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The avifaunal composition of ten western Oregon forest stands located at the eastern base of the Coast Range was examined on a seasonal basis. The stands were dominated by Oregon white oak, Douglas fir or western hemlock. Avian populations were sampled monthly from January 1968 to January 1970, using permanent transects.

In order to determine seasonal changes in bird species composition and diversity, variations in the ecological roles of the bird species, their patterns of habitat utilisation, and the importance of habitat components in determing the abundance of species, information was gathered on the behavior and activity patterns, morphological variation and dietary habits of the bird species, and on the vegetative structure of the stands. Intensive studies were centered on seven permanent resident species: Black-capped Chickadee, Chestnut-backed Chickadee, White-breasted Nuthatch, Red-breasted Nuthatch, Brown Creeper, Rufous-sided Towhee, and Oregon Junco.

Oak-dominated stands had the highest bird species diversity in all seasons. This is in contrast to the expected increase in diversity with each successional sere. In most cases the actual species diversity was at least 90 percent of the maximum possible diversity.

All fir and hemlock stands shared a large number of species and supported roughly similar total populations. In the ecotonal areas diversity was slightly higher than in the surrounding pure stands of either deciduous or coniferous vegetation.

More individuals and species were found in western Oregon forests than reported for forests in eastern United States. Further, a large proportion of these birds were permanent residents. Because of this large number of permanent residents, the percentage of migratory birds was lower than in eastern forests. These differences may in part stem from the milder winter climate characteristic of western Oregon.

More than 50 percent of the birds present during all seasons in all vegetative types belonged to either the foliage-insect or foliage-seed eating ecological roles. Insect activity had a major influence on avifaunal structure, as at any time of the year 60 to 80 percent of the species recorded belonged to the insect-eating roles.

When the effects of vegetative structural features on avian abundance were compared, little difference was found between the importance of variables in the fir and hemlock areas. For the bird species inhabitating all vegetative seres analyzed in this study, the same set of structural components affected each species' abundance throughout its ecological distribution.

The avifauna of these western Oregon forests thus does not fit into any recognized plant community classification. The birds move between areas within their range of ecological tolerance, providing an energy link between the immobile vegetation.

Ecological Relationships of Birds in Forests of Western Oregon

by

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ECOLOGICAL RELATIONSHIPS OF BIRDS IN FORESTS OF WESTERN OREGON

INTRODUCTION

The present trend in ecological studies of birds is to break free of the confines of community concepts and attempt to answer two sorts of questions. First, ecologists are asking the old question, "What factors influence the distribution and abundance of species?" with a new attention to quantification. Second, increasing attention is being given to similar questions concerning the diversity and ecological structure of avifaunas.

These questions have been approached in a variety of ways. MacArthur and MacArthur (1961) and MacArthur et al. (1966), for example, showed that layering of foliage in eastern deciduous forests could predict the species diversity of breeding birds. Sturman (1968b) found that components of the vegetative structure were highly correlated with the abundance of Black-capped and Chestnut-backed Chickadees[1] in western Washington.

Other studies have given greater emphasis to the structure of the avifauna. In a study of avian communities in California and Wyoming, Salt (1953,1957) described the ecological role of species in the avian community in an effort to demonstrate the pathways of energy exchange within an ecosystem and to evaluate ecological relationships between species. Karr (1968) described the avian population of an east-central Illinois strip-mined area in terms of biomass, production, energy, and community structure.

[1] Scientific names of birds are given in Appendix 1.

The intent of this study was to examine such aspects of avian ecology in western Oregon forests. The area chosen for the study was in the western part of the Willamette Valley of Oregon, at the base of the Coast Range. Oregon white oak[2] woods probably originally developed there following settlement by white man, who prevented the brush fires which previously had maintained the oaks in an open savanna. The increased shading from the dense canopy in such oak woods prevented oak seedlings from growing, allowing Douglas fir to germinate under the oak canopy in dry areas. In moist areas near streams and washes and on north facing slopes, big leaf maple developed. Grand fir, western hemlock, or red cedar followed Douglas fir in succession depending on altitude and exposure (Thilenius, 1968).

By censusing the avian population, summarizing behavioral traits, examining habitat utilization, describing vegetative structure, and sampling the dietary habits of the birds, I sought to characterize and compare situations in this area with respect to avian community structure, ecological relations, and energy utilization. The specific questions underlying this study, then, were:

1. What were the seasonal changes in the bird species composition and diversity of western Oregon forests?

2. How did the avian ecological roles and habitat utilization patterns vary on a seasonal and successional basis?

3. Which components of the habitat influenced the abundance of avian species?

In order to examine the last two questions in detail, seven

[2]Scientific names of plants are given in Appendix 2.

species, all permanent residents of the forests, were selected for intensive analysis of habitat utilization and food requirements. The birds selected were the White-breasted Nuthatch, Red-breasted Nuthatch, Black-capped Chickadee, Chestnut-backed Chickadee, Brown Creeper, Rufous-sided Towhee, and Oregon Junco.

METHODS

A. Vegetation Sampling

To characterize and compare the vegetation of the study areas, each area was sampled during June and July, 1967 and 1968, using the point-centered quarter method (Cottam and Curtis, 1956). A sampling point was located by random numbers in each 125-pace interval (95 meters) along a wandering transect 951 meters in length which passed through the center of each area. The area surrounding the sample point was divided into four quarters using the transect as one bisect.

Within each quarter the distance from the point to the nearest tree, its basal area, and its species were determined. To estimate the height of trees sampled, preliminary observations were made to determine the main strata of the forests. Height classes of <30, 30-60, and >60 feet were established from these observations. Using a ruler with height class graduations, I would sight the tree at a distance of 100 feet (30.5 meters) from its base and place it in the proper height class. The canopy diameter of each tree sampled was determined by pacing off the distance between opposite sides of the canopy and converting this measurement to circular area. The average canopy cover per stand was then calculated using the value from all the trees sampled and multipling it by the total number of trees in the area.

The same procedure was followed for the nearest sampling (any individual at least four feet tall and less than four inches DBH). The distance between the point and the nearest shrub and the species of the shrub were also recorded for each quarter.

Relative frequency, relative density, relative dominance, and Importance Values for each tree species in a stand were obtained following the methods of Cottam and Curtis (1956).

To provide more information on the structural characteristics of each stand, 54 structural features of the vegetation were measured 12 times during the months of June and July, 1969, following each avifaunal census of an area. Four 0.1 acre (0.04 hectare) square quadrats were located by randomly selecting a number from the census count points along the transect. A second random number was used to establish which side of the transect would be used and a third which corner of the square would be established as the first point.

Within each quadrat I recorded the number of trees, saplings, and shrubs; the proportion of leaves in the upper, middle and lower strata; the canopy volume; the area of the inner core of the trees (the space between canopy and trunk); an index of downed and dead vegetation; the average length of primary and secondary branches; a bark index; an index of openness; trunk height; and the distribution, number and size of twigs.

In order to determine the proportion of leaves in each of the three strata of forest, a point along the outer edge of the square was selected by random numbers. A second random number was used to determine what direction along the edge of the square would be used and a third determined the distance between each point (0-10 feet). Ten points were selected for each square (a total of 40 for each study area). A camera with a 150 mm lens placed on top of a tripod was pointed skyward over each random point. An acetate sheet with a grid system of

16 squares had been placed in the camera's view finder so that the distance to the nearest leaf above each grid square could be measured by using the camera's focusing mechanism. Since measurement above 50 feet was difficult, the proportion of the sky visible was estimated in these squares. A plumb bob at the end of a string was then dropped to the ground. The number and position of the leaves contacted in one-foot intervals of the plumb line were recorded.

This resulted in a three-fold measurement for each point; first, a series of 16 measurements of heights to the first leaf; second, the percent of sky in the projection of canopy above 50 feet; third, a series of numbers for leaves touching each interval of plumb line.

Using the method of MacArthur and Horn (1969), the proportion of leaves in the three layers was calculated. Several different divisions of strata were analyzed, but the divisions used by MacArthur and MacArthur (1961) were found to be the most significant.

From the proportion of leaves in each layer, foliage height diversity (FHD) was calculated by using the formula:

$$FHD = -\sum_{i=1}^{s} p_i \log_e p_i,$$

where, p_i = the proportion of the total foliage which lies in the i^{th} horizontal layer.

Canopy volume (CV) was obtained following the method of Sturman (1968b). For conifers:

$$CV = \pi/3 \, (h_o r_o^2 - h_i r_i^2),$$

and for deciduous trees:

$$CV = 2\pi/3 \, (h_o r_o^2 - h_i r_i^2),$$

where, h_o = the distance from the bottom of the canopy to the top of the canopy.

h_i = the distance from the bottom of the canopy to the top of the inner core.

r_o = the distance from the center of the trunk to the outside edge of the canopy.

r_i = the distance from the center of the trunk to the beginning of the canopy.

The area of the inner core was found by using the area $h_i r_i^2$.

The proportion of the square covered by downed and dead vegetation was visually estimated and converted to an overall value for the entire stand. Lengths of the primary branches (branches with living vegetation growing from the trunk) and secondary branches (branches with living vegetation growing from the primary branches) were measured in each square.

Each tree in the 0.1 acre quadrat was assigned an index value for bark roughness, where 0 = smooth, 1 = rough (not cracked), 2 = cracked, 3 = ridges $<\frac{1}{2}$ inch deep, 4 = ridges $\frac{1}{2}$-1 inch deep, 5 = ridges >1 inch deep, and 6 = moss covered. An index for the stand was calculated from these values.

A measurement of openness was made at ten points in each quadrat by taking the total height of the vegetation and subtracting the height of the canopy layer and shrub layer. The middle layer (distance between the top of the shrub layer and bottom of the canopy) was measured by placing a vertical rod in this area. One inch was subtracted from the total height for each point on the rod that vegetation touched.

Twigs were counted on each tree and placed in one of seven categories: perpendicular to trunk, projecting upward at 30°, 60°, or 90°, and projecting downward at 30°, 60°, or 90°.

B. Birds

1. Censusing

Two approaches are generally followed in the analysis of avian abundance (Kendeigh, 1944). One is to determine the actual number of individuals of each species present in an area of a known size. The spot map method (Williams, 1936) has frequently been used for this purpose, although in practice it does not yield an absolute census. The other approach is to obtain an index of abundance of each species in order to calculate its relative abundance. The usefulness of relative abundance is based on the assumption that the more abundant species will appear more frequently in samples than the less abundant species. A major source of error with this approach is the difference in conspicuousness of species. Discussion of this problem may be found in Kendeigh (1944).

A great advantage of the relative abundance approach in sampling avian numbers is the sampling time saved. Since avian population sizes are not fixed for any area, the relative abundance approach will present a reasonably accurate picture of the avian population at a particular time. Bond (1957) compared the results of the spot map and sample count (an index method) methods during the breeding season and found the latter gave results which were approximately 75 percent of the number of individuals obtained by the former.

After a preliminary analysis of the avifauna of Oregon white oak stands (Anderson, in preparation), a modification of the sample count method (Bond, op. cit.) was adopted for this study. An irregular transect was established through each stand at least 150 meters from the edge. Ten sample points were spaced 95 meters apart along this transect. As I walked along the transect, I stopped at each sample point for ten minutes and recorded all birds seen within 18 meters on either side of the transect. Using a code, the position of each bird with respect to the vegetation and its foraging behavior were recorded.

