BREEDING BIRDS IN A VIRGIN MIXED MESOPHYTIC FOREST IN THE WESTERN ESCARPMENT OF THE CUMBERLAND PLATEAU IN TENNESSEE

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BREEDING BIRDS IN A VIRGIN MIXED MESOPHYTIC FOREST IN THE WESTERN ESCARPMENT OF THE CUMBERLAND PLATEAU IN TENNESSEE

An Abstract

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in Biology

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by

Kathryn Ozelle Lee Robertson

August, 1979

ABSTRACT

Daily censuses of breeding birds were conducted, using the Williams Spot Mapping Method (Williams, 1936), from 1 to 12 June 1977 in a 11.75 ha section of a virgin mixed mesophytic forest in Savage Gulf, Grundy County, Tennessee, a gorge cut into the western escarpment of the Cumberland Plateau. The over- and understory of the forest were sampled using the random pairs method (Cottam and Curtis, 1949 and 1955) at 30 points within the study area. The transgressives and herbs were sampled using a 1 m^2 quadrat at these points. Bird species diversity was calculated for the study area and compared with that of nine other mixed mesophytic areas previously censused by other investigators, by using Shannon's formula (Shannon and Weaver, 1949). Thirty-five bird species were present for a total of 811 territorial males per km^2 and a bird species diversity of 4.32. The dominant breeding birds of the area listed in descending order were the Black-throated Green Warbler, Red-eyed Vireo, Wood Thrush, Acadian Flycatcher, and Northern Parula. The Brown Creeper and Veery had not previously been reported breeding in mixed mesophytic forests. The Mourning Dove and Ruby-throated Hummingbird showed a preference for the virgin mixed mesophytic forests; no bird species showed a preference for the ecologically-disturbed mixed mesophytic forest. No correlation was found between bird species diversity and bird density of ten mixed mesophytic forest study areas.

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August, 1979

To the Graduate Council:

I am submitting herewith a thesis written by Kathryn Ozelle Lee Robertson entitled "Breeding Birds in a Virgin Mixed Mesophytic Forest in the Western Escarpment of the Cumberland Plateau in Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in biology.

David Snyder
Major Professor

We have read this thesis and
recommend its acceptance:

Edward D. Chester
Second Committee Member

Floyd M. Ford
Third Committee Member

Accepted for the Council:

William N. Ellis
Dean of the Graduate School

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I would like to thank my husband, Jim, without whose assistance the entire project, especially the censusing, would have been much more difficult. I thank my father for helping me with the vegetation survey, and both my parents for financing my education and giving me the desire to learn as much as possible.

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CHAPTER I. INTRODUCTION

The purpose of my research presented in this paper was to determine the diversity and density of the breeding bird population in the virgin mixed mesophytic forest on the Cumberland Plateau, in Savage Gulf, Grundy County, Tennessee, and to compare my findings with those of other investigators who have worked in similar areas.

Savage Gulf is a gorge cut into the west-facing escarpment of the Cumberland Plateau. Savage Creek, the degrading stream, drops from 319 m elevation at the head of the gorge to 301 m at its confluence with the Collins River. The rim of the gorge follows closely the 549 m contour line on both the north and south sides for most of its length. Except where breached by old slides and/or tributaries of Savage Creek, precipitous cliffs of Walden sandstone extend 24 m to 31 m below the rim of the gorge (Fenneman, 1938). On the eastern and western ends of the gorge, the forest has been logged, but approximately 200 ha in the central part of the gorge is uncut. This central section has been protected partly by inaccessibility and partly by a legal problem concerning right of way for a spur railroad to the edge of the gorge. This is one of the few stands of virgin forest remaining in eastern North America (Quarterman, et al., 1972).

A knowledge of the breeding avifauna of Savage Gulf is important for several reasons. First, if environmental intrusions (defined as man-made activities that detract from the area's natural characteristics) into the area continue, many changes in the biota of the area could occur.

Surface mining in the Savage Creek drainage basin is one of these intrusions. Prospecting at the headwaters of Caruenger Creek, a tributary

of Savage Creek, has disturbed a 4 ha section of the natural area. Grading work has encroached upon an area near the natural area's boundary. This site has not been reclaimed. Other damage has occurred at a proposed prospecting site for coal on the headwaters of Savage Creek. Non-permitted surface mining activity by another company has caused increased turbidity in Savage Creek. In Big Creek, a tributary of Savage Creek, the waters have given pH readings of less than 4. The acid source is conjectured to be run-off from an unknown mining site.

Land clearing constitutes another intrusion. The Hiwassee Land Company, a lumber company that owns large tracts of land bordering the natural area, has clear-cut timber south of the Chattanooga-McMinnville Stage Road and the study area. Approximately 81 ha has been clear-cut, burned, and converted to Loblolly and Virginia Pine (Pinus taeda and P. virginiana, respectively). These monocultures constitute possible fire, pathological, and entomological hazards to Savage Gulf Natural Area (unpublished paper, Tennessee Department of Conservation, Division of Planning, 1978).

Second, increased usage of the natural area for recreational activities such as hiking, rock climbing, camping, and hunting could be damaging. Hiking trails totaling 80 km in length are used extensively in the natural area. Hunters of various small and large game animals have created scattered dumping sites throughout Savage Gulf.

Any environmental intrusion or recreational activity of man in Savage Gulf could cause a change in the breeding bird population. Changes cannot be shown to have occurred to the breeding bird population if a quantitative knowledge of the avifauna has not been conducted prior to any significant environmental intrusion or recreational activity of man.

Third, records of the present population densities will be necessary as a basis for comparison of ecological studies undertaken in the future.

Finally, the understanding of Tennessee's avifauna cannot be complete until we have an understanding of its pristine character - best preserved in the case of the mixed mesophytic forest in areas such as Savage Gulf.

CHAPTER II. LITERATURE SURVEY

The literature provides very few breeding bird censuses conducted in a virgin mixed mesophytic forest. Smith (1967) surveyed a virgin hemlock-northern hardwood forest in Pendleton County, West Virginia. Although he did not define this area as being part of a mixed mesophytic forest, the description of the vegetation as well as the location of the area fit the description of the mixed mesophytic forest of the Allegheny Mountain region according to Braun (1950). Phillips (1970) censused a small tract of virgin mixed mesophytic forest in Belmont County, Ohio. DeGarmo (1950) reported a census in a virgin cove forest in Greenbrier County, West Virginia. Whittaker (1956) states that the cove forest and the mixed mesophytic forest region are synonymous.

Breeding bird censuses in various areas throughout the mixed mesophytic forest region have been conducted in non-virgin forests by numerous other workers such as Barbour (1951) in eastern Kentucky; Harrison (1960) in Tucker County, West Virginia; Yehner (1972) in Campbell County, Tennessee; Cathers (1977) in Pike County, Ohio; and Simmers (1977) in Madison County, Alabama.

Accounts of the kinds of birds found in Savage Gulf are also few. Albert Ganier (1923) has left us an excellent record of the number of species to be found there in May 1922, but he does not give the numbers of individuals of each species, or the density.

Information-theoretical measures have been used extensively in expressing bird diversity. Two information theory measures of mean diversity per individual are Shannon's formula (Shannon and Weaver,

1949) which is more commonly used, and Brillouin's formula (1956, cited by Lloyd, et al., 1968) which has been used less than Shannon's formula. Tramer (1969) discussed the components of the two formulae. Pielou (1966) described species diversity as a function of the number of species present and the evenness with which the individuals are distributed among these species. Sager and Hasler (1969) and Karr (1971) complained that Shannon's formula is insensitive to the rare species which play a substantial role in the ecosystem. Hurlbert (1971) has criticized Shannon's formula as being biologically meaningless. Lloyd, et al. (1968) discussed both formulae and provided tables for use in their calculations. They point out that Shannon's formula uses true proportions from the population and Brillouin's formula uses actual numbers of observations. Taylor, et al., (1976) determined that the Shannon information index is affected by small-sample bias. Kempton and Wedderburn (1978) found that the Shannon information index depends greatly on the abundances of the commonest species and that the species abundance data are generally uninformative as to the values of the Shannon information diversity index for a species habitat.

