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Frederick Joseph Alsop
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To the Graduate Council:

I am submitting herewith a thesis written by Frederick Joseph Alsop entitled "A Census of a Breeding Bird Population in a Virgin Spruce-fir Forest on Mt. Guyot, Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

James T. Tanner, Major Professor

We have read this thesis and recommend its acceptance:

David A Etnier, J. C. Howell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

February 12, 1968

To the Graduate Council:

I am submitting herewith a thesis written by Frederick Joseph Alsop, III entitled "A Census of a Breeding Bird Population in a Virgin Spruce-fir Forest on Mt. Guyot, Great Smoky Mountains National Park." I recommend that it be accepted for twelve quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Zoology.

James T. Tanner
Major Professor

We have read this thesis and recommend its acceptance:

David A. Ettner

J. C. Howell

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

A CENSUS OF A BREEDING BIRD POPULATION IN A VIRGIN SPRUCE-FIR FOREST ON MT. GUYOT, GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Frederick Joseph Alsop, III

March 1968

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CHAPTER I

INTRODUCTION

I. THE BALSAM WOOLY APHID

"The discovery of the balsam wooly aphid, Chermes picea, on Mt. Sterling in August 1963 represents a very serious threat to the Fraser fir in Great Smoky Mountains National Park." (Stupka, 1964).

"The balsam wooly aphid, Chermes piceae Ratz, threatens to wipe out Fraser fir trees in scenic areas on Mt. Mitchell State Park, the Pisgah, Nantahala, Cherokee National Forests, the Blue Ridge Parkway, and the Great Smoky Mountains National Park in North Carolina and Tennessee," United States Departments of Agriculture and Interior, (1964.)

Much of the following information on the aphid's life history comes from the U.S. Department of Agriculture and Interior (1964). The balsam wooly aphid was accidentally introduced from Europe into New England in 1908. It has since spread to eastern Canada, the Pacific Northwest, and to the Southern Appalachians. In 1957 it was discovered in North Carolina. Due to the difficulty involved in detecting this insect, it had probably been there for several years.

This aphid is a small sucking insect. The adult is blackish and less than one millimeter in length. The insect is found on the surface of the bark where dense populations may cover the trunks so heavily

with a white wooly mass some of the trees appear to be white-washed. The aphid larva is motile soon after hatching, but as soon as it attaches itself to the bark to feed it will remain there the rest of its life.

Because of an exceedingly high reproductive capacity the biotic potential is quite high. The generation time is correspondingly short and two or three generations can be produced in a single year. Under ideal conditions a population could grow from one adult individual to more than three million in one year's time. Only the larval stage survives the winter.

The aphid feeds on living tissue immediately beneath the surface of the bark. During the course of feeding, a toxic salivary substance is injected into the tree causing damage and eventually killing the tree.

Infestation may occur in the crown area or on the main stem. Branch attacks kill or inhibit the growth of buds, preventing new growth of the tree. The crown will gradually become ragged, distorted, thin, and brown in coloration as the tree dies of starvation. The most serious attacks occur on the main stem. Here the insect quickly reduces the flow of nutrients between the roots and the crown. A heavy stem infestation can kill a tree within two years. (United States Departments of Agriculture and Interior, 1964.)

II. THE SPRUCE-FIR FORESTS

In the Great Smoky Mountains National Park, Fraser fir (*Abies*

fraseri) forms almost pure stands above 6,000 feet altitude. Should this species be destroyed the vegetation of these mountain highlands would undergo dramatic changes which would soon be followed by equally intense changes in the kinds of animals living in this biome. In these high-altitude forests many Canadian Zone birds nest in the southernmost extension of their breeding range in the Eastern United States.

Some insight into the ecological changes which could come should the aphid's spread go unchecked is to be seen at present in Mt. Mitchell State Park, North Carolina. Mt. Mitchell rises 6,684 feet above sea level and is the highest point in the eastern half of the United States. When Elisha Mitchell, after whom it is named, first explored its slopes nearly one hundred years ago, it was covered by virgin forests. Above 6,000 feet Fraser fir replaced the dense forest of red spruce (Picea rubens), while below an elevation of approximately 4,500 feet hardwoods grew in place of these conifers. Burleigh (1941) describes it as ". . . accessible only on foot by means of dim narrow trails. So tall and close together did these trees grow that it is said that the sunlight rarely reached the ground, and then only in openings caused by the uprooting of some over-mature trees."

Today the aphid has killed over 275,000 Fraser fir trees in the Mt. Mitchell area alone since its discovery (U.S. Department of Agriculture and Interior, 1964). This destruction, coupled with that caused by logging and repeated fires, has totally changed the picture. The great open areas soon are tangles of deciduous underbrush so dense that spruce and fir reproduction is almost negligible. The crown of the

mountain is still covered with fir in some places, but the spruce remains as only a fringe near the summit. Certainly not all of the destruction was caused by the aphid. Much was due to man's destructiveness. But the changes in the original forests have changed materially the animal life to be found there. Certain Canadian Zone species once found plentiful by Burleigh (1941), such as the Black-capped Chickadee (Parus atricapillus) have completely disappeared. Some species never recorded in the area before such as the Indigo Bunting (Passerina cyanea), Chestnut-sided Warbler (Dendroica pensylvanica), and Song Sparrow (Melospiza melodia) are now seen with regularity, the last two species being listed (Burleigh, 1941) as abundant and plentiful, respectfully, during the summer months.

III. PURPOSE OF THE STUDY

The purpose of this study was to determine as accurately as possible the density of the bird populations in a virgin spruce-fir forest before changes in the forest resulting from aphid damage occurred. Accounts of the kinds of birds to be found in the spruce-fir biome are numerous. Some taken in the Southern Appalachians date almost one hundred years ago (Brewster, 1886). These reports give excellent records of the numbers of species to be found, but none give the numbers of individuals of each species, the density, to be expected for a given unit of measure of spruce-fir forest.

A knowledge of the approximate avian population is of importance for several reasons. First, as far as can be determined from the

literature search, there are no records of population censuses taken in a virgin spruce-fir forest. The study is, therefore, unique. Secondly, should the aphid continue to spread unchecked, there will occur many changes in the flora and fauna of the area. Thirdly, records of the present population densities are needed as a basis for comparison for ecological studies which might be undertaken at some future date.

So that this investigator would have some insight into the succession of changes in the plants and animals that follow the destruction of this forest type, a trip was made to Mt. Mitchell on the completion of the census and a direct comparison was made.

CHAPTER II

STUDY AREA

I. LOCATION

The area chosen for study was a sample plot in the spruce-fir forest on Mt. Guyot in Great Smoky Mountains National Park. Mt. Guyot is the second highest mountain in the Park and the third highest point in the Eastern United States, reaching an altitude of 6,621 feet above sea level at 35°43'N., 83°16'W., (U. S. G. S. map NI 17-1). It is located on the boundary of Haywood County, North Carolina and Sevier County in East Tennessee. The mountain is accessible by United States Highway 441 and by Tennessee Highways 32 and 73. Only foot trails enter the mountain itself.

A base camp from which the census was conducted was established at Tricorner Knob located approximately five and one-fourth statute miles S. S. W. of Cosby campground or ten miles from that point by way of the Snake Den and Appalachian Trails. Tricorner Knob lies at 5,960 feet above sea level, 661 feet lower than Mt. Guyot's peak and one mile by trail to the south of it on the Tennessee, North Carolina state line.

The study plot was a sixty-acre L-shaped grid divided into forty squares 256 feet on a side, each square having an area of one and one-half acres. The long side of the "L" ran northwest to southeast with the short bar of the "L" at the southeast end and pointing southwest. The long rectangle of the "L" measured 3,072 X 512 feet; the short bar

measured 1,024 X 1,024 feet. The long axis of the plot was centered on the Balsam Mt. trail. The northwest boundary was 500 feet from the Park's wooden marker at the junction of that trail and the Appalachian Trail. Elevation of the plot varied from 5,760 to 6,000 feet.

II. CLIMATE

The climate of these higher elevations (6,000 feet) is similar to that found farther to the north. As one ascends the mountain average precipitation and cloudiness increase and temperature decreases with the increasing elevation. The average annual precipitation atop Clingman's Dome, sixteen statute miles southwest of Mt. Guyot and rising to 6,642 feet above sea level, is eighty-three inches. This is over twenty inches more than is received in Gatlinburg at about 1,300 feet elevation, and only fourteen statute miles west of Mt. Guyot. The temperature decreases an average of 3°F. per 1,000 feet of increase in elevation. As a result, the average temperature for January atop a 6,000 foot peak in the Great Smokies is equivalent to that in Central Ohio while the average July temperature is duplicated along the southern edge of Hudson Bay in Canada (United States Department of Commerce, Weather Bureau, 1962).

Summer is the season of greatest rainfall with a secondary maximum of precipitation occurring during the winter and early spring. Fall is the driest period of the year.

During the period of the census, June 17, 1967, to June 27, 1967, the average daily temperature at Tricorner Knob was 58°F., with a low on June 26, of 51°F. and a high of 66°F. on June 23.

III. DESCRIPTION OF THE AREA

The dominant plant association was the spruce-fir forest of the Canadian Zone biome. Because of their remoteness from easily accessible areas the forests of Mt. Guyot were not logged before the national park was established. The spruce-fir forests that exist on the mountain at present are magnificent virgin remnants of the forests that once extended northward from the Southern Appalachians into Canada.

For convenience in describing and recording the association of the avifauna with the vegetation the forest was broken into three divisions: forest crown; understory; and ground cover. For the purposes of this work the following definitions are offered: forest crown -- those woody plants having a height in excess of twenty-five feet; understory -- those woody plants with a height not in excess of twenty-five feet; ground cover -- those nonwoody plants having a height greater than one inch above the ground, but less than thirty-six inches (mosses and lichens excluded).

There was no edge or ecotone in the study area. With the exception of two permanent shelters and approximately 100 square yards of cleared and second growth-vegetation -- chiefly Fraser fir, red spruce, yellow birch, mountain-maple, mountain ash, and smooth blackberry -- about 800 feet south of the western end of the study area, the forest surrounding the grid was the same for miles in all directions. It was broken only by an occasional windfall. The uniformity of the area is an

important factor. Uniform habitats typical of large regions are particularly desirable and at least one-half the value of each count depends upon it (Hall, 1964).

All identification of the plants on the study area was made in the field. Generally this was done in the middle of the day when there was not much avian activity. Photographs were made of all species keyed for later reference and for verification of the investigator's identification by a botanist. Stupka (1964), Fernald (1950), and Small (1938) were used in the identification of the plants on the study area.

A survey of the forest crown vegetation on the census area was made by following the east-west grid lines and making a sample plot count at 256 foot intervals. Circular plots were used with a ten-foot radius and the number and kinds of trees within were scored. The results of this survey are shown in Table I.