Between January 1968 and January 1970, all study areas were censused at least once each month starting one hour after sunrise. Evening censuses were made once each season in each area beginning one hour prior to sunset. During the breeding season (April to August), avian populations fluctuated greatly, so weekly censuses were made in each study area.

2. Habitat Utilization

To supplement the behavioral data gathered at each sample point, separate trips were made to each study area to observe the species selected for more detailed analysis. I walked along the same transect used for censusing until one of the species was located. The duration and sequences of the bird's activities were then timed to the second with a stop watch for a period of 15 minutes or until the bird vanished from sight. The time and the particular part of the vegetation utilized were recorded on a portable tape recorder. These data were summarized on a separate form (Table 1). All behavioral observations were made between 06:00 and 10:00 hours, and the results, therefore, reflect only the activities of the birds during that time of the day.

3. Food

To further assess the patterns of habitat utilization and subdivision by selected species, their food habits were studied. Diets were determined for three periods of the year: May to July 1969, August and September 1969, and November 1969 to February 1970. These studies were conducted in three oak and four fir stands which were as similar as possible to the study areas but a minimum of 1000 meters from them.

Birds were obtained by shotgun and when possible were weighed immediately. The digestive tract was removed immediately in the field and placed in a vial of four percent formalin. Specimens were placed in plastic bags in a container of ice to be frozen later. The food contained in the gizzard and anterior alimentary canal was removed in the laboratory. Identifications were taken as far as possible, usually family, for each food item. The total number of each food type, the greatest length, and an estimate of the percent of the total volume it occupied in the stomach were recorded. Most animal food items were saved individually in small vials of eight percent isopropyl alcohol, while plant materials were dried and saved.

Measurements of the bill length (anterior margin of nostrils to tip), width and depth (both anterior margin of nostrils), tarsus length, and wing length were made of all birds collected. T-tests

Table 1. Habitat utilization data.

I. General
   - A. Vegetation
   - B. Movement between vegetation
   - C. Nest position
   - D. Relation to other species

II. Use of vegetation
   - A. Tree
     1. Trunk
     2. Primary branch
     3. Secondary branch
     4. Twig
     5. Vegetation
   - B. Shrub
     1. Top
     2. Within
   - C. Ground
   - D. Downed vegetation

III. Activity
   - A. Singing
   - B. Perching
   - C. Preening
   - D. Display
   - E. Flight
   - F. Nesting
   - G. Foraging
     1. Method
     2. Stance

were made to determine if the means represented similar populations.

As White-breasted and Red-breasted Nuthatches seemed to segregate into the oak and conifer communities respectively, I additionally examined how their food habits differed where the two species lived sympatrically with the Pigmy Nuthatch in ponderosa pine habitats. Samples of the three nuthatches were taken during the three seasonal periods in a stand of ponderosa pine at Indian Ford (T14S, R9E, Sec. 14, NE$\frac{1}{4}$), six miles west of Sisters, Oregon (Figure 1).

C. Analytic Methods

1. Vegetation

A stepwise multiple linear regression computer program (OSU-01) was utilized with the relative abundance of birds of each species as the dependent variable and the vegetative features as independent variables. This program provided simple correlation coefficients between variables and predicted in a stepwise procedure which variable, when added into the regression equation, effected the greatest reduction in the residual variation around the least squares regression. Often, the addition of further variables did not account for a significant increase in the R^2 value. This point was determined when the standard deviation or square root of the mean square error reached a minimum after fitting the variables to the regression model in each step of the stepwise procedure. As the standard deviation began to rise, little additional variation was explained by the added variables.

2. Birds

To compare the avian populations of the ten study areas during the different seasons, species diversity calculations were made. A number of indices of diversity have been proposed. Simpson (1949), Shannon and Weaver (1949), Margalef (1958), and McIntosh (1967) give examples of a few. In this study, I used the information theory diversity index (Shannon and Weaver, 1949).

The information theory species diversity index, H, is calculated:

$$H = -\sum_{i=1}^{s} p_i \log_e p_i,$$

where, s = the number of species,

p_i = the proportion of the total number of individuals which belong to the i^{th} species.

The values of this index can range from 0 ($\log_e$ of 1) if all of the individuals are of one species to $\log_e$ s if the number of individuals equals the number of species. The maximum diversity of a sample is thus given by:

$$HMAX = \log_e S,$$

while the minimal value is:

$$HMIN = -[(S-1)/T \log_e (1/T) + (T-S+1)/T \log_e (T-S+1)T],$$

where, T = the total number of individuals sampled.

This diversity index may be used in comparisons of any pairing of study areas, following the approach of MacArthur (1965). First, calculate the diversity difference between the two areas by:

$$\bar{H} = [H(1) + H(2)]/2 .$$

Then, calculate the combined species diversity for the two areas:

$$H(T) = -\sum_{i=1}^{s} (p1_i + p2_i)/2 \log_e (p1_i + p2_i)/2.$$

Finally, set up the exponent:

$$e^{[H(T) - \bar{H}]},$$

as a measure of difference. Values will fall between $e^0 = 1.000$ and $e^{0.693} = 2.00$ ($\log_e 1 = 0$, $\log_e 2 = 0.693$). Thus, two areas with identical diversity will have a difference of 1, and two areas with totally different avifaunas will have a difference of 2.0.

Simpson (1949) proposed another measure of diversity. It is the calculation of the number of pairs that would have to be selected at random from a particular population in order to give an even chance of getting one pair with both individuals belonging to the same species. The index (SD) is the sum of the squares of the proportion of the component species:

$$SD = \sum_{i=1}^{s} p_i^2.$$

From this index, a similarity measurement of two study areas (SIM) can be obtained by comparing all possible pairs of species and summing the proportion of species in one area multiplied by the proportion in the second area. A similarity index (SIMI) is developed by dividing SIM by SD_1 and SD_2:

$$SIMI = SIM_{1,2}/(SD_1 \times SD_2).$$

Areas having no species in common have a similarity of 0, while areas with identical populations have a similarity of 1.

STUDY AREAS

The ten study areas used in this study are shown in Figure 1. A permanent transect was established with surveyor's tape in each area so that the same portion could be censused for avifaunal composition on each visit. The areas varied from a pure oak stand (area 1) through the Douglas fir sere and into the beginning of the western hemlock sere (Figure 2). Area one was located on the north facing slope of Pigeon Butte in the southern part of the William Finley Wildlife Refuge, 10 miles south of Corvallis, Oregon (Table 2). Area two was on the edge of a grazed pasture near Soap Creek, 12 miles north of Corvallis. Areas three, four, five and eight were primarily Douglas fir stands in MacDonald Forest, five miles north of Corvallis. Oregon grape covered the ground in many of these areas (Table 4). Area four had a small stream running through one corner with red alder along its banks (Figure 2). Areas six, seven, nine and ten were at the northern base of Mary's Peak about five miles west of Philomath, Oregon. Selective logging had been done in these areas within the past ten years. Areas nine and ten had many large western hemlock trees with hemlock the predominate sapling (Table 3). These areas had a great deal of slash on the ground from logging activity. Area six had a very dense canopy that filtered out the light in some areas, preventing ground vegetation from developing. In other places within this area, dense patches of Oregon grape developed. Area seven was almost entirely Douglas fir with no evidence of species of later successional stages (Table 3).

Although all areas except one had several tree species in the overstory, areas three and nine were the most intermediate or ecotonal (Figure 2).

Figure 1. Location of study areas.

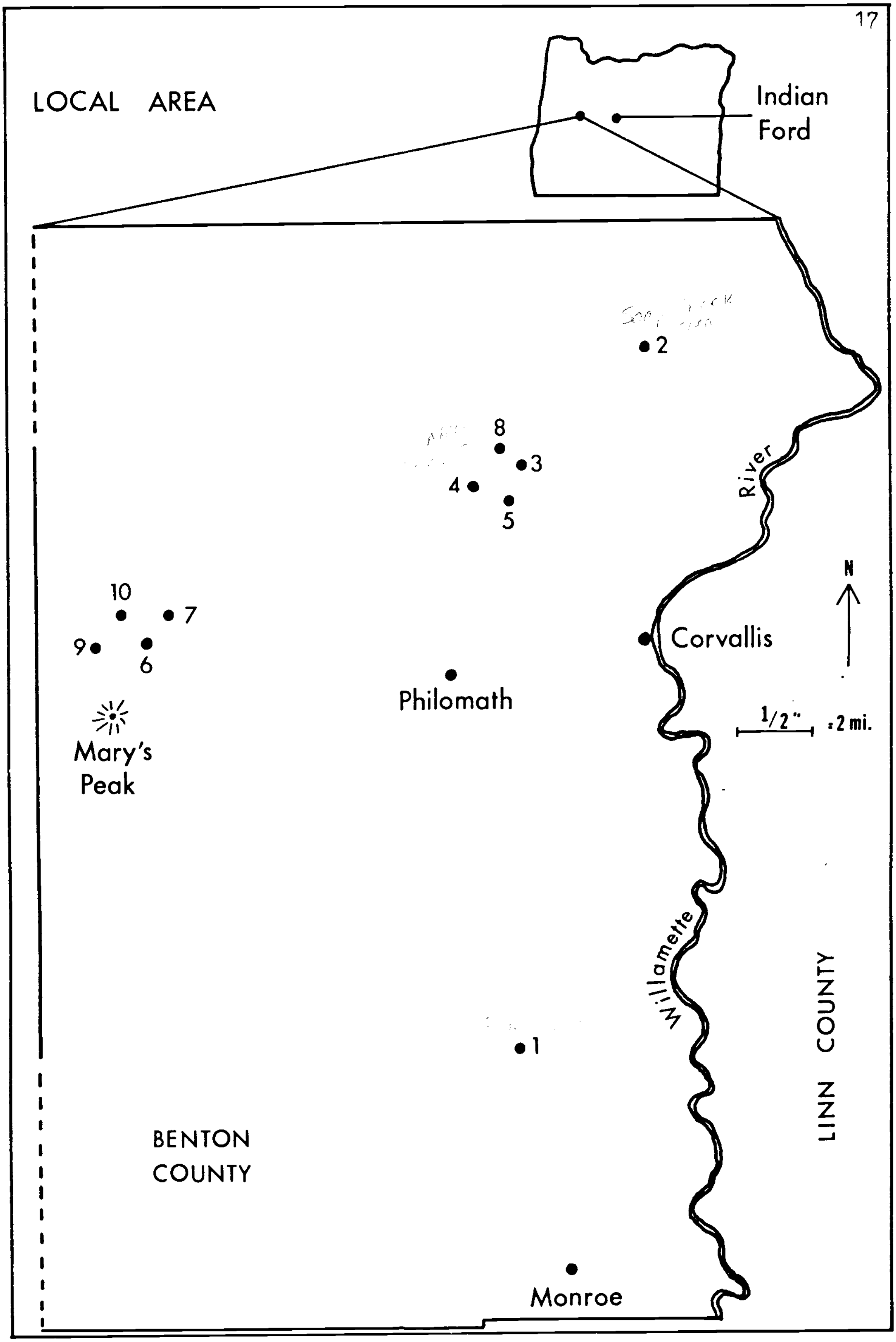
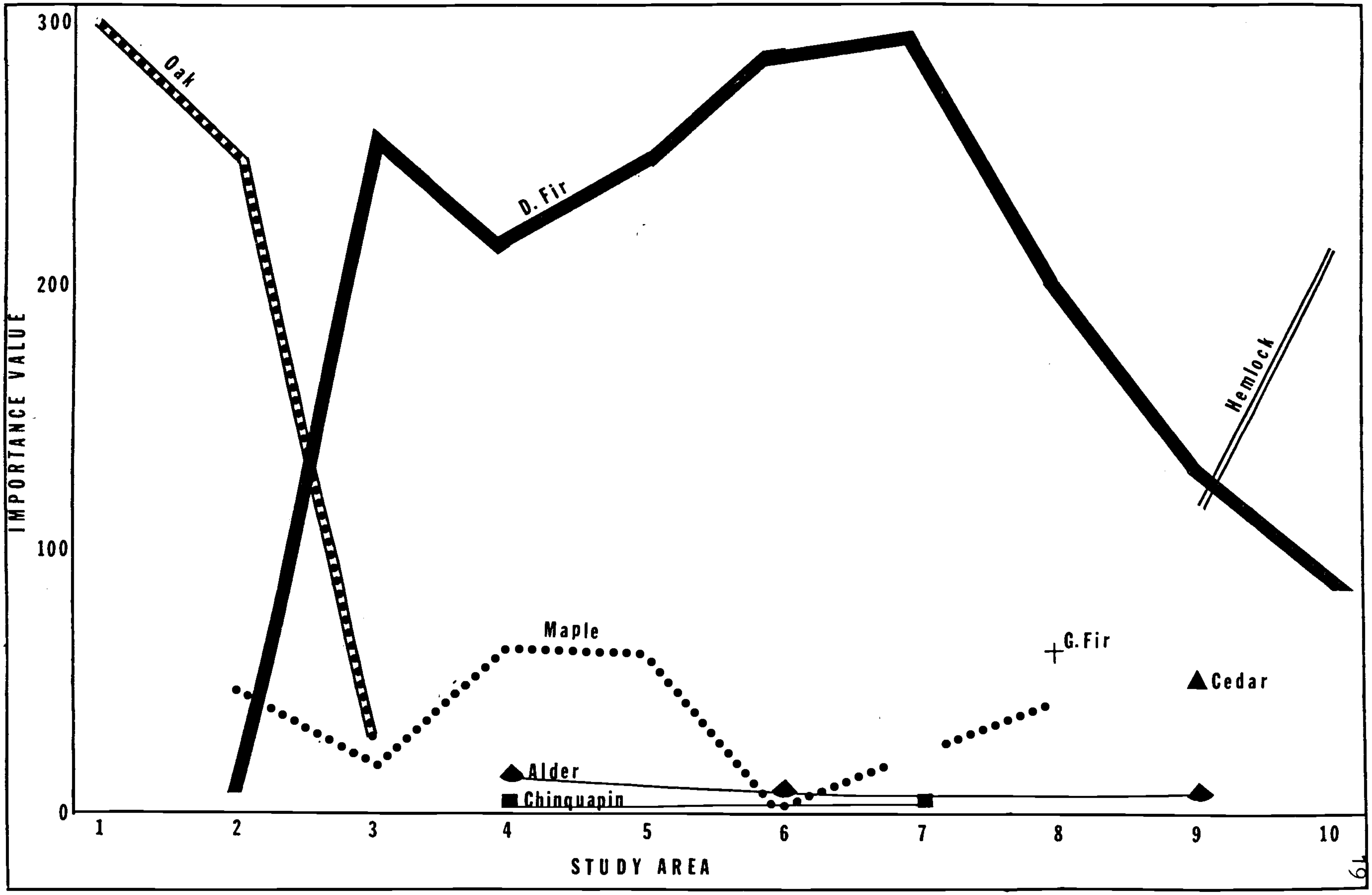