CHAPTER III. METHODS AND MATERIALS

Study Area

The study area was a plot in a section of the virgin mixed mesophytic forest in Savage Gulf State Natural Area, Grundy County, Tennessee (Figure 1). The eastern end of the most southern corner of the study plot was at 35° 26' 27" N, 85° 34' 17" W (U.S.G.S. Map N3522.5 - W8530/7.5). The south rim of Savage Gulf is accessible by Federal Secondary Highway 4350. Only foot trails enter the plot.

A base camp from which the census was conducted was established at the Savage Gulf Natural Area's Ranger Station, 11.5 km north of the intersection of Tennessee Highway 108 and Federal Secondary Highway 4350, 8 km from the study plot. To reach the study plot from the base camp, travel 1.9 km south to the intersection of Federal Secondary Highway 4350 and Chattanooga-McMinnville Stage Road. Then proceed 4.6 km west on the Chattanooga-McMinnville Stage Road to an old logging road which joins from the north side. This logging road is 1.4 km long and terminates 0.1 km from the north-facing escarpment of Savage Gulf. Because of the condition of the road during the time of the study, I walked 0.7 km from the logging road to the study plot.

The study plot was 11.75 ha laid out as a grid of 0.25 ha subplots each 50 m on a side. From the eastern end of its most southern boundary the plot perimeter ran 250 m west, thence 350 m north, thence 250 m east, thence 50 m south, thence 150 m east, thence 200 m south, thence 150 m west, thence 100 m south. The northwest corner of the plot was in Savage Creek. The southwest boundary included a small portion of the southern escarpment of the gulf. The elevation of the plot varied from about 390 m to 550 m.

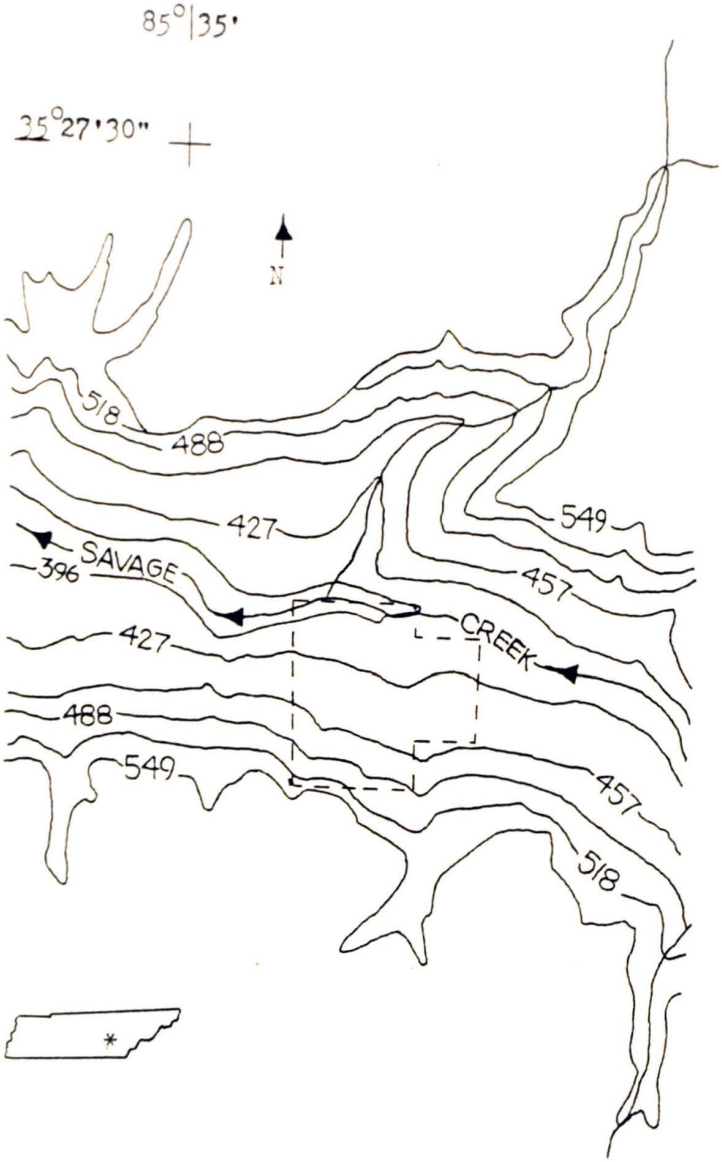

Figure 1. A portion of Savage Gulf occupied by virgin mixed mesophytic forest. Elevation is shown in meters. Scale is 1:1200. Study area is indicated by dashed lines. The map insert of Tennessee shows the location of Savage Gulf with an asterisk. Modified from Collins (Tennessee) Quadrangle, U.S. Geological Survey Map N3522.5-W8530/7.5, 1956.

Climate

As one ascends from the Eastern Highland Rim to the Cumberland Plateau, the average precipitation increases and the average temperature decreases. The average annual precipitation at Monteagle, Grundy County, Tennessee, located 588 m above sea level and 34 km southwest of the study plot, is 154.9 cm. The Monteagle vicinity is comparable physiographically and latitudinally to the study area. The average annual precipitation at Monteagle is 16 cm more than that at Tullahoma, Coffee County, Tennessee, on the Eastern Highland Rim at 327 m elevation and only 56 km west of Savage Gulf and 37 km northwest of Monteagle (United States Department of Commerce, Weather Bureau, 1973).

The temperature decreases an average of 1.9° C per 305 m increase in elevation (Peattie, 1936). Temperatures at Monteagle average one degree less than at Tullahoma, of comparable latitude but 261 m lower. The average annual temperature of Monteagle is 13.8° C, and at Tullahoma it is 14.9° C.

Rainfall is reasonably well distributed throughout the year at the study area. Winter and spring are typically the seasons of greatest precipitation. Early fall is the driest period of the year (United States Department of Commerce, Weather Bureau, 1973).

During the period of the census, 1 to 12 June 1977, the average daily temperature at the study plot was 20° C. This was 2.3° C below the June average for Monteagle from 1941 to 1970 (United States Department of Commerce, Weather Bureau, 1973). The low temperature recorded during the study period was 2.2° C. The high was 31.1° C. I obtained the daily temperature extremes using a Taylor maximum/minimum thermometer. The daily average temperature was calculated by averaging the daily extremes.

Geology

The geology of the Savage Gulf area has been described extensively by E. T. Luther (Tennessee Department of Conservation, Division of Geology, Nashville, Tennessee, unpublished paper, 1973).

The Savage Gulf State Natural Area is part of the Cumberland Plateau, which in turn is part of the Appalachian Plateau physiographic province. The Appalachian Plateau extends from Alabama to New York, separating the Valley and Ridge province of the Appalachian Mountains to the east from the Interior Lowland Plateaus Province to the west.

The topography of the study area is characterized by rugged relief, a steep-sided gorge, and a relatively flat upland surface into which the gorge has been incised.

The north-facing slope of Savage Creek on which the study plot was located was rugged and steep. Slopes ranged from 12.2° to 45° on the upper slope near the rim-rock that forms the edge of the flat plateau above.

The gradient of Savage Creek was also quite steep. Savage Creek dropped over 213.4 m in the approximate 8 km length of its course within the natural area for an average drop of 26.7 m per km.

The geomorphology of the region is controlled primarily by the contrast in resistance to erosion between siliceous and calcareous or shaley rocks. The relatively flat upper surface of the plateau is capped by massive layers of sandstone and conglomerate. The region to the west of the Cumberland Plateau in Tennessee, called the Eastern Highland Rim area of Middle Tennessee, is capped by rocks abundant in chert. Between the sandstone capping the plateau and the cherts capping the rim lie nearly 305 m of mostly limestone and shale. A generalized

section of the rocks of the area is presented in Table I.

