

BIRD POPULATIONS IN THE HEMLOCK SERE ON THE HIGHLANDS PLATEAU, NORTH CAROLINA, 1946 TO 1972

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Bird populations were studied in selected successional stages in the hemlock sere in western North Carolina, in relation to changes that have occurred in the vegetation over a twenty-five year period. The three study areas represent mesic shrubland, intermediate hemlock-hardwood forest, and climax virgin hemlock forest, all occurring at elevations between 3,800 and 4,100 ft. The study areas were initially mapped and censused for breeding birds in 1946 and 1947 by E. P. Odum (1950). I carried out subsequent studies on the same study plots in 1959–1960 and 1971–1972. These combined data provide the basis for this paper.

All of the study areas are located within four mi of Highlands, Macon County, North Carolina. This plateau region, averaging approximately 4,000 ft in elevation, is located at the southern end of the Blue Ridge Mountains, in southwestern North Carolina. Many plants and animals typical of areas farther north are found in this area, and the annual rainfall of more than 80 in supports a luxuriant vegetation. The ecology of the Highlands Plateau has been described by Oosting and Billings (1939) and Odum (1950).

METHODS

The three study plots were censused for breeding birds by using the spot-mapping technique (Williams, 1947; Odum, 1950). Five to six censuses were taken in the mornings on each area in the period 15–30 June 1959, three times on each from 22 May–16 June 1960, and five to seven times on each from 23 May–16 June 1971 and 23 May–7 June 1972. In each daily census the locations were recorded of all birds seen or heard (indicating sex when possible), using individual copies of Odum's original maps of the study areas. From composite maps constructed at the end of each year's study, territories were delineated and the numbers of pairs of each species on each study area were determined. When the territory of a pair of birds did not lie totally within the study area, the appropriate fraction of the territory was estimated from the composite maps and from field observations. All three study areas were visited in rotation for a combined total of three to four hr each morning. Afternoon visits were used to check for nest locations. Population density figures for 1959–1960 and for 1971–1972 were converted to pairs per 100 acres and then averaged to conform to Odum's (1950) 1946–1947 data. Where study plots consisted of less than 10 acres, the density of each species was reduced by 10 percent to compensate for the small sample size (Odum, *op. cit.*).

By 1971, some of the exact boundaries of the original 6.4 acre mesic shrubland tract had become obliterated. This necessitated a remapping of this tract. The presence of old logged hemlock stumps interspersed within the secondary growth made it possible to remain within the original logged hemlock area at all times and to include all of the

TABLE 1
BIRD SPECIES AND THEIR DENSITIES ON THE HIGHLANDS PLATEAU THE HEMLOCK SERE
(A.O.U., 1957, ORDER OF SPECIES)

Species	Pairs per 100 acres							
	Intermediate							
	Mesic shrubland			Hemlock-hardwood			Virgin hemlock	
	1946- 1947	1959- 1960	1971- 1972	1946- 1947	1959- 1960	1971- 1972	1946- 1947	1959- 1960
Broad-winged Hawk <i>Buteo platypterus</i>							2	
Ruffed Grouse <i>Bonasa umbellus</i>		6						
Common Flicker <i>Colaptes auratus</i>			6	10	7	4		8
Pileated Woodpecker <i>Dryocopus pileatus</i>						1		4
Hairy Woodpecker <i>Dendrocopos villosus</i>			6				10	4
Great Crested Flycatcher <i>Myiarchus crinitus</i>					4		4	
Eastern Phoebe <i>Sayornis phoebe</i>						4		
Eastern Wood Pewee <i>Contopus virens</i>				8	7	4	6	
Blue Jay <i>Cyanocitta cristata</i>			6		8	17		8
Carolina Chickadee <i>Parus carolinensis</i>		7	6	5	10	20	8	9
Tufted Titmouse <i>Parus bicolor</i>			13		7	4	2	9
White-breasted Nuthatch <i>Sitta carolinensis</i>			6		7	4	8	4
Red-breasted Nuthatch <i>Sitta canadensis</i>				8	5	7	17	4
Brown Creeper <i>Certhia familiaris</i>					4		8	8
Carolina Wren <i>Thryothorus ludovicianus</i>						7		
Gray Catbird <i>Dumetella carolinensis</i>	42	28	16	25	27	30	16	
Brown Thrasher <i>Toxostoma rufum</i>	14	7	3		4	7		
American Robin <i>Turdus migratorius</i>		14	3	2	10	17		
Wood Thrush <i>Hylocichla mustelina</i>		8	16	42	39	20	10	17