In the forest crown the predominant tree was the Fraser fir [*Abies fraseri* (Pursh) Poir] known locally as "balsam." Many of the firs approached forty feet in height and grew so closely together they allowed little sunlight to penetrate to the forest floor. In close association with the fir was the red spruce (*Picea rubens* Sarg.), many of which approached one hundred feet in height. As the elevation increased the percentage of fir became greater culminating in pure stands in the highest elevations. Scattered throught the study area in slightly more open places was the yellow birch (*Betula lutea* Michx. f.) which almost always occurred as solitary individuals (Figure 1).

Two species of the understory approached twenty-five feet in

TABLE I

FOREST CROWN TREES ON 18,852 SQUARE FEET[a]
OF THE MT. GUYOT STUDY AREA

Plant species	Relative Abundance	
	Number of trees	Percent of total trees
Abies fraseri	529	80%
Picea rubens	107	16%
Betula lutea	26	4%
Totals	662	100%

[a]Area was calculated by multiplying the number of survey plots (60) by 10 feet^2 X 3.142.

Figure 1. Trees of the forest crown and understory.

height. They were the American mountain-ash [Pyrus americana (Marsh)] and the mountain-maple (Acer spicatum Lam.). These, too, were found in the areas that were not so crowded by the conifers. The average height of the understory was nearer to six feet, however, being composed of mountain-cranberry (Vaccinium erythrocarpum Michx.), witch-hobble (Viburnum alnifolium Marsh), smooth blackberry (Rubus canadensis L.), and young fir and spruce. Of these only the Vaccinium and the sapling Abies were found in concentrations covering an area of the forest floor in excess of fifty square feet in one stand (Figure 2).

Three species of nonwoody plants, excluding mosses and lichens, made up the ground cover. Of these, common wood-sorrel (Oxalis montana Raf.) was in greatest abundance, growing wherever there was enough substratum to meet its needs. It was the smallest plant identified. Oxalis was found on fallen logs, in the shade of ferns, and even on the sides of trees and fallen logs where there were heavy growths of mosses.

Growing above the Oxalis, and almost equally abundant, was lady fern [Athyrium asplenioides (Michx.) Farw.]. So dense was the growth of the two aforementioned species it was difficult to see the humus of the forest floor when viewing them from above (Figure 3).

In the areas where more light penetrated Rugel's ragwort (Senecio rugelia A. Gray) was found. It was most evident as a border along the narrow trail that traversed the study area.

Crisscrossing much of the forest floor were the scattered debris of decaying trees (Figure 4). Many had a bundle of roots at their bases. Because topsoil is thin on the mountain slopes roots do not go deep.

Figure 2. Understory growth A. fraseri.

Figure 3. Dense ground cover of Oxallis montana and Athyrium asplenioides.

Figure 4. Decaying debris of forest floor and dense ground cover.

Consequently, when winds become strong some trees are blown over leaving a mass of roots, soil, and matted vegetation standing almost vertically at the butt of the trunk. At least two species of birds, the Winter Wren (*Troglodytes troglodytes*) and the Slate-colored Junco (*Junco hyemalis*), were found to use these upturned tangled masses for nesting sites (Figure 5).

Figure 5. Upturned roots, and Balsam Mt. Trail running through the study area.

CHAPTER III

PROCEDURE ON MT. GUYOT

Because many birds pass through the Great Smokies in the course of their spring migration, the end of the second week of June was chosen as a favorable time to begin the census. At this time no migrants are likely to be found in the spruce-fir forests. Most of the passerine birds in residence in these high elevations are involved in some phase of their nesting activities during this period.

A preliminary trip was made in the company of Dr. James T. Tanner on June 12-13, 1967, to locate a suitable area on Mt. Guyot for the study. The actual field work and census was conducted from June 17, 1967, daily through June 27, 1967.

The size of the study area was important. Hall (1964) states, "Censuses should be taken on contiguous tracts of <u>not less than fifteen acres</u>, and preferably more than twenty acres." Censusing errors are greatest on small tracts, in particular on narrow tracts, and especially if ecotones compose much of the surrounding area. In a small tract very few species will be represented by three or more pairs (Hall, 1964). With smaller populations than this of a single species the density in terms of males scored per hundred acres is not sufficiently accurate to permit meaningful comparisons with populations in other areas.

In order to minimize error in the conversion of the numbers of territorial males on the plot to a basis of the number of males per

hundred acres the plot was made as large as possible. It was felt that sixty acres could be covered by the observer in one census trip before the birds' activity began to decline. Coverage of an area this large by a single observer was possible largely due to the restriction of the environment to a single uniform type and to the persistence of the birds' activity during most of the day at this altitude. Hall (1964) found that thirty acres of dense forest are quite as much as the average beginner can census alone on week-ends throughout the season. Oelke (1966) recommends about twenty acres in woodlands rich with undergrowth, whereas Kendeigh (1944) suggests about fifty acres of forest as a maximum. By living near the study area and using trails wherever possible this investigator found a sixty acre plot of spruce-fir can be censused by one person without undue stress on the part of the census taker. However, an area this size is the maximum this observer would recommend.

With the aid of an assistant, Gary O. Wallace, a base line was run using the Balsam Mountain trail as a center wherever the northwest to southwest course of this trail made its utilization possible. This was done to aid the investigator's movement from station to station while taking the counts. Following the trail was much easier than attempting to traverse the dense vegetation and fallen logs on the forest floor. It was important to complete the count during the birds' most active periods and any time which could be gained by using the path was of value. In addition, the trail provided a permanent landmark of the plot's location. The last will be of importance to any future workers.

A one hundred foot steel tape measure was used to establish the 256 foot intervals, henceforth referred to as "stations," that formed the grid of the study plot.

An engineer's directional compass was used to establish the 90° angles necessary to make each grid square and to make the lines of the grid as straight as possible.

Each station was marked with a bright red-orange strip of 1" X 3' length of surveyor's plastic tape tied at eye level around the tree nearest the measured 256 foot interval. By this method each recording station was visibly marked so it could be found easily by the census taker even when daylight was minimal. The plastic tape was used because of its high resistance to dampness and fading, the ease with which a great quantity could be carried, and because this method of marking caused no damage to the trees. Bright yellow tape, rather than the color selected, would be even more easily seen in the darkness of the spruce-fir forests of the Southern Appalachians.

The elevation in feet above sea level was recorded at each of the forty stations established using a barometric Lufft altimeter. This was checked against a U. S. G. S. benchmark at 5,960 feet located on the Balsam Mountain trail approximately one hundred-fifty feet from its junction with the Appalachian Trail and three hundred-fifty feet from the northwestern boundary line of the census area.

The choice of the distance between stations of 256 feet was strictly a choice of personal judgment. It was made with consideration

of the field ability of the observer to record the singing locations with reasonable accuracy at this distance, the habitat to be covered, and the volume of the songs to be recorded. This distance created a census area composed of a grid of forty squares each having an area of one and one-half acres.

The recording stations were at the intersections of the grid lines and each was given a number. The Balsam Mountain Trail base line was numbered zero at the southeastern boundary and as one moved northwest each succeeding station's number was increased by one, terminating in station twelve at the northwest boundary. Each station parallel to and north of this line was likewise numbered and to each number the postscript N1 was added. This method was also used for the five parallel lines south of the base line. Each was designated as being south by the postscript S followed by a number, 1-5. The row of stations nearest the base line was S1, which S5 was the line most distant.

These symbols made it possible for a record to be made at each station, and later recorded on scale maps of the study area, without the danger of the observer being confused as to his true location at the time of the census.

When the grid was established a map was made of it using a scale of one inch equals 256 feet. All stations, elevations, compass directions, and landmarks were noted as accurately as possible. Later a duplicate of this map was made for each species recorded on or over the study area. These were used to plot the location of each contact and to establish the approximate territorial boundaries. This in turn

would determine the number of territories present, thus establishing the number of territorial males using the area.

"The bird population of any habitat," states Hall (1964), "should be based on the number of territorial males rather than the number of pairs." This, of course, would be ideal because of the difficulty one would encounter in trying to determine the numbers of breeding females under ordinary conditions, but was impossible for this study. The excessive study which would be required to determine the true "marital" status of each male encountered was beyond the scope of this investigation. Only males of species known to be breeders in the spruce-fir forests of Great Smoky Mountains National Park were used in the final evaluations.

At the beginning of each count the following data were recorded: the temperature, the weather conditions in general, the sky condition based on a Beaufort Number, and an estimate of the wind speed (Bureau of Sport Fisheries and Wildlife, 1967). In addition the time was recorded as soon as the investigator reached each station, along with that station's number, before the birds contacted were recorded.

At each station, as soon as the time and station number were recorded, the census taker looked and listened for exactly three minutes. During this time all the birds contacted were recorded. This was done even though the population density would be based on males only, to gain a knowledge of all the birds that occurred on the census area regardless of their status. No contacts made while moving from one station to the next were recorded.

Contacts were scored in three ways using the symbols se for seen, si for heard singing, and h for heard calling only. This procedure was used because it was felt by the observer that a singing bird was probably a male advertising his territory and was therefore more important, from the standpoint of the census results, than a bird detected only by his call notes. In the same manner a bird scored as singing was given priority over one actually seen. Therefore if a bird was first located by his call notes, but later heard to sing during the three minute period of recording, the record was changed in favor of the singing individual.

The type of contact was followed with an estimate of the distance, in feet, from the observer to the bird. Here a sound knowledge of the nature of the bird and previous field experience were invaluable. When the bird could be seen the estimate of distance was relatively simple; it was when the bird was scored by voice alone that the judgment of the investigator was brought to bear.

The bird's direction in relation to that of the observer was found using a compass.

The following is a sample of the form used in recording a contact with a Veery (*Hylocichla fuscescens*) heard at station number eleven at 7:16 a.m. (E.D.S.T.): (11), 0716, Veery, h, 150 ft., N.W.

During each count special notations were made of birds that flew over the area such as Chimney Swifts (*Chaetura pelagica*), Broad-winged Hawks (*Buteo platypterus*), and Ravens (*Corvus corax*). Noted also were the locations of immature birds and birds who actions indicated a nest might be close by. The latter was used to locate several nests while the investigator was on the area.

A special effort was made to record the locations of males of the same species singing simultaneously. This information was much more helpful than clusters of records of singing observations from a series of days because the birds were known to be two different individuals, a fact that enabled one to draw a territorial line between them on a map.

As already noted, the second half of June was chosen as the time to begin the census. Most species are usually at the height of their nesting activities during late May and June in the northern states (Hall, 1964), and those of the Canadian Zone nest a little later than this. Because territories can change during the breeding season the count was conducted during a ten day period during which time the investigator camped within a quarter mile of the study area. The census period began on June 17, 1967 and was terminated on June 27, 1967.

Counts were made twice daily as the weather permitted. There was only one day during which the count had to be abandoned due to rain continuing throughout the daylight hours. In addition two afternoon counts were not completed due to inclement weather conditions. In all nine counts were made during the morning hours and six in the afternoon for a total of fifteen.