Description of Vegetation

The dominant plant association was the mixed mesophytic forest of the Cumberland Plateau. In the eastern and western portions of the gulf the forest had been logged, but approximately 200 ha in the central portion of the gorge were uncut. Because of the remoteness, inaccessibility, and a legal problem concerning right-of-way for a spur railroad to the edge of the gorge, the central portion was not logged prior to the establishment of the area as a Class II Natural-Scientific Area per the State Natural Areas Preservation Act of 1971 (Tennessee Codes Annotated 11-1708). Class II Areas are "associated with and contain floral assemblages, floral types, fossil assemblages, geological phenomena, hydrologic phenomena, swamplands, and other similar features or phenomena which are unique in natural or scientific value and are worthy of perpetual preservation" (Tennessee Codes Annotated 11-1705). The mixed mesophytic forests that exist in Savage Gulf are presently (at the time of the study) virgin remnants of the forests that once extended northward to Pennsylvania and southward to northern Alabama (Braun, 1950).

Savage Creek formed an ecotone in the northern border of the study area. The forest surrounding the study area was virgin mixed mesophytic for approximately 1 km east and west, .5 km north, and .1 km south of the study area. The uniformity of the area was an important factor. Uniform habitats typical of large regions are particularly desirable and at least half the value of each count depends on it (Hall, 1964).

For convenience in describing the association of the avifauna with the vegetation, the forest was broken into three divisions. They were

Table I. Rock units of Savage Gulf study area (modified from unpublished paper by E. T. Luther, Tennessee Department of Conservation, Division of Geology, 1973).

Rock Unit	Thickness (m)	Elevation (Approximate m)
Recent Alluvium Stream boulders	0 ± 3	401 m
Recent Colluvium Talus "rim-rock"	Boulder to pebble size	Throughout study area at all elevations
Sewanee Conglomerate Rim-Rock	30.5	518.1 - 548.6 m
Signal Point Shale	0 - 7.6	? 510.5 - 518.1
Warren Point Sandstone	6.1 - 30.5	480 m - 510.5 m
Raccoon Mountain Formation Silty shale and fine-grained sandstone	18.3 - 33.5	446.5 - 480 m
Pennington Formation Dolomite, silty limestone, shale, sandstone	94.5 - 104	365.75 - 469.4
Bangor Limestone	36.6	329.2 - 365.75
Hartselle Formation Sandstone	15.2	314 - 329.2
Monteagle Limestone	30.5	283.5 - 314

the overstory, the understory, and the herbs, transgressives, and seedlings. The over- and understory layers of the virgin forest were sampled using the random pairs method of Cottam and Curtis (1949, 1955) using the points of the grid plot of the study area. The overstory was defined as those individuals with a basal area at breast height of more than 81 cm^2 which is the approximate equivalent of 10.16 cm dbh. The understory was those trees from 5.1 cm^2 to 12.6 cm^2 basal area (2.54 cm to 10.16 cm dbh) and 3.05 m or more in height. The data collected were analyzed and used to compute an importance value index (sum of relative density, relative frequency, and relative dominance or basal area) for each species. The transgressive layer (0.3 m to 3.05 m in height) and the herb layer (below 0.3 m in height exclusive of mosses and lichens) were sampled by placing 1 m square quadrats around each point in order to obtain data to be used to determine the presence of the species in these two layers. Thirty points were sampled in the study area. Nomenclature follows that of Fernald (1950).

Organization of Plot

The field work for this study was conducted during the first two weeks of June, 1977. In early June the resident species are likely to be found breeding and migrants are not likely to be found in the mixed mesophytic forests of the Cumberland Plateau.

Preliminary trips were made to Savage Gulf on 7, 8, 14, and 21 May 1977 to locate an area for the study. The field work and census were conducted 1 June 1977 daily through 12 June 1977. The number (12) of daily censuses in the study area is more than the 10 visits recommended

for a density determination of birds in a closed habitat according to Robbins (1970).

The size of the census plot is significant. Hall (1964) stated, "Censuses should be taken on contiguous tracts of not less than 15 acres (6.07 ha), and preferrably (sic) more than twenty acres (8.1 ha)." Censusing errors tend to be greater on small tracts. Hall (1964) stated that in a small tract very few species will be represented by three or more pairs. 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 (Hall, 1964). Robbins (1970) stated that the minimum size of the plot in a closed habitat should be 10 to 30 hectares depending on the complexity of the community and the general level of bird density. Oelke (1966) recommends about 8.1 ha in woodlands rich with undergrowth. Kendeigh (1944) suggests about 20.2 ha of forest as maximum.

An area within the size recommendations of Hall, Kendeigh, Oelke, and Robbins was determined to be 11.8 ha. On a trial basis before the actual censusing period this size was determined to be the largest area that could be censused before the activities of the birds began to decrease noticeably. The rugged topography (such as talused slopes ranging in steepness from a slight slope at Savage Creek to a 60° slope), the denseness of the vegetation, and fallen trees prevented me from censusing an area greater than the size chosen. Care also had to be taken with each step to check carefully for venomous snakes, especially the Northern Copperhead, Agkistrodon contortrix mokasen, which I had observed in the study area two times previous to the censusing.

The shape of the census plot is also significant. It should be as near as is practicable to a square. If it is constrained by physical features or is near habitat boundaries, its shape may be other than square, in order to reduce the amount of edge effect (Robbins, 1970). This was the case in Savage Gulf. The southern edge of the study plot could not be extended because of the precipitous cliffs rising 24 to 31 m above the ground level of the plot. Had the northern boundary of the plot been extended northward, the study plot would have extended into the south-facing slope of the gulf, an area of different vegetational composition as compared to the north-facing slope of Savage Gulf as described by Quarterman, et al. (1972).

A grid was established using a Tulip Tree, Liriodendron tulipifera, with a diameter at breast height (dbh) of 0.97 m as the more southerly of the two southeastern corners of the plot. On the south side of the tree a scar 1.5 m in length and 0.7 m in width was evident. The Tulip Tree also had Virginia Creeper (Parthenocissus quinquefolia) growing on it with a dbh of 3.8 cm. A Yellow Birch (Betula lutea) with a 15.2 cm dbh was growing 7.6 m west of the southeastern corner of the plot in a wet weather stream.

A steel tape measure was used to establish the 50 m intervals of the grid. An engineer's directional compass was used to establish the 90° angles necessary to make each grid square as well as to make the lines of the grid as straight as possible.

Each station of the grid, points where 50 m intervals intersected, was marked with red surveyor's tape at eye level on the nearest tree. The plastic tape was used since it posed no damage to the trees, it was easy to visually locate even with minimal light, and it had high resistance

to dampness and fading. One disadvantage was that three of these markers were removed by rodents apparently during the night making it difficult to find the stations associated with those markers the following morning. Markers were immediately replaced at those stations.

The 50 m between stations was a distance recommended by Robbins (1970) to insure that no part of the plot was more than 50 m away from the routes used by the observer during the censusing. This distance created a plot composed of a grid of 47 squares each having an area of 2500 m^2 or 0.25 ha.

Each recording station received an identification number, and these numbers provided a means for recording data pertaining to each grid area.

When the grid was established visit maps were drawn of it using a scale of one centimeter representing 25 m. Robbins (1970) recommended scales of from one inch for each 100 feet to one inch for each 200 feet in woodland habitats (scales from 1:1250 to 1:2500).

At the beginning of each count the following data were recorded: the current temperatures, the general weather conditions, the sky condition based on the Beaufort Number Scale, and an estimate of the wind speed. In addition, the time was recorded as soon as the investigator reached each station. All time references were local standard time.

The elevation in feet above sea level was determined with a Thommen Pocket Altimeter/Barometer and was recorded at the most northern point (located in Savage Creek) and the most southern point of the plot. This instrument was checked at a benchmark at 452 m located on the Chattanooga-McMinnville State Road, 6.4 km from its junction with Federal Secondary Highway 4350.