LOCAL AREA
Indian Ford
2
8
3
4
5
10
7
9
6
Mary's Peak
Philomath
Corvallis
River
N
1/2" = 2 mi.
Willamette
1
LINN COUNTY
BENTON COUNTY
Monroe

Table 2. Features of the study areas.

Area Number	Size in Acres	Location	Exposure	Trees per Acre	Height Class Distribution <30'	30-60'	>60'	Percent Canopy Cover
1	120	T13S, R5W, Sec. 31, NE¼	N	110	16	39	45	82
2	125	T10S, R5W, Sec. 27, SE¼	E	117	42	37	20	72
3	105	T11S, R5W, Sec. 9, NW¼	E	90		15	85	61
4	200	T11S, R5W, Sec. 7, SW¼	N	115	3	9	88	86
5	140	T11S, R5W, Sec. 8, SW¼	W	60	5	10	85	89
6	90	T12S, R7W, Sec. 15, NW¼	S	172	2	4	94	98
7	125	T12S, R7W, Sec. 10, SE¼	E	65		7	93	64
8	140	T11S, R5W, Sec. 8, SE¼	N	54		10	90	89
9	110	T12S, R7W, Sec. 16, NW¼	N	152	2	8	90	72
10	115	T12S, R7W, Sec. 9, SE¼	W	164	4	8	88	78

Figure 2. Importance Values of tree species in study areas.



300
200
100
0
IMPORTANCE VALUE
Oak
D. Fir
Hemlock
Maple
G. Fir
Cedar
Alder
Chinquapin
1
2
3
4
5
6
7
8
9
10
STUDY AREA

Table 3. Sapling composition of study areas.

Study Area	Sapling	Relative Frequency	Total per Acre
1	White Oak	73	76
	Big Leaf Maple	27	
2	White Oak	60	
	Douglas Fir	27	40
	Big Leaf Maple	13	
3	Grand Fir	34	
	Douglas Fir	23	
	Hazel	20	292
	Ocean Spray	20	
	White Oak	3	
4	Douglas Fir	35	
	Hazel	24	
	Big Leaf Maple	18	81
	Ocean Spray	18	
	Grand Fir	4	
5	Grand Fir	30	
	Vine Maple	22	
	Hazel	20	191
	Big Leaf Maple	15	
	Douglas Fir	13	
6	Douglas Fir	45	
	Vine Maple	38	137
	Ocean Spray	16	
7	Vine Maple	35	
	Hazel	23	131
	Ocean Spray	22	
	Douglas Fir	20	
8	Hazel	45	
	Grand Fir	42	145
	Ocean Spray	8	
	Douglas Fir	5	
9	Hemlock	100	229
10	Hemlock	91	271
	Vine Maple	9	

Table 4. Shrub composition of study areas.

Study Area	Shrub	Relative Frequency	Total per Acre
1	Common Rose	60	
	Snowberry	30	1400
	Poison Oak	10	
2	Poison Oak	70	
	Common Rose	15	550
	Hazel	15	
3	Bracken Fern	24	
	Blackberry	21	
	Thistle	18	
	Sword Fern	16	583
	Wood Rose	8	
	Daisy	5	
	Poison Oak	5	
	Hazel	3	
4	Oregon Grape	28	
	Sword Fern	24	
	Bracken Fern	21	3903
	Thistle	20	
	Wood Rose	7	
5	Thimbleberry	29	
	Blackberry	24	
	Wood Rose	17	4808
	Oregon Grape	12	
	Bracken Fern	8	
	Thistle	8	
6	Bracken Fern	42	
	Oregon Grape	42	1861
	Sword Fern	14	
	Wood Rose	2	
7	Oregon Grape	38	
	Bracken Fern	24	
	Wood Rose	24	1991
	Sword Fern	10	
	Thimbleberry	4	

Table 4. Continued.

Study Area	Shrub	Relative Frequency	Total per Acre
8	Oregon Grape	42	
	Ocean Spray	23	
	Sword Fern	9	6753
	Bracken Fern	9	
	Wood Rose	9	
	Thimbleberry	8	
9	Bracken Fern	32	
	Sword Fern	32	1989
	Oregon Grape	26	
	Wood Rose	10	
10	Bracken Fern	40	
	Oregon Grape	25	
	Sword Fern	20	4263
	Ocean Spray	10	
	Wood Rose	5	

AVIFAUNAL STRUCTURE

A. Species Populations

Typically, avifaunal activity follows different seasons than the Julian Calendar. Food supply, nesting material, climate, cover sites, and other factors contribute to changing avifaunal composition and activity. Twomey (1945) in a study of the elm-maple forests in central Illinois, recognized six avifaunal seasons. Anderson (in press) found that the birds of Oregon white oak habitats followed a seasonal pattern similar to the birds of the elm-maple community. They were:

Winter........................ November 2 through March 1
Early Spring.................. March 2 through April 15
Late Spring................... April 16 through June 1
Early Summer.................. June 2 through July 15
Late Summer................... July 16 through September 1
Fall.......................... September 2 through November 1

Preliminary observations indicated that birds of the Douglas fir and western hemlock communities followed the same seasonal patterns as did the birds in Oregon white oak stands. This study, therefore, was conducted within the framework of these six seasons.

Bird species were classified as permanent residents, summer residents, winter residents, and occasional visitors, based on the time spent in the community and the type of occupancy (Tables 18,19 and 20). Some species were classified differently in different communities.

Permanent residents were observed during all seasons and were either directly observed nesting or presumed to be nesting on the basis of indirect evidence (e.g., territorial occupancy). Summer residents included species which arrived in early or late spring, nested, and then left the area. Winter residents were found in the area during the winter but left during the spring to breed elsewhere. Occasional visitors were birds that moved through the area, foraged for a short period of time and then left. This category included birds that visited the area during migration.

Results of the bird censuses, converted to individuals per 100 acres, (40.5 hectares) are presented in Tables 5 through 14.

During the winter, most of the bird species formed flocks. Single species flocks of Oregon Juncos, Ruby-crowned or Golden-crowned Kinglets, or bushtits were common. Mixed species flocks generally included chickadees, nuthatches, creepers, and woodpeckers. The above flocks were the most common grouping of birds observed during winter. Birds found in the oaks during the winter consisted of permanent residents and a few winter residents such as Winter Wrens and Varied Thrushes. Permanent residents of the higher elevation coniferous stands which expanded their habitat occupancy became winter residents in oak stands. The fir and hemlock areas had no winter residents as such. All bird species recorded in these areas during the winter were permanent residents. Area three, which was transitional between oak and fir dominated stands, had no winter residents. It was located in MacDonald Forest at an elevation of approximately 120 meters while the oak stands were at about 60 meters.

Table 5. Population census results for avifauna of study area one.[a]

Species	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Turkey Vulture		22	11	33	22	22
Red-tailed Hawk	11	22	11	11	11	11
Ring-necked Pheasant	22	11				
Band-tailed Pigeon				66	22	55
Great Horned Owl			1			
Rufous Hummingbird				11		
Red-shafted Flicker		44		22		
Pileated Woodpecker				2		
Red-bellied Sapsucker	11					
Hairy Woodpecker	11	22	22	11	11	11
Downy Woodpecker	11	22	22	22	11	11
Western Wood Pewee		11	22	22	22	22
Steller's Jay	33					
Scrub Jay			11			
Crow		11				
Black-capped Chickadee	132	110	110	110	154	198
Common Bushtit	33	22	44	44	22	33
White-breasted Nuthatch	44	66	44	88	88	44
Red-breasted Nuthatch				22		
Brown Creeper	44	66	44	66	66	22
Winter Wren	11	11				
Bewick's Wren	11		22	22	11	
Robin	22	22	88	66	11	11
Varied Thrush	33	22				
Hermit Thrush			11	22		
Western Bluebird	33					
Townsend's Solitaire		11				
Golden-crowned Kinglet	22	77				66
Ruby-crowned Kinglet	33					
Cedar Waxwing	33					
Hutton's Vireo	11	22	22	22		11
Solitary Vireo			22	33		
Warbling Vireo			22	22		
Orange-crowned Warbler			66			
Yellow Warbler			22	22		
Audubon's Warbler	11					
Black-throated Gray Warbler			22	22		22
Townsend's Warbler		22	22	22		
MacGillivray's Warbler			44	44		
Wilson's Warbler			44			
Brown-headed Cowbird			11	22		

[a]Converted to birds per 100 acres.