TABLE 1 (continued)

Species	Pairs per 100 acres							
	Intermediate							
	Mesic shrubland			Hemlock-hardwood			Virgin hemlock	
	1946- 1947	1959- 1960	1971- 1972	1946- 1947	1959- 1960	1971- 1972	1946- 1947	1959- 1960
Rose-breasted Grosbeak <i>Pheucticus ludovicianus</i>		4	3	17	14	24	2	2
Indigo Bunting <i>Passerina cyanea</i>	7	14	9					
American Goldfinch <i>Spinus tristis</i>	14	7	6					
Rufous-sided Towhee <i>Pipilo erythrophthalmus</i>	14	28	19		4	17		
Dark-eyed Junco <i>Junco hyemalis</i>			9	8	20	30		2
Chipping Sparrow <i>Spizella passerina</i>		7	3					
Field Sparrow <i>Spizella pusilla</i>	22	35	6					
Song Sparrow <i>Melospiza melodia</i>	126	28	9					
Total pairs	288	321	296	270	351	349	331	230
Total species	8	22	35	21	28	30	19	23

1946-1947 tract during the process of remapping. The remapped mesic shrubland tract censused in 1971-1972 covered an area of 16 acres, and this acreage figure was used in computing pairs per 100 acres for this period. Although the increase in the number of species from 1959-1960 to 1971-1972 could have been affected by the increase in size of the mesic shrubland tract, I consider the increase primarily a result of change in habitat due to further plant succession. An examination of Table 1 shows the species added in 1971-1972 to be birds typical of woodland habitats.

Unfortunately, an accurate census was not possible in the virgin hemlock forest tract in 1971-1972. Only a trail around one side of this study tract remained open by that time. All remaining trails were completely obliterated by impenetrable tangles of *Rhododendron*, and my single crossing of the tract involved a great effort and progression on hands and knees. Although an accurate census was impossible, it was possible to walk along the open trail and identify the calls of birds breeding in approximately one-fourth of the study tract. This was done on eight mornings in 1971-1972.

Although more refined statistical methods of analyzing bird species diversity exist today, the breeding bird density (in pairs per 100 acres) of one plot is compared with that of another plot according to the "percentage difference" method of Odum (1950). This allows the data from the 1959-1960 and 1971-1972 studies to be treated by the same method as the 1946-1947 data. For example, in comparing avian density in the mesic shrubland with that in the intermediate hemlock in 1959-1960 (Table 1), the species-

by-species difference in pairs per 100 acres are first calculated: e.g. for the Chestnut-sided Warbler the value is 49 and for Gray Catbird it is one (scientific names of birds are given in Table 1). All of the differences are then added, and that total difference is divided by the total number of pairs per hundred acres in the two tracts. The percentage difference is a rough index of difference (or similarity) in species composition and in density. A percentage difference at the low end of the scale indicates a close similarity, while one at the higher end shows that the populations are markedly different.

THE STUDY PLOTS

Mesic Shrubland

The example of this primary successional stage of the hemlock sere is located four mi east of Highlands, North Carolina, on U.S. Highway 64, downstream from the Virgin Hemlock Forest study area. In 1946–1947, Odum (1950) described the vegetation as consisting “. . . of shrubs and small trees chiefly alders, willows, and brambles (*Rubus*) which form dense thickets interspersed with more open areas dominated by grasses and herbs. Huge stumps of hemlock and thickets of laurel (*Kalmia*) and rhododendron remain from the original hemlock forest which occupied the area. The plot has never been cultivated, but has apparently been subjected to some grazing in the past.”