It is generally known that the most intensive period of song for most species begins just prior to daybreak and lasts for only a short period after sun-up. Hall (1964) states, "Cruises made after 6:00 a.m. Standard Time will show only 50 percent or even less of some species still singing."

This investigator found that though the birds of the Southern Appalachians may indeed be stirring before daylight the peak of song was reached only after the heavy fog that had enveloped the mountain top during the night began to dissipate. On several mornings this heavy moist cloud was not sufficiently scattered until the sun had been up for several hours.

The fog seemingly controlled to a degree the active periods in the birds' daily routine. Not only did they remain silent early in the mornings, but on several occasions most singers were silenced if these low clouds began to drift through the conifers during a period of even the most intense activity. The only species to continue or even increase its vocalizations during this condition was the Veery (*Hylocichla fuscescens*). This bird was at its best song in the late afternoons when the daylight was beginning to fade in the shadows of the mountain's peak. Often the liquid song of this thrush was heard long after it had become much too dark for one to see.

For the purposes of the census it is fortunate that the birds were not very active during the presence of the early morning fogs. Not only were the fogs too dense for the birds' activities, but they were much too thick for one to find the station markers. Had avian song continued through these periods of low visibility the census would have been much more difficult to complete.

The following account describes the routine for a normal day on Mt. Guyot. Arise just before daylight and if the morning was clear proceed to the study area and take the census. If the forest was fogged-in

the count was delayed until the birds had begun to sing. When the morning count was completed a meal was prepared. Most of the middle of the day was used to describe the vegetation, photograph flora and fauna, hunt for nests, and for the countless other details of keeping records and maintaining a camp. About 4:00 p.m. the dinner meal was prepared after which the late afternoon census was taken.

In all thirty-two man-hours were used while taking censuses and about one hundred-sixteen man-hours were involved in the gathering of the other data needed for this study while encamped on Mt. Guyot.

The method of plotting the birds contacted on maps to determine the number of territorial males present is known as the Williams Spot-Mapping Method. It is very well adapted for most species of small passerine birds. The method is not used to determine the territorial boundaries, but to determine the number of territories present.

CHAPTER IV

MT. GUYOT BREEDING BIRD CENSUS RESULTS

Twenty-four species of birds were found on or flying over the Mt. Guyot study plot. One additional warbler was observed just off the area with regularity, but was never recorded on it. Of these twenty-four, thirteen were throught to be breeding birds or territory holders. This number is based on observations made on the plot and on nesting records of the species as recorded by Stupka (1963). These thirteen species were represented by one hundred-seventy territorial males, an average of 2.8 territorial males per acre. The results of the census is presented in Table II beginning with the most abundant species and continuing through to the least. Scientific names do not accompany the table as they appear later in a complete species by species account of all the birds scored on the plot.

TABLE II

THE POPULATION DENSITY OF MID-JUNE BREEDING BIRDS OF THE MT. GUYOT SPRUCE-FIR FOREST

Species	Number of males per 60 acres	Number of males per 100 acres
Slate-colored Junco	46	76
Golden-crowned Kinglet	30	50
Winter Wren	20	33
Veery	20	33
Black-throated Blue Warbler	14	23
Solitary Vireo	9	15
Black-throated Green Warbler	7	11+
Brown Creeper	6	10
Red-breasted Nuthatch	5	8
Robin	5	8
Black-capped Chickadee	4	6+
Hairy Woodpecker	2	3
Blackburnian Warbler	2	3
Totals	170	281

CHAPTER V

METHODS ON MT. MITCHELL

A trip was made to Mt. Mitchell in North Carolina to see the effects of the balsam wooly aphid and to conduct a brief census of the bird population. This was done to obtain data for comparison with the Mt. Guyot study.

As previously stated the forests of Mt. Mitchell have undergone several dramatic changes in the past one hundred years. Once they were similar to those found today on Mt. Guyot. Now all that remains of the red spruce forest is a fringe of trees around the Fraser fir which covers the crest of the mountain. In places the fir canopy is open for several acres due to blowdowns and trees destroyed by the aphid. In many areas once covered by the red spruce young spruce trees are growing intermixed with such deciduous species as *P. americana*, *B. lutea*, *Prunus pensylvanica*, and a dense herbaceous undergrowth.

The primary objective in this phase of the research was one of recording the kinds of birds to be found during their breeding season in this disturbed habitat. Since no great amount of time was available for the study it was possible to obtain only a relative density for the population based on two cruises through the area. The investigator was looking for the absences of species recorded on Mt. Guyot and the occurrence of any birds that had not been observed there whose presence could be tied to the ecological changes in the vegetation of Mt. Mitchell.

The study was conducted over a two day period, July 1-2, 1967. On the afternoon of July 1, two suitable areas were located in Mt. Mitchell State Park. The first utilized the Balsam Trail, a self-guided nature trail at 6,625 feet elevation near the mountain's peak, while the second, elevation 6,200 feet, was centered on an overgrown trail beginning near the south corner of the park's restaurant and terminating near the north corner of the ranger's station. The latter ran roughly north to south following the crest of the mountain. A practice run was made on both trails with stops being made at 256 foot, paced intervals.

A strip census was used to collect the data on the morning of July 2, 1967. For the census the investigator walked the trails as soon as the fog had lifted enough for the birds to become active. By pacing to establish approximate 256 foot intervals, as had been done the day before, the stations were located. At each station all contacts were recorded, just as they had been on Mt. Guyot, up to a distance of 250 feet from the observer. This distance was based solely on the judgment of the investigator. The 250 foot limit was imposed to try to keep all contacts within a space that, when plotted on a map of the census area, would establish a strip through the forest approximately five hundred feet wide. This could be divided into a grid of squares each approximately one and one-half acre in area, the size used on Mt. Guyot. In using these strips with a constant width, only the birds that fell within these boundaries were scored, and constant attention was paid to just where these boundaries fell based on the recorder's

experience. After three minutes the observer proceeded to the next station. By this method both areas were covered in a single morning.

Because the fog lifted from the trail leading from the restaurant area before it did higher on the mountain, that census, hereafter designated Mt. Mitchell Census I, was conducted first. It was begun at 0615 E.D.S.T. and terminated at 0728. During the counting period the ceiling was low, there were small areas of fog in the trees, the wind was constant at about 5-10 m.p.h., and the temperature rose from 53°F. to 54°F. The area covered was a strip approximately 500 feet wide and 3,584 feet long containing an area of about thirty-nine acres. There were ecotones of considerable extent near this strip.

The second census on the Balsam Trail, hereafter called Mt. Mitchell Census II, was begun at 0815 E.D.S.T. and terminated at 0937. The area covered was a flattened oval about 768 feet wide and 2,816 feet in length containing an area of about twenty-eight acres. During the census the ceiling sometimes was in the canopy, there were several brief scattered clouds of fog, the wind was in gentle gusts to 10 m.p.h., and the temperature rose from 54°F. to 55°F. The ecotone effect was small.

The temperature recorded at an elevation of 6,578 feet above sea level by the park service for July 2, 1967, was a low of 52°F. and a high of 58°F. for Mt. Mitchell.

The results of the two strip counts are shown in Table III.

TABLE III

KINDS AND FREQUENCIES OF BIRDS RECORDED IN DISTURBED SPRUCE-FIR FORESTS ON MT. MITCHELL

Species	Number of males scored on Mt. Mitchell Census I	Number of males scored on Mt. Mitchell Census II	Number of males per 100 acres based on one census
Slate-colored Junco	9	7	24
Veery	8	0	12
Winter Wren	7	7	22
Song Sparrow	4	0	6
Chestnut-sided Warbler	4	1	8
Golden-crowned Kinglet	3	6	13
Black-throated Green Warbler	2	0	3
Solitary Vireo	2	0	3
Robin	2	1	4
Canada Warbler	1	0	1+
Catbird	1	0	1+
Red-breasted Nuthatch	0	1	1+
Totals	43	23	98+

CHAPTER VI

BIRDS OF THE SPRUCE-FIR FORESTS

The following section is a species-by species presentation of all the birds identified in, or in flight over, the spruce-fir forests while the investigator was resident on Mt. Guyot and visiting Mt. Mitchell. All records are from elevations ranging from 5,760 to 6,000 feet on Mt. Guyot, and from 6,200 to 6,625 feet on Mt. Mitchell. The period of coverage is June 17, 1967 through June 27, 1967 for Mt. Guyot, and July 1-2, 1967 for Mt. Mitchell. No detailed description of the bird is attempted. The account covers only remarks on the status of the bird, notes on habits and ecology as recorded by the investigator, and all records relating to eggs, nests, and young birds. The common and scientific names used are from the A. O. U. Check-List of North American Birds, fifth edition (1957), and are presented in A. O. U. order.

To give some significance to the terms abundant, common, fairly common, uncommon, and occasional as measures of a species relative abundance the following designations are given: rare, a species recorded less than five times in the last thirty years; occasional, a species having less than one pair per sixty acres of spruce fir forest; uncommon, those with one pair; fairly common, two to five pairs; common, six to twenty pairs; abundant, those having more than twenty pairs.

Turkey Vulture (*Cathartes aura*). Occasional over Mt. Guyot. One adult was observed overhead on June 20, 1967. Stupka (1963) gives its

status in the Smokies as an uncommon permanent resident, while Burleigh (1941) records it as infrequent on Mt. Mitchell.

Broad-winged Hawk (Buteo platypterus). Six sighting of this hawk were recorded on Mt. Guyot. All were made of single birds, and four were during the afternoons. The status on Guyot was occasional. In the Great Smoky Mountains it is a fairly common summer resident (Stupka, 1963), but is relatively rare (Brewster, 1886; Burleigh, 1941; and Adams, 1959) on Mt. Mitchell.

Ruffed Grouse (Bonasa umbellus). Occasional, with but two records from the Mt. Guyot study area. These nonterritorial birds were sometimes heard booming at great distances down the mountain slopes, but were rarely encountered as visitors on the census plot. Stupka (1963) records it as a fairly common permanent resident in all altitudes and in all forests of the National Park. Though Burleigh (1941) designates them as fairly plentiful in the spruce-fir of Mt. Mitchell, Adams (1959) did not list them in his census of those forests and this investigator did not detect their presence during his study there.

Barred Owl (Strix varia). Occasional. This investigator recorded only one on Mt. Guyot. It was heard singing approximately 1,000 feet east (6,000 feet elevation) of Tricorner Knob at 10:30 E.D.S.T. on the nights of June 18, and June 23, 1967. It is recorded as an uncommon permanent resident in the park (Stupka, 1963) with most of the records 60 percent) coming from the higher elevations. None was found on Mt. Mitchell and Burleigh (1941) has only one record for that species" occurrence in the spruce-fir of that mountain, having seen one on January 4, 1933.