Table 5. Continued.

Species	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Western Tanager			44	66		
House Finch			44	44		
American Goldfinch				66		
Rufous-sided Towhee	55	44	88	88	44	44
Oregon Junco	88	44	66	66	33	33
Chipping Sparrow			44	44		
Golden-crowned Sparrow			66			
Total individuals	715	704	1111	1223	528	616
Total species	22	21	30	31	14	16

Table 6. Population census results for avifauna of study area two.

Species	Season Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Turkey Vulture		22	11	22	22	
Red-tailed Hawk	11	22	11			
Ring-necked Pheasant	11					
Mourning Dove						22
Rufous Hummingbird			11	11		
Red-shafted Flicker						11
Hairy Woodpecker	11					22
Downy Woodpecker	11	11	22	22	11	22
Western Wood Pewee		11	11	22	22	22
Steller's Jay	11	11	11	44	33	
Scrub Jay			11			
Black-capped Chickadee	198	132	66	66	132	121
Common Bushtit	22	22	22			
White-breasted Nuthatch	22	22	44	44	44	44
Red-breasted Nuthatch		11	11	22	22	22
Brown Creeper	22	22	77	44	44	22
Winter Wren	11					
Bewick's Wren	22	22	44	22	22	22
Robin	22	22	22	11	22	11
Varied Thrush	22	33				
Hermit Thrush					11	
Western Bluebird	33					
Golden-crowned Kinglet	33	44				22
Ruby-crowned Kinglet	44					
Cedar Waxwing	33					
Hutton's Vireo	11	11	22	22	11	11
Solitary Vireo			11			
Warbling Vireo			22			
Orange-crowned Warbler			22			
Black-throated Gray Warbler			22			
Townsend's Warbler			22			
MacGillivray's Warbler			22			
Wilson's Warbler				22		
Brown-headed Cowbird				11		
Western Tanager			22	44	44	
Black-headed Grosbeak				22		
Lazuli Bunting			22	22		
House Finch			22	22		
American Goldfinch				44	44	33
Rufous-sided Towhee	11	22	22	22	44	22
Oregon Junco	33	44	44	44	44	44
Chipping Sparrow			33	22	22	
Song Sparrow			11			

Table 6. Continued.

	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Total individuals	594	484	693	627	594	473
Total species	20	17	28	22	17	16

Table 7. Population census results for avifauna of study area three.

Species	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Turkey Vulture			11	11	5	
Red-tailed Hawk			1		1	
Blue Grouse		22				
Ruffed Grouse		22				
Great Horned Owl		1	1			
Rufous Hummingbird				22		
Hairy Woodpecker			22	22		
Downy Woodpecker			22			
Western Wood Pewee				44		
Steller's Jay			22	44	22	
Chestnut-backed Chickadee	176	198	154	66	176	132
Red-breasted Nuthatch	44	44	66	44	99	88
Brown Creeper	22	44	44	55	44	44
House Wren			22	44	44	
Winter Wren	22	22	44		22	22
Golden-crowned Kinglet	88			22		
Hutton's Vireo			22	22		
Solitary Vireo			22			
Orange-crowned Warbler			22			
Audubon's Warbler			22			
Townsend's Warbler			22			
Hermit Warbler			44	44	22	
MacGillivray's Warbler			22	22	22	
Wilson's Warbler			22	22		
Western Tanager			44	44		
Black-headed Grosbeak				22		
Purple Finch			22			
House Finch			11			
Pine Siskin		22				
Red Crossbill					44	
Rufous-sided Towhee			22			
Oregon Junco	22	22	66	44	66	110
Total individuals	374	397	869	594	545	374
Total species	6	9	24	17	12	5

Table 8. Population census results for avifauna of study area four.

Species	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Turkey Vulture		22	11	11		
Blue Grouse					22	
Ruffed Grouse				11		
Rufous Hummingbird			11	11	11	
Red-shafted Flicker				11		
Pileated Woodpecker			2	2	2	
Hairy Woodpecker					11	22
Downy Woodpecker					22	22
Western Flycatcher			22	22	22	
Western Wood Pewee		22	11	22	22	
Steller's Jay	22				22	22
Chestnut-backed Chickadee	132	176	66	88	132	110
Red-breasted Nuthatch	22	44	44	44	44	22
Brown Creeper	22	44	44	44	44	22
House Wren						22
Winter Wren	33	33	22		22	33
Varied Thrush	22	22				
Golden-crowned Kinglet	22	44		44		
Orange-crowned Warbler			22			
MacGillivray's Warbler			11			
Wilson's Warbler			33	22		
Brown-headed Cowbird			44			
Western Tanager			22	22	44	
Evening Grosbeak			44	11		
American Goldfinch					22	
Oregon Junco	22	44	44	22	44	22
Song Sparrow			11		22	
Total individuals	297	451	464	387	508	297
Total species	8	9	17	15	16	9

Table 9. Population census results for avifauna of study area five.

Species	Season: Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Turkey Vulture				33		
Red-tailed Hawk	1	1	2	2	2	1
Blue Grouse					11	
Ruffed Grouse			11		11	11
Vaux's Swift				110		
Rufous Hummingbird			22	22		
Hairy Woodpecker			11	22	22	11
Downy Woodpecker					22	
Western Flycatcher				22	22	
Western Wood Pewee				22		
Olive-sided Flycatcher			11			
Steller's Jay	33	22	22	22	22	22
Chestnut-backed Chickadee	198	66	66	88	88	88
Red-breasted Nuthatch	22	44	44	66	66	44
Brown Creeper	22	44	22	22	66	22
House Wren				22		
Winter Wren	22	22	22	22	22	22
Varied Thrush	11	11				
Hermit Thrush				11		
Golden-crowned Kinglet		22		22		
Yellow Warbler				11		
MacGillivray's Warbler					22	
Wilson's Warbler			22	22		
Western Tanager			44	44	44	
Rufous-sided Towhee			22	22	22	
Oregon Junco	33	55	44	44	44	66
Song Sparrow					11	
Total individuals	342	287	365	651	497	298
Total species	8	9	14	20	16	10

Table 10. Population census results for avifauna of study area six.

Species	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Downy Woodpecker			22	22		
Dusky Flycatcher			22	22		
Western Flycatcher			44	66		
Western Wood Pewee			22	22	22	
Olive-sided Flycatcher				22		
Steller's Jay			44			
Chestnut-backed Chickadee	44	22	66	44	88	44
Red-breasted Nuthatch	66	22	44	22	44	44
Brown Creeper	22	44	44	44	22	22
Winter Wren	44	44	44	44	44	44
Robin					22	
Varied Thrush	22					
Hermit Thrush			44	77		
Golden-crowned Kinglet			22	22	88	
Hutton's Vireo			22			
Hermit Warbler			44			
MacGillivray's Warbler			22			
Western Tanager			44			
Oregon Junco	44	22	44	44	33	44
Total individuals	242	154	594	451	369	198
Total species	6	5	16	12	8	5

Table 11. Population census results for avifauna of study area seven.

Species	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Ruffed Grouse	11	22	22			
Mountain Quail			22			
Band-tailed Pigeon					11	
Pileated Woodpecker	11					
Hairy Woodpecker			22			
Downy Woodpecker	11					22
Hammond's Flycatcher			22			
Dusky Flycatcher			22			
Western Flycatcher			22	22		
Western Wood Pewee			33			
Steller's Jay	33	22	22	22	22	11
Chestnut-backed Chickadee	88	66	88	66	88	88
Red-breasted Nuthatch	66	44	66	66	44	22
Brown Creeper	44	44	66	44	44	44
Winter Wren	22	22	22	22	22	22
Hermit Thrush				22		
Ruby-crowned Kinglet	22					
Cedar Waxwing					66	
Hermit Warbler			44	44		
MacGillivray's Warbler			22	22		
Wilson's Warbler		11	22	22		
Western Tanager			44	44		
Evening Grosbeak			66	44		
Rufous-sided Towhee		22				
Oregon Junco	22	22	44	44	33	22
White-crowned Sparrow			11			
Total individuals	330	275	685	484	330	231
Total species	10	9	19	13	8	7

Table 12. Population census results for avifauna of study area eight.

Species	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
			Season			
Red-tailed Hawk				1	1	
Ruffed Grouse		11	11	22	11	
Mountain Quail			22	22	11	22
Pileated Woodpecker				11		
Hairy Woodpecker		11	22	22	22	11
Downy Woodpecker		11	22	22	22	
Western Flycatcher			22	22		
Western Wood Pewee				22		
Steller's Jay	22		44	22		
Chestnut-backed Chickadee	88	154	66	110	132	132
Common Bushtit		44				
Red-breasted Nuthatch	44	44	44	33	44	66
Brown Creeper	22	22	66	55	44	44
Winter Wren	44	22	22			22
Varied Thrush	22	22				
Golden-crowned Kinglet		66	22			
Hutton's Vireo			22			
Orange-crowned Warbler			22			
Audubon's Warbler			44			
Townsend's Warbler			22			
Hermit Warbler			22			
MacGillivray's Warbler			22			
Western Tanager			44			
Purple Finch			22			
Pine Siskin		22				
Oregon Junco			44	55	44	44
Total individuals	242	429	638	418	331	363
Total species	6	11	20	13	9	8

Table 13. Population census results for avifauna of study area nine.

Species	Winter	Early Spring	Season Late Spring	Early Summer	Late Summer	Fall
Great Horned Owl			1			
Pileated Woodpecker		2	4			
Hairy Woodpecker			22	22	22	
Downy Woodpecker	22		22	22	22	
Hammond's Flycatcher			22	22	22	
Dusky Flycatcher			22	22	22	
Western Flycatcher			44	22	44	
Western Wood Pewee			22	22		
Gray Jay			22	22		
Chestnut-backed Chickadee	176	44	88	110	198	88
Red-breasted Nuthatch	66	22	44	22	44	22
Brown Creeper	44	22	22	22	44	22
Winter Wren	44	44	44	44	44	44
Varied Thrush	55					
Hermit Thrush			22			
Golden-crowned Kinglet			22	22	22	110
Hutton's Vireo				22		
Hermit Warbler			44			
MacGillivray's Warbler			22	22	22	
Wilson's Warbler		22	22			
Western Tanager			44	44		
Black-headed Grosbeak			22			
Evening Grosbeak			88			
Pine Siskin			22			
Red Crossbill	44	44	66			
Oregon Junco			44	44	44	88
Song Sparrow			22			
Total individuals	451	200	814	506	520	374
Total species	7	7	25	16	12	6

Table 14. Population census results for avifauna of study area ten.

