INSECTICIDE SPRAYING: ITS EFFECT ON PASSERIFORM POPULATIONS OF CENTRAL NEWFOUNDLAND

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of CENTRAL NEWFOUNDLAND

by

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ABSTRACT

Bird populations were studied during the 1979 breeding season by means of the mist-net technique in 3 areas of central Newfoundland in an attempt to identify possible longer-term effects of the 1978 application of the insecticide Matacil. Raw data obtained for 2 of the areas during the 1978 breeding season were used for comparative purposes. Structural features of the vegetation were measured at all net sites in 1979. These data were subjected to a principal components analysis to determine relationships among the measured variables. The percentage variation of the distribution attributable to vegetation differences between net sites was determined for the adults and immatures of 7 passeriform species by step-wise multiple regression analyses. The numbers of adults and immatures of these species expected at each sprayed area on the basis of the vegetation were obtained from regression equations developed from the control area data. Blood parasite levels were investigated in an attempt to gain indirect evidence of the impact of the spray applications on the insect population and hence on the food supply available for insect-eating birds.

The number of parulid immatures captured at the control area was higher than at the sprayed areas. Adults of 4 species occurred at the sprayed areas in lower numbers than predicted by the regression equations. Immatures of 6 species at Big Careless Cove Brook and 5 species at Little

Careless Cove Brook also occurred in lower numbers than predicted by the regression equations. No trends were detected among the areas in the blood parasite levels of the birds.

The 1978 aerial application of Matacil appears to have directly and/or indirectly affected the avian communities of the areas studied. The high numbers of immatures at the control area probably result from immatures invading the area to forage on the high density spruce budworm population. Comparably, the low numbers in the sprayed areas result from the immatures leaving the areas where the food supply has been diminished (presumably due to insecticide applications) to forage in areas of more abundant food supply. In view of the higher predicted than observed abundances at the sprayed areas for the adults and for the immatures of several species it is also probable that there was a depressed success rate in the sprayed areas.

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INTRODUCTION AND HISTORICAL REVIEW

Avian population monitoring

The onrush of industrialization has led to ever increasing competition between man and his fellow species for the world's natural resources. One such struggle is currently being waged between man and the spruce budworm, Choristoneura fumiferana Clemens, for the productive forests of northeastern North America. The present outbreak of spruce budworm on the island of Newfoundland alone, involves some 3 million hectares of economically important woodlands.

In an attempt to control spruce budworm population levels over the past several decades, areas of infested forests have been aerially sprayed with numerous kinds of chemical insecticides. Types of insecticides used have varied. Application rates of a particular chemical have also been variable as foresters search for the most effective dosage. This has occasionally reached bizarre proportions, as for example, some 23 different spray and dosage regimes were used in New Brunswick alone, in 1976 (Pearce and Peakall, 1977).

A heightened awareness by the general public of the possible dangers inherent in the spraying of chemical insecticides has led to the monitoring of the impact of spraying operations on non-target organisms. As recently as 1977, however, in the proceedings of a National Research Council of Canada symposium on fenitrothion and its long-term effects in forest ecosystems, the panel's current status report stated that the panel was appalled by the general quality of ecological research conducted in conjunction with the fenitrothion spray program. In a reply to this report Varty (1977) stated that two options are available for a monitoring program: (1) concentrated sampling of a localized area or (2) scanty sampling of larger areas. Since the second option enables the detection of gross short-term changes, it has been the method used by most ecologists.

The tensusing of most passerine birds during the breeding season has primarily been based on aural and visual detections. According to Emlen (1971), five basic methodologies have been utilized: (1) mapping and counting of singing males - the locations of singing positions are mapped for each survey. Clusters of singing positions from composite maps are assumed to represent individual territorial males (Williamson, 1964) and each male a breeding pair; (2) counting of each species in strips - Emlen (1971) described two variations of this method, firstly that of Merikallio, 1946; 1958, in which the strip censused is of a designated width and area and secondly, that of Kendeigh, 1956, in which the strip may be of different widths according to the detection distances characteristic of individual species. Emlen (1971) described the summation procedure of Palmgren (1930) whereby the largest number for each species from a series of 7 or more transect replicates is used as a means of compensating for the incompleteness of each transect; (3) counting total to flushing distance - all observations and the distances from the observer at detection are recorded. The mean distance from the observer designates one half the width of the censusing strip; (4) count of singing males x effectivity - in this method an effectivity coefficient, (% of completeness indicated for a species, Enemar, 1959), is obtained by evaluating the completeness of coverage in wide strips by comparison with performance levels obtained through intensive censusing of areas by method (1) or by noting occurrence indices of particular individuals in a series of replicated surveys. Singing males are assumed to represent a breeding pair; (5) counting total x detectability - Emlen (1971) suggested that all observations be recorded to the detection limit and that the count for each species be multiplied by a detectability coefficient based on the percentage of the population usually detected.

Emlen (1971) described four types of problems which are inherent in the above techniques. First, observer related problems such as acuity, experience and coverage speed. In the 1973 study of Bell et al., it was found that census accuracy increased in the second year of the study. It was suggested that this improvement resulted from the experience and knowledge of species problems and habitat which had been gained in the previous year. Bell et al., further stated that a consistent level of accuracy, regardless of the level being high or low, will record annual population changes. However, if the accuracy level is low, the occurrence of errors will distort the results more than if the accuracy level is high. Presumably similar discrepancies within a season would also produce inaccurate results. The second problem is that of observation conditions e.g. weather, time of day, etc.. Jarvinen et al. (1978) found, for example, that an afternoon census recorded less than 60% of the birds which were recorded in an early morning census. The third problem is the screening effect of the habitat in that the aural and visual range of the observer will be narrowed with increasing density and height of the vegetation. The fourth problem is that of the conspicuousness of the birds e.g. size and colour, movement and song frequency. Francis (1973) in a study of territorial Red-winged Blackbirds found that some individual males were much less likely to be seen than others. Although some of the censusing methods previously described include visual as well as aural contacts, it appears that the majority of contacts made are aural. Dickson (1978), for example, reported that approximately 90% of contacts during the breeding season were aural. The timing of the census within the season greatly affects the census accuracy. Armstrong (1963) stated that individual differences occurred between males according to their phase in the breeding cycle and that differences also occur between species. Slagsvold (1973a) found that the song frequency of a bird community followed the same pattern over a period of years. Two peaks of song activity were observed, separated by some 30 days. During the interval between peaks, frequencies showed minimum values of 50% of the value at the first peak. Slagsvold (1973b) in a study of the Song Thrush, found that the size of the male population determined by the mapping method was entirely dependent on the time of the season. For example, a one week displacement of the census period gave a 50% change in the determined density. Best (1975) found that singing in the Field Sparrow was most evident when the males were unmated. The number of visits made also affects the accuracy of the census results. Bell *et al.*, (1973) obtained a high census accuracy of the relatively sedentary Reed Bunting when surveys were spread widely over the entire breeding season. With the migratory Acrocephalus warbler with its condensed period of territoriality, however, greater accuracy was obtained by fewer visits in close succession. Dickson (1978) recommended the use of 8 surveys with the mapping method and found that in spot mapping from transects, estimated populations increased steadily as surveys increased from six to eleven. Slagsvold (1973b) stated that, for the mapping method, 5 surveys may suffice if they are conducted during the first peak of song activity and at the time of day when song activity is highest. He further stated that at least 20 surveys should be made after clutch laying had occurred. Annual displacement of song activity has been suggested by Slagsvold (1973a) who found an apparent correlation with variations in the time of snow melt and leafing of birch trees. Jarvinen et al., (1978) also suggested the occurrence of annual differences in the singing of species. Bell et al. (1973) found accurate interpretation was complicated by polygamy, promiscuity and the presence of unmated territorial males. Emlen (1971) stated that interpretation problems also resulted from the inclusion of transients and irregular movements across territorial boundaries. Best (1975) stated that differing interpretations of census data is a major source of error. He found the relationships between territories delimited by 5 independent interpretations of the same data to be "fragmentary at best". He further stated that caution is necessary when comparing data interpreted by different individuals.

To minimize the effects of the preceeding problems certain forms of design control are necessary. Observers must be experienced and surveys conducted under optimum weather conditions. Emlen (1971) suggested the development of "graded adjustments for suboptimum conditions". Measurements and descriptions of vegetation type and density must be included for each censused area and bird species must be dealt with separately (Emlen, 1971). Both Emlen (1971) and Slagsvold (1973a) stated the necessity of accumulating data on the seasonal changes in the song activity of species. The "coefficient of detectability" proposed by Emlen (1971) was intended to correct to some degree for the changes in rates of singing and transmission of sounds through the habitat. It's effectiveness as a correction factor has not been carefully documented, however (J.C. Rice, pers. comm.).

One of the newest methods available for the censusing of birds is that of Reynolds et al., (1980) who described a variable circular-plot method for estimating bird numbers. By this technique all birds heard or seen around a station are counted and an estimate is made of the horizontal distance of each bird from the station. The number of individuals per unit area in concentric bands of predetermined widths about the station is plotted for each species. The band (with outer radius x) where the density begins to decline is chosen and the number of individuals within the circle of radius x is summed and divided by the area (x2) to determine the density of each area. By using a standard fixed maximum distance, coefficients of detectability may be determined for each species. This method greatly alleviates the problems associated with rough terrain by allowing an observer to census from fixed points, but sill requires the design controls previously described.

Monitoring of the impact of insecticide spraying on forest songbird populations has almost exclusively consisted of the censusing of singing males. The technique involved has primarily been the mapping method. However, elements of the population additional to the presence of singing males are also included. A pre-determined route of two or more miles, oriented across the anticipated spray swaths, is traversed to obtain population indices, expressed as birds seen and songs heard per unit of time. The population index of each species is intended to provide a basis for comparison of the relative abundances of various species or of the same species before and after a spray application in an area of unknown size (Buckner and Turnock, 1965). Buckner (1974) noted the major shortcoming of this method to be the masking of those birds singing at a distance from the observer by those birds singing near the observer. He further stated that, therefore, a population reduction due to spraying may not be accurately reflected in the population indices since such an occurrence would increase the range of hearing of the observer.

Searching for dead birds in a treated area has been another method of assessing the short-term (<1 week post spray) impact of spray applications. Unfortunately, however, dead birds are extremely difficult to locate in the forest environment and therefore the actual mortality suffered by the population is often impossible to accurately determine by this method. Observations of aberrant behaviour due to insecticide poisoning seem also to be largely due to chance sightings and therefore of limited value in determining the impact of a spray application over a large area.

A combination and/or modification of these methods of impact assessment have been used in monitoring programs in recent years (Buckner, 1974; Buckner and McLeod, 1975; 1977; Buckner and Sarrazin, 1975; Buckner et al., 1974; Buckner et al., 1975a; 1975b; 1975c; Buckner et al., 1976; Germain and Tingley, 1980; Gov't. of Newfoundland and Labrador, Dept. of Consumer Affairs and Environment, Information Report RA-79-2, 1979; Pearce and Peakall, 1977; Pearce et al., 1976; 1979; Varty, 1976; Sarrazin, 1978). These studies have been summarized, where possible, and are provided in Appendix A.

While the methods of data collection in the above studies may be considered basically similar, the amount and type of data provided in each study varied considerably, making comparisons between them of doubtful validity. The dates of spray applications and/or spray regimes used for the bird plots studied are often difficult, if not impossible, to extract. If the spray regime for each study area used is not clearly stated along with the actual spraying dates involved, it is unknown whether a comparison between areas is in any way relevant or valid. Detailed weather information e.g. temperature, precipitation, wind velocity, etc. is not provided. Habitat information is often not provided and where present is of a rather sketchy, qualitative form. In at least one study (Germain and Tingley, 1980), data had been pooled from areas which had apparently undergone different spray regimes. Monitoring is often conducted for 5 days (or fewer) prior to a spray application and a similar post-spraying period.

McNeil (1978) points out the need for a number of 3 - 5 year studies in different untreated forest ecosystems to provide the data base essential to meaningful evaluation of non-target effects resulting from anti- spruce budworm treatments. He further emphasizes the necessity of selecting indicator species on the basis of "importance" and abundance and the need for obtaining data on the dynamics of populations.

The capture-recapture method of sampling animal populations has been described extensively by Seber (1973). Models have been developed to study both open and closed populations. Open population models allow for additions (through birth and/or immigration) to the population and for deletions (through death and/or emigration) from the population. Closed population models as described by Otis <u>et al.</u>, (1978) and others do not allow for such additions and deletions. Basically in capture-recapture studies a population is sampled two or more times and at each sampling: every unmarked animal caught is given a unique mark; previously marked animals are recorded; and the animals are released back into the population.

In long-term field studies an open population is usually the case. Pollock (1980) cited the Jolly-Seber (J-S) Model (after Jolly (1965) and Seber (1965)) as being the most important open population model. The J-S Model has the following assumptions (Pollock, 1980): (i) equal catchability of live animals; (ii) equal survival rates of all animals; (iii) the animals do not lose their marks and all marks are recorded on recovery; and (iv) the actual time spent sampling occupies a short period. If any of the above assumptions are violated (which is the usual case in bird censusing studies), modifications or alternative models must be employed in order to estimate the population size with any degree of accuracy. There appears, however, to be a shortage of suitable techniques to allow for the violation of these assumptions.

One of the more common capture-recapture methods used in the study of bird populations is the mist-netting technique. This method has several inherent biases: (i) birds may vary in their likelihood of capture according to age, sex, behavioural characteristics, the position of their territories relative to the mist net, etc.. It is known, for example, that species utilizing the high canopy area for nesting and foraging are less likely to be captured in mist nets than are ground nesting and foraging species; (ii) individuals and/or species may develop a "net response" which alters the likelihood of their being recaptured; and (iii) adult and immature birds are known to have different survival rates.

To determine the long-term impact of an insecticide spray, it is essential to know if the same individuals are remaining in an area in the period following a spray application, and also if the adults are returning to breed in subsequent years. Without such information, declines in the population of an area may be masked by members of the same species moving in to the area from adjacent unsprayed areas. It is also imperative that information be obtained on the numbers of offspring being fledged in an area so that it can be determined, by comparison with a control, if spray applications are affecting the reproductive success of the bird populations.

Baseline (i.e. pre-spray) data on the bird population dynamics of the areas to be studied were very limited. Therefore, any impact on the communities from spray applications could be detected only by means of comparison with an unsprayed area. Because of the lack of baseline data and the lack of trained observers it was decided that data collection for the current study would be accomplished by means of a mist-netting and banding program. It was recognized that the sizes of the bird communities would not be accurately estimated by this method. However because the biases of the technique should be relatively constant in all the areas to be studied the samples taken should therefore be comparable. It was recognized however that certain spraying impacts might not be detected by this technique. For example: (i) any impact on the high canopy foragers whose food supply would be potentially most greatly affected by aminocarb spraying would probably not be observed because these species are least well sampled by mist-netting; (ii) a depressed population in a sprayed area might be masked if the birds in that area had to increase their food searching activity to compensate for lowered food availability due to spraying effects, because such increased activity might be reflected in increased net catches relative to actual population size; and (iii) any differences in habitats between sprayed and unsprayed areas which might affect catchability of birds (such as more understorey or a higher canopy) would be confounded with the spray treatments (J.C. Rice, pers. comm.).

Bird distribution in relation to habitat

According to Hilden (1965), ultimate factors (factors essential for the survival of the species) in the habitat selection of birds are food, requirements imposed by the structural and functional characteristics of the species, and shelter from enemies and adverse weather. He further suggested that proximate factors (factors which serve to release the settling mechanism) are landscape, terrain, nest-, song-, look-out, feeding and drinking sites, and other animals. Proximate factors may be said to be cues for the presence or absence of ultimate factors. The selection mechanism guides the birds to an environment meeting their ecological requirements, i.e. ultimate factors, and the choice of breeding station is released by proximate factors. Anderson (1979) noted that minor habitat alterations which destroy such "sign stimuli" can result in changes in bird species composition of an area.