The visit maps were used to register contacts on or over the study plot. These registrations were used to plot the location of each contact

and to establish the approximate territorial boundaries. The number of territories present was established by determining the number of territorial males using the area.

"The population (or community) density should be stated as the number of stationary males (mapped territories) per ten hectares or per square kilometer," states Robbins (1970). The bird population of any habitat should be based on the number of territorial males rather than the number of pairs (Hall, 1964). To determine the number of breeding females is difficult under most circumstances, but for this study in Savage Gulf it would have been exceptionally so.

At each station, I observed for three minutes. During that time all birds contacted were recorded. Although population densities were determined from data for males only, all contacts were recorded in order to gain knowledge on as many of the birds occurring in the study plot as I could, regardless of their status. I recorded no contacts made as I moved from one station to another.

Contacts were recorded using the International System (Robbins, 1970) with my modifications. Times were recorded with all registrations on the visit map. The symbol "W" was used when a simple sight or sound contact with a bird of species "W" was observed. The symbol was recorded directly on the visit map at the point correspondent to the bird's position when it was observed. The symbol "Ⓦ" represented a contact with a singing bird of species "W" which had been seen or precisely located. The symbol "(W)" was used when the location of species "W" was not precisely located; this was especially useful with birds with large territories such as the woodpeckers and owls. An aggressive encounter between two birds of species "W" was represented with the symbol "W W". Two contacts with

the same individual of species "W" were recorded using the symbol "W——W". Arrows were utilized to indicate observed movement. To denote separate singing males with simultaneous contacts of two different kinds of a species "W", the symbol "W-----W" was used. A nest of species "W" was denoted with "W*" on the visit map. Numbers of eggs or young, nesting material, and other information pertaining to the nest was recorded in the "remarks" portion of the visit maps. The symbol "W^1" was used to show species "W" carrying food and "W^2" was used to show species "W" carrying nesting material. Abbreviations representing each species contacted in the study plot were used on the visit maps.

During each visit, remarks were recorded concerning the birds that flew over the area such as the Red-tailed Hawk (Buteo jamaicensis), Broad-winged Hawk (Buteo platypterus), and Chimney Swift (Chaetura pelagica). Sightings of immature birds and observations of other birds whose actions indicated a nest might be present were also recorded. This information was valuable in locating many nests during the investigation.

Counts were made daily. In all, twelve counts were made in the morning hours and six during the afternoon hours. Robbins (1970) suggested that two counts should not normally be made on the same day. Three nocturnal observations were also made to determine the presence of other birds not detected during the diurnal observations.

The method of plotting the birds contacted and recorded on the visit maps to determine the number of territorial males present is called the Williams Spot Mapping Method (Williams, 1936). This method is not used to determine the territorial boundaries, but rather is used to estimate the number of territories present. A territory, in the restricted sense

of the mapping method, is the area over which the registrations of a cluster are distributed. The minimum number of registrations required before a cluster can be accepted is related to the number of valid visits. If ten valid visits are made, three registrations must be made before the cluster can be accepted. At least two of these registrations should have high territorial significance (Robbins, 1970).

The most intensive period of song for most species begins just before sunrise. Censusing cruises made after 0600 standard time may show only fifty percent or even less of the individuals of some species still singing (Hall, 1964). Since some species are more conspicuous at times of the day other than early morning, six observations were made in the late afternoon hours. For example, a contact with the Veery (Catharus fuscescens) was never made before 0800 and he mainly sang at dusk.

Although 0600 is the recommended time for beginning surveying (Hall, 1964), the birds did not begin singing in the study area in Savage Gulf until 0630. Because of the thick canopy of the forest of this north-facing slope, the sunlight did not penetrate to the forest floor as early as it did on the escarpment. On 31 May 1977, on a trial census of the area, it had been the original plan to begin censusing at 0600. It was impossible to walk safely through the area at this time without a flash-light. No bird activity was detectable until approximately 0630. All daily censusing therefore began at 0630. Had singing begun before this time, the census would have been very difficult to complete.

Various routes through the plot were used with different starting and ending points.

On 11 June 1977, immediately after completing the morning census, a qualitative survey of the birds of the south-facing slope north of the study plot was undertaken.

The following account describes the routine for a normal day at Savage Gulf. Arise at 0530, hike 0.8 km to automobile. Eat breakfast and make lunch during 6.6 km ride to old logging road leading to the study plot. Hike 0.72 km to census plot. Begin census at 0630 and complete it at approximately 0930. When the census was completed, the remainder of the day was used to describe vegetation, photograph various areas, hunt for nests, re-record visit maps, and perform the other details of keeping records. At 1830, the late afternoon census was begun and ended about 2130. On the occasions when **nocturnal observations** were made, they began at 2130 and were completed at 2200. On those nights dinner was eaten on the escarpment above the census area. On other nights dinner was prepared at the base camp near the ranger station at 1930 and bedtime was around 2100.

In all, fifty-eight person-hours were used during censusing and about ninety-six person-hours were involved in the gathering of other field data needed for this study.

Comparison of Savage Gulf Breeding Birds to the Breeding Birds of other Mixed Mesophytic Forests

The breeding birds of the study area were compared to the breeding birds of three other virgin mixed mesophytic forests and six ecologically-disturbed mixed mesophytic forests to determine which birds were found only in one or the other of these habitats.

The breeding bird density of each species was totalled for all ten areas so that the percentage of the total densities of all bird species could be determined for each species. This demonstrated the dominant bird species of these ten mixed mesophytic forests.

Bird species diversity was calculated for all ten study areas to determine if there was a correlation between bird species diversity and bird density of ten mixed mesophytic study areas in various seral stages.

Since the spot mapping method was used by the other investigators to determine the density of the avian population in the nine other mixed mesophytic forest areas a comparison of their breeding bird densities was made to the breeding bird densities of Savage Gulf.

Significance of differences in relative abundance of individual species between the virgin mixed mesophytic forest and the ecologically-disturbed mixed mesophytic forest was used to determine preference or non-preference for those areas.

Diversity Index and Statistics

Indices of diversity were determined for ten mixed mesophytic censused areas by using Shannon's formula,

$$H' = -\sum_{i=1}^{s} pilogpi,$$

where the pi were estimated from n_1/N as the proportion of the total population of individuals (N) belonging to the ith species (n_i). Using logarithms to the base 2, the expressions of diversity are in units of bits per individual per square kilometer.

The Spearman rank correlation test was used in determining the relationship between breeding bird density and bird species diversity. Significance of differences in relative abundance of individual bird species between virgin mixed mesophytic forest and ecologically-disturbed mixed mesophytic forests were tested using chi-square tests. In all cases the 95 percent level of significance was used.

The chi-square test was performed on an equal number (four) of virgin and ecologically-disturbed mixed mesophytic forests. All four virgin mixed mesophytic forests were compared with the mature forest in Wayne County, West Virginia, and the second growth forests in Webster County, West Virginia; Campbell County, Tennessee; and Madison County, Alabama. The bird species with breeding ranges that did not overlap all the study areas used in these calculations were not included in these comparisons.

CHAPTER IV. RESULTS

Breeding Birds of Savage Gulf

Thirty-five species of birds were found on or flying over the Savage Gulf study area. Of the 35, 29 are believed to have been breeding species. Those 29 species were represented by 94.5 males or 811 territorial males per square kilometer. The results of the census are presented in Table II. The bird species diversity was 4.32.

Analysis of Breeding Birds of Savage Gulf Compared to other Mixed Mesophytic Forest Study Areas

There are some close parallels and some significant differences among the bird populations found in the other mixed mesophytic forests censused by other investigators (Table III and IV). The Red-eyed Vireo was found in all ten censused areas. It comprised 12.3 percent of the total population of territorial birds. The Acadian Flycatcher, which was found in 90 percent of the censused areas, comprised 7.2 percent of the total territorial males and ranked second, behind the Red-eyed Vireo, in dominance. The Wood Thrush was found in 80 percent of the study areas and comprised 5.6 percent of the total territorial males. The Hooded Warbler ranked with the Wood Thrush in dominance, comprising also 5.6 percent of the total territorial males.