Species	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
Hairy Woodpecker			22			
Downy Woodpecker			22			
Hammond's Flycatcher			22			
Dusky Flycatcher			22			
Western Flycatcher			22	22	66	
Western Wood Pewee			22	44	11	
Olive-sided Flycatcher					22	
Steller's Jay						33
Chestnut-backed Chickadee	88	66	88	165	88	22
Red-breasted Nuthatch	44	44	22	22	22	22
Brown Creeper	44	44	22	44	22	22
Winter Wren	66	88	44	44	22	88
Varied Thrush		44				
Hermit Thrush			22			
Golden-crowned Kinglet		22	22			
Hutton's Vireo			22			
Orange-crowned Warbler			22			
Hermit Warbler			22			
MacGillivray's Warbler			22			
Wilson's Warbler			44			
Western Tanager			44			
Evening Grosbeak			44			
Red Crossbill			44			
Rufous-sided Towhee					33	22
Oregon Junco	33	22	44	22	22	44
Total individuals	275	330	660	363	308	253
Total species	5	7	21	7	9	7

Altitude as well as the presence or absence of foliage may play a role in the type of wintering species found in the areas. When the total number of individuals present during each of the seasons in the study areas was calculated as a percentage of the total for the season having the largest number of individuals, the values in areas one and two, the oak stands, were somewhat higher than those for the coniferous areas (Table 15). Influx of winter residents was largely responsible for this difference. Only 69 percent of the individuals wintering in the oaks were permanent residents, while 100 percent of the birds in the conifers were permanent residents (Figure 3).

During early spring, permanent residents in the study areas began to establish territories. Several summer resident species arrived in all areas (Figure 3); however, in most areas the total number of individuals decreased as bird species began to spread out (Table 15).

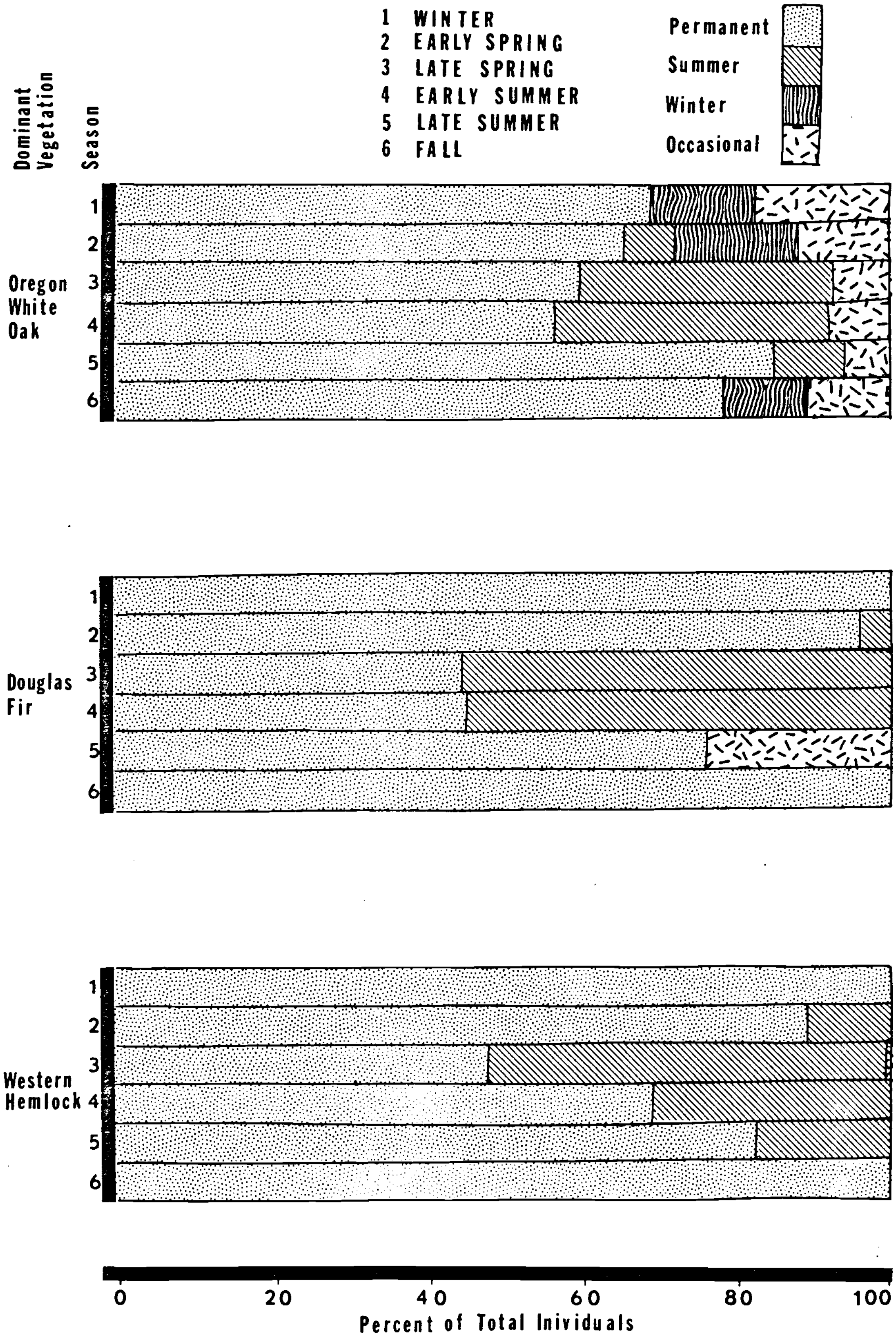
By the beginning of late spring, the permanent resident species were all nesting. During this period, a large influx of summer residents occurred (Figure 3). There were no longer any winter residents in the oaks, as these species had withdrawn to their coniferous breeding habitats. Summer residents comprised 51 to 55 percent of all individuals in the conifers while only 33 percent in the oaks. In the oaks, the summer residents were almost exclusively neotropical migrants, (sensu MacArthur, 1959), which arrived, nested, and quickly departed. Some of the summer resident species of the conifers were species which are characteristically nomadic in the forests and valleys of the Pacific Northwest during most of the year, but which select an area to nest during this period. Evening Grosbeaks and Pine

Table 15. Percentage of the maximum individual birds in each study area.

Study Area	Season					
	Winter	Early Spring	Late Spring	Early Summer	Late Summer	Fall
1	58.5	57.5	90.9	100.0[a]	43.2	50.4
2	85.7	69.8	100.0	90.5	85.7	68.3
3	43.0	45.7	100.0	68.5	62.7	43.0
4	58.5	88.8	91.3	76.2	100.0	58.5
5	52.5	44.1	56.1	100.0	76.3	45.8
6	40.7	25.9	100.0	75.9	62.1	33.3
7	48.2	40.1	100.0	70.7	48.2	33.7
8	37.9	67.2	100.0	65.5	51.9	56.9
9	55.4	24.6	100.0	62.2	63.8	45.9
10	41.7	50.0	100.0	55.0	46.7	39.3

[a]The season with the highest total number of individuals was considered 100 percent in each study area.

Figure 3. Comparison of residents in vegetation types.


1 WINTER
2 EARLY SPRING
3 LATE SPRING
4 EARLY SUMMER
5 LATE SUMMER
6 FALL
Permanent
Summer
Winter
Occasional
Dominant Vegetation
Season
Oregon White Oak
Douglas Fir
Western Hemlock
1
2
3
4
5
6
0
20
40
60
80
100
Percent of Total Inividuals

Siskins were in this category. In most areas the late spring or early summer seasons had the highest total number of individuals for the year (Table 15), with little variation between the two seasons.

Most permanent residents had completed nesting by early summer and were dispersed throughout the area, no longer defending territories. The percent of all individuals which were summer residents remained high during this season (Figure 3).

Summer residents generally completed nesting during the late summer and left the forest. Study area four was unusual in that the largest number of individuals was found in the area during this season. This high figure resulted from the large number of flycatchers and chickadees present. As this area was near a small permanent stream with swampy borders, it is likely that insects were particularly abundant. American Goldfinches and Lazuli Buntings nested in the oaks, while nests of Cedar Waxwings were occasionally found in the conifers.

When compared to the spring and summer seasons, the fall was a period of relative calm in the study areas. Most of the species were silent. Several species, including the chickadees, juncos, and bushtits, were found in small single species flocks. In most areas the number of individuals was less than in the winter. Winter species occurred in the oak stands while only permanent residents inhabitated the conifers (Figure 3).

B. <u>Diversity of Avifauna</u>

Comparison of the species diversity, H, of the avifauna in the ten study areas is shown on a seasonal basis in Table 16. Total diver-

Table 16. Seasonal species diversity of avifauna in study areas.

Season	H	HMAX	H/HMAX
Study area 1			
Winter	2.706	2.996	0.903
Early spring	2.826	3.045	0.928
Late spring	3.210	3.434	0.935
Early summer	3.234	3.434	0.942
Late summer	2.257	2.639	0.855
Fall	2.434	2.833	0.859
Study area 2			
Winter	2.525	2.996	0.842
Early spring	2.527	2.833	0.892
Late spring	3.112	3.296	0.944
Early summer	2.979	3.091	0.964
Late summer	2.606	2.833	0.920
Fall	2.523	2.773	0.910
Study area 3			
Winter	1.447	1.792	0.808
Early spring	1.718	2.197	0.782
Late spring	2.971	3.219	0.923
Early summer	2.825	2.890	0.977
Late summer	2.110	2.485	0.849
Fall	1.461	1.609	0.908
Study area 4			
Winter	1.761	2.079	0.847
Early spring	1.909	2.197	0.869
Late spring	2.644	2.833	0.933
Early summer	2.467	2.708	0.808
Late summer	2.477	2.773	0.894
Fall	1.982	2.197	0.902
Study area 5			
Winter	1.504	2.079	0.723
Early spring	1.949	2.079	0.937
Late spring	2.476	2.639	0.938
Early summer	2.762	2.996	0.921
Late summer	2.548	2.773	0.918
Fall	1.922	2.179	0.875

Table 16. Continued.

Season	H	HMAX	H/HMAX
Study area 6			
Winter	1.702	1.792	0.969
Early spring	1.554	1.609	0.963
Late spring	2.712	2.773	0.978
Early summer	2.375	2.485	0.956
Late summer	1.926	2.079	0.926
Fall	1.581	1.609	0.982
Study area 7			
Winter	2.055	2.303	0.892
Early spring	2.187	2.303	0.950
Late spring	2.763	2.944	0.939
Early summer	2.401	2.485	0.966
Late summer	1.916	2.080	0.922
Fall	1.724	1.946	0.886
Study area 8			
Winter	1.642	1.792	0.916
Early spring	2.043	2.398	0.852
Late spring	2.938	3.045	0.965
Early summer	2.431	2.639	0.921
Late summer	1.846	2.197	0.840
Fall	1.805	2.079	0.860
Study area 9			
Winter	1.701	1.946	0.874
Early spring	1.850	1.946	0.951
Late spring	3.070	3.219	0.954
Early summer	2.605	2.773	0.939
Late summer	2.151	2.485	0.865
Fall	1.673	1.792	0.934
Study area 10			
Winter	1.548	1.609	0.961
Early spring	1.841	1.946	0.946
Late spring	2.939	3.045	0.953
Early summer	1.635	1.946	0.840
Late summer	1.989	2.271	0.905
Fall	1.787	1.946	0.918

Table 17. Similarities and differences of avifauna between study areas during late spring.