Chimney Swift (Chaetura pelagica). Common on Mt. Guyot, one to several of these lively birds could be detected at almost any hour of the day in flight over the tree tops. None were ever observed to alight, and there are no records of their nesting in locations other than in man-made structures in the Park. Stupka (1963) gives them a status of common summer resident in all elevations, a direct contrast to their status on Mt. Mitchell which must be given as rare to occasional. This observer did not record them there, and they are only mentioned by Brewster (1886), noted once by Burleigh (1941), and seen once by Adams (1959).

Ruby-throated Hummingbird (Archilochus colubris). This species was not recorded on Mt. Guyot, but was seen on Mt. Mitchell on July 1, 1967, at an altitude of 6,450 feet. It is a common summer resident occurring in the Smokies at all altitudes (Stupka, 1963). Burleigh (1941) gives the extreme dates for this bird's occurrence on the summit of Mt. Mitchell as July 20, and September 17.

Hairy Woodpecker (Dendrocopos villosus). This observer found the Hairy Woodpecker to be a fairly common species in the spruce-fir forests. It was recorded on seven of the censuses. Stupka (1963) designates this species a common permanent resident, and records the discovery of its nest on Mt. Guyot by R.J. Fleetwood on June 2, 1934. It was not observed on Mt. Mitchell where Burleigh (1941) records its occurrence in the spruce-fir as casual.

Blue Jay (Cyanocitta cristata). Occasional on Mt. Guyot. This bird was recorded twice on the study area, once as a single individual

and once (June 27) two were found. These were the only contacts with this species while the observer was in residence there. It is interesting to speculate on the presence of this bird in these high altitudes during the breeding season for there are no published records of its nesting in the Canadian Zone of the Smokies. One was observed feeding young on July 10, 1947, at an altitude of 5,375 feet in the Park (Stupka, 1963), but no nests have been found for this species in this biome. Stupka (1963) gives its status as a common permanent resident. One was heard on Mt. Mitchell (6,200 feet)on July 2, 1967. Its occurrence on that mountain top is casual (Burleigh, 1941), and it is not known to nest above an altitude of 4,500 feet.

Common Raven (Corvus corax). Though this bird was recorded almost daily on Guyot, by my previous designations it must be given the status of uncommon. Its guttural croaks could often be heard coming from a considerable distance. C. corax was recorded in pairs on all occasions save one, when three birds were observed in flight over the area. On several days two would inspect the camp from the tops of red spruce, but I never saw them on the ground in the shelter area. This largest of our songbirds is recorded as an uncommon permanent resident in the higher elevations (Stupka, 1963). Two were recorded at 6,200 feet on Mt. Mitchell where Burleigh (1941) says at least two have nested yearly, at least one of which he had recorded almost daily over the mountain top.

Black-capped Chickadee (Parus atricapillus). This investigator found this small bird to be a fairly common resident on the study plot. Almost all contacts were with single birds. It is interesting to note a

subspecies of the Black-capped Chickadee (Parus atricapillus practicus) is the only bird originally described from the Great Smoky Mountains National Park (Stupka, 1963), and that the specimen from which it was described was collected at 6,500 feet on Mt. Guyot, April 15, 1932, by T. D. Burleigh. Stupka (1963) describes it as a fairly common permanent resident occurring mostly at higher altitudes. P. atricapillus was not contacted on Mt. Mitchell. It was not recorded there by Adams (1959) when he censused the Fraser fir forest. Burleigh (1941) had only one record of two birds there on May 8, 1930. In discussing the Black-capped Chickadee he (Burleigh) says, "Once plentiful here, this species has been driven away by the cutting of the spruce wood and at best can be considered of merely accidental occurrence now."

Red-breasted Nuthatch (Sitta canadensis). A fairly common bird on Mt. Guyot. It was almost always observed in pairs, and on several occasions small companies of three or four individuals were heard. These birds were most frequently detected by their vocalizations, some notes being made almost continuously between feeding individuals as they searched the tree trunks and larger branches. I could not determine if one or both sexes were responsible for these "songs" as a variety of sounds was produced by every bird I had occasion to observe.

Though it is a permanent resident in the Park, Stupka (1963) carries its relative abundance no farther because its numbers fluctuate considerably from season to season, especially in the winter months.

Only one was found on Mt. Mitchell, though Adams (1959) found four pairs on a twenty acre plot in the fir forests there. Burleigh

(1941) designates it as a resident whose abundance varies with the amount of spruce and fir seed that has ripened in the fall.

Brown Creeper (Certhia familiaris). Given a status of fairly common permanent resident by Stupka (1963) the creeper was found by this observer to be common in the spruce-fir of the study area. Its musical song was heard quite commonly here on the birds' breeding grounds, making a bird otherwise difficult to detect easily scored.

No creepers were found on Mt. Mitchell. Burleigh (1941) gives it no status there though his writing indicates it must have been fairly common. Adams (1959) found less than a pair on a twenty acre plot.

Winter Wren (Troglodytes troglodytes). Very common on Mt. Guyot where its lengthy song could be heard at almost any daylight hour. This small, brown bird stayed mostly in the ground cover, especially on the fallen logs and in the maze of roots at their bases. The latter served as favorite nesting sites, and the two nests located were hidden in niches in them. The nests were located by making squeaking sounds on the back of my hand while standing near an uprooted tree or a dense pile of brush created by trail crews. On the few occasions that the squeaks were answered by a scolding wren a search was initiated, only two of these revealed very well hidden nests after much effort. Both of the nests found seemed unusually large for such a small bird. Each was approximately six-and-one-half to seven inches in height and about four inches in diameter. The entrance hole was small, about one inch, and located on the side about half the distance from the roof. Both had small twigs in their bases, but were composed mostly of mosses. A

flashlight was used to check the interiors. Both contained eggs resting on a bed of feathers and moss, and one had a few black hairs placed in the lining. One must assume these came from a Black Bear (Euarctos americanus), but can only guess at the circumstances. The first nest found near station 11 contained four white eggs with fine reddish brown spots, the second, at station 1S4, held six which were similarly marked.

Stupka (1963) gives its status as a fairly common permanent resident.

Fourteen contacts were made on Mt. Mitchell where Burleigh (1941) gives its status as abundant, and Adams (1959) estimated thirty-five pairs per hundred acres.

Mockingbird (Mimus polyglottos). This species was not scored on Mt. Guyot, but one was seen near a maintenance shed at about 6,400 feet on Mt. Mitchell. No records are given by Burleigh (1941) or Adams (1959) for this bird on Mt. Mitchell.

Catbird (Dumetella carolinensis). One recorded at 6,200 feet on Mt. Mitchell, but none observed in the spruce-fir of Mt. Guyot. Stupka (1963) notes the occurrence of the Catbird in openings in the spruce-fir forest in the summer months. Burleigh (1941) records it as breeding sparingly in cut-over areas at about 6,000 feet on Mt. Mitchell.

Robin (Turdus migratorius). Fairly common on the Mt. Guyot study plot. Their notes and songs were most commonly heard in the evenings. Of all the birds recorded this familiar visitor to the lawns of the lowlands seemed the most out of place in the darkness of the conifers. Recorded as common to abundant in the Park by Stupka (1963).

Three contacts were made on Mt. Mitchell. Adams (1959) found three pairs, and Burleigh (1941) states it is a fairly plentiful breeding bird of the spruce-fir.

Veery (Hylocichla fuscescens). This bird with its beautifully unique song of the high places was very common on the census area. It was a very difficult species to census. Its favorite period for song was in late evening when it was too dark to take the census and early in the mornings when it was too foggy. Estimating the distance to the singer, and at times the direction, was also difficult. The song at times had a ventriloquial effect, and the apparent distance to the bird changed even with a turning of the singer's head. Stupka (1963) gives the status as common summer resident of the higher altitudes.

The Veery was also common on Mt. Mitchell. Burleigh (1941) lists it as plentiful in the cut-over areas, and of casual occurrence in the spruce-fir forests.

Golden-crowned Kinglet (Regulus satrapa). Abundant on Mt. Guyot, exceeded in numbers only by the Slate-colored Junco. They were almost always seen in twos, occasionally in threes or fours, high in the forest crown. Two came to the spring at Tricorner Knob every afternoon to bathe. Kinglets were very difficult to see in the dark canopy and most were scored by their voices alone. It is a common permanent resident in the Park (Stupka, 1963).

Adams (1959) found one pair per two acres on Mt. Mitchell, the exact ratio this observer found on Mt. Guyot. Burleigh (1941) states they are one of the characteristic birds of the spruce-fir woods at the top of Mt. Mitchell.

Cedar Waxwing (Bombycilla cedrorum). This species was recorded only once on the Mt. Guyot study area. On June 27, 1967, four individuals were observed at station 1S2. They were observed almost daily in camp. Each visit was made about dusk by two birds that came to drink, and sometimes bathe in the spring. It is noted by Stupka (1963) as a vagrant species that is a common summer resident in the Smokies and erratic the remainder of the year.

This observer recorded five birds in flight on Mt. Mitchell, July 1, 1967. Burleigh (1941) gives only one record for this bird outside the summer months, and lists it as breeding sparingly there.

Solitary Vireo (Vireo solitarius). This vireo was common on the study area. It was usually seen in the understory and on the lower branches of the conifers. Stupka (1963) calls it a common summer resident in the middle and high elevations.

The investigator scored two individuals on Mt. Mitchell where Adams (1959) found eight territorial males on twenty acres, and Burleigh (1941) lists it as fairly plentiful.

Black-throated Blue Warbler (Dendroica caerulescens). This warbler was found to be common on the Mt. Guyot study area. Females of this species were very defensive when one approached their nesting territory too closely, and on several occasions the investigator was met with a deluge of scolding notes and tail flicking during the course of one of the census rounds. These protective females were in every instance associated with fairly dense areas of understory, and in particular

those containing young yellow birch.

When a female persisted in these noisy actions she was soon joined by a male. The location of such an occurrence was carefully marked, and if the actions were repeated on the following cruises the place where the female was first noted was marked again. In this manner the nest location was narrowed to the point that two were found after some searching. One was located June 21, at station 3S3 in a small thicket of yellow birch and mountain-cranberry. It was situated about eight inches above the ground in the forks of a small yellow birch. It was constructed chiefly of small twigs from red spruce and Fraser fir, and from shreds of bark from yellow birch. Outside diameter was approximately three to four inches, and it was about two and one-half inches tall. Its inside cup was lined with a little moss, a few feathers, and dark rootlets which were the chief component. It contained four pale buffy white eggs with small dark brownish spots scattered over their surfaces. Most of the spots were near the larger end of the eggs.

The second nest was located June 23, about fifty feet west of station 11. It was placed about eighteen inches from the ground in the forks of yellow birch. It also contained four eggs which looked very much like the first with the exception of the spots which showed more shades of brown. The nest was constructed of the same materials as the one previously described.

No young were seen to hatch from these nests while the observer was on Mt. Guyot.

Stupka (1941) describes the Black-throated Blue Warbler as a

common summer resident above 2,800 feet.

This species was not observed on Mt. Mitchell. It was not reported by Adams (1959), but Burleigh (1941) records it as a plentiful breeding bird in the cut-over area to an altitude of about 6,000 feet.