The territorial male birds not found in the six ecologically-disturbed mixed mesophytic forests included the Mourning Dove, Screech Owl, Brown Creeper, Veery, Magnolia Warbler, Orchard Oriole, and Rose-breasted Grosbeak.

The territorial males not found in the four virgin mixed mesophytic forests included the Cooper's Hawk, Broad-winged Hawk, Black-billed Cuckoo, American Robin, White-eyed Vireo, Chestnut-sided Warbler,

Table II. Breeding bird density of the Savage Gulf mixed mesophytic forest. Names and ordination follow the checklist of North American Birds (American Ornithologists' Union, 1956, 1973, and 1976).

Species	Territorial Males per 11.75 ha	Territorial Males per 1 km^2
Turkey Vulture, Cathartes aura[1]		
Red-tailed Hawk, Buteo jamaicensis[1]		
Red-shouldered Hawk, Buteo lineatus[1]		
Broad-winged Hawk, Buteo platypterus[1]		
Mourning Dove, Zenaida macroura	1	9
Barred Owl, Strix varia	1	9
Chimney Swift, Chaetura pelagica[1]		
Ruby-throated Hummingbird, Archilochus colubris[1]		
Common Flicker, Colaptes auratus	1	9
Pileated Woodpecker, Dryocopus pileatus	1	9
Red-bellied Woodpecker, Melanerpes carolinus	2	17
Hairy Woodpecker, Picoides villosus	1	9
Downy Woodpecker, Picoides pubescens	1	9
Acadian Flycatcher, Empidonax virescens	5	43
Blue Jay, Cyanocitta cristata	2	17
Carolina Chickadee, Parus caolinensis	3	26
Tufted Titmouse, Parus bicolor	2	17
White-breasted Nuthatch, Sitta carolinensis	3	26
Brown Creeper, Certhia familiaris	1	9

Table II.(continued)

Species	Territorial Males per 11.75 ha	Territorial Males per 1 km^2
Carolina Wren, Thryothorus ludovicianus	1	9
Wood Thrush, Hylocichla mustelina	7	60
Veery, Catharus fuscescens	2	17
Yellow-throated Vireo, Vireo flavifrons	1	9
Solitary Vireo, Vireo solitarius	2	17
Red-eyed Vireo, Vireo olivaceus	13	111
Black-and-White Warbler, Mniotilta varia	4	34
Worm-eating Warbler, Helmitheros vermivorus	4	34
Northern Parula, Parula americana	5	43
Black-throated Green Warbler, Dendroica virens	20	170
Cerulean Warbler, Dendroica cerulea	1	9
Louisiana Waterthrush, Seiurus metacilla	2	17
Kentucky Warbler, Oporornis formosus	2	17
Hooded Warbler, Wilsonia citrina	3.5	30
Scarlet Tanager, Piranga olivacea	2	17
Cardinal, Cardinalis cardinalis	2	17
Totals	94.5	811

[1]Birds seen flying over study plot but never recorded on it.

Table III. Total territorial males in censused mixed mesophytic forests in various stages of succession.

Symbol abbreviation, stage of succession, and location	Total territorial males per 1 km^2	Bird species diversity
V-1 Virgin, Grundy County, Tennessee (Present Study)	811	4.32
V-2 Virgin, Pendleton County, West Virginia (Smith, 1967)	618	3.06
V-3 Virgin, Belmont County, Ohio (Phillips, 1970)	687	4.25
V-4 Virgin, Greenbrier County, West Virginia (DeGarmo, 1950)	600	3.93
M-5 Mature, Wayne County, West Virginia (Koch, 1969)	840	3.87
M-6 Mature, Webster County, West Virginia (Heimerdinger and Chandler, 1956)	1095	4.27
S-7 Second growth, Webster County, West Virginia (Hurley and Miller, 1956)	502	3.14
S-8 Second growth, Tucker County, West Virginia (Harrison, 1960)	576	4.29
S-9 Second growth, Campbell County, Tennessee (Smith, 1977)	953	1.49
S-10 Second growth, Madison County, Alabama (Simmers, 1977)	336	3.78

Table IV. A comparison of the number of territorial males per square kilometer in various mixed mesophytic forests. Names and ordination follow the checklist of North American Birds, (American Ornithologists' Union, 1956, 1973, and 1976). The symbol "+" represents species found breeding in area but less than one territorial male occurs per unit area. (V = Virgin mixed mesophytic forest. M = Mature mixed mesophytic forest, S = Second growth mixed mesophytic forest; see Table III for location of these mixed mesophytic forests).

Species	Mixed Mesophytic Forest Areas										Totals	Percent of Total Population
	V-1	V-2	V-3	V-4	M-5	M-6	S-7	S-8	S-9	S-10		
Cooper's Hawk								+			+	
Red-tailed Hawk			+						5		5+	.07
Broad-winged Hawk									5	+	5	.07
Ruffed Grouse			6	+		16					22+	.31
Mourning Dove	9			8							17	.24
Yellow-billed Cuckoo			13			8			5	6	32	.45
Black-billed Cuckoo						16					16	.23
Screech Owl			13	+							13+	.18
Barred Owl	9								5		14	.20
Ruby-throated Hummingbird			13	33		16					62	.88
Common Flicker	9		+	+					5		14+	.20

Table IV. (Continued)

Species	Mixed Mesophytic Forest Areas										Totals	Percent of Total Population
	V-1	V-2	V-3	V-4	M-5	M-6	S-7	S-8	S-9	S-10		
Pileated Woodpecker	9		+	+	+	+	16		5	3	33+	.47
Red-bellied Woodpecker	17		25		16					19	77	1.10
Hairy Woodpecker	9		13		8				5	6	41	.58
Downy Woodpecker	9		25			16			10	13	73	1.04
Great Crested Flycatcher			13		25	33		8		6	85	1.20
Eastern Phoebe				16					10		26	.37
Acadian Flycatcher	43		91	33	180	41	82	5	20	9	504	7.2
Eastern Wood Pewee			72		49	25		25			171	2.44
Blue Jay	17		+	+	8				5	+	30+	.43
Common Crow		+	+	+				+			+	
Black-capped Chickadee		+						16			16+	.23
Carolina Chickadee	26		25		+				15	9	75+	1.07
Tufted Titmouse	17		25		67	41	25	8	22	13	218	3.11
White-breasted Nuthatch	26		25		49	16			13	13	142	2.02

Table IV. (Continued)

Species	Mixed Mesophytic Forest Areas										Totals	Percent of Total Population
	V-1	V-2	V-3	V-4	M-5	M-6	S-7	S-8	S-9	S-10		
Brown Creeper	9										9	.13
Carolina Wren	9				16				8	32	65	.93
Gray Catbird			13			+					13+	.19
American Robin									5		5	.07
Wood Thrush	60		52	49	+	106	57	16	55		395+	5.63
Veery	17										17	.24
Blue-gray Gnatcatcher			40		49	49			15	63	216	3.08
White-eyed Vireo									5		5	.07
Yellow-throated Vireo	9				25	25			22	6	87	1.24
Solitary Vireo	17	99							5		121	1.72
Red-eyed Vireo	111	49	67	98	82	116	67	106	95	73	864	12.31
Black-and-White Warbler	34	+			+	41	49	33	30		187+	2.66
Worm-eating Warbler	34			25	49		33	25	45		211	2.97
Northern Parula	43			91		67	16				217	3.12

Table IV. (Continued)