When studying bird species diversity, MacArthur and MacArthur (1961) found it to be unrelated to plant species diversity. Noon and Able (1978) stated that habitat selection in passerines seems to be influenced by the physical structure of the vegetation, without particular regard to the plant species present. However recent work has indicated that when distributions of individual species are examined, plant species may be important factors (Wiens and Rotenberry, 1981). Tomoff (1974) found that populations of breeding birds became denser, and the species diversity increased, as nest sites and food niches became more complex. A high degree of specificity was also demonstrated in the selection of plant species for nest placement. Anderson (1979) stated that very few areas have an extensive uniform habitat, and noted that areas having a diversity of structure generally attract the largest bird diversity. Other authors (e.g. James, 1971; Whitmore, 1975; 1977) have tended not to include the individual tree species, as such, in their analyses, but rather to include the number of species of trees as a single category. Because the mist netting technique of the current study captures not only those birds nesting at the site but also any birds which are moving around in the area, the species of trees may, in themselves, provide an explanation for the presence of the birds in the area. Franzreb (1978) suggested that birds do not regard all trees of the same height and profile, but of different species, as being equally desirable for such activities as nesting and foraging. She noted that leaf size and morphology may influence the degree to which birds use a given tree species, for example, trees with larger leaves making it difficult for smaller passerines to sit on a twig and still reach the middle and outer portions of the leaves where insects may be found. She further pointed out that leaf movements (such as in Populus spp.) may cause problems for hovering forms such as the Ruby-crowned

Kinglet. Southwood (1961) found that the number of insect species associated with given tree genera varied in Britain, e.g. Picea and Abies having 137 and 15 species respectively. It should be noted, however, that birds would also forage on a tree with only a few insect species providing these species were abundant.

Because differences in habitat structure may result in dissimilar bird populations, it is necessary to determine the extent to which habitat preferences are involved in bringing about the species distribution observed in nature. Hutchinson (1957) described the niche as an n-dimensional Euclidian space with each axis of this hyperspace corresponding to some variable which is relevant in the biology of the species. James (1971) assumed that predictable relationships exist between the occurrence of a bird and of its characteristic vegetational requirements. She termed this basic configuration of the ecological niche, the "niche-gestalt". As pointed out by Niemi (1977), habitat selection at the species level is individualistic, in that a given species may select a habitat on the simple presence or absence of a given factor whereas another species may select a habitat on the basis of a combination of factors. Rice and Ohmart (Ecological Monographs in press) found the number of habitat selection criteria of species to be a random variable across an entire avian community.

Multivariate statistical techniques have been used by numerous authors to describe the distributions of bird species in relation to the nature of the vegetation (Anderson, 1979; Anderson and Shugart, 1974; Inkley, 1980; James, 1971; Johnston, 1979; Morse, 1976; 1978; Niemi and Pfannmuller, 1979; Noon and Able, 1978; Sabo and Whittaker, 1979; Shugart et al., 1975; Smith, 1977; Stauffer and Best, 1980; Titterington et al., 1979; Whitmore, 1975; 1977). The basic premise of the multivariate approach to habitat selection assumes that the habitat selected by birds can be measured mathematically (see Green, 1971; 1974). By such studies, certain species have been shown to display habitat preferences, although the nature and extent of these preferences have been variable. Despite the variability of habitat preference studies, it was expected, however, that such a study could provide an additional basis on which to interpret the population characteristics of the sprayed and unsprayed areas.

Birds and the spruce budworm

Insectivorous birds are known to have a significant influence on the population dynamics of many insect species. Analysis of stomach contents has shown that at outbreak levels, spruce budworm forms an important part of the diet of birds [Otvos (1979) quoted 40% found by Mitchell, 1952 and 7-46% from a 4 year study in Newfoundland].

Functional responses have been noted in certain bird species during spruce budworm outbreaks. For example, Zach and Falls (1975), found an unusual method of foraging in Ovenbirds. This species, usually restricted to foraging on the forest floor and within reach of the ground (Chapman, 1917), was found by Zach and Falls to frequently forage in infested conifers well above ground level.

It is generally believed that the densities of certain species of Warblers (Parulidae) fluctuate in response to the numbers of spruce budworm present. MacArthur (1958) suggested that Cape May and Bay-breasted Warblers, probably due to their extra large clutches, are able to increase more rapidly than other species. In years between outbreaks, these two species become reduced in numbers and may even be eliminated locally. Morris et al., (1958) reported a direct numerical response to increasing spruce budworm levels by the Bay-breasted, Blackburnian and Tennessee Warblers, and an inverse response by Magnolia, Yellow-rumped and Black-throated Green Warblers. The inverse response is presumed to be due to interspecific competition with the species showing a direct response. Morse (1971) suggested that the ecological release, shown by the Yellow-rumped Warbler in the absence of congeners, is correlated with a low level of interspecific social dominance. Morse (1974) further suggested that the occurrence and abundance of socially subordinate species should be less predictable than that of socially dominant species because competitive displacement may be of major importance. Sanders (1970), in a period of low spruce budworm levels, found the density of breeding bird pairs to be lower than those recorded in the same area by Kendeigh (1947) in a time of spruce budworm outbreak. Sanders attributed this lower bird density almost entirely to the absence of Bay-breasted, Blackburnian and Tennessee Warblers. Morse (1978) found the densities of Bay-breasted and Cape May Warblers in an area of budworm outbreak to be higher than those typical of non-outbreak areas, as reported in Sanders, 1970 and Erskine, 1971, 1972 and 1976. He pointed out that part of the change in insectivorous bird populations, even at a high food density, results from a substitution of species.

Otvos (1979) stated that the role of birds in controlling epidemic populations of spruce budworm is negligible. He gave the concensus opinion that the major influence of birds occurs at the beginning or the declining phases of an outbreak, and further suggested that these may be, in fact, the most important control periods.

Blood parasites

Aminocarb insecticide is not spruce budworm specific. It is expected therefore, that a spray application will also affect other insect populations. Such effects may vary from slight reductions of populations to local eliminations, the degree mainly depending on the habits of the particular insect species. Certain insect species produce a potentially detrimental effect on a bird population, in that they serve as vectors for the transmission of avian haematozoa. Bennett and Coombs (1975) in insular Newfoundland, found Simulium latipes auct., nec Meigen and S. aureum Fries to be vectors of the blood parasites of Leucocytozoon spp, Culicoides stilobezzioides Foote and Pratt, a vector of the blood parasites of Haemoproteus spp and circumstantially, Aedes (Ochleratatus) punctor Kirby as a vector of Plasmodium spp.

Bennett et al., (1975) suggested that the effects of spraying on the vector population should be reflected in gross changes in the prevalence of avian haematozoa. They further suggested the occurrence of three possible situations: (1) a direct effect on the vector population resulting in a lowering of the prevalence of avian haematozoa, (2) an increase in the prevalence of avian haematozoa as a result of the normal predators of the vector population being affected more severely than the vector population and (3) the prevalence of avian haematozoa remaining similar to that of comparable, untreated areas if the insecticide has no effect. While the third situation is correct as far as it goes, it should be noted that this situation may also arise if the effects of the insecticide are of short duration, (as with the carbamate "aminocarb" according to Sundaram and Hopewell, 1977), because emigration of insects from adjacent populations into the area would rapidly compensate for any losses sustained.

Because infection of birds with blood parasites is thought to occur in the natal area it was postulated that differences in the blood parasite levels might be observed betwen sprayed and control areas. Preliminary observations by Bennett (pers. comm.) on the west coast of Newfoundland had indeed recorded a lowered blood parasite level in a Matacil treated area relative to a control area. Such differences could provide indirect evidence of the impact of the spray application on the insect population and hence on the food supply available for insect-eating birds. Therefore it was decided that blood smears would be taken from the netted birds.

Purpose of the current study

The current study was designed to investigate the longer term (1 year post-spray) effects of aminocarb spraying on bird populations of central Newfoundland. The study attempted to provide insights into the population dynamics and the blood parasite levels of avian species undergoing the combined peturbations of a spruce budworm outbreak and an aerial application of aminocarb insecticide.

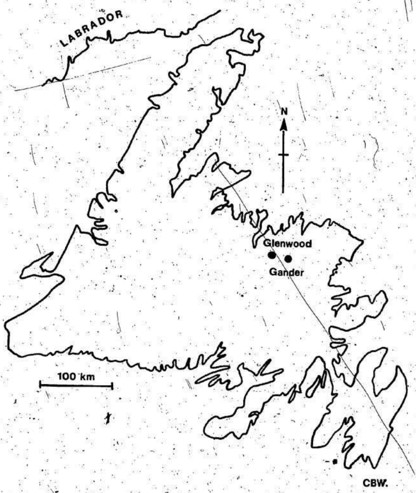
MATERIALS AND METHODS

Study areas

Studies were conducted in central Newfoundland, at Big Careless Cove Brook, (Fig. 1), approximately 16km southwest of Glenwood; Little Careless Cove Brook, approximately 12km southwest of Glenwood; and Joe Batt's Pond, 11km west of Gander. Both the Big and Little Careless Cove Brook areas received an aerial application of Matacil (4-dimethylamino-m-tolyl methylcarbamate), on June 18th and again on June 26th, 1978. The intended dosage rate was 70 g/ha at an emission rate of 1.46 l/ha. The first application of insecticide resulted in a light deposit within the sprayed area (0.109 l/ha) while the second application proved even lighter (0.028 l/ha) (Gov't. of Newfoundland and Labrador, Dept. of Consumer Affairs and Environment, Information Report RA-79-2). Because the Big Careless Cove Brook area was at the fringe of the spray block, the possibility exists that the spraying of this area in 1978 may have been relatively light. Analysis of Kromcote cards indicated that the deposit was 0.032 l/ha from the first spray application (Northcott, 1979). Little Careless Cove Brook, which is in the centre of the spray block and would presumably be more likely to have been uniformly sprayed during 1978 was therefore chosen as an

Figure 1

Map of the island of Newfoundland


LABRADOR
N
Glenwood
Gander
100 km
CBW.

additional area to be studied in 1979. The control area for this study was Joe Batt's Pond. Analysis of Kromcote cards showed no traces of Matacil in the control area from either spray application (Northcott, 1979). The mean numbers of budworm pupae per tree (1.5–2.1m in height) in the 3 areas were as follows: 1978- Joe Batt's Pond 37.00, Little Careless Cove Brook 0.625 and Big Careless Cove Brook, 4.80; 1979- Joe Batt's Pond 42.53 ± 26.82, Little Careless Cove Brook 6.13 ± 4.89 and Big Careless Cove Brook 22.83 ± 12.56. These figures were obtained by studies conducted by the Department of Consumer Affairs and Environment and have been provided by Bruce Thompson. It should be noted that slightly different locations were sampled at Little Careless Cove Brook in 1978 and in 1979. In addition, the sample size at Big Careless Cove Brook in 1978 was relatively small and this result should therefore be regarded with caution (Bruce Thompson, pers. comm.). The Department of Consumer Affairs and Environment carried out monitoring studies of the avian populations at Big Careless Cove Brook and Joe Batt's Pond, from May 30th, 1978 to August 9th, 1978 and have kindly provided the raw data from these studies for comparative purposes.

Mist-netting studies

Ten Japanese mist nets were set in each of the sprayed areas and in the control area. At the control area, nets 1,2,4,5,6,7,8 and 9 (Fig. 2) were set in the exact locations used in 1978. At Big Careless Cove Brook, nets 1,2,3,7,9 and 10 (Fig. 3) were unchanged from 1978. Net locations at Little Careless Cove Brook are shown in Figure 4. Nets were 9m or 12m in length and 2m in width and were set on 3m aluminium poles. Nets were positioned across probable bird flight paths, set as inconspicuously as possible, with the bottom panel of the net touching the ground or the top of the understorey. Nets were set at a minimum of 200m apart. Mist netting was conducted during the period 28th May, 1979 to 18th August, 1979. Netting was not attempted during periods of rain or when wind velocity was in excess of 25km per hour. In the control area, netting was carried out twice a week, weather permitting. In the sprayed areas, weather permitting, netting was carried out twice per week in each area prior to fledging of immatures and subsequently once per week in each area. All netting commenced shortly after dawn with nets usually remaining open for some 4-6 hours.

All birds captured in the mist nets were identified, aged and sexed according to Robbins et al., (1966). The names of the birds used in the current study follow the

Figure 2

Net sites - Joe Batt's Pond


2
1
4
3
5
6
7
8
9
10

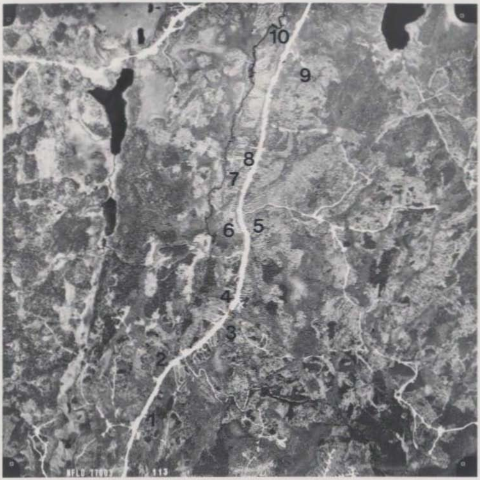
Figure 3

Net sites - Big Careless Cove Brook

10
9
8
7
6
5
4
3
2
1

Figure 4

Net sites - Little Careless Cove Brook


10
9
8
7
6
5
4
3
2
1
113

American Ornithologist's Union Check-List of North American Birds (1957) and its 32nd. Supplement (1973). Scientific names and authorities of the bird species are given in Appendix B. Passeriforms were then banded under permit as set forth in the Migratory Bird Act, following procedures described in the North American Bird Banding Techniques manual. A blood smear was taken from the brachial vein of each bird, using the technique and smearing apparatus outlined by Bennett (1970).

Vegetation measurements

To quantify habitat differences and/or similarities among the three areas, structural features of the vegetation (Table 1) were measured at all mist net sites, based on a method described by James (1971) and James and Shugart (1970), with several modifications deemed better suited to the present study, as suggested in Hudson (1978).

A circular plot of 0.0405 hectares, centred at the midpoint of the mist net was sampled at each site. Two transects were made at 45o angles from the mist net centre across the plot, and all plant stems intersected at breast height were classified according to size, and identified to species, according to Ryan (1978). Scientific names and authorities of the plant species are given in Appendix C. Maximum canopy height was estimated by triangulation, while

Table 1. Vegetation variables measured at 30 net sites.

1	ALD	Total number of Alder in all size classes
2	WSP	Total number of White Spruce in all size classes
3	WIL	Total number of Willow spp. in all size classes
4	BAF	Total number of Balsam Fir in all size classes
5	BSP	Total number of Black Spruce in all size classes
6	PIC	Total number of Pin Cherry in all size classes
7	ASH	Total number of Mountain Ash in all size classes
8	WHB	Total number of White Birch in all size classes
9	MAP	Total number of Maple in all size classes
10	ASP	Total number of Trembling Aspen in all size classes
11	YEB	Total number of Yellow Birch in all size classes
12	POP	Total number of Balsam Poplar in all size classes
13	CHC	Total number of Choke Cherry in all size classes
14	OTH	Total number of other species in all size classes
15	Z	Total number of stems less than 2.54cm intercepted at breast height (DBH)
16	A	Total number of stems 2.54cm - 7.62cm DBH
17	B	Total number of stems 7.62cm - 12.70cm DBH
18	C	Total number of stems 12.70cm - 17.78cm DBH
19	D	Total number of stems greater than 17.78cm DBH
20	GC	Percentage ground cover
21	CC	Percentage canopy cover
22	MCH	Maximum canopy height

canopy cover and ground cover were estimated as suggested in James and Shugart (1970).

Blood parasites

Blood films were examined under oil immersion (400X) for approximately 5 minutes per slide, during the fall and winter of 1979/80, in the International Reference Centre for Avian Haematozoa at Memorial University of Newfoundland, St. John's, Newfoundland.

Statistical analyses

Because of the multiple comparisons made in this study $\alpha=0.01$ was chosen as the significance level required for concluding that differences were significant. An analysis of variance of hours by area and week was performed to determine if the sampling effort was matched among the three areas. G-tests for goodness of fit (Sokal and Rohlf, 1969) were used to compare the time distributions of the adult captures and of the immature captures of the areas for the year 1979. Analyses of frequencies using arcsine transformations of the data (Sokal and Rohlf, 1969) were used to compare the 1979 return and repeat rates of the adult birds for each area and these rates between the adults and the immatures. The 1979 adult repeat rates were regressed against the weeks of netting for each area for the total netting weeks, for the weeks prior to fledging of young and for the weeks post fledging of young to determine their seasonal pattern(s). A G-test for goodness of fit was used to determine if the "same net" repeat rates of the adult birds were similar among the areas.