Black-throated Green Warbler (Dendroica virens). This species was found to be fairly common in the spruce-fir of the census area. No females were noted. It is a fairly common summer resident in all elevations of the Park (Stupka, 1963).

Two contacts were scored at 6,200 feet on Mt. Mitchell. Adams (1959) found it to be his most common breeding bird with fifteen males on twenty acres of Fraser fir. Burleigh (1941) lists this warbler as a plentiful breeding bird of the mountain's top.

Blackburnian Warbler (Dendroica fusca). Only two contacts were made on the study area, the status is therefore given as uncommon. It is the opinion of the investigator that there were more in the general area than were detected. It is believed that the bird's habit of frequenting the tree tops, coupled with its high-pitched song, made its detection very difficult under the conditions that exist in the higher elevations of the Smokies. A pair of this species visited the camp area almost daily, and drank and bathed in the spring.

The Blackburnian Warbler was not observed on Mt. Mitchell. Adams (1959), however, found seven males on his census area, and was the first to record its presence at about 6,500 feet (June 3, 1959) on that mountain where he gives its status as one of the more common breeding birds of the fir forest. Burleigh (1941) does not record it as a breeding

bird above 5,000 feet.

Chestnut-sided Warbler (Dendroica pensylvanica). Only one pair occurred in the general study area. Their nest was off the census plot in a small blow-down, second growth area near the shelters. On four occasions the male was detected by his song as he penetrated the spruce-fir up to a distance of about seven hundred feet at the extreme northwestern boundary of the plot. This individual was heard daily in the open area just up the slope from the camp. It was of occasional occurrence in this biome, being found only in open disturbed areas. Stupka (1963) lists it as a common summer resident above 3,000 feet.

Five contacts were made with this species on Mt. Mitchell above 6,200 feet, all in the cut-over, second growth areas. In these areas it is described as fairly plentiful by Burleigh (1941), and as casual in the more dense spruce-fir.

Canada Warbler (Wilsonia canadensis). One male was observed in the same area as described above for the Chestnut-sided Warbler, but unlike the preceding it was never found on the study area. It could be heard singing daily from the shelter area. Its status in the spruce-fir is uncommon to occasional. Stupka (1963) designates the species as a common summer resident above 3,400 feet.

One was found at 6,200 feet on Mt. Mitchell by this observer. Adams (1959) found one male during his study in the fir forest. Burleigh (1941) states it was not known to nest in the spruce-fir of Mt. Mitchell until two pairs were found there May 23, 1934.

Indigo Bunting (Passerina cyanea). Two adult males were recorded

at 6,600 feet on Mt. Mitchell, and a third was heard to sing at 6,200 feet. All records were for July 1, 1967. This bird was not recorded on Mt. Guyot. In the Smokies Stupka (1963) lists the bird a common summer resident of lower and middle elevations. He also notes there have been numerous high-altitude records of adult males only, in the Park. Burleigh (1941) also describes the presence of males only at 6,500 feet during the month of July.

American Goldfinch (Spinus tristis). All individuals scored were in small flocks of two to five birds. One contact was made on June 27, 1967, with a flock of five passing overhead at station 7S1. This was the only record for the study plot. The other two observations were two birds on June 23, and three on June 24, in flight over the camp area. Their status for Mt. Guyot is occasional. They are common permanent residents, and are found at all altitudes of the Park except the high mountains in late winter (Stupka, 1963).

None were detected on Mt. Mitchell. Adams (1959) records them as visitors to the spruce-fir, and Burleigh (1941) lists them as casual there.

Red Crossbill (Loxia curvirostra). Six contacts were made on the Mt. Guyot study area, all of birds passing overhead. On four of the ten days the observer was in camp a pair of these birds visited the camp grounds. I placed salt on the ground at the corner of the shelter and both birds would fly down and eat it. This process required the birds to turn the side of their heads parallel to the ground and to stick their tongue out one side of the crossed mandibles. The male was much

bolder than the female, and would allow an approach to within about four feet. This pair always came from and departed in a southwesterly direction. Had time permitted the investigator would have tried to follow the course of their flight, as the nest of this species has not been discovered in Great Smoky Mountains National Park. This crossbill was fairly common during the period of the census.

Stupka (1963) regards it as a fairly common summer and early fall visitor, an occasional summer resident, and at other seasons unpredictable and very erratic. An almost identical status is given by Burleigh (1941) of the crossbills' occurrence on Mt. Mitchell, and this investigator observed none there.

Slate-colored Junco (Junco hyemalis). Abundant on Mt. Guyot, this was the most numerous species found on the study area with forty-six territorial males scored on the sixty acres. In all, three nests were located for this species. They were so similar in construction that one description will be used for all. Each was a rather deep cup of grasses, mosses, bark shreds, and rootlets, and was lined with finer pieces of the same materials. The search for each nest's location was begun without previous plan, when a female would fly up from the ground almost at the observer's feet. Some searching at this point usually revealed a rather well concealed nest. On June 21, one was located just above the trail at station 6. It was nestled in the roots of a Fraser fir where they broke the surface. A dense growth of ferns overhung and shadowed the nest. The nest contained three eggs of greenish-white base all having some dark brown dots scattered lightly over their

surfaces. The second located the same day was also on the ground near the trail near station 9. It too was concealed by ferns and by a slight overhang of soil and humus under which it had been constructed. Four greenish-white eggs, also spotted with brown were inside. On June 25, a third nest was discovered near station 2 S4. The structure was placed about three inches above the ground in the upturned roots of a red spruce. More dark rootlets were utilized in its construction making it very difficult to detect in the shadows of the root tangles. Four eggs were found in it as well, the background of these having a pale bluish cast covered with finely distributed brownish spots.

On June 26, two parents and three newly fledged young were observed on the ground in camp. The next day a Junco's scolding led the observer to two more juveniles in yellow birch near station 3S1. These are the only young birds recorded on Mt. Guyot during the census period. Stupka (1963) lists their status as abundant and characteristic of the higher elevations.

Sixteen contacts were recorded for Mt. Mitchell where Burleigh (1941) lists the Junco as the most common bird, and Adams (1959) found it abundant on his census area.

Song Sparrow (Melospiza melodia). Though this bird was not observed on Mt. Guyot, it was recorded four times at 6,200 feet on Mt. Mitchell. There it is recorded as a plentiful breeding bird in the cut-over area, and is to be observed in the edge of the spruce-fir forests in the summer months (Burleigh, 1941). It has been observed in the higher altitudes in the Smokies as well, and it is believed to be

extending its breeding range in recent years due to large-scale changes in the habitat (Stupka, 1963).

CHAPTER VII

DISCUSSION

There is no true timberline in the Southern Appalachians. The spruce-fir forests that crowned the crests of this chain of mountains bisecting much of the eastern United States have been reduced to a remnant by the activities of man. More than ninety percent of the virgin spruce stands of these mountains have been lost due to lumbering and fires (Stupka 1963). The unspoiled Canadian Zone forests of Mt. Guyot and the other high mountains within the boundaries of the Great Smoky Mountains National Park are unique in eastern North America, both in their fauna and flora. Not every species of bird found in the boreal spruce-fir forests of northern Maine (Cadbury and Cruickshank, 1947) and western Ontario (Kendeigh, 1947) are to be found there. Indeed, many characteristic of the forests of the north are rare in the spruce-fir of these southern highlands (Stewart and Aldrich, 1952), but enough boreal species inhabit the biome to make it the only clearly-defined "life zone" in the mountains.

Spot-mapping methods have been used in many spruce-fir forests to determine the density of their avian populations. In every published census located by this investigator, with one exception, the study was conducted in an ecologically disturbed biome. The exception was a census done by Scheid (1955) in a spruce-fir forest still in a primitive state on an island forty-five miles from the mainland in Lake Superior.

Only two censuses had fewer territorial males per hundred acres than was found on Mt. Guyot. Cope and Hensley (1951) recorded only two hundred forty-one males per hundred acres in a spruce-fir, mixed northern hardwood forest in Maine, and Scheid (1955) scores ninety-three territorial males in the same amount of forest. The lower density in the first count can be explained by the inclusion of the hardwood forest. Uniform hardwoods without ecotones are noted as biomes with moderate bird populations. Fales (1964) found only one hundred fifty territorial males per hundred acres in this latter habitat, a density typical of mixed hardwood forests. The second is explained in that it is an island population some distance from the mainland.

All the other counts when compared to the two hundred eighty territorial males per hundred acres on Mt. Guyot's census area have a higher density. All the following figures are expressed in the number of territorial males per hundred acres: Fraser fir, 340 males (Adams, 1959); spruce-fir, 349 males (Martin, 1960), 323 males (Stewart and Aldrich, 1952), 370 males (Stewart and Aldrich, 1951), 319 males (Kendeigh, 1947); young spruce-fir forests, 318 males (Stewart and Webster, 1951); virgin spruce, 325 males (Stewart and Aldrich, 1949); and second-growth spruce, 295 males (Stewart and Aldrich, 1949).

The higher densities are explained by the many ecotones present in a disturbed forest which provide numerous niches that can support a greater variety and higher populations of birds. Also most were conducted north of Tennessee where there are greater numbers of species normally breeding in the Canadian Zone habitat. Much of the preceding

points again to the distinctness of the characteristic populations of Mt. Guyot.

It can be assumed from the close proximity of Mt. Guyot to Mt. Mitchell (they are about fifty-five statute miles apart) that the forests and the birds found on both were originally identical. This can be further substantiated by the records of early naturalists such as Brewster (1886). Today they are quite different. The forests on Guyot are in their primitive condition; those of Mt. Mitchell have been logged, burned, infested, and left to the ravages of the winds except for some Fraser fir at the very summit which now face the threat of the aphid.

There are some close parallels and some vast differences in the bird populations found on the two mountains (Table IV). The numbers of Slate-colored Juncos, Golden-crowned Kinglets, and Winter Wrens found on Mt. Guyot by this investigator are very similar to those given by Adams (1959) for Mt. Mitchell. However, Adams' population densities for these birds are all higher than the strip census conducted by this observer indicated them to be in July, 1967. Adams (1959) found sixty-five juncos, fifty kinglets, and thirty Winter Wrens per hundred acres. I found twenty-four juncos, thirteen kinglets, and twenty-two Winter Wrens per hundred acres on Mt. Mitchell. It should be pointed out, however, that two strip censuses cannot be considered quantitatively accurate measurements of the actual numbers of birds present. They give no more than an index of their relative abundance.

Veerys were scored by this investigator as common Mt. Mitchell where Adams (1959) found less than one male on twenty acres.