Species	Mixed Mesophytic Forest Areas										Totals	Percent of Total Population
	V-1	V-2	V-3	V-4	M-5	M-6	S-7	S-8	S-9	S-10		
Magnolia Warbler		62									62	.88
Black-throated Blue Warbler		62					16	16			94	1.34
Black-throated Green Warbler	170	49					49		5		273	3.89
Cerulean Warbler	9		40		82	49			110	19	309	4.4
Blackburnian Warbler		148		16		91	33	41			313	4.46
Chestnut-sided Warbler						+					+	
Ovenbird		49		74	16	116	16	49			320+	4.56
Louisiana Waterthrush	17	49	13	33		8	33			3	156	2.22
Kentucky Warbler	17		13		33	16	16		75	3	173+	2.46
Hooded Warbler	30			25	25	67	16	67	155	6	391	5.57
American Redstart						49		8	130	13	200	2.84
Orchard Oriole			6								6	.08
Brown-headed Cowbird		+	+						10		10+	.14

Table IV. (Continued)

Species	Mixed Mesophytic Forest Areas										Totals	Percent of Total Population
	V-1	V-2	V-3	V-4	M-5	M-6	S-7	S-8	S-9	S-10		
Scarlet Tanager	17	49	13	49		41	25	41	40		275	3.92
Summer Tanager					25					9	34	.48
Cardinal	17		47	+	25	8			13	9	119+	1.70
Rose-breasted Grosbeak		+									+	
Indigo Bunting				8	8			25			41	.58
Rufous-sided Towhee			19	8	25			41			93+	1.33
Sub-total	811	618	687	600	840	1095	502	576	953	336		
GRAND TOTAL											7018	100.00

American Redstart, and Summer Tanager.

The breeding birds found by Ganier (1923) which were not detected in my June, 1977 census were the Peregrine Falcon, Black-billed Cuckoo, Red-headed Woodpecker and Warbling Vireo. Those I found that Ganier did not in May 1922 were the Brown Creeper, Veery, and Solitary Vireo.

Using a chi-square test for significance of differences in relative abundance of individual species between the virgin mixed mesophytic forest and the ecologically-disturbed mixed mesophytic forest, preference or non-preference for those areas was determined (see Table V). No species preferred the ecologically-disturbed area over the virgin mixed mesophytic forests. The Mourning Dove ($.01<\alpha<.05$) and Ruby-throated Hummingbird ($.01<\alpha<.05$) showed preference for the virgin mixed mesophytic forests. Species that showed no preference for either of these seral stages of the mixed mesophytic forest were the Yellow-billed Cuckoo, Red-bellied Woodpecker, Hairy Woodpecker, Downy Woodpecker, Great Crested Flycatcher, Eastern Phoebe, Acadian Flycatcher, Eastern Wood Pewee, Blue Jay, Carolina Wren, Wood Thrush, Blue-gray Gnatcatcher, Yellow-throated Vireo, Red-eyed Vireo, Black-and-White Warbler, Carolina Chickadee, Tufted Titmouse, White-breasted Nuthatch, Worm-eating Warbler, Northern Parula, Black-throated Blue Warbler, Black-throated Green Warbler, Cerulean Warbler, Overbird, Louisiana Waterthrush, Kentucky Warbler, Hooded Warbler, American Redstart, Scarlet Tanager, Summer Tanager, Cardinal, Indigo Bunting, and Rufous-sided Towhee, (all cases $\alpha > .95$ except American Redstart and Summer Tanager $.1<\alpha<.5$).

Other species were only observed in one or two study areas by various investigators. These rare species which raised the bird species diversity slightly are found in Table IV. The Ruffed Grouse, Black-capped Chickadee, and Blackburnian Warbler were not included in chi-square calculations for

Table V. Summary data based on chi-square test on habitat preferences of all birds found in ten mixed mesophytic forest study areas[3].

Species	V/ED[4]	ED/V[4]
Ruffed Grouse[5]		
Mourning Dove	.01<∝<.05*	
Yellow-billed Cuckoo	∝>.95	
Ruby-throated Hummingbird	.01<∝<.05*	
Pileated Woodpecker	∝>.95	
Red-bellied Woodpecker	∝>.95	
Hairy Woodpecker	∝>.95	
Downy Woodpecker	∝>.95	
Great Crested Flycatcher		∝>.95
Eastern Phoebe		∝>.95
Acadian Flycatcher		∝>.95
Eastern Wood Pewee		∝>.95
Blue Jay		∝>.95
Black-capped Chickadee[5]		
Carolina Chickadee		∝>.95
Tufted Titmouse		∝>.95
White-breasted Nuthatch		∝>.95
Carolina Wren		∝>.95
Wood Thrush	∝>.95	
Blue-gray Gnatcatcher		∝>.95
Yellow-throated Vireo		∝>.95
Solitary Vireo	.5<∝<.9	

Table V. (Continued)

Species	V/ED[4]	ED/V[4]
Red-eyed Vireo	$\alpha > .95$	
Black-and-White Warbler		$\alpha > .95$
Worm-eating Warbler		$\alpha > .95$
Northern Parula		$\alpha > .95$
Black-throated Blue Warbler	$\alpha > .95$	
Black-throated Green Warbler	$\alpha > .95$	
Cerulean Warbler		$\alpha > .95$
Blackburnian Warbler[5]		
Ovenbird		$\alpha > .95$
Louisiana Waterthrush	$\alpha > .95$	
Kentucky Warbler		$\alpha > .95$
Hooded Warbler		$\alpha > .95$
American Redstart		$.1 < \alpha < .5$
Scarlet Tanager	$\alpha > .95$	
Summer Tanager		$.1 < \alpha < .5$
Cardinal	$\alpha > .95$	
Indigo Bunting	$\alpha > .95$	
Rufous-sided Towhee	$\alpha > .95$	

[3] Those species with a density of less than 15 territorial males per km are excluded.

[4] V/ED indicates preference for virgin mixed mesophytic forest over ecologically-disturbed mixed mesophytic forest; ED/V represents preference of ecologically-disturbed mixed mesophytic forest.

[5] No alpha-value is given to these species since their range does not include all areas included in chi-square calculations.

*Indicates those birds which show significant preferences.

preference between the virgin or ecologically-disturbed mixed mesophytic forests since the breeding ranges of these birds do not include all the study areas used in these comparisons.

The results of the Spearman rank correlation test ($N = 10$, $r = 0.115$, $\alpha > .1$) showed there was no correlation between the bird density and bird species diversity.

Vegetation

In the forest overstory 68 percent of the total overstory importance value (Table VI) was made up of Tsuga canadensis, Lirodendron tulipfera, Acer saccharum, Tilia heterophylla, and Aesculus octandra. Diameter at breast height of individuals ranged from 1.04 dm to 10.7 dm. Of the nine species comprising the typical dominants of the mixed mesophytic forest climax (Braun, 1950), only Quercus alba and Castanea dentata are not represented in this data. Standing dead trees, dead stumps, and sprouts of C. dentata were still to be found in the study area.

The understory of the study area was dominated by Cornus florida, Acer saccharum, Tsuga canadensis, Fagus grandifolia, and Hamamelis virginiana, which together comprised 66 percent of the total importance of this layer (Table VII).

Transgressives, herbaceous species, and ferns with the greatest presence included Hepatica acutiloba, Parthenocissus quinquefolia, Heuchera villosa, Polystichum acrostichoides, Arisaema triphyllum, Osmunda cinnamomea, and Acer saccharum. The transgressive and herbaceous species that occurred in more than ten percent of the sample plots are listed in order of presence in Table VIII. A total of 38 species were listed at the 30 quadrats.

Table VI. Composition and importance value indices of overstory species in Savage Gulf study area. Names of plants follow Fernald (1950).