Upper right: DIFFERENCES; lower left: SIMILARITIES

Study Area	1	2	3	4	5	6	7	8	9	10
1		1.175	1.440	1.568	1.574	1.614	1.665	1.526	1.649	1.522
2	0.749		1.490	1.513	1.598	1.607	1.616	1.550	1.639	1.610
3	0.312	0.312		1.274	1.215	1.251	1.287	1.138	1.320	1.260
4	0.284	0.378	0.746		1.258	1.309	1.218	1.303	1.237	1.225
5	0.314	0.288	0.846	0.756		1.308	1.262	1.252	1.397	1.334
6	0.248	0.308	0.756	0.653	0.714		1.209	1.179	1.219	1.162
7	0.196	0.323	0.740	0.791	0.717	0.744		1.210	1.189	1.173
8	0.334	0.406	0.824	0.687	0.759	0.802	0.751		1.320	1.220
9	0.195	0.245	0.661	0.735	0.601	0.703	0.791	0.593		1.091
10	0.307	0.260	0.762	0.760	0.707	0.762	0.775	0.703	0.896	

sity was higher in the predominately oak areas (one and two). The highest diversity for all seasons occurred in area one, the pure oak stand. For late spring, the breeding season for which most diversity indices in the literature are calculated, the highest diversity (3.2) was obtained in area one. In area two the value dropped slightly to 3.1, while area three was again slightly less diverse (3.0). Area four, dominated by Douglas fir, dropped to 2.6, and area five to 2.5. In area six the value rose to 2.6. In each succeeding area, diversity increased up to area ten which had a diversity of 2.9—lower than that of the oak stands, but higher than in early fir stages. Area three was transitional, while areas four and five were stands dominated by Douglas fir. There may have been some feature of the areas (e.g., dense shrub layer) which accounted for such low diversity. When comparisons of H/HMAX were made (Table 16), the late spring avifaunal diversity indices closely approached HMAX, indicating that individuals were fairly evenly divided between all species. In fact, during most of the year, the avifaunal diversity of the study areas was relatively close to HMAX. In the majority of the comparisons H was at least 90 percent of HMAX.

A further comparison of the study areas was made using differences in avifauna occupying study areas in late spring (Table 17). The difference between areas one and two was 1.175, while comparisons between coniferous areas with areas one and two showed a difference ranging from 1.440 to 1.665, indicating a considerable difference in numbers of individuals and types of species. Areas nine and ten, the hemlock stands, were the most similar.

When comparisons were made between the hemlock and fir stands, greater difference values were obtained than in fir-fir or hemlock-hemlock comparisons (Table 17). Since no great difference was found between the total number of individuals and species in late spring in the two coniferous types, it is apparent that while some of the species were different in the two vegetation types, there was not a greater variety of species in either sere. Amplification of this comparison was made using the similarity index, (SIMI) (Simpson, 1949). Here, the areas most similar in avian species and individuals have index values approaching 1 while in dissimilar areas the values approach 0. Areas one and two had a high similarity (0.75) while comparison of these areas with the fir and hemlock stands showed similarities from 0.20 to 0.37 (Table 17). Most fir areas had similarity values of 0.75 to 0.84, while fir-hemlock similarity was generally slightly lower. Comparison of area three, the ecotonal area, with the hemlock areas showed a relatively high similarity. Thus, some of the birds found in the oak-fir ecotone can also be found in the hemlock stands.

C. Ecological Role

The foregoing analysis treated the avifaunal composition of the study areas in terms of its taxonomic structure, but to assess the avifaunas of these areas as part of ecological communities, it seems more meaningful to analyze the ecological structure of the avifauna. In this analysis each species inhabitating a stand was assigned to one of eight "ecological roles" (Tables 18,19,and 20), based on feeding

Table 18. Ecological role and resident type of bird species found in oak stands.

Ecological role	Resident type
AIR-INSECT	
Western Wood Pewee	Summer
FOLIAGE-INSECT	
Black-capped Chickadee	Permanent
Common Bushtit	Permanent
Bewick's Wren	Permanent
Hermit Thrush	Summer
Western Bluebird	Occasional
Golden-crowned Kinglet	Winter
Ruby-crowned Kinglet	Winter
Hutton's Vireo	Permanent
Solitary Vireo	Summer
Warbling Vireo	Summer
Orange-crowned Warbler	Summer
Yellow Warbler	Summer
Audubon's Warbler	Occasional
Black-throated Gray Warbler	Summer
Townsend's Warbler	Summer
MacGillivray's Warbler	Summer
Wilson's Warbler	Summer
Western Tanager	Summer
Lazuli Bunting	Summer
FOLIAGE-SEED	
Band-tailed Pigeon	Occasional
Rufous Hummingbird	Summer
Steller's Jay	Permanent
Scrub Jay	Permanent
Varied Thrush	Winter
Townsend's Solitaire	Occasional
Cedar Waxwing	Occasional
House Finch	Permanent
TIMBER-SEARCHING	
White-breasted Nuthatch	Permanent
Red-breasted Nuthatch	Winter
Brown Creeper	Permanent
TIMBER-DRILLING	
Red-shafted Flicker	Occasional
Pileated Woodpecker	Occasional
Red-breasted Sapsucker	Occasional
Hairy Woodpecker	Permanent
Downy Woodpecker	Permanent

Table 18. Continued.

Ecological role	Resident type
GROUND-INSECT	
Winter Wren	Winter
Chipping Sparrow	Summer
GROUND-SEED	
Ring-necked Pheasant	Occasional
Mourning Dove	Occasional
Crow	Occasional
Robin (ground-insect)[a]	Permanent
Brown-headed Cowbird	Summer
American Goldfinch	Summer
Rufous-sided Towhee (ground-insect)	Permanent
Oregon Junco	Permanent
Golden-crowned Sparrow	Occasional
GROUND-PREDATOR	
Turkey Vulture	Occasional
Red-tailed Hawk	Occasional
Great Horned Owl	Occasional

[a]Occupied this role during one season.

Table 19. Ecological role and resident type of bird species found in fir stands.

Ecological role	Resident type
AIR-INSECT	
Vaux's Swift	Summer
Hammond's Flycatcher	Summer
Dusky Flycatcher	Summer
Western Flycatcher	Summer
Western Wood Pewee	Summer
Olive-sided Flycatcher	Summer
FOLIAGE-INSECT	
Hermit Thrush	Summer
Ruby-crowned Kinglet	Permanent
Hutton's Vireo	Permanent
Solitary Vireo	Summer
Orange-crowned Warbler	Summer
Audubon's Warbler	Summer
Townsend's Warbler	Summer
Hermit Warbler	Summer
Yellow Warbler	Summer
MacGillivray's Warbler	Summer
Wilson's Warbler	Summer
Western Tanager	Summer
Black-headed Grosbeak	Summer
Song Sparrow	Permanent
FOLIAGE-SEED	
Band-tailed Pigeon	Permanent
Rufous Hummingbird	Summer
Steller's Jay	Permanent
Varied Thrush	Permanent
Cedar Waxwing	Occasional
Evening Grosbeak (foliage-insect)[a]	Summer
Purple Finch	Summer
House Finch	Summer
Red Crossbill	Permanent
TIMBER-SEARCHING	
Red-breasted Nuthatch	Permanent
Brown Creeper	Permanent
TIMBER-DRILLING	
Red-shafted Flicker	Occasional
Pileated Woodpecker	Permanent
Hairy Woodpecker	Permanent
Downy Woodpecker	Permanent

[a]Occupied this role during one season.

Table 19. Continued.

Ecological role	Resident type
GROUND-INSECT	
Winter Wren	Permanent
Robin (ground-predator)	Permanent
GROUND-SEED	
Ruffed Grouse	Permanent
Mountain Quail	Permanent
American Goldfinch	Summer
Pine Siskin	Summer
Rufous-sided Towhee (ground-insect)	Permanent
Oregon Junco	Permanent
White-crowned Sparrow	Summer
GROUND-PREDATOR	
Turkey Vulture	Occasional
Red-tailed Hawk	Occasional
Great Horned Owl	Occasional

Table 20. Ecological role and resident type of bird species found in hemlock stands.

Ecological role	Resident type
AIR-INSECT	
Hammond's Flycatcher	Summer
Dusky Flycatcher	Summer
Western Flycatcher	Summer
Western Wood Pewee	Summer
Olive-sided Flycatcher	Summer
FOLIAGE-INSECT	
Chestnut-backed Chickadee	Permanent
Hermit Thrush	Summer
Golden-crowned Kinglet	Summer
Hutton's Vireo	Summer
Orange-crowned Warbler	Summer
Hermit Warbler	Summer
MacGillivray's Warbler	Summer
Wilson's Warbler	Summer
Western Tanager	Summer
Black-headed Grosbeak	Summer
FOLIAGE-SEED	
Steller's Jay	Permanent
Gray Jay	Permanent
Varied Thrush	Permanent
Evening Grosbeak	Permanent
Red Crossbill	Permanent
TIMBER-SEARCHING	
Red-breasted Nuthatch	Permanent
Brown Creeper	Permanent
TIMBER-DRILLING	
Pileated Woodpecker	Permanent
Hairy Woodpecker	Permanent
Downy Woodpecker	Permanent
GROUND-INSECT	
Winter Wren	Permanent
GROUND-SEED	
Pine Siskin	Summer
Rufous-sided Towhee (ground-insect)[a]	Permanent
Oregon Junco	Permanent
Song Sparrow	Summer

[a]Occupied this role during one season.

Table 20. Continued.

Ecological role	Resident type
GROUND-PREDATOR	
Great Horned Owl	Occasional

station, and foraging pattern, and the population census data for the avifaunal composition of the oaks, firs, and hemlocks were summarized and recalculated on this basis (Figures 4, 5, and 6). When the diet of a bird species was not known, data from Martin, Zim and Nelson (1951) was used.

The importance of foliage is apparent from these figures. In this case the term foliage is applied to the leaves, twigs, and needles of the trees and shrubs, while timber refers to the trunks and larger branches of the trees. More than 50 percent of the birds present during all seasons were either foliage-seed eaters or foliage-insect eaters. The largest number of individuals was found in the foliage-insect category in all areas during all seasons. When included with ground-insect eaters, timber searchers and timber drillers, which also eat insects, it is easy to see that the activity of many avian species is controlled by insect activity. During the spring and summer, the flycatchers were present as air-insect eaters. Most of the summer residents were foliage-insect eaters, including all of the warblers. Several of the species, such as chickadees and Robins, changed categories during the seasons, utilizing the food which was most abundant during a particular season.

All of the species classed ecologically as timber-searching or drilling, were permanent residents. The number of individuals in these categories did not vary greatly during the year; however, the percent of the total population may have been different due to changes in other categories.