To determine if there were significant differences between the areas in the numbers of adult individuals of a particular family, adult Parulidae, Fringillidae and Turdidae were tested between areas for each year (1978, 1979) and between the years. Testing was by means of a G-test for godness of fit. Analyses of frequencies using arcsine transformations of the data were used to determine differences in the proportions of insectivorous individuals captured, between the areas for 1978 and 1979 and between the years, 1978 and 1979. The numbers of individual males and females of the families Parulidae and Fringillidae captured in each area were tested by G-tests to compare the captures of each family by sex between 1978 and 1979. The pooled data for both years were then tested for each area to compare the composition by sex of captures of the 2 families.

Chi-square tests were performed to detect significant differences between the adult and immature individuals captured of the families Parulidae, Fringillidae and Turdidae between the 3 areas. As well, these ratios were tested for the two areas studied in 1978, and 1978 was tested against 1979.

The vegetational variables measured were subjected to a principal components analysis to simplify and condense the data so as to bring out relationships among the measured variables (Pielou, 1977). This analysis transformed the original variables (vegetation measurements) into a new set of quantitative variables which according to Green (1979) have the following properties: (1) each new variable is a linear function of the old variables, (2) the first new variable extracted (PC1) is the linear additive function accounting for the largest possible variation in the data and (3) each additional new variable (PC2, PC3,...etc.) accounts for the largest possible variation remaining in the data and does so independently of the principal components which have previously been extracted. Therefore, it follows that while the original variables were intercorrelated, the principal components are orthogonal. The principal components were next orthogonally rotated to simplify the factor patterns and thereby facilitate a more meaningful interpretation. Factor scores (in this context, rotated principal component scores) were then extracted to determine the relationship between each net site and the principal components. Means, standard deviations and confidence limits were determined for each of the 3 areas for each of the principal components. An F max* test described by

Hartley (1950) was used to test the homogeneity of the variances among the areas for each principal component.

Because habitat selection criteria may vary by species within a family, eleven bird species were selected on the basis of their abundances. For each of these species, using total individuals captured in the 3 areas, step-wise multiple regression analyses were performed in an attempt to determine the percentage variation of bird species distribution (dependent variables) attributable to the vegetation differences betwen net sites, as represented by the principal components (independent variables). By this method, various combinations of the independent variables were tried, in order to obtain a minimum unexplained residual variance in terms of the smallest number of principal components. This is accomplished by the dropping of any principal component which did not independently remove a significant amount of the variation (Sokal and Rohlf, 1969). Multiple regression analyses were also performed for adults only, and immatures only, of species of which sufficient numbers had been captured. Regression equations determined from step-wise multiple regression analyses of the control area only were used (for those species which occurred in sufficient numbers at the control area) to predict the expected number of adults (5 species) and the expected number of immatures (6 species) of each species at each net site. Locale predictions were obtained for both age classes of each species by summing net predictions. The observed totals were then compared to the predicted totals by means of chi-square tests.

The overall prevalence, i.e. the number of infected birds, and the prevalence of the blood parasites, Haemoproteus and/or Leucocytozoon, were tested by chi-squares for the families Parulidae, Fringillidae and Turdidae, between all areas for both 1978 and 1979 and between the years 1978 and 1979.

RESULTS

Avian populations

Eight hundred and sixty-six individuals, representing 27 species, were captured in the control area, (Table 2) in 1979, and in 1978, 448 individuals in 29 species, Table 3. At Big Careless Cove Brook, 467 individuals in 28 species were captured in 1979, and 378 individuals in 30 species in 1978 and at Little Careless Cove Brook, 890 individuals in 32 species. Captures of the 19 species common to all 3 areas in 1979 accounted for 93.2% of total individuals captured in the control area, 95.1% at Big Careless Cove Brook and 95.6% at Little Careless Cove Brook. The composition of the population by family for each of the areas is given in Table 4. An analysis of variance indicated that no significant differences occurred in netting effort between areas ($F=3.371$, d.f.=2,18, $p>0.01$) nor was there a significant interaction between area and week ($F=1.595$, d.f.=19,18, $p>0.01$).

The number of adult birds captured per netting-hour (Fig. 5), remained relatively similar for all 3 areas throughout the greater part of the netting season. All 3 areas were found to be similar for all weeks tested (G-statistic=16.9146 $< \chi^2=18.42$, d.f.=16, $p>0.30$). with the exception of week 11. For week 11, only the control area

Table 2. Composition of bird populations - 1979.

	Joe Batt's Pond					Big Careless Cove Brk.					Little Careless Cove Brk.				
	M **	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total
PALCONIDAE															
Sparrow Hawk					0		1			1					0
PICIDAE															
Yellow-shafted Flicker	1				1					0	2				2
Hairy Woodpecker					0					0		1			1
Downy Woodpecker					0			1		1	1	2			3
TYRANNIDAE															
*Yellow-bellied Flycatcher			11	18	29			17	5	22	1	5	19	16	41
HIRUNDINIDAE															
*Tree Swallow					0					0			2		2
CORVIDAE															
Gray Jay			1	3	4					0			2		2
PARIDAE															
Black-capped Chickadee	1		3	1	5		1	1		2			1		1
Boreal Chickadee			6	3	9			3		3					0
TURDIDAE															
American Robin	5	4		11	20	8	1	1	3	13	2	4		23	29
Hermit Thrush			1	7	8			2	6	8	1	2	2	36	41
Swainson's Thrush	3	4	6	45	58	4	1	14	24	43	17	7	16	144	184
Gray-cheeked Thrush					0			1		1			1	2	3
SYLVIIDAE															
*Ruby-crowned Kinglet	2	3	1	38	44		1		6	7	1			28	29
Golden-crowned Kinglet	1	1		2	4					0					0

Table 2 (cont'd.). Composition of bird populations - 1979.

Species	Joe Batt's Pond					Big Careless Cove Brk.					Little Careless Cove Brk.				
	M	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total
PARULIDAE															
*Black-and-white Warbler	11	9		24	44	12	8		3	23	12	18		6	36
*Tennessee Warbler	1	3			4	1	1		1	3	1			4	5
*Nashville Warbler					0		1			1					0
*Yellow Warbler		1			1	1				1	1	1		1	3
*Magnolia Warbler	6			5	11	7	1		5	13	8	1		9	18
*Yellow-rumped Warbler	18	7		212	237	8	5		48	61	4	5		48	57
*Blk.-throated Green Warbler	1	1		3	5					0					0
*Bay-breasted Warbler					0		1			1					0
*Blackpoll Warbler	2	1		27	30	13	3		16	32	13	9		39	61
*Palm Warbler					0	1			10	11			1	8	9
*Ovenbird	3	2	3	8	16					0			2	1	3
*Northern Waterthrush	8	8	16	84	116	8	6	16	20	50	16	6	14	59	95
*Mourning Warbler	7	1	1	8	17	3	1			4	6	3		12	21
*Wilson's Warbler	6			4	10	6	3			9	15	4	2	3	24
*American Redstart	4	1		13	18					0				5	5
FRINGILLIDAE															
Purple Finch	2	3			5	1			4	5	2	1		5	8
Pine Grosbeak					0	1	1			2		4			4
Pine Siskin					0					0				1	1
Slate-colored Junco					0				1	1				1	1
White-throated Sparrow	16	12	8	61	97	15	9	9	60	93	16	10	15	80	121
Fox Sparrow	1	2		5	8	4	3	1	3	11	3	12	3	3	21
Lincoln's Sparrow	4	7	9	43	63	1	7	17	19	44	2	9	10	35	56
Swamp Sparrow	1			1	2					0				2	2
TOTAL BIRDS	104	70	66	626	866	94	55	83	234	466	124	104	90	571	889

* - insectiverous species
** - M = male adult, F = female adult, AHY-U = adult of unknown sex, HY = immature

Table 3. Composition of Bird Populations - 1978.

Species	Joe Batt's Pond					Big Careless Cove Brk				
	* M	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total
PICIDAE										
Hairy Woodpecker				1	1					0
Downy Woodpecker				2	2					0
TYRANNIDAE										
Yellow-bellied Flycatcher			9	2	11			13	3	16
Unidentified *Empidonax*			1		1			1		1
CORVIDAE										
Gray Jay			2		2			1		1
PARIDAE										
Black-capped Chickadee			3	1	4			1		1
Boreal Chickadee			8	3	11			4	1	5
TURDIDAE										
American Robin	4	2	1	4	11			1	1	2
Hermit Thrush			1		1			2		2
Swainson's Thrush			6	1	7			13		13
Gray-cheeked Thrush					0			1		1
Unidentified Thrush				21	21				19	19
SYLVIIDAE										
Ruby-crowned Kinglet				12	12				3	3
BOMBYCILLIDAE										
Cedar Waxwing					0		1			1

Table 3 (cont'd.). Composition of Bird Populations - 1978.

Species	Joe Batt's Pond					Big Careless Cove Brk				
	* M	F	AHY-U	HY	Total	M	F	AHY-U	HY	Total
PARULIDAE										
Black-and-white Warbler	1	1		18	20	7	3		5	15
Tennessee Warbler	3	2		8	13	2	1			3
Yellow Warbler					0	1				1
Magnolia Warbler			1		1	9	1	1	2	13
Yellow-rumped Warbler	9	3		112	124	9	6		35	50
Blk.-throated Green Warbler				1	1					0
Blackpoll Warbler		1		11	12	9	4	1	17	31
Palm Warbler					0				4	4
Ovenbird			7	3	10					0
Northern Waterthrush			22	37	59			31	18	49
Mourning Warbler	4			2	6	5			4	9
Wilson's Warbler	1	1		2	4	7			4	11
American Redstart				3	3					0
ICTERIDAE										
Rusty Blackbird					0	1				1
FRINGILLIDAE										
Purple Finch	2	9			11		2			2
Pine Grosbeak					0	1				1
Pine Siskin	2	1			3					0
Slate-colored Junco					0				1	1
White-throated Sparrow	14	6		53	73	18	9		34	61
Fox Sparrow	2	1		2	5	3	3	1	2	9
Lincoln's Sparrow			8	6	14			22	27	49
Swamp Sparrow	1	1		3	5			1	2	3
TOTAL BIRDS	43	28	69	308	448	72	30	94	182	378

* - M = male adult, F = female adult, AHY-U = adult of unknown sex, HY = immature

Table 4. The percentage distribution of the avian populations by Family.

Family	Joe Batt's Pond	Big Careless Brk.	Little Careless Brk.
Parulidae -1979	58.8	44.8	37.9
-1978	56.5	49.2	–
Fringillidae -1979	20.2	33.4	24.0
-1978	24.8	33.3	–
Turdidae -1979	9.9	14.1	29.0
-1978	8.9	9.8	–
Sylviidae -1979	5.5	1.5	3.3
-1978	2.7	0.8	–
Tyrannidae -1979	3.4	4.7	4.6
-1978	2.7	4.5	–
Paridae -1979	1.6	1.1	0.1
-1978	3.3	1.6	–
Corvidae -1979	0.5	0.0	0.2
-1978	0.4	0.3	–
Picidae -1979	0.1	0.2	0.7
-1978	0.7	0.0	–
Other -1979	0.0	0.2	0.2
-1978	0.0	0.5	–

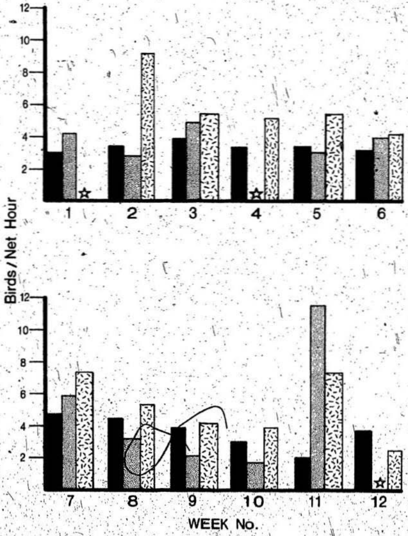
Figure 5

Number of adult birds captured per netting-hour

- Joe Batt's Pond
- Big Careless Cove Brook
- Little Careless Cove Brook

☆ - Not sampled

- Week 1: May
- Weeks 2-5: June
- Weeks 6-10: July
- Weeks 11-12: August


Birds / Net Hour
12
10
8
6
4
2
1
2
3
4
5
6
12
10
8
6
4
2
7
8
9
10
11
12
WEEK No.

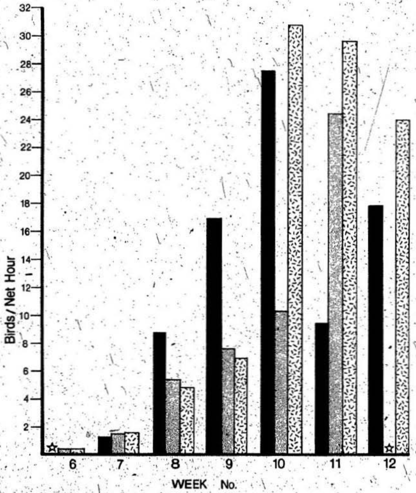
and Little Careless Cove Brook were statistically similar (G-statistic=26.0638 < χ^2=26.296, d.f.=16, p>0.05). The capture rate of the immature birds (Fig. 6) shows the same general trend in all the 3 areas, however, Big Careless Cove Brook was somewhat later in reaching its peak capture rate. The control area and Big Careless Cove Brook were statistically similar for all weeks tested (G-statistic=12.1099 < χ^2=13.362, d.f.=8, p>0.10) except week 11 while Big Careless Cove Brook and Little Careless Cove Brook were statistically similar for all weeks tested (G-statistic=3.7682 < χ^2=4.59, d.f.=8, p>0.80) except week 10. There was no significant difference between the 3 areas for weeks 7,8 and 9 (G-statistic=10.4687 < χ^2=11.03, d.f.=8, p>0.20).

Of the 326 individuals banded in the control area in 1978, 12 (all banded as adults) were recaptured in 1979, a return rate of 3.7%. Since 132 adults were banded in this area in 1978, the return rate of adults was 9.1%. At Big Careless Cove Brook, 247 individuals were banded in 1978 and of these, 30 were recaptured in the same area in 1979, a return rate of 12.1%. One hundred and sixty-eight adults were banded in this area in 1978 and 28 of these were recaptured in 1979, a return rate of 16.7%. The adult return rate of Big Careless Cove Brook was statistically similar to that at the control area (ts=1.96, d.f.=∞, p>0.01). The return rate of immatures at the control area was 0.0%. At

Figure 6

Number of immature birds captured per netting-hour

- ■ - Joe Batt's Pond
- ▒ - Big Careless Cove Brook
- ░ - Little Careless Cove Brook
- ☆ - Not sampled
- Weeks 6-10: July
- Weeks 11-12: August



32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
Birds / Net Hour
6
7
8
9
10
11
12
WEEK No.

Big Careless Cove Brook, 2 of the 192 immatures which were banded in 1978 were recaptured in 1979, a return rate of 1.0%. The immature return rate at Big Careless Cove Brook and at the control area were statistically similar (ts=2.01, d.f.=∞, p>0.01). The adult return rate was significantly higher than the immature return rate at the control area (ts=7.02, d.f.=∞, p<0.01) and at Big Careless Cove Brook (ts=6.02, d.f.=∞, p<0.01).