TABLE IV

A COMPARISON OF THE NUMBERS OF MALE BIRDS PER HUNDRED ACRES ON MT. GUYOT AND MT. MITCHELL

Species	Plot Census Mt. Guyot Alsop, 1967	Strip Census Mt. Mitchell Alsop, 1967	Plot Census Mt. Mitchell Adams, 1959
Slate-colored Junco	76	24	65
Golden-crowned Kinglet	50	13	50
Winter Wren	33	22	35
Veery	33	12	+
Black-throated Blue Warbler	23	0	0
Solitary Vireo	15	3	40
Black-throated Green Warbler	11+	3	75
Brown Creeper	10	0	+
Red-breasted Nuthatch	8	1+	20
Robin	8	4	15
Black-capped Chickadee	6+	0	0
Hairy Woodpecker	3	0	+
Blackburnian Warbler	3	0	35
Song Sparrow	0	6	0
Chestnut-sided Warbler	0	8	0
Canada Warbler	0	1+	1
Catbird	0	1+	0
Totals	281	98+	340

The most dramatic differences in the avifauna were the absences of the Black-capped Chickadee and the Black-throated Blue Warbler on Mt. Mitchell. Both were common in the spruce-fir of Mt. Guyot. Similarly, the Song Sparrow and the Chestnut-sided Warbler were plentiful on Mt. Mitchell, but the Song Sparrow was never recorded on Mt. Guyot and only one Chestnut-sided Warbler was a visitor to the study plot.

If Adams'(1959) figures are to be believed, the strip censuses taken by this observer on Mt. Mitchell in 1967 also indicate decreases in the populations of Solitary Vireos, Black-throated Green Warblers, Red-breasted Nuthatches, Robins, and Blackburnian Warblers. Is it possible, if the decreases noted are accurate observations, that the aphid is a factor in the loss of numbers of birds on Mt. Mitchell?

Possibly the bird that has benefited the most by the changes in Mt. Mitchell's vegetation is the Song Sparrow. This seems to be a "disaster" species in the higher elevations of the Southern Appalachians. It extends its range to the very peaks of these mountains when sufficient damage has been done to the vegetation to establish the open second-growth areas it prefers. Today it can be found nesting to the very edge of the fir at 6,300 feet on Mt. Mitchell (Burleigh, 1941). It is not found in undisturbed areas of similar elevations and habitat in the Smokies. It may be a relatively late-comer to the Southern Appalachians, themselves, as it was not recorded by Brewster in 1885. During the weeks, from May 23 into June, that he spent on and near Mt. Mitchell he does not record this species, even from lower elevations (Brewster, 1886).

Since no absolute counts of the bird population on Mt. Mitchell have been made after the discovery of the balsam wooly aphid there in 1957, except for Adams in 1959 at which time the insect was not well established on the mountain, it is not possible to make a direct comparison with the study completed on Mt. Guyot. No statement can therefore be made as to the aphid's effect on the avifauna there. The gathering of this data could provide a valuable insight into what changes might be expected on Mt. Guyot should the insect become established there and spread uncontrolled. This investigator saw no evidence of the aphid's presence while the study was being carried out on Mt. Guyot, but time did not permit an intense search for it. That the aphid will reach the spruce-fir of Mt. Guyot seems inevitable. At this time there are no methods by which the insect can be eliminated over wide areas. Control using insecticides is limited because of the excessive cost, the ruggedness of the terrain, and the lack of knowledge of its possible harmful impact on other living things.

It is possible that some of the birds of the biome could reduce the aphid or even check its spread in its early stages of infestation, but these species could not control dense infestations because the biotic potential of the aphid is much greater than those of any avian predator. During spruce-budworm outbreaks in Canada many warblers of the genus Dendroica moved into areas where the prey reached dense populations (Kendeigh, 1947), but though the birds fed readily on the budworm they could not control the outbreaks. Several of the species on the study plot are known to eat aphids and aphid-like insects. These

are the Golden-crowned Kinglet (Bent, 1949) (Forbush, 1929), Red-breasted Nuthatch (Bent, 1948) (Forbush, 1929), Brown Creeper (Bent, 1948), Black-throated Blue Warbler (Bent, 1953), Black-throated Green Warbler (Bent, 1953), and possibly the Black-capped Chickadee. Unfortunately not much is known of the food habits of any of these species, and their possible impact on a species such as the balsam wooly aphid is pure speculation.

The forests of Mt. Guyot are protected from the hand of man, barring accidents such as a fire, but the fir now faces the aphid. This work provides a basis of knowledge of the present condition of the birds on Mt. Guyot. Hopefully it will serve as a yardstick for comparisons of their fluctuations in numbers or changes in the kinds of birds found there in the years to come.

CHAPTER VIII

SUMMARY

The introduction of the European Balsam Wooly Aphid into the United States poses a threat to the Fraser fir of this country. A census was conducted in the virgin spruce-fir forests of Mt. Guyot in the Great Smoky Mountains National Park using a spot-mapping method to determine the absolute breeding bird population on a sixty-acre plot before ecological changes were brought about by aphid destruction. The results of this census were compared to findings of other investigators in similar biomes. A trip was made to, and a strip census was conducted on, Mt. Mitchell where the forests have undergone dramatic changes due to the destruction of the trees by man and aphid infestation. The findings on Mt. Mitchell were compared to those of Mt. Guyot to see if any changes in the avifauna could be linked directly to the aphid.

This research was important not only in providing a basis for comparison by future investigators, but also in that censuses in undisturbed spruce-forests are few in general and unique in the Southern Appalachians.

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APPENDICES

APPENDIX A

The five figures in this appendix show by graphic means the approximate territorial boundaries of one hundred-seventy individual male birds of thirteen species found on the Mt. Guyot census area using a spot-mapping technique. All are composite census maps for the ten day study period.

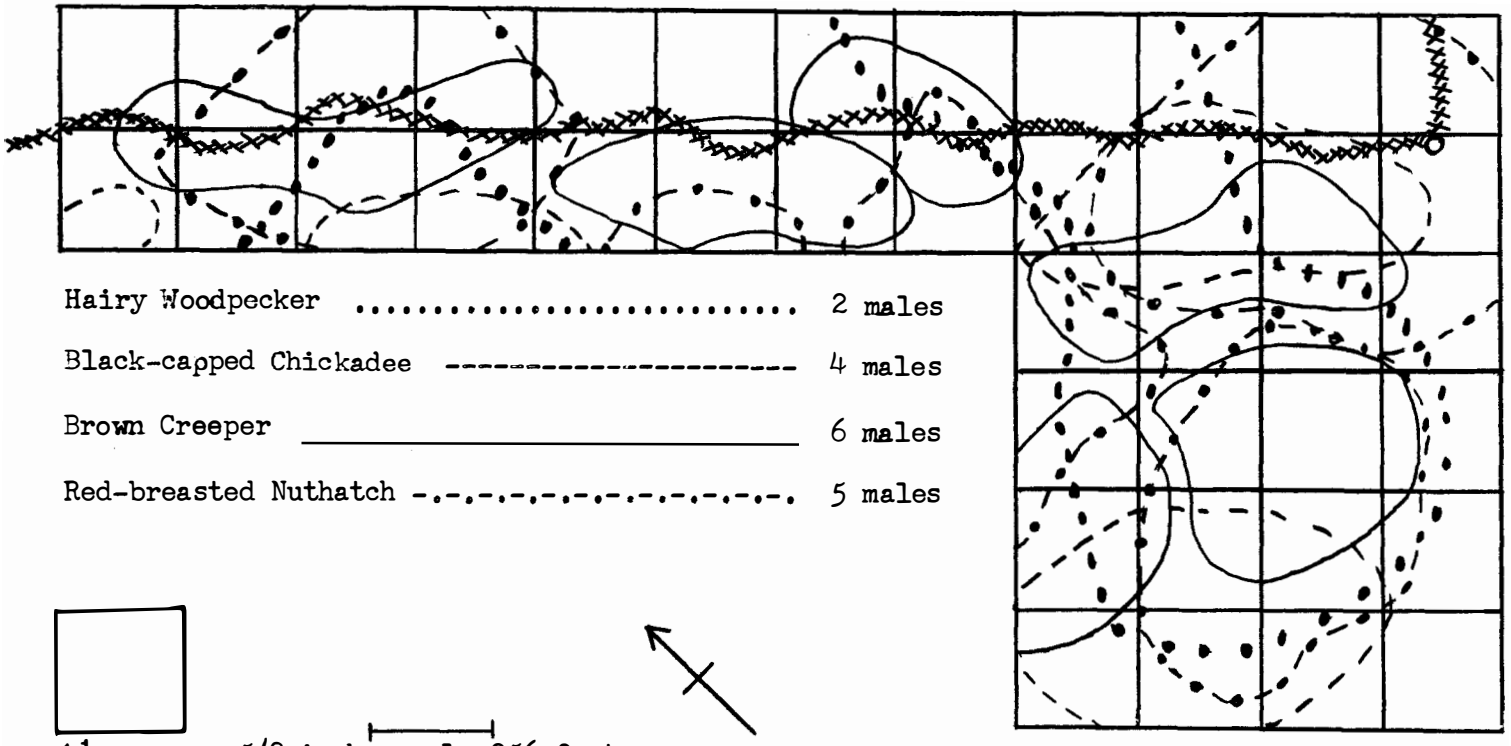

Figure 6. Composite census map for the Hairy Woodpecker, Black-capped Chickadee, Brown Creeper, and Red-breasted Nuthatch.