Ground predators were the large birds such as some owls and

Figure 4. Ecological roles of Oregon white oak avifauna. (Percentage of individuals in each role)(according to Salt, 1953)

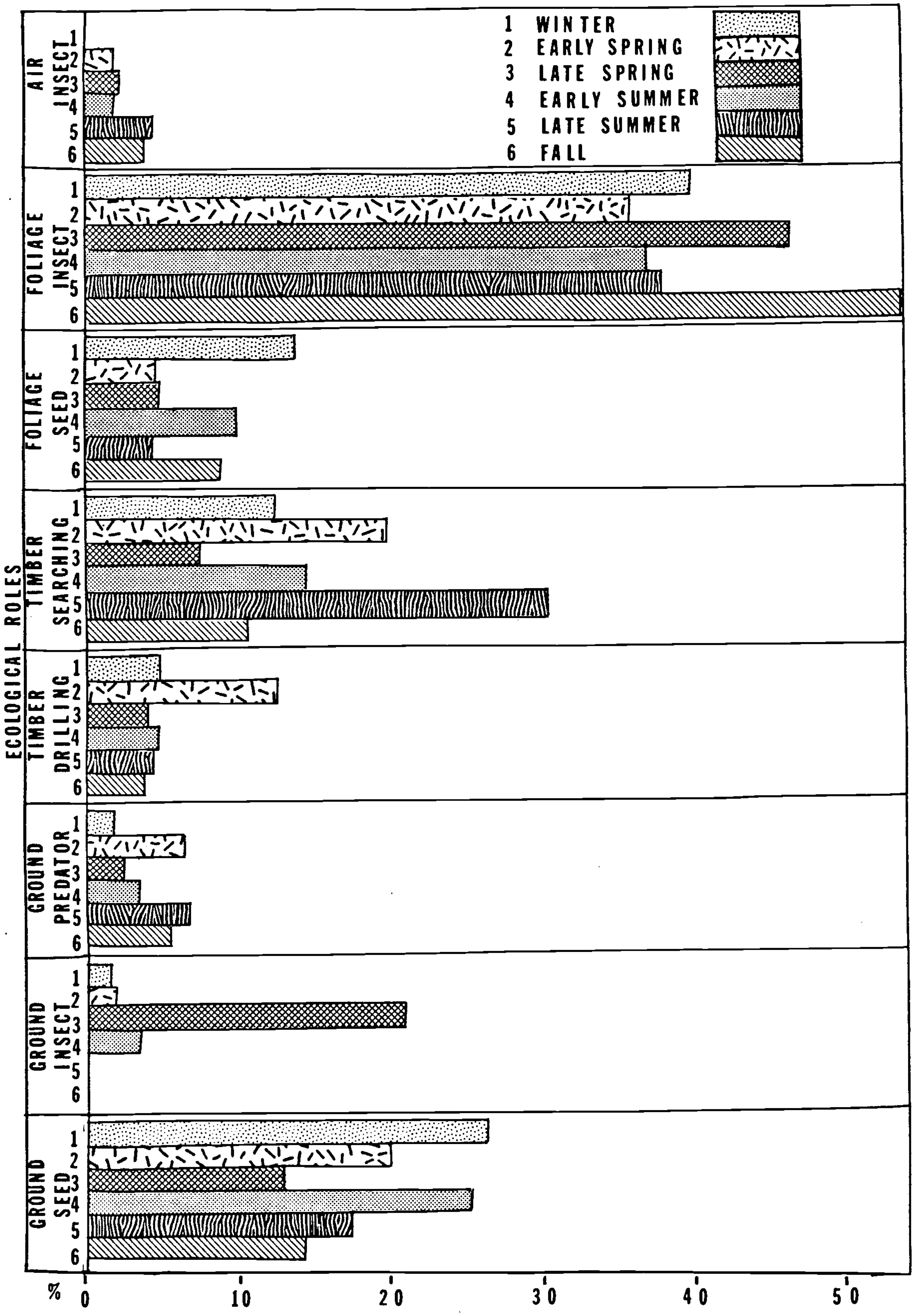

1 WINTER
2 EARLY SPRING
3 LATE SPRING
4 EARLY SUMMER
5 LATE SUMMER
6 FALL
ECOLOGICAL ROLES
AIR INSECT
FOLIAGE INSECT
FOLIAGE SEED
TIMBER SEARCHING
TIMBER DRILLING
GROUND PREDATOR
GROUND INSECT
GROUND SEED
%
0
10
20
30
40
50

Figure 5. Ecological roles of Douglas fir avifauna. (Percentages of individuals in each role)

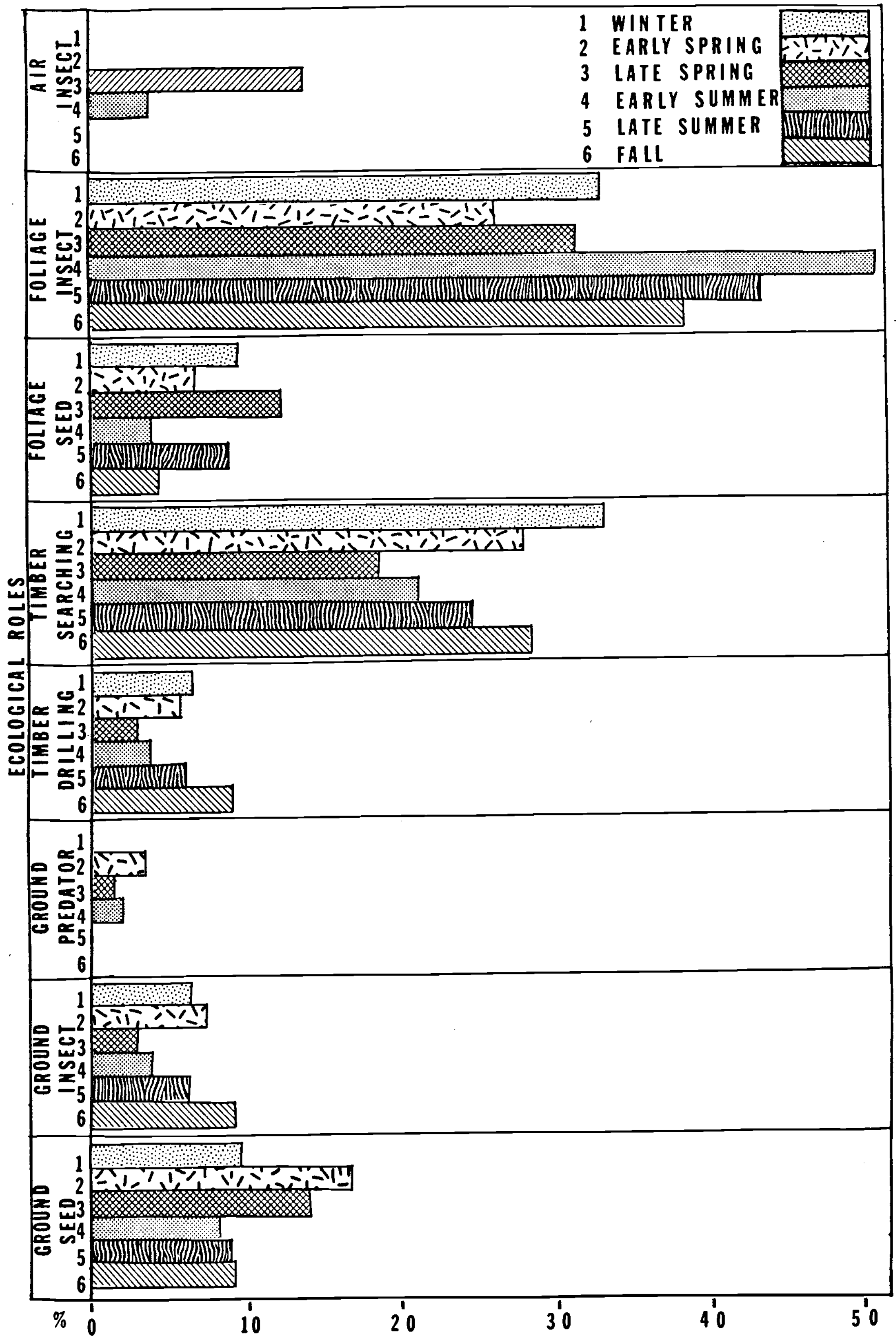
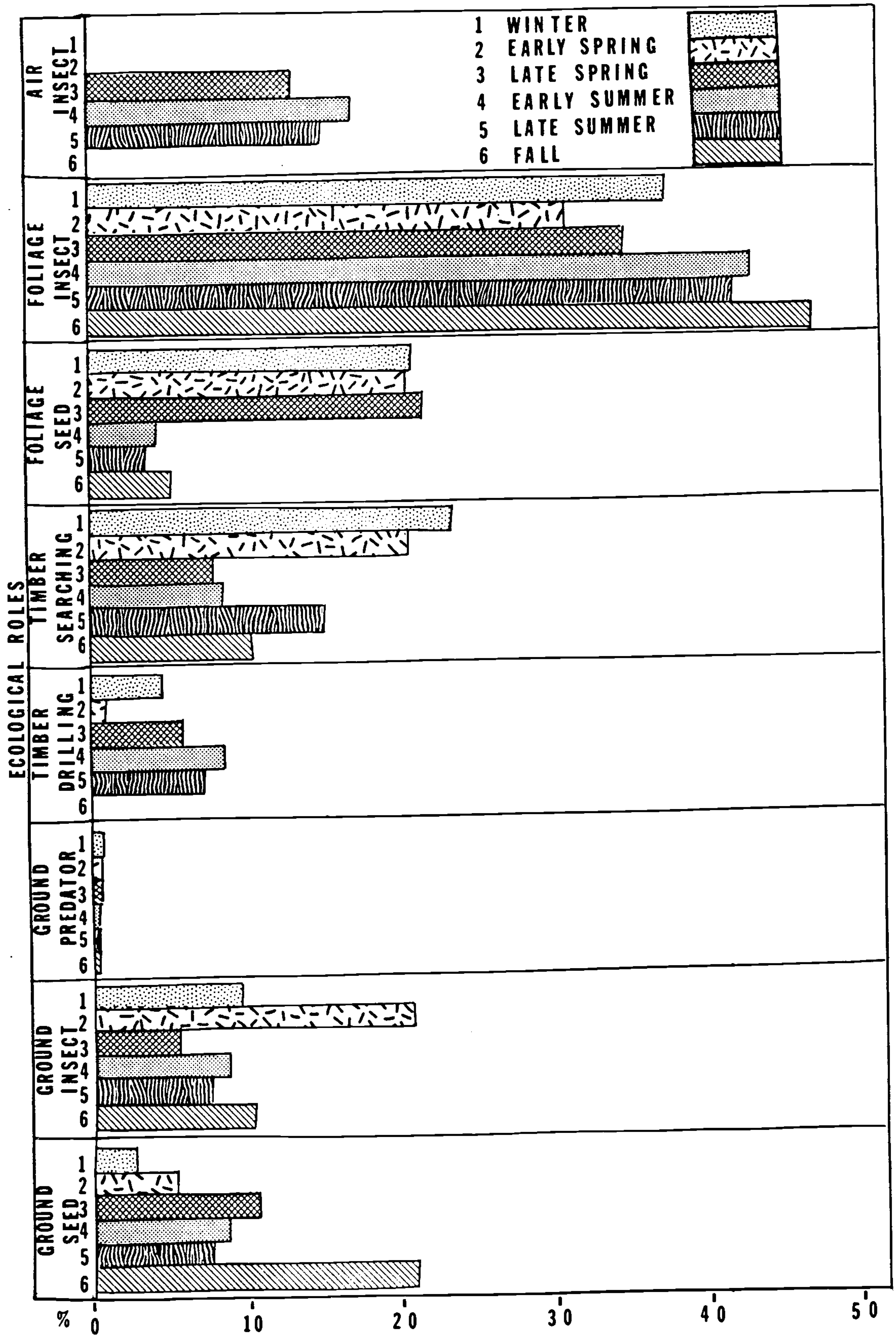

1 WINTER
2 EARLY SPRING
3 LATE SPRING
4 EARLY SUMMER
5 LATE SUMMER
6 FALL
ECOLOGICAL ROLES
AIR INSECT
FOLIAGE INSECT
FOLIAGE SEED
TIMBER SEARCHING
TIMBER DRILLING
GROUND PREDATOR
GROUND INSECT
GROUND SEED
%
0
10
20
30
40
50

Figure 6. Ecological roles of western hemlock avifauna. (Percentages of individuals in each role)