Of the total captures in the control area, 9.4% were repeats, i.e., banded birds captured within the same 10' grid of latitude and longitude within the same 3-month period in which they were originally banded or recaptured (1978 - 12.8%). At Big Careless Cove Brook, 11.7% were repeats (1978 - 13.7%) and at Little Careless Cove Brook, 5.5%. In 1979, of the total adult captures in the control area, 21.6% were repeats. At Big Careless Cove Brook, 20.3% of the adults captured were repeats and at Little Careless Cove Brook 11.1%. The adult repeat rates did not differ significantly between the control area and Big Careless Cove Brook (ts=0.403, d.f.=∞, p>0.10). However, the adult repeat rate was significantly lower at Little Careless Cove Brook than at the control area (ts=3.72, d.f.=∞, p<0.01) and at Big Careless Cove Brook (ts=3.25, d.f.=∞, p<0.01). Adult repeat rates throughout the season were determined by dividing the number of "repeat" birds caught on a netting day by the number of birds banded in that area prior to that netting day. Analyses of variance for the regressions showed that these adult repeat rates dropped significantly over the netting season at the control area ($F=56.132$, d.f.=1,17, $p<0.01$) and at Big Careless Cove Brook ($F=58.114$, d.f.=1,14, $p<0.01$). The adult repeat rates remained similar over the first 5 weeks of netting at the control area ($F=0.921$, d.f.=1,5, $p>0.05$) and at Big Careless Cove Brook ($F=2.604$, d.f.=1,4, $p>0.05$). At Little Careless Cove Brook the adult repeat rates remained similar throughout the entire netting season ($F=3.071$, d.f.=1,11, $p>0.05$). The adult "same net" repeat rates did not differ significantly between the three areas (G-statistic=2.96 $< \chi^2=3.22$, d.f.=2, $p>0.20$). The repeat rate of immature birds at the control area was 3.1%, at Big Careless Cove Brook 1.3% and at Little Careless Cove Brook 1.9%. The immature repeat rates did not differ significantly between the control area and Big Careless Cove Brook (ts=1.69, d.f.=∞, $p>0.025$), the control area and Little Careless Cove Brook (ts=1.59, d.f.=∞, $p>0.05$) or between Big and Little Careless Cove Brooks (ts=0.49, d.f.=∞, $p>0.10$). The adult repeat rate was significantly higher than the immature repeat rate at the control area (ts=8.87, d.f.=∞, $p<0.01$), Big Careless Cove Brook (ts=8.11, d.f.=∞, $p<0.01$) and Little Careless Cove Brook (ts=6.27, d.f.=∞, $p<0.01$).

No significant differences were found between the control area and Big Careless Cove Brook in the numbers of adult parulid, fringillid and turdid individuals (Table 5) captured in 1978 nor were there differences found between the years 1978 and 1979 (G-statistic=13.4003 < χ^2=14.067, d.f.=7, p>0.05). Additionally, no significant differences were found between the numbers of adult parulid, fringillid and turdid individuals captured at Little Careless Cove Brook, Big Careless Cove Brook and the control area in 1979 (G-statistic=6.7083 < χ^2 =7.23, d.f.=6, p>0.30).

The number of adults of insectivorous species netted, (Table 2), at the control area represented 57.5% of the total adult individuals netted (1978 - 47.1%, Table 3), at Big Careless Cove Brook, 53.4% of the total (1978 - 56.6%) and at Little Careless Cove Brook, 53.4% of the total. In 1979, there were no significant differences between the three areas in the numbers of insectivorous adults captured as percentages of the total adults captured. The proportions of insectivorous adults were similar in 1978 and 1979 for both the control area (ts=1.98, d.f.=∞, p>0.01) and Big Careless Cove Brook (ts=0.62, d.f.=∞, p>0.10).

No significant differences were found in the male : female ratios (Table 6) of the family Parulidae or of the family Fringillidae, between the years 1978 and 1979. When the pooled 1978/1979 data of the parulids were compared to those of the fringillids, no significant differences were shown at the control area (G-statistic = 3.949 < χ^2 =5.024, d.f.=1, p>0.025), at Big Careless Cove Brook (G-statistic=

Table 5. Summary of adult and immature birds by Family.

Family	Joe Batt's Pond AHY*	Joe Batt's Pond HY**	Big Careless Brk. AHY	Big Careless Brk. HY	Little Careless Brk. AHY	Little Careless Brk. HY
Falconidae -1979			1			
-1978					-	-
Picidae -1979	1		1		6	
-1978		3			-	-
Tyrannidae -1979	11	18	17	5	25	16
-1978	10	2	14	3	-	-
Hirundinidae -1979					2	
-1978					-	-
Corvidae -1979	1	3			2	
-1978	2		1		-	-
Paridae -1979	10	4	5		1	
-1978	11	4	5	1	-	-
Turdidae -1979	23	63	32	33	52	205
-1978	14	26	17	20	-	-
Sylviidae -1979	8	40	1	6	1	28
-1978		12		3	-	-
Bombycillidae -1979						
-1978			1			
Parulidae -1979	121	388	106	103	142	195
-1978	56	197	97	89	-	-
Icteridae -1979						
-1978			1			
Fringillidae -1979	65	110	69	87	87	127
-1978	47	64	60	66	-	-
TOTALS - 1979	240	626	232	234	318	571
- 1978	140	308	196	182	-	-

* - After Hatching Year = Adult
** - Hatching Year = Immature

Table 6. Composition of selected families by sex.

	Joe Batt's Pond			Big Careless Cove Brk.			Little Careless Cove Brk.		
	M*	F**	M:F Ratio	M	F	M:F Ratio	M	F	M:F Ratio
PARULIDAE***									
1979	59	26	2.26 : 1	52	24	2.17 : 1	60	41	1.46 : 1
1978	18	8	2.25 : 1	49	15	3.27 : 1	-	-	-
FRINGILLIDAE****									
1979	20	17	1.18 : 1	21	13	1.61 : 1	21	27	0.78 : 1
1978	21	18	1.17 : 1	22	14	1.57 : 1	-	-	-

* - M = Male Adult

** - F = Female Adult

*** - omitting Northern Waterthrushes because a high proportion were of unknown sex.

**** - omitting Lincoln's Sparrows because a high proportion were of unknown sex.

1.984 $< \chi^2 = 2.71$, d.f.=1, $p>0.10$) or at Little Careless Cove Brook (G-statistic = 2.611 $< \chi^2 = 2.71$, d.f.=1, $p>0.10$).

A total of 626 individual birds of the year i.e. birds hatched in 1979, were netted in the control area for a ratio (Table 5) of 1 adult : 2.61 immatures (1978 ratio - 1 adult : 2.2 immatures). At Big Careless Cove Brook, 235 individual immatures were netted for a ratio of 1 adult : 1 immature (1978 ratio - 1 adult : 0.93 immatures). At Little Careless Cove Brook, 572 immatures were netted for a ratio of 1 adult : 1.80 immatures.

The number of immature parulids captured was significantly higher in the control area than at Big Careless Cove Brook in 1978 ($\chi^2=43.31$, d.f.=1, $p<0.001$) and in 1979 ($\chi^2=51.57$, d.f.=1, $p<0.001$) and than at Little Careless Cove Brook ($\chi^2=29.54$, d.f.=1, $p<0.001$). Little Careless Cove Brook and Big Careless Cove Brook had statistically similar numbers of immature parulids ($\chi^2=4.96$, d.f.=1, $p>0.025$). No significant differences were found in the numbers of immature parulids captured between 1978 and 1979. No significant differences were found between areas or between years in the numbers of immature fringillids captured. The number of immature turdids captured was significantly higher in the control area ($\chi^2=7.19$, d.f.=1, $p<0.01$) and at Little Careless Cove Brook ($\chi^2=20.54$, d.f.=1, $p<0.01$) than at Big Careless Cove Brook in 1979. No significant differences were found in 1978 or between 1978 and 1979.

Vegetation analysis

The correlation matrix (Table 7) derived from the 22 measured variables, showed these variables to be, for the most part, independent of one another. Values of 'r' $>\pm 0.46$ are significantly correlated at $\alpha=0.01$. Alder was shown to be positively correlated with size class Z, (<2.54cm DBH), and negatively correlated with size class B, (7.62cm - 12.70cm DBH); Willow was positively correlated with Pin Cherry and White Birch; Pin Cherry with White Birch; Maple with Balsam Poplar; Choke Cherry with Others and size class B, (7.62cm - 12.70cm DBH); size class A, (2.54cm - 7.62cm DBH), with canopy cover; maximum canopy height with size class D, (>17.78cm DBH), and with ground cover.

The results of the principal components analysis (after orthogonal rotation) are summarized in Table 8. Eight factors were found to explain 79.2% of the variation. All values of 'r' $>\pm 0.46$ are significantly correlated at $\alpha=0.01$.

Factor 1 which accounts for 16.8% of the total variance in the original data is associated with the presence of Willow, Pin Cherry and White Birch. Areas with high scores on Factor 1 would have large numbers of these tree species. The negative correlation with ground cover is probably a

Table 7. Correlation matrix (r) for 22 vegetational variables measured at 30 net sites. N = 30

***	ALD	WSP	WIL	BAF	BSP	PIC	ASH	WHB	MAP	ASP	YEB	POP	CHC	OTH	Z	A	B	C	D	GC	CC
ALD																					
WSP	-0.08																				
WIL	-0.21	-0.06																			
BAF	-0.34	0.25	0.07																		
BSP	-0.16	0.01	-0.18	-0.16																	
PIC	-0.45**	-0.04	0.49*	-0.02	-0.19																
ASH	-0.00	0.11	-0.15	0.08	-0.08	-0.08															
WHB	-0.30	0.12	0.47*	-0.02	-0.07	0.77*	-0.10														
MAP	-0.13	-0.30	-0.12	-0.11	-0.21	0.06	0.09	-0.08													
ASP	-0.13	0.00	0.08	0.33	-0.13	-0.03	-0.09	0.02	-0.26												
YEB	-0.17	-0.14	0.13	-0.09	-0.10	0.16	-0.10	0.08	0.27	-0.03											
POP	-0.09	-0.26	-0.13	-0.09	-0.07	-0.06	-0.00	-0.10	0.63*	0.10	-0.04										
CHC	-0.18	-0.11	0.14	-0.05	-0.11	-0.11	0.16	-0.12	0.19	0.02	-0.06	0.10									
OTH	0.05	-0.17	-0.02	0.06	-0.16	-0.20	0.12	-0.31	0.31	0.05	0.06	0.41**	0.47*								
Z	0.77*	0.03	0.16	-0.08	-0.26	-0.12	-0.08	0.11	-0.03	0.14	-0.07	0.08	-0.14	0.20							
A	0.19	-0.14	0.40**	0.20	-0.23	0.15	0.10	0.14	-0.06	-0.25	0.43**	-0.36	-0.01	-0.15	0.13						
B	-0.46*	-0.11	0.42**	0.26	-0.21	0.23	-0.05	0.06	-0.00	0.20	0.07	-0.10	0.54*	0.27	-0.31	0.07					
C	-0.08	-0.28	0.19	0.04	-0.03	0.02	0.20	-0.00	0.13	0.36**	-0.01	0.45**	0.27	0.18	0.14	-0.21	0.19				
D	0.22	0.04	-0.19	-0.18	0.02	-0.27	0.63*	-0.19	0.21	-0.03	0.05	0.32	-0.12	0.15	0.16	-0.11	-0.19	0.30			
GC	0.05	-0.00	-0.21	0.31	0.14	-0.45**	0.30	-0.42**	0.16	0.16	-0.05	0.32	0.11	-0.01	-0.06	0.13	0.01	0.31	-0.35		
CC	0.39**	-0.19	0.32	-0.16	-0.32	0.13	0.20	0.17	0.02	0.01	0.31	-0.16	0.13	0.01	0.42**	0.56*	0.29	0.11	0.30	0.06	
MCH	0.13	-0.20	-0.23	0.22	0.15	-0.27	0.25	-0.21	0.15	0.35**	0.03	0.26	-0.04	0.16	0.19	-0.02	-0.12	0.23	0.48*	0.54*	0.09

* Significant at $\alpha = 0.01$
** Significant at $\alpha = 0.05$
*** Description of variables is given in Table 1, page 31

Table 8. Correlations of factors with 22 measured vegetational variables.

	Factors							
	1	2	3	4	5	6	7	8
% of total variance accounted for	16.8	13.4	12.2	9.2	7.9	7.8	6.4	5.6
Cumulative % of total variance accounted for	16.8	30.2	42.4	51.6	59.5	67.2	73.7	79.2
Correlations to original variables**								
ALD	-0.37	0.86*	-0.19	-0.13	-0.11	0.05	0.07	-0.19
WSP	0.05	-0.02	-0.16	-0.31	-0.19	-0.31	0.22	0.65*
WIL	0.64*	0.11	0.34	-0.18	0.13	0.26	-0.12	-0.05
BAF	-0.08	-0.23	0.06	-0.08	0.42	0.23	-0.09	0.74*
BSP	-0.22	-0.45	-0.29	-0.27	0.10	-0.21	0.02	-0.46*
PIC	0.89*	-0.17	-0.02	0.08	-0.09	0.12	-0.08	0.02
ASH	-0.07	-0.05	0.13	-0.01	-0.01	0.01	0.89*	0.14
WHB	0.89*	-0.01	-0.15	-0.07	-0.02	0.03	-0.02	0.04
MAP	-0.04	-0.09	0.06	0.87*	-0.12	0.19	0.12	-0.08
ASP	0.08	0.10	0.10	-0.09	0.78*	-0.18	-0.19	0.22
YEB	0.10	-0.11	-0.07	0.26	-0.01	0.71*	-0.08	0.03
POP	-0.03	0.01	-0.00	0.82*	0.30	-0.22	0.09	-0.13
CHC	-0.11	-0.08	0.85*	0.09	-0.03	-0.06	0.08	-0.09
OTH	-0.25	0.23	0.56*	0.50*	0.03	-0.11	0.00	0.10
Z	0.06	0.92*	-0.13	0.04	0.17	0.00	-0.01	0.03
A	0.08	0.16	0.04	-0.25	-0.11	0.87*	0.06	0.05
B	0.21	-0.25	0.81*	-0.09	0.16	0.16	-0.09	0.08
C	0.17	0.05	0.29	0.23	0.63*	-0.16	0.24	-0.26
D	-0.13	0.17	-0.14	0.22	0.17	-0.03	0.83*	-0.12
GC	-0.49*	-0.16	-0.01	0.05	0.52*	0.20	0.37	0.03
CC	0.22	0.50*	0.26	-0.14	0.05	0.57*	0.32	-0.19
MCH	-0.32	0.06	-0.18	0.16	0.65*	0.14	0.31	-0.04

* - significant at $\alpha = 0.01$
** - Description of variables is given in Table 1, page 31.

reflection of the lack of dense ground vegetation in such areas. Such areas would be in an intermediate stage of regeneration since the stem size of trees is variable and the canopy height is low.

Factor 2, accounting for 13.4% of the variance, is associated with the presence of Alder, trees of size class Z, (<2.54cm DBH), and canopy cover. The structure of such an area is that of a typical thicket of young alders with very little intrusion of other tree species. Growth is quite dense as shown by the correlation with canopy cover.

The third Factor, explaining 12.2% of the variance, is positively correlated with Choke Cherry, Others and size class B, (7.62cm - 12.70cm DBH). Areas described by this Factor are those of shrubby, mixed deciduous growth, intermediate in density and low in height. A further 9.2% of the variance is represented by Factor 4, which is associated with the presence of Maple, Balsam Poplar and also the Other class. With the exception of the difference in species composition, the structure of this area is similar to those described by Factor 3. An additional 7.9% of the variance is explained by Factor 5, the presence of Trembling Aspen, trees of size class C, (12.70cm - 17.78cm DBH), ground cover and maximum canopy height. The lack of correlation with canopy cover may indicate that distribution is scattered, or that little of the variation in canopy cover is associated with Trembling Aspen, while the correlation with ground cover indicates the presence of considerable undergrowth. The sixth Factor, the presence of Yellow Birch, trees of size class A, (2.54cm - 7.62cm DBH), and a substantial canopy cover, accounted for 7.8% of the variance. Factor 7, the presence of Mountain Ash and trees of size class D, (>17.78cm DBH), explained a further 6.4% of the variance. Growth of trees in such an area would be advanced, yet not necessarily dense, with a moderate ground cover. The eighth Factor, representing 5.6% of the variance, is significantly correlated with the presence of White Spruce and Balsam Fir, and the absence of Black Spruce. As evidenced by the correlations with ground cover and maximum canopy height, growth is not necessarily high nor dense. The remaining 20.8% of the variation may be attributed to unsystematic variation in the forest structure and to random error of the vegetation measurements.