Of the three study plots, naturally the mesic shrubland has undergone the greatest change during the twenty-five years since 1947. Approximately one acre of this tract has continued under intermittent grazing or cultivation. An additional acre appears to have been disturbed by 1971–1972. The size of the tract censused in 1946–1947 and 1959–1960 was 6.4 acres. As explained earlier, the censused area was enlarged in 1971–1972 to 16 acres, including the two which had been disturbed in the past.

In the disturbed area, blackberry (*Rubus* sp.) forms a dense cover, with herbs and grasses covering the more open areas. A dense stand of sassafras (*Sassafras albidum*) has grown up at one end. The stream runs through a portion of the disturbed area. The remaining part of the study tract is covered with maples (*Acer* spp.), oaks (*Quercus* spp.), birches (*Betula* spp.), tulip poplar (*Liriodendron tulipifera*), cherry (*Prunus* sp.), sourwood (*Oxydendrum arboreum*), Fraser magnolia (*Magnolia fraseri*), locust (*Robinia* spp.), dogwood (*Cornus* spp.), and hemlock (*Tsuga* spp.). Thickets of rhododendron and laurel persist along the stream. Stumps of the old logged hemlocks may still be seen. In some cases hemlock sprouts from these stumps have produced trees more than twenty ft in height. The forest canopy averages approximately 20 ft in height, with some individual maples and hemlocks 30 to 40 ft high. The plot is in an intermediate stage of succession, but will continue to be termed the “mesic shrubland” for purposes of comparison.

Intermediate Hemlock-hardwood Forest

The example of this secondary successional stage covers an area of 15 acres, located around the Highlands Biological Station but excluding the clearings for the buildings, etc. Most of the trees are hemlock, white pine (*Pinus strobus*), birch, and maple, with evergreens comprising approximately 50 percent of the total. Most of these trees comprise second growth, but some are quite large and may represent remnants of the original virgin forest. Dense stands of rhododendron, laurel, witch hazel (*Hamamelis* sp.), and azalea (*Rhododendron* spp.) form the understory. Little change has occurred in this tract since 1946–1947, except an increase has occurred in the size of the trees and the density of the understory in some areas. The size of the tract was decreased slightly with clearing for the erection of some new buildings at the Highlands Biological Station.

Virgin Hemlock Forest

The final successional stage studied is the virgin hemlock forest, a 12 acre tract located four mi east of Highlands on U.S. Highway 64 (opposite the Mesic Shrubland). In 1946–1947, Odum (1950) stated that three-fourths of the stand was comprised of hemlock trees three to four ft in diameter and 400 or more years old. This virgin forest is a remnant of a once extensive stand of hemlock known as the "Primeval Forest" or "Ravenel's Woods." Large black birch (*Betula lenta*), red maple (*Acer rubrum*), Fraser magnolia, red oak, and other deciduous trees are widely scattered through the stand. Rhododendron makes up the dense understory.

This plot has been subjected to one man-made alteration since 1946, the addition of a small pond (approximately 30 by 50 ft), close to the center of the study area. Observations of the species nesting there in 1959–1960 indicated that the pond did not affect species or numbers of breeding birds during that period. At that time access to the interior of this forest was gained along primitive roads around part of the perimeter and paths to the center. By 1971–1972 these had become obliterated by rhododendron.

RESULTS

Table 1 shows species composition and densities of birds in the three study areas of the hemlock sere. Bird names are listed in A.O.U. Check-list order (1957; Eisenmann et al., 1973). In the interval from 1946–1947 to 1959–1960, 14 additional species were added in the mesic shrubland, eight in the intermediate hemlock-hardwood tract, and eight in the virgin forest. One species which occurred in the intermediate hemlock-hardwood forest in 1946–1947 was not found in 1959–1960 and four species were absent from the virgin forest. In the 1971–1972 census, fourteen additional species were

TABLE 2
PERCENTAGE DIFFERENCE IN THE BREEDING BIRD POPULATIONS OF THE THREE STUDY PLOTS
COMPARED WITH EACH OTHER

	Census year		
	1946-1947	1959-1960	1971-1972
Mesic shrubland and virgin hemlock	97.9	83.5	—
Mesic shrubland and intermediate hemlock	95.8	70.2	50.1
Virgin hemlock and intermediate hemlock	50.5	33.2	—

recorded in the mesic shrubland and one species found in 1959-1960 was absent, while five species were added in the intermediate hemlock-hardwood tract and three species were absent. The number of species common to all three tracts increased from one in 1946-1947 to seven in 1959-1960.