Species	Importance Value	Percent of Total Importance Value
Tsuga canadensis	76.6	25.2
Liriodendron tulipifera	51.1	16.8
Acer saccharum	35.9	11.9
Tilia heterophylla	22.3	7.3
Aesculus octandra	21.3	7.0
Fagus grandifolia	13.8	4.5
Carya ovata	12.9	4.2
Magnolia acuminata	11.4	3.8
Carya tomentosa	9.7	3.2
Acer pensylvanicum	7.6	2.5
Betula lutea	7.4	2.4
Magnolia tripetala	7.2	2.4
Nyssa sylvatica	5.4	1.8
Prunus serotina	4.2	1.4
Quercus rubra	3.7	1.2
Fraxinus americanus	3.4	1.1
Cornus florida	3.4	1.1
Hamamelis virginiana	3.3	1.1
Sassafras albidum	3.3	1.1

Table VII. Composition and importance value indices of understory species in Savage Gulf study area. Names of plants follow Fernald (1950).

Species	Importance Value	Percent of Total Importance Value
Cornus florida	74.7	24.9
Acer saccharum	33.4	11.1
Tsuga canadensis	33.2	11.1
Fagus grandifolia	30.3	10.1
Hamamelis virginiana	26.2	8.7
Carya tomentosa	17.1	5.7
Tilia heterophylla	16.6	5.5
Acer pensylvanicum	15.9	5.3
Liriodendron tulipifera	14.7	4.9
Betula lutea	14.0	4.7
Magnolia tripetala	11.0	3.7
Carpinus caroliniana	7.4	2.4
Ulmus serotina	5.8	1.9

Table VIII. Transgressive and herb layer presence in Savage Gulf study area. Names of plants follow Fernald (1950).

Species	Presence Percent
Hepatica acutiloba	60.0
Parthenocissus quinquefolia	60.0
Heuchera villosa	53.3
Polystichum acrostichoides	46.7
Acer saccharum	23.3
Osmunda cinnamomea	23.3
Asarum canadense	20.0
Boehmeria cylindrica	20.0
Rhus radicans	20.0
Anemonella thalictroides	16.7
Euonymus americanus	16.7
Actaea alba	13.3
Amianthium muscaetoxicum	13.3
Impatiens sp.	13.3
Mitchella repens	13.3

CHAPTER V. DISCUSSION AND CONCLUSIONS

Although Savage Gulf is located in the southern section of the mixed mesophytic forest region, its breeding bird population closely resembles that of more northern mixed mesophytic forests in the Cumberland Mountains and that of the southern Appalachian Mountain region in eastern Tennessee, western North Carolina, and northern Georgia. Two of the birds found at Savage Gulf by Ganier in 1922 and one by me in this investigation breed otherwise in Tennessee only in the Appalachian Mountains. The Brown Creeper, Veery, Solitary Vireo, and Black-throated Green Warbler are usually found at more northern latitudes and/or higher elevations.

Few Brown Creepers have been found breeding at low altitudes such as at Savage Gulf. In 1894 and 1898, several nests were found in a cypress swamp in southeast Missouri (Widman, 1907). In May of 1937, Pickering observed this species at Reelfoot Lake, Obion County, Tennessee. He indicated the late date suggested possible nesting (Pickering, 1937). A recent nesting at Radnor Lake represents the first recorded nesting in Tennessee outside of the Appalachian Mountains (Bierly, 1978). My finding at Savage Gulf represents the second record. The male was observed singing several times and food was observed being carried, presumably to young, although a nest was never located.

My record of a Veery breeding at Savage Gulf is the only one for Tennessee outside of the Appalachian Mountains. The minimum breeding altitude in Tennessee previous to this record was 853 m in Sevier County, (Stevenson and Stupka, 1948); I could find no breeding records of the Veery at elevations lower than that in any of Tennessee's surrounding states. Bent (1949) spoke of the Veery as a middle-of-the-mountain bird in the central Appalachian region. He stated, though, that where extensive hemlock stands occur, at whatever elevations, Veeries are apt to be found.

The Solitary Vireo has now been recorded at two different sites breeding outside of its normal range in Tennessee. Records exist for Campbell County (Howell and Campbell, 1972 and Smith, 1977) and now at Savage Gulf. When this bird was first described by Brewster in 1886, it was considered a bird of the southern Appalachians. In recent years, however, it has extended its breeding southward and to lower elevations (Burleigh, 1958 and Fleetwood, 1947).

The western-most breeding record in Tennessee of the Black-throated Green Warbler, a species commonly found in the Smokies, is at Savage Gulf. This bird is known to breed at 131 m above sea level in Alabama (Imhof, 1976) but the breeding birds I found at Savage Gulf represent the lowest-elevation records known in Tennessee for this species.

Many species, such as the Acadian Flycatcher and Red-eyed Vireo, showed no preference for either the virgin or ecologically-disturbed mixed mesophytic forests and were common in both. Obviously, the requirements for these birds are met in both the non-ecologically-disturbed and ecologically-disturbed mixed mesophytic forests, as well as other habitats where these species are found.

None of the bird species found in any of the ten mixed mesophytic forests study areas are thought to be dependent on mixed mesophytic forests. Bent (1940) does not describe the Mourning Dove or the Ruby-throated Hummingbird as preferring virgin forests for breeding. Possibly, before man arrived in North America and disturbed the virgin forests, the Mourning Dove and Ruby-throated Hummingbird preferred the virgin forests. But presently, these two species seem to thrive in both virgin and ecologically-disturbed forested areas. Requirements such as nesting site, food, nesting materials, and/or competition for these requirements

with members of a birds own species or other species could all be factors affecting suitability of specific habitats for particular species, but it was not the scope of this research to determine such factors and measure their relationship to the avifauna.

Willson's (1974) study showed also that correlations between density and diversity often do not occur in mature deciduous woodlands. It has been shown that bird species diversity increases as succession proceeds and the prevailing vegetation changes to a mature climax forest (Kendeigh, 1974). There has also been a suggestion that the highest diversity occurs preceding the climax, when there is still a remnant of seral species mingling with a full complement of species belonging to the climax forest (Kendeigh, 1974). However, of the areas included in Table III, that with the highest bird species diversity was Savage Gulf, a virgin mixed mesophytic forest. The fact that the area with the lowest bird species diversity was a recently reclaimed strip-mined area and the successionally youngest of the ten areas compared, suggests that early seral stages have less diversity.

A factor that could have affected the density is edge effect. More bird species are found at ecotones. The area with the highest density, the mature mixed mesophytic forest in Webster County, West Virginia, was ecotonal.

Quarterman, et al. (1972) found the greatest overstory importance values of the north-facing slope of the virgin forest of Savage Gulf for the same five species as I found in my study area. The rank order of the importance values differed in the two studies. Quarterman, et al. (1972) found the Tilia heterophylla, Tsuga canadensis, Acer saccharum,

Liriodendron tulipifera, and Aesculus octandra to account for 72 percent of the importance values for their study areas at Savage Gulf. Of the 21 overstory species found by Quarterman, et al. (1972), five were not found in the overstory of my study area; these five species were Quercus prinus, Carya glabra, C. cordiformis, Carpinus caroliniana, and Ulmus serotina. Braun's (1950) description of hemlock-mixed mesophytic communities of the Cumberland Mountains indicated that "sugar maple, basswood, and buckeye are usually poorly represented" and "hemlock, beech, and tuliptree are usually abundant," comprising 45 to 70 percent of the canopy. This order was found in my study area in Savage Gulf with sugar maple, basswood, and buckeye comprising 26 percent of the canopy importance value and hemlock, beech, and tuliptree making up 47 percent. Except for the presence of hemlock, the Savage Gulf forest bears a strong resemblance in its major co-dominants to the all-deciduous mixed mesophytic community of the Cumberland Mountains in Kentucky (Braun, 1950).

Savage Gulf, the largest remnant of our virgin mixed mesophytic forest of Tennessee, possesses a unique avifauna. Perhaps, through this study, a better understanding of the status of the birds of Savage Gulf has been attained. If the pristineness of the area persists, natural changes in the area's avifauna can be studied in the future.