Confidence intervals calculated from the factor scores for the 10 net sites within each area, show the differences and similarities between the 3 areas in the habitat attributes as represented by the 8 Factors (Fig. 7). Factor 1 was shown to be the only factor for which a significant difference occurred between any of the 3 study areas. At Little Careless Cove Brook Willow, Pin Cherry and White Birch were present at most net sites, whereas at all the net sites in the control area (and at most net sites at Big Careless Cove Brook) these species were absent. For the

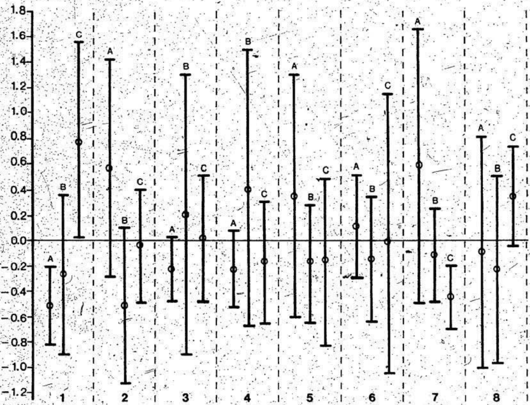
Figure 7

Representation of vegetational structure of areas

A - Joe Batt's Pond

B - Big Careless Cove Brook

C - Little Careless Cove Brook



1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
1
2
3
4
5
6
7
8
A
B
C

remaining Factors, whereas the abundance of the vegetation described by each component varied between areas, overlapping of all 3 areas was observed. The variances of the Factors for the 3 areas were homogeneous for Factors 1,2,3,6 and 8. For Factors 3,4 and 7, however, these variances were heterogeneous (F max=20.668, F max=13.2787 and F max=18.482 respectively at d.f.=3,9, p<0.005).

Multiple regression analyses

The results of the multiple regression analyses are summarized in Tables 9, 10 and 11. Included in these tables are values for Multiple R, R2, F of Step and Overall Step. Multiple R - the multiple correlation coefficient, describes the linear correlation between the dependent variables, the birds, and the independent variables, the vegetation factors. The absolute value of R describes the relative strength of this relationship and the sign of R indicates whether the relationship is positive or negative. The R2 statistic is somewhat easier to interpret, since it indicates the proportion of variation in the bird distribution which is predictable from the vegetational factors included in the regression equation. Both Multiple R and R2 values are cumulative as additional independent variables are added to the prediction equation in step-wise

Table 9. Summary of step-wise regression analyses of 11 bird species on factors of the vegetation. Degrees of freedom for F of Step: 1, N-k-1 and for Overall F: k, N-k-1 where N = number of cases = 30 and k = number of independent variables.

Species	Step	Factor	Multiple R	R^2	F of Step	Overall F
Yellow-rumped Warbler	1	PC7	0.41	0.17	5.66*	5.66*
Northern Waterthrush	1	PC2	0.50	0.25	9.55*	9.55*
Black-and-white Warbler	1	PC2	0.59	0.35	15.11*	15.11*
	2	PC3	0.70	0.49	7.39*	12.97*
	3	**PC4	0.75	0.56	4.50*	11.27*
	4	PC1	0.79	0.63	4.32*	10.61*
	5	PC6	0.83	0.69	4.75*	10.71*
Blackpoll Warbler	1	PC1	0.28	0.08	2.45	2.45
White-throated Sparrow	1	PC1	0.33	0.11	3.46	3.46
Lincoln's Sparrow	1	**PC5	0.47	0.22	8.03*	8.03*
Ruby-crowned Kinglet	1	PC6	0.23	0.05	1.55	1.55
Yellow-bellied Flycatcher	1	**PC7	0.36	0.13	4.28*	4.28*
Swainson's Thrush	1	PC1	0.55	0.30	12.07*	12.07*
	2	PC3	0.69	0.47	8.90*	12.19*
American Robin	1	PC1	0.48	0.23	8.26*	8.26*
	2	PC2	0.60	0.36	5.85*	7.77*
	3	**PC5	0.67	0.45	3.93*	7.05*
Hermit Thrush	1	PC1	0.46	0.21	7.35*	7.35*

* - significant at $\alpha = 0.05$
** - negative regression coefficient.

Table 10. Summary of step-wise regression analyses of adults of 7 bird species on factors of the vegetation. Degrees of freedom for F of Step: 1, N-k-1 and for Overall F: k, N-k-1 where N = number of cases = 30 and k = number of independent variables.

Species	Step	Factor	Multiple R	R^2	F of Step	Overall F
Yellow-rumped Warbler	1	PC7	0.62	0.38	17.40*	17.40*
Northern Waterthrush	1	PC2	0.45	0.21	7.28*	7.28*
	2	PC6	0.62	0.39	8.01*	8.56*
	3	PC3	0.71	0.50	6.06*	8.79*
Black-and-white Warbler	1	PC3	0.41	0.17	5.84*	5.84*
	2	PC1	0.58	0.33	6.49*	6.74*
	3	PC2	0.68	0.46	6.05*	7.35*
Blackpoll Warbler	1	**PC7	0.37	0.13	4.36*	4.36*
White-throated Sparrow	1	PC3	0.44	0.19	6.58*	6.58*
Lincoln's Sparrow	1	**PC5	0.25	0.06	1.90	1.90
Swainson's Thrush	1	PC3	0.68	0.46	23.74*	23.74*
	2	PC1	0.82	0.67	17.16*	27.30*
	3	PC6	0.86	0.74	7.56*	25.14*

* - significant at $\alpha = 0.05$

** - negative regression coefficient.

Table 11. Summary of step-wise regression analyses of immatures of 7 bird species on factors of the vegetation. Degrees of freedom for F of Step: 1, N-k-1 and for Overall F: k, N-k-1 where N = number of cases = 30 and k = number of independent variables.

Species	Step	Factor	Multiple R	R^2	F of Step	Overall F
Yellow-rumped Warbler	1	PC7	0.36	0.13	4.12	4.12
Northern Waterthrush	1	PC2	0.43	0.19	6.43*	6.43*
Black-and-white Warbler	1	PC2	0.50	0.25	9.20*	9.20*
Blackpoll Warbler	1	PC6	0.33	0.11	3.33	3.33
White-throated Sparrow	1	PC1	0.31	0.09	2.90	2.90
Lincoln's Sparrow	1	**PC5	0.46	0.21	7.45*	7.45*
Swainson's Thrush	1	PC1	0.54	0.30	11.82*	11.82*

* - significant at $\alpha = 0.05$

** - negative regression coefficient.

regressions. Each independent variable is tested for its independent contribution as it is included in the regression equation, by the F of Step. Overall F is a significance test of the multiple correlation value.

The regression analyses using total individuals captured in all 3 areas (Table 9), showed the distribution of 8 of the 11 species tested, to be significantly correlated with structural characteristics of the vegetation. Abundances of adults of 6 out of 7 species tested (Table 10), were found to be significantly correlated with vegetational factors, however, the abundances of immatures of only 4 of these 7 species (Table 11), were significantly correlated with vegetational factors. In only one case, the Lincoln's Sparrow, was the distribution of immatures found to be correlated with vegetational structures while the distribution of adults was uncorrelated. Bird abundances predicted from regression equations determined by step-wise multiple regression analyses of the control area only are given in Table 12. For all but one of the species tested the predicted numbers of adults and/or immatures were significantly higher than the observed numbers at both Big and Little Careless Cove Brooks, the exception being the Lincoln's Sparrow. For this species the predicted adult and immature abundances were

Table 12. Predicted and observed bird abundances.

Species	[1]Age	[2]Location	Predicted Abundance	Observed Abundance	X^2 (d.f.=1)	[3]p (0.001)
Yellow-rumped Warbler	AHY	B.C.C.B.	68.8798	13	46.14	*
	AHY	L.C.C.B.	194.74872	9	178.12	*
	HY	B.C.C.B.	729.51441	48	637.61	*
	HY	L.C.C.B.	1794.93217	48	1701.19	*
Northern Waterthrush	AHY	B.C.C.B	90.78004	30	41.36	*
	AHY	L.C.C.B.	290.54477	37	222.13	*
	HY - insufficient numbers at control area to predict					
Black-and-white-Warbler	AHY	B.C.C.B.	111.30583	20	75.72	*
	AHY	L.C.C.B.	414.8441	30	357.94	*
	HY	B.C.C.B.	36.57234	3	31.74	*
	HY	L.C.C.B.	20.03703	5	12.04	*
Blackpoll Warbler	AHY - insufficient numbers at control area to predict					
	HY	B.C.C.B.	129.74925	16	100.60	*
	HY	L.C.C.B.	414.94885	39	341.52	*
White-throated Sparrow	AHY	B.C.C.B.	147.30166	33	89.47	*
	AHY	L.C.C.B.	480.91955	40	405.16	*
	HY	B.C.C.B.	125.06872	60	34.37	*
	HY	L.C.C.B.	129.27958	80	19.16	*

Table 12 (cont'd.). Predicted and observed bird abundances.

Species	Age	Location	Predicted Abundance	Observed Abundance	X^2 (d.f.=1)	P (0.001)
Lincoln Sparrow	AHY	B.C.C.B.	42.82355	25	7.83	N.S.
	AHY	L.C.C.B.	3.86545	23	89.77	*
	HY	B.C.C.B.	65.44852	19	33.67	*
	HY	L.C.C.B.	2.96697	35	335.05	*
Swainson's Thrush	AHY - insufficient numbers at control area to predict					
	HY	B.C.C.B.	118.52702	23	77.80	*
	HY	L.C.C.B.	306.20176	142	88.59	*

[1]AHY = after hatching year; HY = hatching year

[2]B.C.C.B. = Big Careless Cove Brook; L.C.C.B. = Little Careless Cove Brook

[3]* = significant

significantly higher than the observed abundances at Big Careless Cove Brook while at Little Careless Cove Brook the predicted abundances were significantly lower than the observed abundances.

Blood parasites

In 1978, there were no significant differences between the control area and Big Careless Cove Brook in the prevalence of parasitism of the adult parulids, fringillids or turdids (Table 13). In 1979, however, adult fringillids showed a significantly higher prevalence of parasitism at Big Careless Cove Brook (X^2=9.96, d.f.=1, p<0.01) and at Little Careless Cove Brook (X^2=10.17, d.f.=1, p<0.01) than at the control area (Table 14). The prevalence of parasitism of adult fringillids did not differ significantly from 1978 to 1979. It was observed that the prevalence in 1979 dropped slightly at the control area and rose slightly at Big Careless Cove Brook. The prevalence of parasitism of adult parulids and turdids did not differ significantly from 1978 to 1979.

The prevalences of parasitism of immature parulids, fringillids and turdids in 1978 (Table 15) were statistically similar between the control area and Big Careless Cove Brook. In 1979, the immature parulids (Table 16), showed a significantly higher prevalence of parasitism

Table 13. Prevalence of blood parasites in adult birds in 1978.

Species	Joe Batt's Pond: Total Birds	Total Infected	Infections of H.*	Infections of L.**	Big Careless Cove Brk.: Total Birds	Total Infected	Infections of H.*	Infections of L.**
TYRANNIDAE								
Yellow-bellied Flycatcher	3	0			2	0		
PARIDAE								
Boreal Chickadee	2	0						
TURDIDAE								
American Robin	4	3	2	3				
Hermit Thrush	1	1		1	1	0		
Swainson's Thrush	3	3	2	3	7	5	3	2
	8	7	4	7	8	5	3	2
Prevalence ***		87	57	100		62	60	40
		±6%	±7%	±7%		±6%	±10%	±10%
BOMBYCILLIDAE								
Cedar Waxwing					1	0		
ICTERIDAE								
Rusty Blackbird					1	1		1
					1	1		1
Prevalence						100		100
						-50%		-50%

Table 13 (cont'd.). Prevalence of blood parasites in adult birds in 1978.

Species	Joe Batt's Pond				Big Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
PARULIDAE								
Black-and-white Warbler	2	0			3	2	1	2
Tennessee Warbler	2	1		1				
Yellow Warbler					1	0		
Magnolia Warbler	1	0			4	3		3
Yellow-rumped Warbler	9	8	3	6	10	8	7	2
Blackpoll Warbler	1	1		1	10	4	1	4
Ovenbird	2	1		1				
Northern Waterthrush	6	1		1	6	3		2
Mourning Warbler	4	2		2	4	1		1
Wilson's Warbler	2	0			5	3		3
	29	14	3	12	43	24	9	17
Prevalence		48%	21 +3%	86 +3%		56%	37%	71%
FRINGILLIDAE								
Purple Finch	2	1		1				
Pine Grosbeak					1	0		
Pine Siskin	3	1		1				
White-throated Sparrow	16	13	7	10	22	20	17	15
Fox Sparrow	3	2	1	2	5	4	1	3
Lincoln's Sparrow	5	3	1	2	8	5	4	3
Swamp Sparrow					1	0		
	29	20	9	16	37	29	22	21
Prevalence		69%	45	80%		78%	76%	72%
Totals	71	41	16	35	92	59	34	41
Prevalence		58%	39%	85%		64%	58%	69%

* - *Haemoproteus* spp. ** - *Leucocytozoon* spp. *** - range not given when less than 5%.

Table 14. Prevalence of blood parasites in adult birds in 1979.

Species	Joe Batt's Pond				Big Careless Cove Brk.				Little Careless Cove Brk.			
	Total Birds	Total Infections	Infections of H.*	Infections of L.**	Total Birds	Total Infections	Infections of H.*	Infections of L.**	Total Birds	Total Infections	Infections of H.*	Infections of L.**
FALCONIDAE												
Sparrow Hawk					1	0						
PICIDAE												
Yellow-shafted Flicker	1	0							2	0		
Hairy Woodpecker									1	0		
Downy Woodpecker					1	0			3	0		
	1	0			1	0			6	0		
TYRANNIDAE												
Yellow-bellied Flycatcher	20	0			23	0			49	1		
HIRUNDINIDAE												
Tree Swallow									2	1		1
CORVIDAE												
Gray Jay	1	0							2	0		
PARIDAE												
Black-capped Chickadee	4	2		2	2	0			1	0		
Boreal Chickadee	5	1		1	3	0						
	9	3		3	5	0			1	0		
Prevalence***		33 ±5%		100 ±17%								

Table 14 (cont'd.). Prevalence of blood parasites in adult birds in 1979.

Species	Joe Batt's Pond				Big Careless Cove Brook				Little Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
PARULIDAE												
Black-and-white Warbler	20	3		3	20	6		6	29	9	2	8
Tennessee Warbler	4	1		1	2	2		2	1	0		
Yellow Warbler	1	0			1	0			2	1		1
Magnolia Warbler	6	2	1	2	7	2		2	9	2/3	1	1
Yellow-rumped Warbler	25	21	17	8	13	12	12	4	9	9	9	3
Blk.-throated Green Warbler	2	2	1	2								
Blackpoll Warbler	3	1	1	1	17	7	2	5	22	9	1	8
Palm Warbler					1	1	1					
Ovenbird	8	1	1						1	0		
Northern Waterthrush	28	4		3	29	10	2	7	34	11	2	10
Mourning Warbler	8	2		2	4	1	1		9	1		1
Wilson's Warbler	6	1		1	10	4	1	4	17	2		2
American Redstart	4	1		1								
Bay-breasted Warbler					1	0						
Nashville Warbler					1	0						
	115	39	21	24	106	47	19	30	133	55	15	34
Prevalence		34%	54%	61%		44%	40%	64%		41%	27%	62%

* - *Haemoproteus* spp.

** - *Leucocytozoon* spp.

*** - range not given when less than 5%

Table 14 (cont'd.). Prevalence of blood parasites in adult birds in 1979.

Species	Joe Batt's Pond				Big Careless Cove Brook				Little Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
TURDIDAE												
American Robin	10	10	7	6	8	8	8	2	6	4	2	4
Hermit Thrush	1	0			2	0			6	0		
Swainson's Thrush	14	8	5	5	19	7	5	3	39	22	18	10
Gray-cheeked Thrush					1	0			1	0		
	25	18	12	11	30	15	13	5	52	26	20	14
Prevalence		72%	67 ±3%	61 ±3%		50	87 ±3%	33 ±3%		50%	77%	54%
SYLVIIDAE												
Ruby-crowned Kinglet	5	0			1	0			1	0		
Golden-crowned Kinglet	2	0										
	7	0			1	0			1	0		
FRINGILLIDAE												
Purple Finch	5	3	2	3	1	0			3	2		2
Pine Grosbeak					2	1	1	1	3	3	1	1
White-throated Sparrow	36	24	18	10	33	29	27	11	40	36	36	13
Fox Sparrow	3	1	1		8	7	5	5	17	14	12	9
Lincoln's Sparrow	17	10	10	5	25	22	21	12	21	16	16	8
Swamp Sparrow	1	0										
	62	38	31	18	69	59	54	29	84	71	65	33
Prevalence		61%	82%	47%		85%	91%	49%		84%	91%	46%

Table 15. Prevalence of blood parasites in immature birds in 1978.

