparrow | <i>Zonotrichia albicollis</i> (Gmelin) |
| Swamp sparrow | <i>Melospiza georgiana</i> (Latham) |
| Song sparrow | <i>Melospiza melodia</i> (Wilson) |

APPENDIX B SCIENTIFIC NAMES OF TREES MENTIONED IN THIS PAPER

| | |
|------------------|--|
| Balsam | <i>Abies balsamea</i> (L.) Mill. |
| Hemlock | <i>Tsuga canadensis</i> (L.) Carr. |
| White spruce | <i>Picea glauca</i> (Moench) Voss |
| Red spruce | <i>Picea rubens</i> Sarg. |
| Black spruce | <i>Picea mariana</i> (Mill.) B.S.P. |
| White pine | <i>Pinus Strobus</i> L. |
| White cedar | <i>Thuja occidentalis</i> L. |
| Trembling aspen | <i>Populus tremuloides</i> Michx. |
| Largetooth aspen | <i>Populus grandidentata</i> Michx. |
| Ironwood | <i>Ostrya virginiana</i> (Mill.) K. Koch |
| Yellow birch | <i>Betula lutea</i> Michx. f. |
| White birch | <i>Betula papyrifera</i> Marsh. |
| Beech | <i>Fagus grandifolia</i> Ehrh. |
| Pin cherry | <i>Prunus pensylvanica</i> L.f. |
| Black cherry | <i>Prunus serotina</i> Ehrh. |
| Choke cherry | <i>Prunus virginiana</i> L. |
| Striped maple | <i>Acer pensylvanicum</i> L. |
| Sugar maple | <i>Acer saccharum</i> Marsh. |
| Red maple | <i>Acer rubrum</i> L. |
| Black ash | <i>Fraxinus nigra</i> Marsh. |

NATIONAL PARKS BRANCH • DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

CANADIAN
WILDLIFE
SERVICE