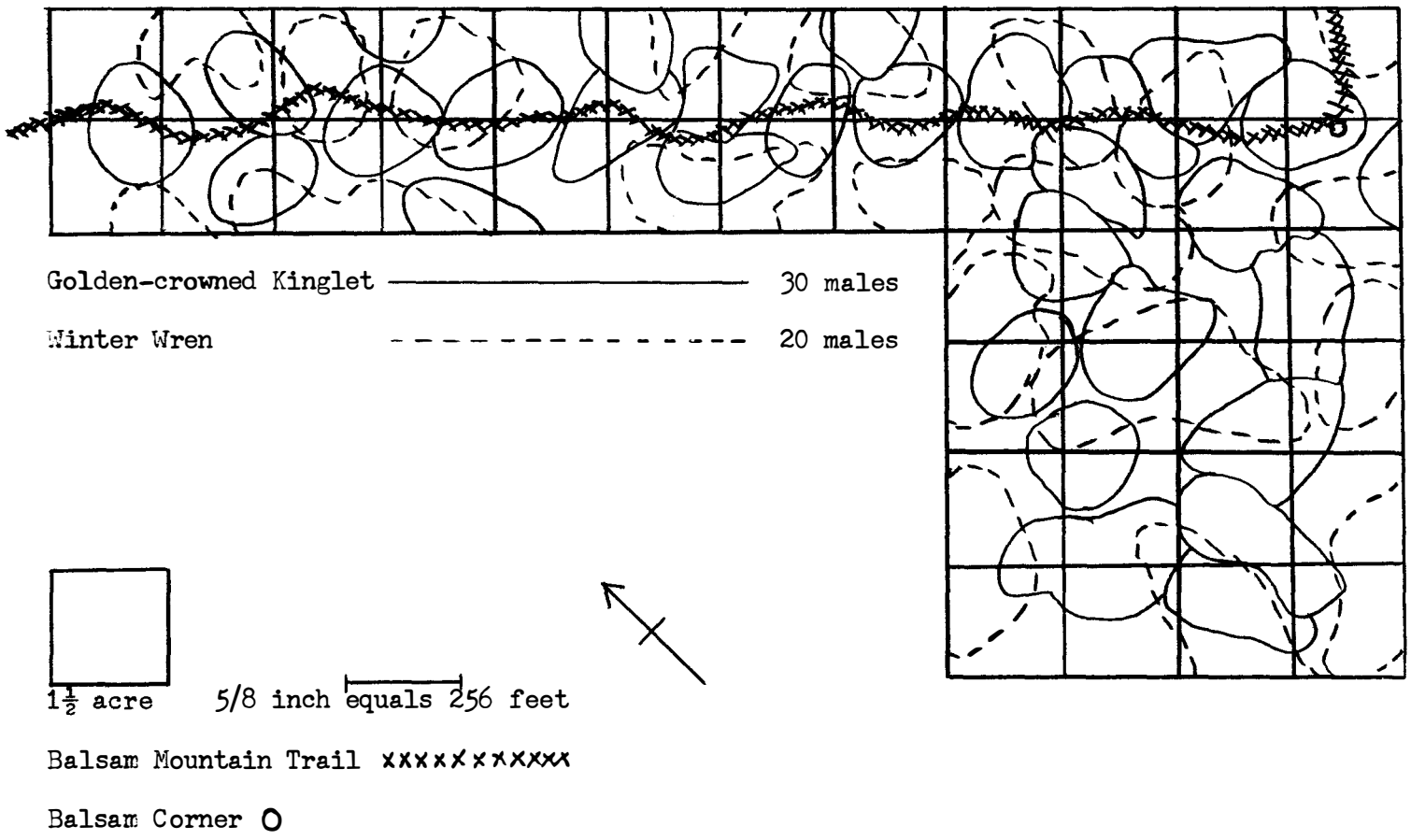

Figure 7. Composite census map for the Golden-crowned Kinglet and Winter Wren.

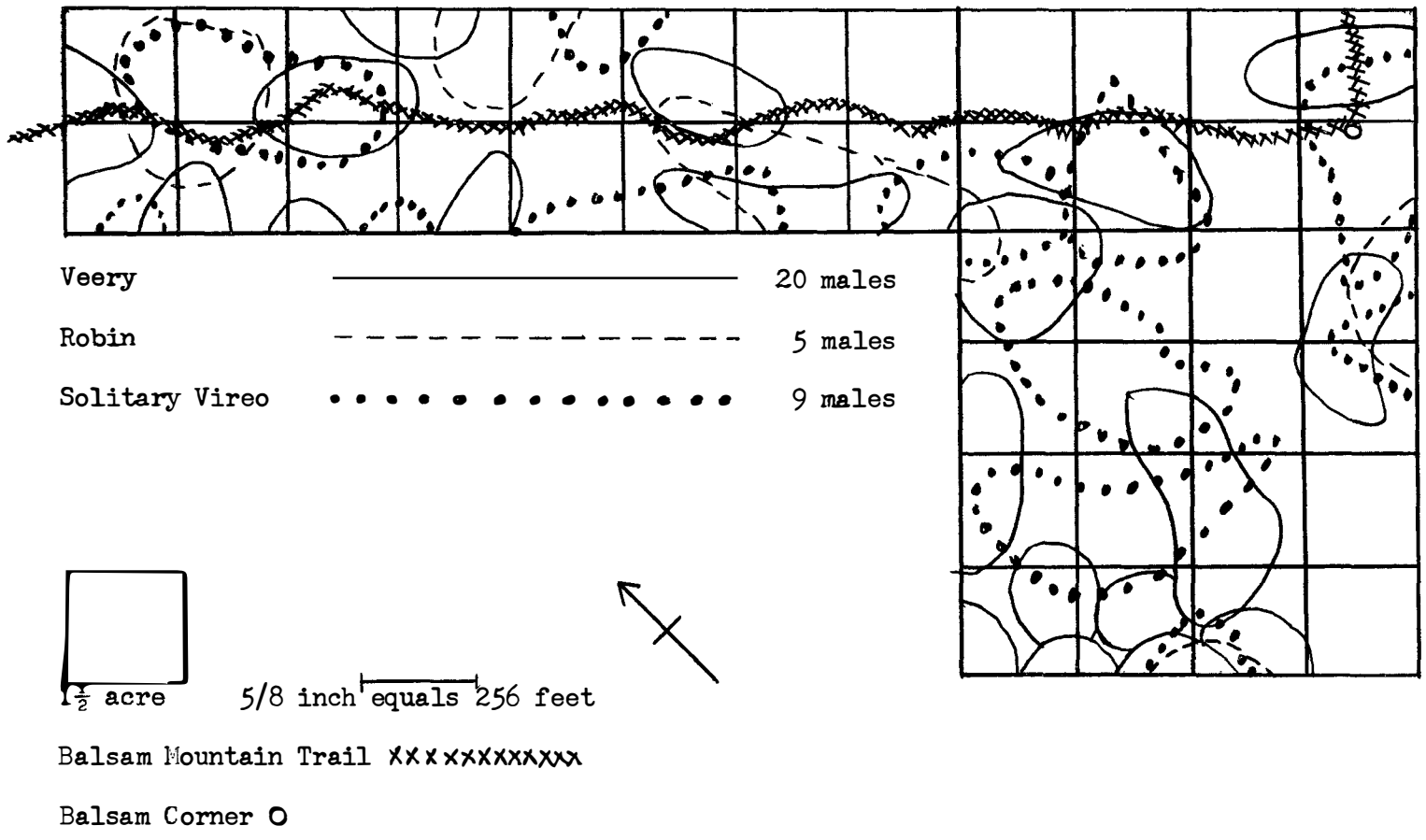

Figure 8. Composite census map for Veery, Robin, and Solitary Vireo.

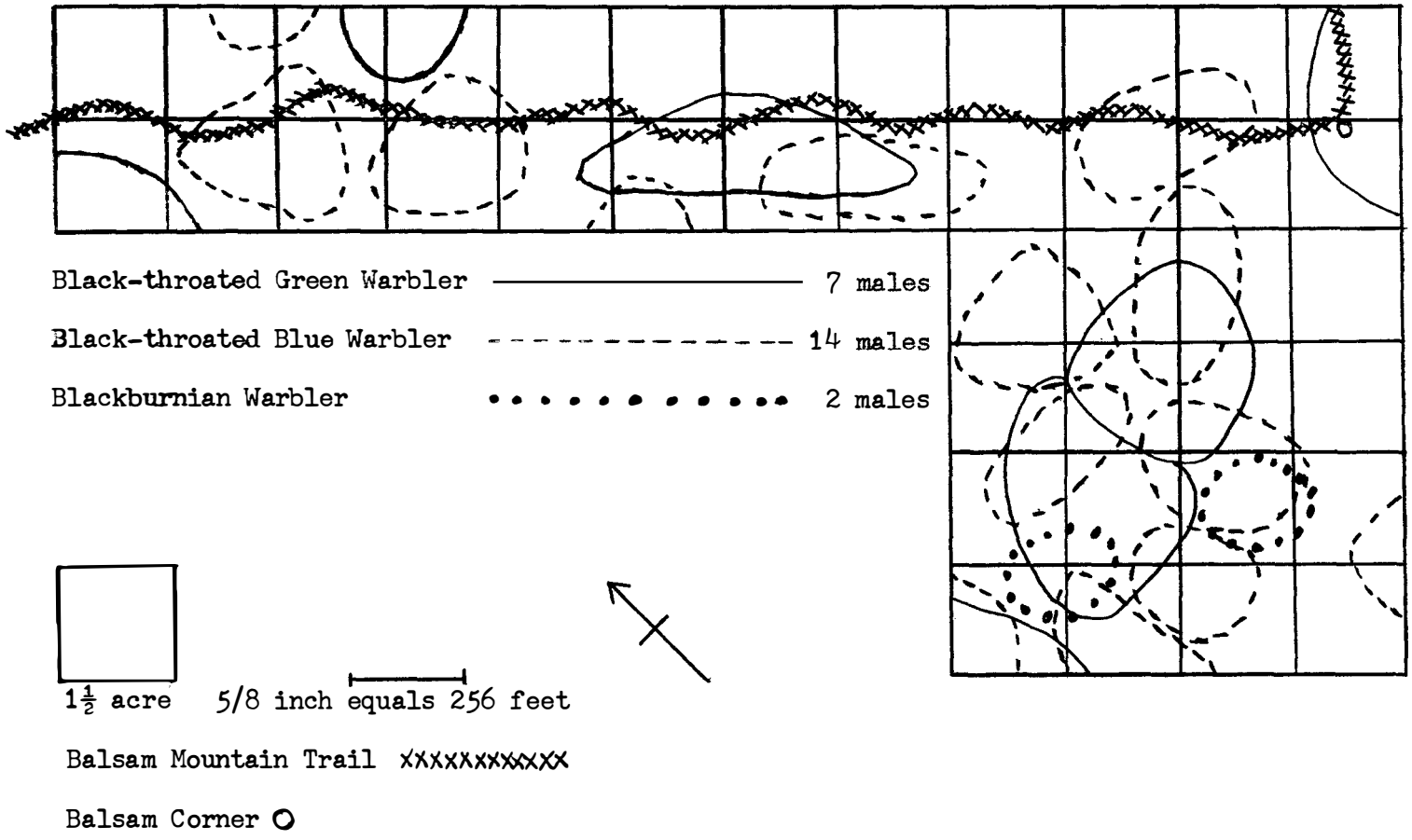

Figure 9. Composite census map for the Black-throated Green Warbler, Black-throated Blue Warbler, and Blackburnian Warbler.