Species	Joe Batt's Pond				Big Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
PICIDAE								
Hairy Woodpecker	1	0						
Downy Woodpecker	1	0						
	2	0						
TYRANNIDAE								
Yellow-bellied Flycatcher	3	0			8	2		1
Prevalence***	3	0			8	2 25 ±6%		1 50 ±25%
PARIDAE								
Black-capped Chickadee	2	0						
Boreal Chickadee	3	0			2	1		1
Prevalence	5	0			2	1 50 ±25%		1 100 ±50%
TURDIDAE								
American Robin	2	1	1	1	1	1		1
Swainson's Thrush	3	1			3	1		
Prevalence	5	2 40 ±10%	1 50 ±25%	1 50 ±25%	4	2 50 ±13%		1 50 ±25%
SYLVIIDAE								
Ruby-crowned Kinglet					1	0		

Table 15 (cont'd.). Prevalence of blood parasites in immature birds in 1978.

Species	Joe Batt's Pond				Big Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
PARULIDAE								
Black-and-white Warbler	1	0			4	1		1
Tennessee Warbler	1	1		1				
Magnolia Warbler					3	2		2
Yellow-rumped Warbler	13	9	8	7	19	15	13	6
Blk.-throated Green Warbler	1	1		1				
Blackpoll Warbler	1	1		1	10	2		2
Palm Warbler					4	3	3	
Ovenbird	3	1		1				
Northern Waterthrush	13	9		9	23	11	1	11
Mourning Warbler					3	3		3
Wilson's Warbler					2	0		
	33	22	8	20	68	37	17	25
Prevalence		67%	36%	91%		54%	46%	68%
FRINGILLIDAE								
Purple Finch					1	0		
Slate-coloured Junco					1	1		1
White-throated Sparrow	8	6	2	6	19	18	[illegible]	[illegible]
Fox Sparrow	1	0			1	1	1	1
Lincoln's Sparrow	3	2	2	1	12	9	6	6
Swamp Sparrow	1	0			1	1		
	13	8	4	7	35	30	20	21
Prevalence		61 +3%	50 +6%	87 +6%		86%	67%	70%

* - *Haemoproteus* spp.

** - *Leucocytozoon* spp.

*** - range not given when less than 5%

Table 16. Prevalence of blood parasites in immature birds in 1979.

Species	Joe Batt's Pond				Big Careless Cove Brk.				Little Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
TYRANNIDAE												
Yellow-bellied Flycatcher	18	1		1	5	0			13	0		
Prevalence ***		5%		100 -50%								
CORVIDAE												
Gray Jay	3	0										
PARIDAE												
Black-capped Chickadee	1	0										
Boreal Chickadee	3	0										
	4	0										
TURDIDAE												
American Robin	12	6	4	3	3	2	1	1	22	11	6	9
Hermit Thrush	7	1		1	6	1		1	34	5	1	2
Swainson's Thrush	45	7	5	1	24	4	2	1	141	12	4	6
Gray-cheeked Thrush									2	0		
	64	14	9	5	33	7	3	3	199	28	11	17
Prevalence		22%	64 ±3%	36 ±3%		21%	43 ±7%	43 ±7%		14%	39%	61%
SYLVIIDAE												
Ruby-crowned Kinglet	37	0			5	0			25	0		
Golden-crowned Kinglet	2	0										
	39	0			5	0			25	0		

Table 16 (cont'd.). Prevalence of blood parasites in immature birds in 1979.

Species	Joe Batt's Pond				Big Careless Cove Brk.				Little Careless Cove Brk.			
	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**	Total Birds	Total Infected	Infections of H.*	Infections of L.**
FRINGILLIDAE												
Purple Finch					4	0			5	0		
Slate-colored Junco					1	1	1	1	1	0		
White-throated Sparrow	59	26	16	14	49	39	35	20	66	55	50	18
Fox Sparrow	5	5	4	5	3	3	3	2	2	2	2	1
Lincoln's Sparrow	43	21	13	11	18	13	11	7	30	23	18	11
Swamp Sparrow	1	0							1	1	1	1
	108	52	33	30	75	56	50	30	100	81	71	31
Prevalence		48%	63%	58%		75%	89%	54%		81%	88%	38%
PARULIDAE												
Black-and-white Warbler	22	3		3	3	1		1	4	2		2
Tennessee Warbler					1	0			4	0		
Yellow Warbler									1	1		1
Magnolia Warbler	5	3		3	4	2		2	7	1		1
Yellow-rumped Warbler	198	122	97	62	44	33	27	17	46	34	33	12
Blk.-throated Green Warbler	3	1		1								
Blackpoll Warbler	26	12		12	13	8	6	7	33	10	3	8
Palm Warbler					9	5	3	3	8	3		3
Ovenbird	8	0							1	0		
Northern Waterthrush	84	19		19	20	9		9	57	14	2	13
Mourning Warbler	8	1		1					11	0		
Wilson's Warbler	4	0							3	0		
American Redstart	14	2		2					5	1		1
	372	163	97	103	94	58	36	39	180	66	38	41
Prevalence		44%	59%	63%		62%	62%	67%		37%	58%	62%

* - *Haemoproteus* spp.

** - *Leucocytozoon* spp.

*** - range not given when less than 5%

at Big Careless Cove Brook than at both Little Careless Cove Brook (χ^2=15.60, d.f.=1, p<0.001), and at the control area (χ^2=9.62, d.f.=1, p<0.01). Both Big and Little Careless Cove Brooks had significantly higher prevalences of parasitism of immature fringillids in 1979 than did the control area, (χ^2=29.38, d.f.=1, p<0.001) and (χ^2=19.07, d.f.=1, p<0.001) respectively.

The prevalence of Haemoproteus in adult parulids was significantly higher in 1979 (Table 14) at Little Careless Cove Brook than at the control area (χ^2=6.82, d.f.=1, p<0.01). The Haemoproteus prevalence was also significantly higher in 1979 as compared to 1978 in adult fringillids at the control area (χ^2=8.21, d.f.=1, p<0.01). The prevalence of Haemoproteus in immature fringillids was significantly lower at the control area in 1979 (Table 16), than at both Big and Little Careless Cove Brooks, (χ^2=10.11, d.f.=1, p<0.01) and (χ^2=10.87, d.f.=1, p<0.001) respectively.

In adult fringillids, the Leucocytozoon prevalence was similar at the control area (χ^2=5.75, d.f.=1, p>0.01) and Big Careless Cove Brook (χ^2=4.28, d.f.=1, p>0.025) in 1978 compared with 1979. In 1978 the prevalence of Leucocytozoon in immature parulids at the control area was significantly higher (χ^2=6.68, d.f.=1, p<0.01) than in 1979.

DISCUSSION

Differences were observed in the species abundances of the bird populations of the 3 areas studied. Habitat variation accounts for a portion of these differences. Before possible effects of spraying on the bird populations could be quantified, the expected bird abundances had to be adjusted for these habitat differences between the sites. The results of the regression analyses (Tables 9, 10 and 11, pages 59, 60 and 61) were used. Net sites scoring high on Factor 1 were present throughout Little Careless Cove Brook, at one site at Big Careless Cove Brook and virtually absent at the control area. This Factor accounted for 16% of the variation in distribution of adult Black-and-white Warblers, for 21% in adult Swainson's Thrushes and for 30% in immature Swainson's Thrushes. Therefore, for these species a substantial amount of any differences in abundance between sprayed and control areas could be due to this habitat difference. Before spraying, populations of these species in the control area are expected to be lower than the population at Little Careless Cove Brook, making evaluations of the impact of the spray program on these species difficult. Areas scoring high on Factor 2 were present throughout most of the control area but less abundantly at Little and Big Careless Cove Brooks. This Factor accounted for 21% of the distribution variation of adult Northern Waterthrushes, for 13% in adult Black-and-white Warblers, for 19% in immature Northern Waterthrushes and for 25% in immature Black-and-white Warblers. Areas rating highly on Factor 3 were most abundant at Little Careless Cove Brook. The variances of the 3 areas for Factor 3 were heterogeneous with the largest variance occurring at Big Careless Cove Brook (Fig. 7, page 57). From the factor scores it was observed that the net 2 score at Big Careless Cove Brook was more than 2 standard deviations larger than the mean score of the nets in this area for Factor 3. Because a regression equation which includes a variable with an "outlier" value may overemphasize that variable it was necessary to examine the predicted abundances (at net 2) of species which had been shown to choose for Factor 3. Seventeen percent of the variation in distribution of adult Black-and-white Warblers, 19% in adult White-throated Sparrows and 46% in adult Swainson's Thrushes were explained by this factor. The predicted abundances of adult Black-and-white Warblers and White-throated Sparrows at net 2 were lower than the observed abundances. Because predicted abundances overall for Big Careless Cove Brook were significantly higher than the observed abundances for both species the inclusion of the deviant net 2 does not greatly confound the results. Because of low numbers of adult Swainson's Thrushes at the control area the predicted abundance was derived from the pooled data of 3 areas and is therefore less rigorous, as it reflects any effects of the spray program as well as effects of habitat differences between sites. By this method the predicted and observed abundances for this species were similar at net 2 and additionally for the locale as a whole. Twenty-one percent of the distribution variation of immature Lincoln's Sparrows was explained by Factor 5. The regression coefficient was negative, indicating that areas scoring high on Factor 5 (i.e. areas with many Trembling Aspens and trees of size class C) would have the fewest Lincoln's Sparrows. Factor 6 explained 18% of the variation in distribution of adult Northern Waterthrushes and 7% of the variation in adult Swainson's Thrushes. The variances of the 3 areas for Factor 7 were heterogeneous with the greatest variance occurring at the control area. Nets 2 and 9 in this area were outliers for this factor (both in a positive direction). Thirty-eight percent of the variation in distribution of adult and 13% in immature Yellow-rumped Warblers were attributable to Factor 7. For these populations, densities increased with increasing scores on Factor 7. Thirteen percent of the variation in distribution of adult Blackpoll Warblers was explained by a negative relationship to this factor. Because the predicted abundances of adult and immature Yellow-rumped Warblers at the sprayed areas were determined from regression equations captured. Other species, e.g. Tree Swallows and Sparrow Hawks, are rarely caught in mist nets due to their high flying habits. Since the mist netting technique does not provide information on the population dynamics of uncommon species or of species with certain behavioural patterns, the current study cannot evaluate the effects of the spray applications on such species. However, because the largest number of individuals captured (more than 90%) were members of the species common to all 3 areas, the communities are sufficiently similar, once vegetational effects have been accounted for, to allow comparisons of the effects of spray applications on these more common species.

In a study of passeriforms of insular Newfoundland during 1969-71, Bennett et al., (1974) report that the family Parulidae comprised 35.6% of the individuals captured by mist nets, the family Fringillidae 29.8% and the family Turdidae 18.7%. The percentages determined by the current study differ somewhat from these figures, especially for the family Parulidae. This discrepancy is probably due to both the considerable time span over which the Bennett study was conducted and the 5 widely separated (geographically and ecologically) areas which it sampled. The results of the current study also diverge somewhat from the Family composition of 3 Newfoundland communities as shown by Woodworth (1978), probably as a result of the small sample size and possible habitat differences of the latter.

The relative consistency of the rate of capture of adult birds throughout the season confirms the exclusion from the data of large numbers of birds passing through the areas on migration routes. The adults captured may be presumed to be on or near their breeding/foraging areas. The slight variation at the beginning of the season is probably due to the greater mobility of birds who are not yet involved in egg-laying and whose territorial boundaries are not settled. The variation observed at the end of the netting season is probably a result of the increased activity levels of the adult birds whose young have fledged and who would therefore, be less restricted to the nesting areas. The inclusion of small numbers of late spring migrants and early fall migrants may also contribute to the observed variations.

The first immatures of the year were netted in all 3 areas during the early part of July. Immatures were first captured several days later in the control area than in the two sprayed areas. This difference was probably an artifact of the sampling regime in that netting was carried out at the control area on only 1 of the 3 days between the first immature capture at the sprayed areas and the first immature capture at the control area. The peak capture rate of immatures at Big Careless Cove Brook occurred a week later than at the control area and Little Careless Cove Brook. Since weather conditions appeared similar on the netting days involved, it seems that the fledging of young in the Big Careless Cove Brook area may have been somewhat later than in the other areas. The lag in fledging time might imply a lower food supply in this area. At the end of the season, the capture rate of immature birds declined at both the control area and Little Careless Cove Brook. A similar decline was not observed at Big Careless Cove Brook. Considering the time lag in peak capture at this area, however, netting may have ceased prior to this phase. The reason for the observed increase in the immature capture rate during the final week of netting in the control area is unclear. If the increase was a result of the initial assembling of the birds prior to fall migration similar increases should have been observed in the other areas.

Species substitution as suggested by Morris et al., (1958) was not observed, although this may be due in part to the fact that budworm specialists such as the Cape May, Bay-breasted and Blackburnian Warblers (see Kendeigh, 1947; MacArthur, 1958; Morris et al., 1958; Sanders, 1970) are uncommon in Newfoundland (Tuck and Maunder, 1975). The Tennessee Warbler, another budworm specialist, while common in Newfoundland according to Tuck and Maunder (1975), was not captured in large enough numbers to enable valid comparisons between the 3 areas.

A comparison of the adult return rates indicated that the proportion of adult birds returning to Big Careless Cove

Brook was higher than the proportion of adult birds returning to the control area. The difference observed was not however, significant at the required level of significance. Hinde (1956) says that circumstantial evidence suggests that familiarity with an area may assist feeding, predator avoidance and fighting potential. Hilden (1965) says that the learned characteristics of the familiar breeding station increase the effect of the innate sign stimuli to the point where a bird will settle in the familiar place, even though that place may, through various disturbances, be no longer within the desired habitat range of the bird. It would appear, therefore, that a decrease in food supply, as could occur in a sprayed area, might not decrease the number of adults returning to breed in that area, at least not for the first season subsequent to spraying. However, the optimality of habitat selection can produce annual fluctuations in the density of birds in an area. According to Wiens (1976) habitat types in an ideal situation should be selected by individuals on the basis of fitness prospects. These prospects may be a function of the population density in the habitat and the intrinsic quality of the habitat type. At low population levels only optimum habitat would be utilized but with increasing density a point is reached where other habitats have equal potential. The bird density of the areas may be an additional explanation of the observed adult return rates. For example, a low density in a sprayed area may increase its desirability despite a potentially lower food abundance while a high density in an unsprayed area may lessen its desirability despite a potentially higher food supply. Additionally, because Hudson (pers. comm.) has found significant differences in the degree of site tenacity of certain species of passerines in New Brunswick, it should be noted that the return rates determined by the current study provide an average figure only, since, due to insufficient numbers, they have been calculated on a combined basis rather than separately by individual species.

The return rate of immature birds in the present study was considerably lower than that of adult birds. This was not unexpected since Hilden (1965) states that in all species so far studied, the young birds return to the birth-place in a smaller proportion than the old birds. He suggests that imprinting of the young birds onto their environment occurs some weeks after they have left the nest and may have already dispersed at a distance from their birth-place. In addition, birds breeding for the first time may not be able to establish territories near their birth-place due to the presence of older males who usually are earlier migrants and are also superior in territorial defense. The results showed the immature return rate for the control area to be somewhat lower than that for Big Careless Cove Brook. This would be consistent with the adult bird density being depressed at the sprayed area and/or the adult bird density being at or near a maximum at the control area. However it should be noted that this comparison is based on small percentages and should be regarded with caution. Additionally, the immature return rate is, like the adult rate, based on combined species returns and is subject to the same constraints as noted for adults. Furthermore, in 1978, from the raw data provided, the banding of immatures appears to have been irregular and may have introduced additional error in the form of differential banding of species.