CHAPTER VI. SUMMARY

From 1 to 12 June 1977, daily censuses of breeding birds were conducted, using the Williams Spot Mapping Method (Williams, 1936), in a 11.75 ha section of a virgin mixed mesophytic forest in Savage Gulf, Grundy County, Tennessee, a gorge cut into the western escarpment of the Cumberland Plateau. Two layers of the forest (over- and understory) were sampled at 30 points within the study area, using the random pairs method of Cottam and Curtis (1949, 1955). The presence of the transgressives and herbs was determined by using a 1 m^2 quadrat at each of these 30 points, also. Bird species diversity was calculated for the study area and compared with nine other mixed mesophytic areas previously censused by other investigators, by using Shannon's formula (Shannon and Weaver, 1949).

Thirty-five bird species were present for a total of 811 territorial males per square kilometer and a bird species diversity of 4.32. The dominant breeding birds of the area listed in descending order were the Black-throated Green Warbler, Red-eyed Vireo, Wood Thrush, Acadian Flycatcher, and Northern Parula. Birds not previously found breeding in mixed mesophytic forests included the Veery and Brown Creeper.

The Mourning Dove and Ruby-throated Hummingbird, showed a preference for the virgin mixed mesophytic forests. No bird species showed a preference for the ecologically-disturbed mixed mesophytic forest.

No correlation was found between bird species diversity of ten mixed mesophytic study areas in various seral stages and bird density.

LITERATURE CITED

American Ornithologists' Union. 1957. Check-list of North American Birds, 5th Edition. American Ornithologists' Union. Baltimore, Maryland. 691 pp.

_____. 1973. Thirty-second supplement to the American Ornithologists' Union checklist of North American birds. The Auk 90: 411-419.

_____. 1976. Thirty-third supplement to the American Ornithologists' Union checklist of North American birds. The Auk 93: 875-879.

Barbour, R. W. 1951. The summer birds of Rowan and adjacent counties in eastern Kentucky. Kentucky Warbler 27: 31-39.

Bent, A. C. 1940. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. United States National Museum Bulletin 176.

_____. 1949. Life histories of North American thrushes, kinglets, and their allies. United States National Museum Bulletin 196.

_____. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. United States National Museum Bulletin 197.

Bierly, M. L. 1978. Brown Creeper nests in Nashville. Migrant 49: 86-87.

Braun, E. L. 1950. Deciduous forests of eastern North America. Hafner Publishing Company, New York. 596 pp.

Brillouin, L. 1956. Science and information theory. Second edition. Academy Press, New York. 351 pp. (cited in Lloyd, et al, 1968).

Burleigh, T. D. 1958. Georgia birds. University of Oklahoma Press, Norman. 746 pp.

Cathers, C. 1977. Mixed mesophytic forest, breeding bird census. Audubon Field Notes 31: 45-56.

Cottam, G. and J. T. Curtis. 1949. A method for making rapid surveys of woodlands by means of pairs of randomly selected trees. Ecology 30: 101-104.

_____. 1955. Correction for various exclusion angles in the random pairs method. Ecology 36: 767.

DeGarmo, W. R. 1950. Virgin cove hardwood forest, breeding bird census, Audubon Field Notes 4: 262-297.

Fenneman, N. M. 1938. Physiography of eastern United States. McGraw-Hill, New York. 691 pp.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th Edition. American Book Company, New York. 1632 pp.

Fleetwood, R. J. 1947. The Mountain Vireo nesting for the first time in the Lower Piedmont Plateau of Georgia. Auk 64: 462-463.

Ganier, A. F. 1923. Notes from the Tennessee Cumberlands. Wilson Bulletin 35: 26-34.

Hall, G. A. 1964. Breeding-bird censuses - why and how. Audubon Field Notes 18: 413-416.

Harrison, G. H. 1960. Cove and northern hardwood forest, breeding bird census. Audubon Field Notes 14: 491-492.

Heinerdinger, H. and E. R. Chandler. 1956. Fairly mature deciduous forest with some hemlock, breeding bird census. Audubon Field Notes 10: 425-426.

Howell, J. C. and J. M. Campbell. 1972. Observations of Campbell County Birds. Migrant 43: 1-4.

Hurlbert, S. H. 1971. The nonconcept of species diversity: a critique and alternative parameters. Ecology 52: 577-586.

Hurley, G. and C. Miller. 1956. Upland second growth mixed hardwoods and hemlock, breeding bird census. Audubon Field Notes 10: 425.

Imhof, T. A. 1976. Alabama birds. University of Alabama Press, University. 445 pp.

Karr, J. R. 1971. Structure of avian communities in selected Panama and Illinois habitats. Ecological Monographs 41: 207-233.

Kempton, R. A. and R. W. M. Wedderburn. 1978. A comparison of three measures of species diversity. Biometrics 34: 25-37.

Kendeigh, S. C. 1944. Measurement of bird populations. Ecological Monographs 14: 67-106.

_____. 1974. Ecology with special reference to animals and man. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. 474 pp.

Koch, G. 1969. Mature mesophytic forest, breeding bird census, Audubon Field Notes 23: 708-709.

Lloyd, M., J. H. Zar, and J. R. Karr. 1968. On the calculation of information - theoretical measures of diversity. American Midland Naturalist 79: 257-272.

Oelke, H. 1966. Thirty-five years of breeding-bird census work in Europe. Audubon Field Notes 9: 635-642.

Peattie, R. 1936. Mountain geography. Harvard University Press, Cambridge, Massachusetts. 257 pp.

Phillips, G. 1970. Mature northern hardwoods, breeding bird census. Audubon Field Notes 24: 748-749.

Pickering, C. F. 1937. September visit to Reelfoot Lake. Migrant 8: 49-50.

Pielou, E. C. 1966. Shannon's formula as a measurement of species diversity and its use and misuse. American Naturalist 103: 75-80.

Quarterman, E., B. H. Turner, and T. E. Hemmerly. 1972. Analysis of virgin mixed mesophytic forests in Savage Gulf, Tennessee. Bulletin of the Torrey Botanical Club 99: 228-232.

Robbins, C. S. 1970. Recommendations for an international standard for a mapping method in bird census work. Audubon Field Notes 24: 723-726.

Sager, P. E. and A. D. Hasler. 1969. Species diversity in lacustrine phytoplankton. I. The components of the index of diversity from Shannon's formula. American Naturalist 103: 51-59.

Shannon, E. E. and W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Urbana. 125 pp.

Simmers, R. W., Jr. 1977. Mixed mesophytic hardwoods, breeding bird census. American Birds 21: 47-48.

Smith, A. B. 1977. Maple-gum-hickory forest, breeding bird census, American Birds 31: 47.

Smith, J. L. 1967. Virgin hemlock-northern hardwoods, breeding bird census. Audubon Field Notes 21: 627-628.

Stevenson, H. M. and A. Stupka. 1948. The altitudinal limits of certain birds in the mountains of the southeastern states. Migrant 19: 33-60.

Taylor, L. R., R. A. Kempton, and I. P. Woiwod. 1976. Diversity statistics and the log-series model. Journal of Animal Ecology 45: 255-272.

Tennessee Codes Annotated 11-1705. 1971. Natural Areas Act of 1971, classifications.

Tennessee Codes Annotated 11-1708. 1971. Natural Areas Act of 1971, designation of areas.

Traner, E. J. 1969. Bird species diversity: components of Shannon's formula. Ecology 50: 927-929.

United States Department of Commerce, Weather Bureau. 1973. Climatography of the United States No. 81, monthly normals of temperature, precipitation, and heating and cooling days, 1941-1970, Tennessee.

Whittaker, R. H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs 26: 1-80.

Widmann, O. 1907. Preliminary catalogue of the birds of Missouri. Transactions of the Academy of Science, St. Louis 17: 1-288.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecological Monographs 6: 317-408.

Willson, M. F. 1974. Avian community organization and habitat structure. Ecology 55: 1017-1029.

Yehner, Richard H. 1972. Mixed deciduous forest, breeding bird census. American Birds 26: 951-952.