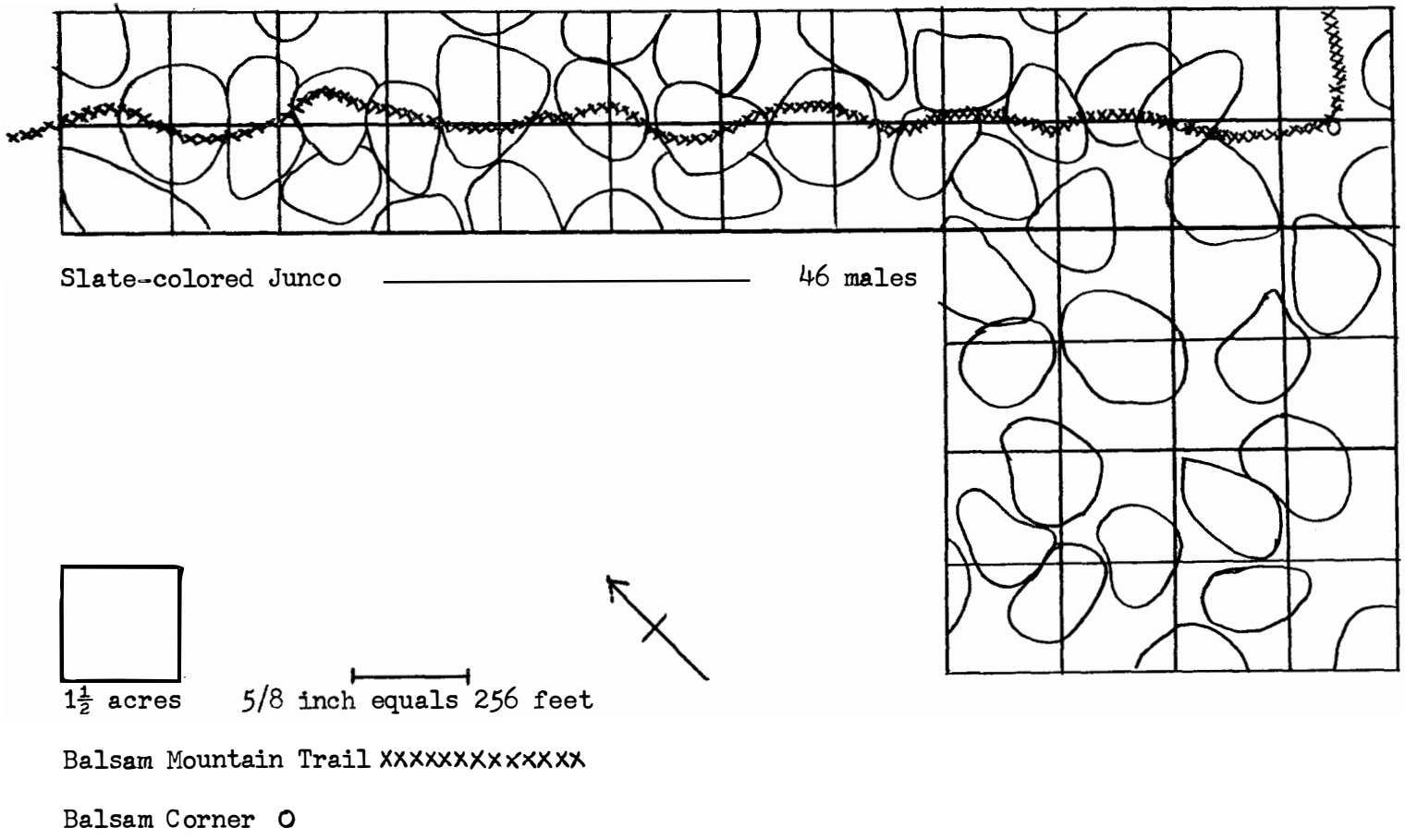

Figure 10. Composite census map for the Slate-colored Junco.

APPENDIX B

The two figures of this appendix show the location of each individual bird recorded during the conduction of two strip census on Mt. Mitchell the first two days of July, 1967.

The area of the count at 6,600 feet elevation (Figure 11) is approximately twenty-eight acres in Fraser fir and some red spruce. Its location is given graphically in relation to permanent landmarks in Mt. Mitchell State Park, North Carolina, as is the census area in Figure 12. The second strip count covers an area of about thirty-nine acres at an elevation of 6,200 feet. It was conducted in a Fraser fir and red spruce forest in which many of the trees were secondary growth.

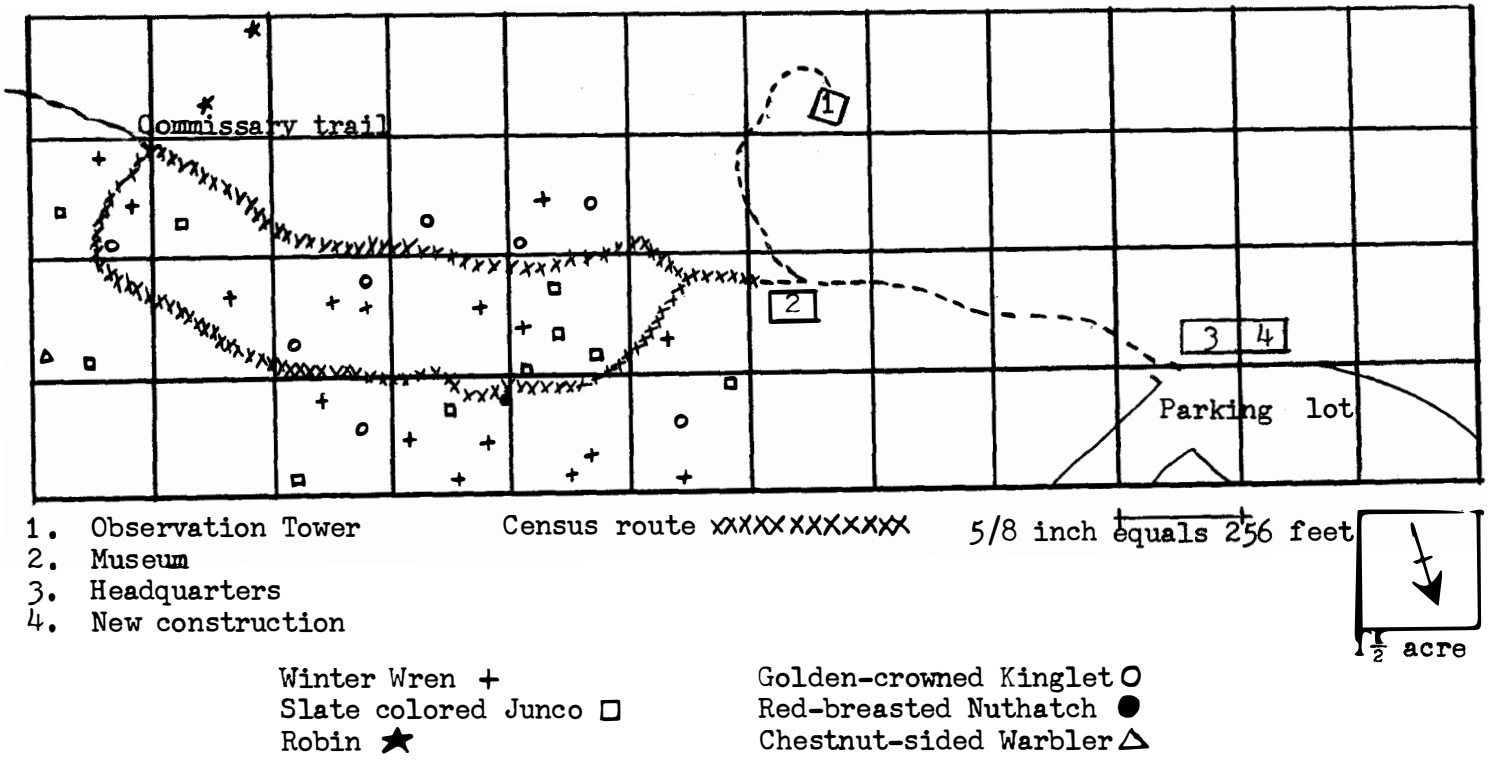

Figure 11. The Strip census at 6,600 Feet on Mt. Mitchell.

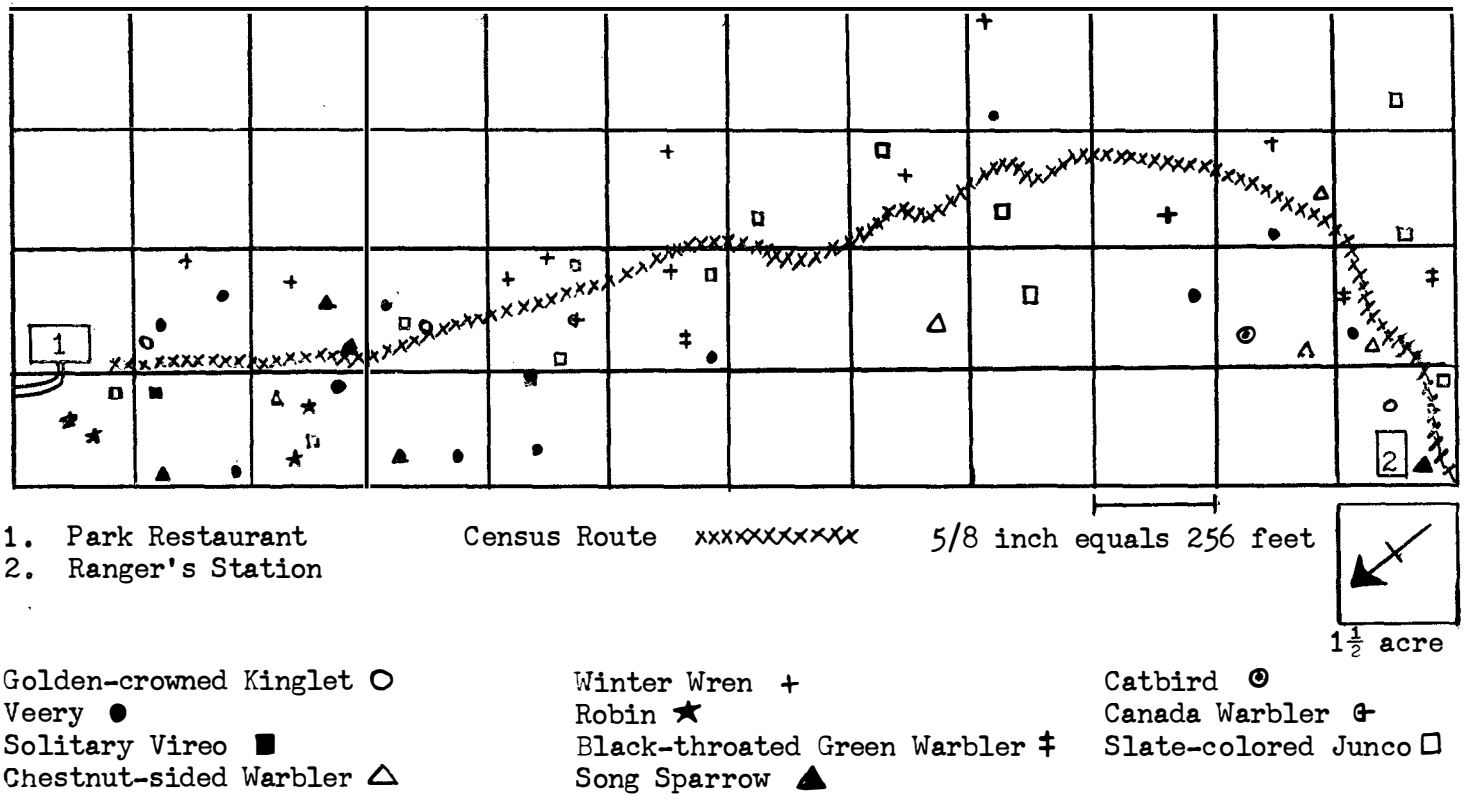

Figure 12. Strip Census at 6,200 Feet on Mt. Mitchell.