The similarity between the repeat rates of adult birds, at the control area and Big Careless Cove Brook in 1979, indicates that the communities were equally sampled in both areas. At both areas the adult repeat rates showed the same pattern throughout the season with higher rates during the first 5 weeks of netting and a sharp decline around the time of first capture of immatures followed by a more gradual decline. The adult repeat rates at Little Careless Cove Brook during the 3 weeks netted prior to fledging of young were lower than at the other areas. Little difference was observed between the repeat rates of the areas in the post-fledging period. The lower adult repeat rate at Little Careless Cove Brook may be due to the somewhat larger sampling area involved. Because the adult same net repeat rates (which would not have been affected by size or area) were similar among the 3 areas, it does not appear that the adults were moving more in any one of the areas. The immature repeat rate was similar in all 3 areas. The larger sampling area of Little Careless Cove Brook would not be expected to have as great an effect on the more mobile immatures. The repeat rates given by Northcott (1979) for the bird communities at Joe Batt's Pond and Big Careless Cove Brook are 28% and 26% respectively. This rate would appear to be somewhat high unless it is meant to refer to the adult repeat rate only. Bragg (1977) at Salmonier Park, Newfoundland, gives a repeat rate of 20%. Because both the Northcott (1979) and Bragg (1977) studies involved relatively small sample sizes it would seem likely that the repeat rates found by the current study are the least biased. Between otherwise comparable studies, accuracy varies as 1/n. Therefore, the sampling error in the present study (0.034 for the control area, 0.046 for Big Careless Cove Brook and 0.034 for Little Careless Cove Brook) is about half that of Bragg (1977 - 1/n =0.080). The accuracy of the Northcott (1979) study could not be determined because of a differing methodology.

The results clearly show the proportions of the communities composed of adults of insectivorous species to be approximately the same in all 3 areas in 1979. While the control area showed a slight increase from 1978 to 1979 in the proportion of adult insectivores this increase was not significant at the required level of significance. Because of the similarity between areas in 1979, it seems likely that the 1978 capture of insectivores at the control area was artificially somewhat low, possibly due to a differential netting effort.

The results show the sex composition of the parulid adults to be somewhat different from that of the fringillid adults at the control area. The number of parulid males observed was greater than the number of parulid females while male and female fringillids were observed in relatively equal numbers. This was not however different at the required level of significance. The reasons for this difference could not be determined within the parameters of the current study. It is possible that male parulids were invading the control area to forage, however the similarity of the male:female ratios at the control area and Big Careless Cove Brook would appear to negate this hypothesis. The difference may result from a differential likelihood of capture of the males of the two families, to the presence of male parulid "floaters" or to chance.

It is assumed that the netting technique will sample the same species equally, in different areas. Therefore, if the numbers of adults of a particular family are similar in different areas, it follows that the numbers of immatures of that family captured should also be similar between the areas. Conversely, if there were a greater number of adults of a particular family caught in an area, then one would expect to capture a higher number of immatures of that family in the area. It should be noted however that mist nets may capture adults and immatures differentially and therefore any adult:immature ratios given may be biased. This bias would not, however, be expected to affect the three areas differentially, unless the vegetational differences discussed earlier are reflected in different habitat use patterns of juvenile and adult birds.

Because the adults of the family Parulidae occurred as similar proportions of the community in the areas studied, in both 1978 and 1979, it was expected that the numbers of parulid immatures captured would be similar among the areas, and, for both years. From the results, however, it can be seen that this did not occur. Rather, the number of immatures captured at the control area was far higher in 1978 than at Big Careless Cove Brook, and, in 1979 than at either of the sprayed areas. Furthermore, predictions from the regression equations on the basis of the vegetation indicate that the numbers of immature Yellow-rumped Warblers, Black-and-white Warblers and Blackpoll Warblers were lower than expected at Big Careless Cove Brook and at Little Careless Cove Brook.

Because it seemed unlikely that the netting technique was capturing immatures disproportionately between the areas, it became necessary to postulate alternative explanations for the observed differences: (1) that the adult birds at the control area produced more young, either by increasing clutch size, increasing fledging success, the successful completion of second broods, or a combination of these factors, (2) that the large number of immatures at the control area had not all been fledged in the area but were coming in to the area to forage, presumably due to the high budworm level, (3) that the adult birds of the sprayed areas produced fewer than the maximum possible number of young, (4) that the spray applications had, in some manner, affected the biological reproductive processes of the birds.

According to Chapman (1917), the average clutch size of parulids is 4 for every breeding pair. Assuming a high degree of success, it seems likely that a maximum of 3.5 young would be successfully fledged by each breeding pair.

Considering postulate (1) above, while this could not be conclusively proven, due to the lack of pre budworm infestation data, it could be subject to rejection, if for example, the number of immatures captured was in excess of that which the adults of the area could reasonably be expected to produce. The observed parulid ratio at the control area was 3.21 immatures for every 1 adult or 6.42 immatures for every 2 birds. It can be seen from the results, as well, that the number of male parulids captured was consistently higher than the number of female parulids captured, possibly due to a greater mobility of the males who spend a lesser time incubating than do the females. If the possibility of a floater population is ignored and it is assumed that each individual male captured was a territory holder in the general area and further assumed that each male captured represents a breeding pair, then the ratio at the control area in 1979 would be 5.79 immatures for every breeding pair. If double clutching by many of the breeding pairs occurred, this ratio is within the realm of plausibility especially in view of the exceptionally good weather of the 1979 season. However, if one makes the same assumptions for 1978, the ratio at the control area would be 10.94 immatures for every breeding pair. This ratio is somewhat elevated because Northern Waterthrushes were all recorded as sex unknown in 1978. Since the spring and summer of 1978 were cold and wet, it is unlikely that more than a hardy few could have produced double clutches. It seems highly unlikely that breeding pairs would have been more successful in a poor weather season than in a good weather season in the same area. Since postulate (1) is not, therefore, acceptable as a complete explanation of the observed differences, the second postulate, that the large number of immature parulids captured at the control area had not been produced there but were coming in to the area to forage would seem to be the more plausible.

The testing of postulate (3) follows the same reasoning as that for postulate (1) above. At Big Careless Cove

Brook, again assuming that each male captured represents a breeding pair, the ratio was 1.72 and 1.82 immatures for every breeding pair for 1979 and 1978, respectively (the unadjusted ratios being 2 adults : 1.94 immatures in 1979 and 2 adults : 1.83 immatures in 1978). At these levels, if adult and immature mortality rates were to average greater than 50% per year, the population would be declining. It should be noted that a decline could be occurring and not be detected if there was yearly influx from successful progeny of neighbours. However, alternatively, since as noted earlier, immatures are less attached to their birth-place and consequently move over larger areas than do adults, it is also possible that they are moving out of the low budworm density, sprayed area to forage in adjacent high budworm density, unsprayed areas.

While the proportions of adult parulids did not differ between the Big and Little Careless Cove Brook areas, the capture of immature parulids was somewhat larger at the latter area as compared with the former (2 adults : 1.94 immatures compared with 2 adults : 2.75 immatures). Since Little Careless Cove Brook was the area which presumably received the greater spray deposit, it appears that the spray application may not have altered the biological reproductive processes of the birds. A definitive conclusion can not, however, be made within the parameters of the current study. It should be noted in addition, that the observed decrease in the post-fledging adult repeat rates is consistent with (i) the large number of immatures at the control area not being fledged in the area but coming into the area to forage and/or (ii) that the adult birds at the sprayed areas produced fewer young because both options would result in increased adult mobility. In addition, the results may be confounded by seemingly minor differences in habitat between the sprayed areas. Further differences may be foraging related since actual budworm densities may fluctuate within and between sprayed areas.

Considering the Family Fringillidae, the numbers of adults, as a proportion of the total adult population, showed no differences either between areas or between years. There were also no differences observed in the immatures captured. However, the numbers of both adult and immature White-throated Sparrows predicted by the regression equations were significantly higher than the observed numbers at both sprayed areas. Additionally, at Big Careless Cove Brook the predicted numbers of immature Lincoln's Sparrows was also higher than the observed numbers. For Little Careless Cove Brook, however, the predictions for adult and immature Lincoln's Sparrows were lower than the observed numbers. The reason for the higher than predicted numbers of Lincoln's Sparrows at Little Careless Cove Brook is unclear especially in view of the fact that the habitat the immatures "disliked" occurred relatively equally in the three areas (see Fig. 7, page 57). The observed adult:immature ratios of the fringillids were somewhat lower than expected since Bent (1968) gives the usual clutch size as being from 4-5. This may be due to the greater mobility of the immatures and the shorter time period over which the immature portions of the communities are sampled.

In 1978 the adult : immature ratios for the family Turdidae were similar in both the control and the sprayed area. In 1979, however, captures of immature turdids at Big Careless Cove Brook were lower than at the other 2 areas. According to Bent (1949) the usual clutch size of the turdid species captured is 3-4. The observed ratios in 1979 are for the control area 5.48 immatures for each breeding pair, for Little Careless Cove Brook 7.88 immatures for each breeding pair and for Big Careless Cove Brook 2.06 immatures for each breeding pair. The ratio at Big Careless Cove Brook may be considered usual in view of the predicted clutch sizes. The number of immature Swainson's Thrushes was, however, lower than predicted by the regression equation on the basis of the vegetation. The multiple regression analyses indicate that the high number of immature turdids observed at Little Careless Cove Brook was at least partially habitat related. Areas scoring high on Factor 1 were present throughout the area, and 30% of the variation in the distribution of immature Swainson's Thrushes was shown to be attributable to this factor. Nevertheless predictions from the regression equations indicated that the observed numbers were lower than expected on the basis of the vegetation.

Because the mist-netting technique captures those birds which are moving about in the vicinity of the net and because a major mobile activity of birds is foraging related, it seems reasonable to suggest that the birds captured in this study represent the birds foraging in the area. For the adult portion of the population whose movements are restricted by such pressures as territory defense, nest-building, incubation and feeding of young, it may be assumed that their foraging will be done as closely as possible to the nesting area. Therefore, for the most part, the adults captured by netting at least in the period prior to fledging are probably nesting within a short distance of the net. From the seasonal patterns of the adult repeat rates at the control area and Big Careless Cove Brook it was observed that the rates prior to the fledging period were highest, a steep drop occurred at the time of fledging followed by lower repeat rates throughout the post-fledging period.

The overall prevalences of blood parasites observed in the current study were not as would be expected if the spray applications had affected the vector populations. Instead, where differences did occur between the sprayed areas and the control, it was the sprayed areas which showed the higher level of parasitism. While these differences should be regarded with caution since they did not appear consistently for both years or for all of the families tested, it is possible that birds of the sprayed areas were undergoing stress due to food shortages and hence would be more susceptible to, and carry higher levels of, the blood parasites.

The prevalences of parasitism in the total populations of the control area and Little Careless Cove Brook, in 1979, were similar to those reported by Bragg (1977) (see Appendix D), Woodworth (1978) and as suggested by Greiner _et al._, (1975) for Region 5 of North America. They were, however, considerably lower than reported by Bennett _et al._, (1974). Unfortunately, previous research on the blood parasites of the Newfoundland avifauna does not separate the adult and immature portions of the populations studied. Therefore, comparison between studies may be invalid due to disproportionate age compositions of the various populations. In addition, disproportionate representation of families may also produce differences which preclude comparisons between studies.

The prevalences of the individual parasites determined by the current study do not allow the drawing of any conclusions. As with the overall prevalence, differences, when present within a year, involved higher levels of parasitism in one or other of the sprayed areas. No consistent pattern was, however, discernable.

In viewing the various components of the current study as a whole, it is evident that the major difference between the areas studied is the larger than expected number of immature birds present in the control area and the lower than expected number of immatures in the sprayed areas. It seems probable that this difference is directly related to the available food supply. The high numbers at the control area result from immatures invading the area to forage on the high density spruce budworm population. Comparably, the low numbers in the sprayed areas result from the immatures leaving the areas where the food supply has been diminished (presumably due to insecticide applications) to forage in areas of more abundant food supply. In view of the higher predicted than observed abundances at the sprayed areas for the adults and for the immatures of several species it is also probable that there was a depressed success rate in the sprayed areas.

It should be noted that while the regression predictions made are the best possible, there are 2 areas of possible weakness: (i) there are 8 independent variables (the principal components) and only 10 cases (the control net sites), and (ii) at the 10 cases, for some species there are quite low numbers of captures/net, so small differences (e.g. 2 compared to 5 captures) could easily be sampling related rather than "real", but could still greatly affect the regression equation. Ideally future studies should include more control net sites (which would lower the Type I error rate) and each net should catch more birds (giving greater accuracy in resolution of the regression line).

In the 3 areas studied, the bird populations are each responding to abnormal situations i.e. an insect epidemic at the control area and insecticide spraying in the other 2 areas. It seems probable that large scale insecticide applications could reduce the available food supply, particularly in marginal habitats, to a level where the survival of the insectivorous bird populations is threatened.

SUMMARY AND CONCLUSIONS

1. Avian communities were monitored by a mist-netting census technique in 3 areas of central Newfoundland during the breeding season of 1979 to investigate the longer-term effects of an aerial insecticide application. Comparative studies from 1978 were presented for 2 of the areas.

2. In 1979, 19 species captured were common to the 3 areas. These species comprised 93.2% of the total individuals captured at the control area, 95.1% at Big Careless Cove Brook and 95.6% at Little Careless Cove Brook.

3. The number of adult birds captured per netting-hour in 1979 was relatively similar in all 3 areas throughout the season. The capture rate of immature birds followed the same pattern in all 3 areas, however a lag (possibly food supply related) was observed in the peak capture time at Big Careless Cove Brook.

4. The adult and immature return rates were similar at Big Careless Cove Brook and at the control area. The adult return rate was higher than the immature return rate at both areas.

5. The adult repeat rate in 1979 was similar at the control area and Big Careless Cove Brook. At Little Careless Cove Brook the adult repeat rate was lower than at the other two areas. It is suggested that this may be a result of the larger area censused at Little Careless Cove Brook. The immature repeat rates were similar at all 3 areas. The adult repeat rate was higher than the immature repeat rate at all areas.

6. Adult "same net" repeat rates indicated that the adults were not moving more in any one of the areas. The seasonal pattern of the adult repeat rates was similar at the control area and Big Careless Cove Brook.

7. Adult parulids, fringillids and turdids comprised similar proportions of the total adult individuals at all 3 areas in 1979, at both areas studied in 1978 and in both years.

8. The number of insectivorous adults as a proportion of adult individuals was similar in all 3 areas in 1979.

9. The number of immature parulids captured was higher at the control area than at Big Careless Cove Brook (1978 and 1979) and than at Little Careless Cove Brook (1979). Little Careless Cove Brook had a higher number than did Big Careless Cove Brook. The numbers captured were similar in both years. The large number of immature parulids captured at the control area were probably coming in to the area to forage. The lower numbers captured at the sprayed areas may indicate that the parulid immatures were moving out of an area of low budworm density to forage in adjacent high budworm density, unsprayed areas and/or reproductive success was depressed in these areas.

10. The number of immature fringillids captured was similar for all areas and for both years.

11. The number of immature turdids captured in 1979 was lower at Big Careless Cove Brook than at the control area and Little Careless Cove Brook. This difference was partially explained by vegetational variation.

12. Principal component analysis of 22 measured vegetational variables gave 8 Factors which explained 79.2% of the variation in the data. Confidence intervals calculated from the factor scores for the 10 net sites within each area showed sites scoring high on Factor 1 were absent at the control area and present throughout Little Careless Cove Brook indicating a habitat difference between these areas. Overlapping of all 3 areas was observed for all other Factors. Variances were found to be heterogeneous for Factors 3,4 and 7, indicating that some net locations were vegetationally different for these factors from the vegetation typical of the areas as a whole.

13. Step-wise multiple regression analyses showed the distribution of adults of 6 out of 7 species tested to be predicted by vegetational factors as were the immatures of 4 of these 7 species. Adults of 4 species occurred at Big Careless Cove Brook and at Little Careless Cove Brook in lower numbers than predicted by the regression equations. Immatures of 6 species at Big Careless Cove Brook and 5 species at Little Careless Cove Brook occurred in lower numbers than predicted by the regression equations on the basis of the vegetation. These differences between observed and predicted numbers are probably an impact of insecticide spraying.

14. Blood smears taken in 1978 and 1979 were examined to determine the overall prevalences of blood parasites and the prevalences of the parasite species <u>Haemoproteus</u> and <u>Leucocytozoon</u>. While differences were observed between areas and between years no overall pattern could be determined.

15. The 1978 aerial application of the insecticide Matacil appears to have directly and/or indirectly affected the avian communities of the areas studied probably through food supply disruptions.