Percentage differences (Table 2) showed marked declines. The decrease is particularly striking when the mesic shrubland is compared with the intermediate hemlock-hardwood forest, the value shifting from 95.8 percent in 1946-1947 to 50.1 percent in 1971-1972.

Table 3 shows the species of birds common to both mesic shrubland and intermediate hemlock-hardwood tracts increased from 12.5 percent in 1946-1947 to 65.7 percent in 1971-1972. The greatest change in bird species richness on any of the tracts during the twenty-five year period occurred in the mesic shrubland, where the number of species increased from eight in 1946-1947, 22 in 1959-1960, and 35 in 1971-1972.

Although the virgin tract was too dense for accurate census in 1971-1972, two additional species were recorded during visits to this tract. The Golden-crowned Kinglet was consistently present both years and a nesting Rufous-sided Towhee was noted in 1971.

TABLE 3
COMPARISON OF BIRD SPECIES COMPOSITION OF MESIC SHRUBLAND TRACT WITH
INTERMEDIATE HEMLOCK-HARDWOOD FOREST TRACT

Census year	Total species mesic shrubland	Species common to both tracts	Percentage of species common to both tracts
1946-1947	8	1	12.5
1959-1960	22	12	54.5
1971-1972	35	23	65.7

DISCUSSION

In the 1946–1947 census, only the Gray Catbird was found in all three study areas. By 1959–1960, the number of species common to all three study areas had increased to seven. Calculations of the percentage difference of the three study plots also confirm greater similarity. The difference between the mesic shrubland and intermediate hemlock-hardwood tracts decreased from 95.8 percent in 1946–1947 to 70.2 percent in 1959–1960 and 50.1 percent in 1971–1972.

The species in common between mesic shrubland and intermediate hemlock-hardwood tracts over the twenty-five year period increased from 12.5 to 65.7 percent. The similarity of species in the three plots would have been even greater in 1971–1972, if the entire mesic shrubland plot had been left undisturbed. Disturbance served to maintain prime habitat for several species characteristic of early stages of succession. These include such birds as the Song and Field Sparrows and the very high concentration of Chestnut-sided Warblers. The American Goldfinch, Indigo Bunting, Yellow-breasted Chat, Chipping Sparrow, Golden-winged Warbler, and Northern Yellow-throat also occurred in the area. These nine species, together with birds characteristic of the later successional stages, account for the high figures of 35 species and 296 pairs listed for this period.

The former mesic shrubland is now entering the intermediate hemlock-hardwood stage, as is evidenced by the presence of the Blackburnian Warbler which now breeds there. Bent (1953) describes this bird as nesting to heights of over 80 ft above ground in coniferous trees, with males singing from tall trees. The habitat preference of this bird and its presence in this study tract certainly reflect the degree of plant succession which has occurred.

The number of species represented within all seral stages in the 25 year period has increased markedly. The most dramatic increase shown in this study is in the mesic shrubland where the number increased from eight to 35 species. The increases in the intermediate hemlock-hardwood forest from 21 to 30 and in the virgin forest from 19 to 23 species (in the first thirteen years of this study) are less striking.

Kricher (1972) found that bird species richness at all seasons increased with the age of the seral stages. When the Highlands area seral stages are compared with each other, however, species richness peaked as the former mesic shrubland entered the intermediate hemlock-hardwood stage (1971–1972), rather than in the climax virgin forest. Mesic seres are known to have peaks in avian diversity in the middle rather than at the end (Adams, 1908; Aldrich, 1943).