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APPENDIX A

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner (1974)	Larose For., Ontario	Not given	Fenitrothion	2 oz/acre 3-4 oz/acre 4 oz/acre 18 oz/acre	Not given	Reduced singing and movement Some mortality - mainly nestlings and fledglings. Adult mortality Complete mortality in: Chipping Sparrows, Maryland Yellowthroats and Yellow Warblers. Reduced numbers in: Nashville and Blackburnian Warblers and Purple Finches. Impaired fledglings in: Tennessee Warbler and Pine Siskin.
Buckner et al., (1974)	Menjou, Que.	Not given	Fenitrothion Matacil	Not given Not given	?June 1, 1973 ?June 11, 1973	Not monitored Post-spraying monitoring only. Bay-breasted Warblers appear immediately affected - some territories re-established 4 days after spray. Evening Grosbeaks- apparently left sprayed area.
Buckner & McLeod (1975)	Larose For., Ontario	Qualitative	Orthene	0.56 kg/ha	June 19,1975	N.B. - 4 treated plots monitored 5 pre and 5 post spray days. #1 - no impact - spray deposit 0.5 kg/ha #2 - " " " 0.1 kg/ha #3 - increase in bird population partially accounted for by flock of Common Grackles. Spray deposit 0.8 kg/ha. #4 - populations recorded as increasing over the post-spray period. Daily census data indicates no effect. Spray deposit 7.3 kg/ha.
	Petawawa, Ontario	Qualitative	Orthene	?	May 30, 1975	N.B. - 2 treated plots monitored 5 pre and 5 post spray days. Over the treatment period, populations of certain species declined in the treated areas and in the control.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner & Sarrazin (1975)	Quebec	Not given	Fenitrothion	140 g/ha	May 15–16, 1974 & June 6–7, '74	N.B.– 3 treated plots monitored a maximum of 5 pre and 5 post spray days. After 1st spray Winter Wrens declined. After 2nd spray Black-and-white Warblers declined, large reductions in Tennessee Warblers and light reduction in Nashville Warblers.
			Fenitrothion	140 g/ha	June 6, 1974	N.B. – 1 treated plot monitored. Black-and-white Warblers affected for 2 days (either recovered or replaced). Reduction in Tennessee Warblers.
			Fenitrothion plus Zectran	140 g/ha 52 g/ha	May 20, 2974 June 7, 1974	N.B. – 3 treated plots monitored. Solitary Vireo declined in 1 treated plot. Some slight population changes especially on 1 treated plot where some species of Parulidae showed slight decline. Variation thought to be due to factors other than insecticide.
			Matacil	52 g/ha	June 4, 1974 and June 15, 1974	N.B. – 1st spray – 2 treated plots monitored 2 days pre and 5 days post spray. #1 – Ruby-crowned Kinglets reduced, Blk.-throated Green and Mourning Warblers not recorded after treatment. #4 – Evening Grosbeaks not found after treatment, also decline of Swamp Sparrows, Slate-colored Juncos slightly reduced on both plots. 2nd spray – 3 plots monitored (#s 1& 4 above plus #3) for a maximum of 5 pre and 5 post spray days. Nashville and Magnolia Warblers declined on #s 3 & 4. Winter Wrens reduced on #4.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner et al., (1975 a)	Manitoulin Is. Ontario	Not given	Dimilin	350 g/ha	June 9-10, 1975.	N.B.-1 treated plot monitored 5 pre and 5 post spray days. No immediate or short-term effects.
Buckner et al., (1975 b)	Anticosti Is. Quebec	Qualitative	Juv. Hormone Analogue	Not given	Jul. 19, 1975	N.B.-2 treated plots monitored for a maximum of 4 pre and 4 post spray days. Populations increased slightly on control plot while remaining relatively constant on the treated plots.
Buckner et al., (1975 c)	Menjou, Quebec	Qualitative	Fenitrothion plus Matacil	140 g/ha 52 g/ha	? in 1974 2 wks later	1st spray not monitored. Post-spray data from 1 treated plot compared to a control for 2nd spray. Reductions in the populations of Ruby-crowned Kinglets, Black-and-white Warblers, Bay-breasted Warblers and Yellowthroats. Evening Grosbeaks disappeared for several days.
	Parent, Quebec.	Qualitative	Matacil	52 g/ha	? in 1974 plus 2 weeks later	After 2nd application: Winter Wrens and Nashville Warblers declined. N.B. Limited pre spray #1 data (2-3 days).
	Larose, Ontario	Qualitative	Matacil	70 g/ha	? in 1974	Total population reduced somewhat on 1 treated plot (average plot deposit 2.59 g/ha), unchanged on the other treated plot (avg. deposit 1.12 g/ha).
Buckner et al., (1976)	New Brunswick	Not given	Phosphamidon	0.210 kg/ha	May 13, 1976	Treated plots:- #1 - not affected. N.B. no residue in foliage #2 - overall bird population reduced, White-throated Sparrow, Dk.-eyed Junco and Ruby-crowned Kinglet declined. N.B. Foliage residue 0.31 ppm.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner et al., (1976) (cont'd.)						#3 - population reduced by 50% and Ruby-crowned Kinglet population completely eliminated. N.B. Foliage residue 5.12 ppm. #4 - similar to #3 with Ruby-crowned Kinglet recorded only on morning after spray. N.B. Foliage residue 6.90 ppm.
				0.280 kg/ha	May 13, 1976	#5 - reduction in activity the morning after. Ruby-crowned Kinglet population reduced to 0. N.B. Foliage residue 4.29 ppm. #6 - populations fairly stable throughout post spray period. Ruby-crowned Kinglet populations reduced. N.B. Foliage residues 5.17 ppm. #7 - populations not affected. N.B. No detectable foliage residue. #8 - populations not seriously affected but did not increase at same rate as control. Ruby-crowned Kinglet population reduced although mortality may have been light as birds seen on plot although only 1 territory remained occupied over the census period. N.B. No detectable foliage residue.
				0.210 kg/ha	May 30, 1976	#1 - Tennessee Warblers declined, Ruby-crowned Kinglets not as active as during previous spray but still could be identified in their territories. N.B. Foliage residue 0.02 ppm.
				0.140 kg/ha	May 30, 1976	#5 & #6 - no additional effects. N.B. Foliage residues 0.02 & 0.07 ppm, respectively.
				0.070 kg/ha	July 4, 1976 6, 1976 9, 1976	#1, #2, #3 & #4 - no effects observed. #1, #2, #3 & #4 - no effects observed #1, #2, #3 & #4 - no effects observed. N.B. In this last series, foliage residues with 1 exception less than 0.75 ppm, the exception being #3 on July 4 at 1.36 ppm.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner et al., (1976) (cont'd.)			Acephate	0.560 kg/ha	June 10, 1976	#1 - no observed effects - increase parallel to control.
				0.280 kg/ha		#2 - population remained relatively constant.
					16, 1976	#2 - no observed effects.
			Carbaryl	1.121 kg/ha	9, 1976	#1 - not specified
				0.560 kg/ha		#2 - remained close to pre treatment levels.
					15, 1976	#2 - activity declined paralleling the control except for short increase recorded 2 days after treatment.
			Aminocarb	0.070 kg/ha	Jul. 5, 1976	#5 and #6
					7, 1976	#5 and #6
					9, 1976	#5
						Slight suppression of activity one day after the 2nd spray. Activity increased prior to 3rd application. Aberrant behaviour observed in immature Purple Finch outside of #5.
			Fenitrothion	0.210 kg/ha	May 20/21, '76 and May 26, 1976	4 plots monitored. After 1st treatment - slight decrease in population of 1 plot, declines of Ruby-crowned Kinglets, Blk.-throated Blue Warblers and White-throated Sparrows. After 2nd treatment - no reductions.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Varty (1976)	New Brunswick	Not given	Fenitrothion	Twice at 3 oz/acre	1976	Sprayed by TBM: - caused a significantly greater reduction of singing activity for forest canopy birds, especially Ruby-crowned Kinglets, than the same insecticide sprayed by DC-6.
			Phosphamidon	3 oz/acre and 2 oz/acre	May, 1976	When applied by TBM caused severe reductions of Ruby-crowned Kinglets.
				1 oz/acre (3 app.)	Jul., 1976	Little measurable effect
				2 oz/acre		Sprayed by C-46: - reduced the numbers of some species of forest canopy birds.
			Aminocarb	1 oz/acre twice		Little effect when applied operationally by TBM and experimentally (July) by Agwagon aircraft.
			Carbaryl	Twice at 8 oz/acre or Once at 16 oz/acre		No significant effect
			Acephate	Twice at 4 oz/acre or Once at 8 oz/acre		No significant effect

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	*Insecticide	Dosage	Treatment Date	Effect on songbirds
Buckner & McLeod (1977)	Pinchgut L., Nfld.	Not given	Aminocarb	0.070 kg/ha	June 17, 1977 23, 1977 July 1, 1977	No immediate or short-term impact.
	Spruce Brk., Nfld.	Not given		0.087 kg/ha	June 19, 1977 24, 1977	No observed effects
	Hampden, Nfld.	Not given	Fenitrothion	0.210 kg/ha	19, 1977 25, 1977	No immediate or short term impact Sharp decline in Warbler (Parulidae) activity.
			plus Aminocarb	0.070 kg/ha	July 2, 1977	No observed effects
	Noel Paul's Brk., Nfld.	Not given	Acephate plus B. t.	0.056 kg/ha 19.8 BIU/ha	June 21 and July 2, 1977	Warbler activity much reduced on morning following each spray, reduction longer following 2nd spray.
Gov't. of Nfld. & Lab., Dept. of Cons. Aff. & Env., Inf. Rep. RA-79-2 (1979)	Big Careless Cove Brk., Nfld.	Qualitative	Aminocarb	70 g/ha	June 18, 1978 26, 1978	White-throated Sparrow activity declined. No observed effects.
Sarrazin (1978)	Quebec	Not given	Fenitrothion	.210 kg/ha	1978	N.B. Could not determine exactly which areas were sprayed with which insecticides and exact dates of spraying
			Aminocarb	0.53 kg/ha		1st spray in May - no impact. Subsequent sprays - late May to early June - no observed impact. End of June sprays - no observed impact.

APPENDIX A (cont'd.)

Summary of selected environmental monitoring reports of insecticide spraying.

Author	Locality	Habitat Description	Insecticide	Dosage	Treatment Date	Effect on songbirds
Pearce et al., (1979)	New Brunswick	Not given	Fenitrothion	210 g/ha	1976	Sprayed by TBM: - demonstrable impacts on some transects but not on others. Ruby-crowned Kinglets declined on 9 out of 10 transects but not always significantly. Three transects showed post spray declines in Northern Parula, Cape May, Blk.-throated Green, Magnolia and Chestnut-sided Warblers, Common Yellowthroats and American Redstarts. 25 scattered dead and moribund birds found on those 3 transects. Sprayed by DC-6: - very little observable effects on birds on most of the 6 transects.
			Aminocarb¹	70 g/ha	1976	In 2 of the 3 areas had little apparent impact. Ruby-crowned Kinglet affected in the 3rd area. N.B. Sprays followed prior application of either phosphamidon or fenitrothion.
			Phosphamidon	140 g/ha		Sprayed by TBM: - striking reduction of Ruby-crowned and Golden-crowned Kinglets and Yellow-rumped Warblers. White-throated Sparrows also apparently affected. N.B. Ruby-crowned Kinglets also declined by 1/3 on control. Sprayed by C-46: - much less damage apparent.

Appendix B. Common and scientific names of bird species

FALCONIDAE	
Sparrow Hawk/ American Kestrel	Falco sparverius Linnaeus
PICIDAE	
Yellow-shafted Flicker/ Common Flicker	Colaptes auratus (Linnaeus)
Hairy Woodpecker	Picoides villosus (Linnaeus)
Downy Woodpecker	Picoides pubescens (Linnaeus)
TYRANNIDAE	
Yellow-bellied Flycatcher	Empidonax flaviventris (Baird and Baird)
HIRUNDINIDAE	
Tree Swallow	Iridoprocne bicolor (Viellot)
CORVIDAE	
Gray Jay	Perisoreus canadensis (Linnaeus)
PARIDAE	
Black-capped Chickadee	Parus atricapillus Linnaeus
Boreal Chickadee	Parus hudsonicus Forster
TURDIDAE	
American Robin	Turdus migratorius Linnaeus
Hermit Thrush	Catharus guttatus (Pallas)
Swainson's Thrush	Catharus ustulatus (Nuttall)
Gray-cheeked Thrush	Catharus minimus (Lafresnaye)
SYLVIIDAE	
Golden-crowned Kinglet	Regulus satrapa Lichtenstein
Ruby-crowned Kinglet	Regulus calendula (Linnaeus)

Appendix B (cont'd.). Common and scientific names of bird species.

BOMBYCILLIDAE	
Cedar Waxwing	Bombycilla cedrorum Viellot
PARULIDAE	
Black-and-white Warbler	Mniotilta varia (Linnaeus)
Tennessee Warbler	Vermivora peregrina (Wilson)
Nashville Warbler	Vermivora ruficapilla (Wilson)
Yellow Warbler	Dendroica petechia (Linnaeus)
Magnolia Warbler	Dendroica magnolia (Wilson)
Yellow-rumped Warbler	Dendroica coronata (Linnaeus)
Black-throated Green Warbler	Dendroica virens (Gmelin)
Bay-breasted Warbler	Dendroica castanea (Wilson)
Blackpoll Warbler	Dendroica striata (Forster)
Palm Warbler	Dendroica palmarum (Gmelin)
Ovenbird	Seiurus aurocapillus (Linnaeus)
Northern Waterthrush	Seiurus noveboracensis (Gmelin)
Mourning Warbler	Oporornis philadelphia (Wilson)
Wilson's Warbler	Wilsonia pusilla (Wilson)
American Redstart	Setophaga ruticilla (Linnaeus)
ICTERIDAE	
Rusty Blackbird	Euphagus carolinus (Müller)
FRINGILLIDAE	
Purple Finch	Carpodacus purpureus (Gmelin)
Pine Grosbeak	Pinicola enucleator (Linnaeus)
Pine Siskin	Spinus pinus (Wilson)
Slate-colored Junco/ Dark-eyed Junco	Junco hyemalis (Linnaeus)
White-throated Sparrow	Zonotrichia albicollis (Gmelin)
Fox Sparrow	Passerella iliaca (Merrem)
Lincoln's Sparrow	Melospiza lincolnii (Audubon)
Swamp Sparrow	Melospiza georgiana (Latham)

APPENDIX C

Common and scientific names of plant species.

PINACEAE	
Balsam Fir	Abies balsamea (L.) Mills
White Spruce	Picea glauca (Moench) Voss
Black Spruce	Picea mariana (Mill.) B.S.P.
SALICACEAE	
Balsam Poplar	Populus balsamifera L.
Trembling Aspen	Populus tremuloides Michx.
Willow	Salix spp.
CORYLACEAE	
Mountain Alder	Alnus crispa (Ait.) Pursh
Yellow Birch	Betula lutea Michx. f.
White Birch	Betula papyrifera Marsh.
ROSACEAE	
Pin Cherry	Prunus pensylvanica L.f.
Choke Cherry	Prunus virginia L.
American Mountain-Ash	Sorbus americana Marsh.
ACERACEAE	
Red Maple	Acer rubrum L.

APPENDIX D

Prevalence of blood parasites in total populations.

Area	Total Birds	Total Infected	% Infected	Prevalence of H.*	Prevalence of L.**
Joe Batt's Pond - 1979	848	328	38.7	61.6%	59.4%
- 1978	132	73	55.3	39.7%	86.3%
Big Careless Cove Brk. - 1979	448	240	53.6	72.9%	56.7%
- 1978	210	131	62.4	54.2%	68.7%
Little Careless Cove Brk. - 1979	850	319	37.5	69.0%	63.6%
Insular Newfoundland (Woodworth, 1978)	405	158	39.0	82.3%	34.8%
Salmonier Park, Newfoundland (Bragg, 1977)	157	62	39.5	37.1%	58.1%
Insular Newfoundland (Bennett *et al.*, 1974)	2675	1872	70.0	32.6%	92.2%
Region 5, North America (Greiner *et al.*, 1975)			40.0		

* - *Haemoproteus* spp.

** - *Leucocytozoon* spp.