While the number of species increased within each seral stage, the number of individuals in the virgin hemlock tract declined markedly from 331 pairs

per 100 acres in 1946–1947 to 230 in 1959–1960. This decline probably can be attributed to continued growth of the rhododendron understory, which characteristically is poor bird habitat.

Several observations concerning the distribution of particular species are of interest. Odum (1950) noted in 1946–1947 that the Highlands area lacked such northern species as Golden-crowned Kinglet, Magnolia Warbler, and Black-throated Green Warbler. Recently, Johnston (1964) lists the Golden-crowned Kinglet as an uncommon permanent resident of the area, and a nest was found in Highlands on 11 June 1951. In 1971–1972, I recorded this species consistently as a breeding bird of both the intermediate hemlock-hardwood and virgin hemlock forests. Johnston (1964) classifies the Black-throated Green Warbler as a summer visitor of the Highlands area, but with no definite evidence of breeding. I observed this species in the virgin hemlock forest tract once during the census of 1959 and again in 1960. As it was not observed more than once, it was not included in the breeding bird list; nevertheless, its presence during the breeding season may indicate that further study will prove it to be a member of this breeding avifauna. The Magnolia Warbler, although a regular migrant, has not been recorded as a summering or breeding species.

Another species which appears to have extended its breeding range into the Highlands plateau is the Brown-headed Cowbird. This bird was not recorded in the pre-1972 breeding bird counts, and Johnston (1964) classified it as uncommon—with only one observation appearing on the Highlands Biological Station records. In 1972 this cowbird appeared in both the intermediate hemlock-hardwood forest around the Highlands Biological Station and in the mesic shrubland, four mi east of Highlands. Both adults and young were commonly noted in May and June and its population density should be monitored in the future.

SUMMARY

Breeding bird population studies were carried out in the hemlock sere at elevations of 3,800 to 4,100 ft on the Highlands Plateau, western North Carolina, over a twenty-five year period. Populations of three carefully selected stages of succession in the sere (mesic shrubland, intermediate hemlock-hardwood, and virgin forest) were studied using the spot-mapping technique. Breeding bird population analyses in 1959–1960 and 1971–1972 were compared with the initial survey of these study areas by Odum (1950) in 1946–1947, and population density and species composition were compared with changes in the vegetation. Increases in density and species richness were correlated with the age of the seral stages, as evidenced by comparing percentage differences in bird populations of the study areas in the different census years. Both avian density and species richness showed an increase in the intermediate stage and a decline in the climax stage of the hemlock sere.

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LITERATURE CITED

- ADAMS, C. C. 1908. The ecological succession of birds. *Auk*, 25:109-153.
- ALDRICH, J. W. 1943. Biological survey of the bogs and swamps in northeastern Ohio. *Amer. Midland Nat.*, 30:346-402.
- A.O.U. 1957. Check-list of North American birds. 5th ed. American Ornithologists' Union
- EISENMANN, E. (chairman). 1973. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. *Auk*, 90:411-419.
- BENT, A. C. 1953. Life histories of North American wood warblers. U.S. Natl. Mus. Bull. 203.
- JOHNSTON, D. W. 1964. The birds of Highlands, North Carolina, with a preliminary list from Cashiers and nearby gorges. *Jour. Elisha Mitch. Sci. Soc.*, 80:29-38.
- KRICHER, J. C. 1972. Bird species diversity: the effect of species richness and equitability on the diversity index. *Ecology*, 53:278-282.
- ODUM, E. P. 1950. Bird populations of the Highlands (North Carolina) Plateau in relation to plant succession and avian invasion. *Ecology*, 31:587-605.
- OOSTING, H. J., AND W. D. BILLINGS. 1939. Edapho-vegetational relations in Ravenel's Woods, a virgin hemlock forest near Highlands, North Carolina. *Amer. Midland Nat.*, 22:333-350.
- WILLIAMS, A. B. 1947. Breeding-bird census: climax beech-maple forest with some hemlock (15 year summary). *Audubon Field Notes*, 1:205-210.

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