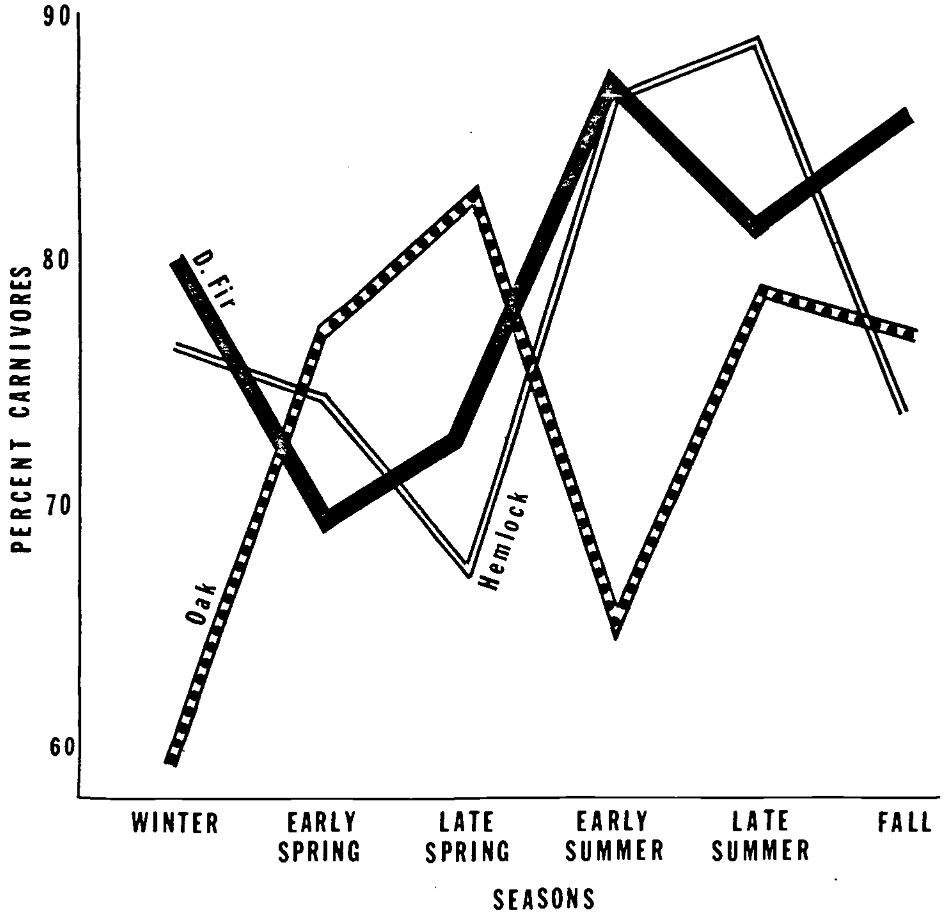
1 WINTER
2 EARLY SPRING
3 LATE SPRING
4 EARLY SUMMER
5 LATE SUMMER
6 FALL
ECOLOGICAL ROLES
AIR INSECT
FOLIAGE INSECT
FOLIAGE SEED
TIMBER SEARCHING
TIMBER DRILLING
GROUND PREDATOR
GROUND INSECT
GROUND SEED
%
0
10
20
30
40
50

hawks which preyed upon small mammals and birds, and Turkey Vultures which ate carrion. Thus, birds which searched for food over a large area and, therefore, could not be considered residents of any area, at least in terms of energy flow, were in this category.

Comparison of the three major vegetative types was made on the basis of the proportion of carnivorous bird individuals (Figure 7). Values ranged from 60 to 87 percent of the total individuals present. The oaks had a low of 60 percent in the winter when there was no foliage on the trees. Both fir and hemlock areas had a high proportion of carnivorous birds during the winter. The lowest proportion of carnivores (69 percent) in fir stands occurred in the early spring, and was not greatly different from that in the oak or hemlock stands. The large influx of migrants swelled the ranks of carnivorous birds in the oaks during the late spring. In early summer in the fir and hemlock stands, carnivorous birds comprised 87 percent of all individuals, representing the highest percentage recorded in all areas. In early spring, on the other hand, the smallest proportion of carnivores was present in all areas. Over all, the conifers supported a larger proportion of carnivores during the six seasons. The fact that vegetative cover was present throughout the year was undoubtedly a contributing factor.

Comparing these results with the ecological roles of the birds, the ground-seed eaters were more important in the oaks than in the conifers. Several factors were involved in this distinction. First, the oaks often bordered the grassy fields and had open areas of grass within the stands, where seeds could easily be found. Secondly, the

Figure 7. Percentage of bird individuals with carnivorous diet.


90
80
70
60
PERCENT CARNIVORES
D. Fir
Oak
Hemlock
WINTER
EARLY SPRING
LATE SPRING
EARLY SUMMER
LATE SUMMER
FALL
SEASONS

variety of ground vegetation was less in the conifers than in the oaks, allowing a more varied diet for the small seed eaters in the latter stands. Many fir and hemlock stands had very few ground-seed eaters; those present were usually Oregon Juncos and Rufous-sided Towhees.

D. Vegetation Gradient

Areas one and two, the oak stands, (Figure 2) supported the highest number of species among the study areas. The highest total number of individuals and species of all areas, when compared on a yearly basis, was recorded in area one. This may have resulted from several factors. First, the oaks bordered pastures and brushy fields which supported a variety of bird species, some of which moved into the oaks to nest or forage. Population pressure in such fields may have accounted for some of the species, such as the Bewick's Wren and Ring-necked Pheasant, breeding in the oaks. Bewick's Wrens were found in dense breeding populations with adjacent territories in the dense bottomlands adjoining the oak stands (D. Kroodsma, personal communication) but were found only sporadically occupying territories in the oaks. Secondly, it is likely that many of the insectiverous birds found food along the oak-grass ecotone, making nesting in the nearby oaks more feasible than in the more distant conifers. Thirdly, the understory vegetation was more dense in the oaks, providing more cover and food sources.

A marked drop in total numbers of species and individuals was noted upon moving from the oak to fir areas (Tables 5 to 14), with the highest counts in conifer habitats being in areas three and nine. These areas were intermediate in the successional sequence between oak and fir, and fir and hemlock respectively; they may have provided a greater variety of habitats so that a larger number of species could be supported.

The number of individuals and species in the Douglas fir areas varied greatly (Tables 7 to 12). During the non-breeding seasons, the lower number of species in the conifers was explained by the lack of winter residents.

E. Vegetation Structure

Vegetation serves as the basic living component of any community. Not only does vegetation act as the primary producer in a food chain but also provides shelter and reproductive sites for the animals within the community. One approach to plant community ecology involves a description of the taxa present. Another approach characterizes vegetation objectively by its own structural features (Küchler, 1966). The latter appears to be quite valuable in correlating the animal component of a community with the vegetative component.

Many studies have been developed to describe functional and structural components of vegetation, usually involving some form of symbolism denoting each item that a particular worker thinks is important (see summary by Wiens, 1969). Since no one approach is best for all studies, one must carefully define the goals of a particular project and select the best suited approach.

MacArthur and MacArthur (1961) developed a technique to describe the layering of vegetation. They found that by computing a foliage height diversity, based upon the distribution of the vegetation in layers of 0-2', 2-25' and greater than 25', they could accurately predict the bird species diversity of a community. Many structural features of the vegetation come under consideration when one talks about vegetation layering (e.g., trunk height, branch structure, area of openness, etc.). Thus, a comprehensive measure such as foliage height diversity may provide a better picture of the area under investigation.

Sturman (1968), in his analysis of the breeding habits of the Black-capped and Chestnut-backed Chickadees, found that canopy volume and upper story vegetation were significantly correlated with chickadee abundance. Both canopy volume and upper story vegetation were part of MacArthurs' foliage height diversity.

When the results of the regression analysis in my study were combined for the different vegetation types, no differences were found between the variables that affected avian abundance in the fir and hemlock areas. The results for these areas were combined and presented as characterizing coniferous stands.

Table 21 shows the variables which had the greatest correlation with the abundance of Black-capped Chickadees and White-breasted Nuthatches in the Oregon white oak. Number of trees and canopy volume were important factors influencing the abundance of the Black-capped Chickadees. Most significant in predicting the abundance of the White-breasted Nuthatch was the average length of secondary

Table 21. Vegetative variables influencing the abundance of Black-capped Chickadees and White-breasted Nuthatches in oak stands.

Black-capped Chickadee	R^2	White-breasted Nuthatch	R^2
Trees per acre (>60 feet)	0.7096	Average length of secondary branches	0.7907
Canopy volume per acre	0.7597	Vegetation in upper layer	0.8348
Foliage height diversity	0.8790	Index of openness	0.8544
Diameter of trunk at 4 feet	0.8930		
Canopy cover per acre	0.9085		
Index of openness	0.9239		

Table 22. Vegetative variables influencing the abundance of Chestnut-backed Chickadees and Red-breasted Nuthatches in conifer stands.

Chestnut-backed Chickadee	R^2	Red-breasted Nuthatch	R^2
Inner core per acre	0.6223	Canopy volume per acre	0.7210
Bark index	0.8111	Canopy cover per acre	0.7734
Twigs per tree	0.8566	Dead trees per acre	0.8173
Trees per acre (>60 feet)	0.8667	Trees per acre (>60 feet)	0.8310

Table 23. Vegetative variables influencing the abundance of Brown Creepers.

Oak	R^2	Conifers	R^2
Inner core per acre	0.7835	Inner core per acre	0.7923
Trees per acre	0.8534	Trees per acre	0.8301
Average height of tree trunks per acre	0.8875	Average height of trees per acre	0.8711
Average height of trees per acre	0.9101	Average height of tree trunks per acre	0.8901

Table 24. Vegetative variables influencing the abundance of Rufous-sided Towhees.

Oak	R^2	Conifers	R^2
Foliage height diversity	0.7050	Foliage height diversity	0.8876
Shrub cover per acre	0.8106	Vegetation in lower layer	0.9280
Dead vegetation per acre	0.8666	Dead vegetation per acre	0.9462
Index of openness	0.8779		
Vegetation in lower layer	0.8943		

Table 25. Vegetative variables influencing the abundance of Oregon Juncos.

Oak	R^2	Conifers	R^2
Shrub cover per acre	0.7050	Index of openness	0.7310
Dead vegetation per acre	0.8106	Shrubs per acre	0.7743
Index of openness	0.8497	Shrub cover per acre	0.8058
Shrubs per acre	0.8557	Dead vegetation per acre	0.8466

branches. This feature was undoubtedly important both as a foraging and nesting substrate.

The important factors influencing the abundance of the Chestnut-backed Chickadee and Red-breasted Nuthatch in coniferous stands are shown in Table 22. Again, many features which were important to the foraging and nesting areas of the species appear. Dead trees per acre were an important prerequisite for the nesting of the Red-breasted Nuthatch.

Comparison of the factors influencing Brown Creeper abundance in the two vegetative types is shown in Table 23. The inner core of the canopy was the most important factor in both tree types, presumably relating to the area available for the creeper to manuever and to find its insect food on the tree trunk. The four features which showed the greatest affect on creeper abundance were the same for both areas, with the last two features reversed in rank in the two habitat types.

When the major vegetative variables affecting the Rufous-sided Towhee were compared in the two communities, fewer features were of major importance in the conifers, although these features were also important in the oak stands. For towhees, foliage height diversity was the most important variable affecting their abundance in both areas (Table 24).

The variables affecting the abundance of Oregon Juncos in the oaks and conifers (Table 25) were the same, but entered into the regression in a different order. In the conifers, open areas were most important in determining the greater abundance of juncos, while shrub cover was more important in the oaks.

In comparing the factors influencing the bird species in the two vegetative types, it is instructive to examine the creeper, towhee and junco. Here, the same components of the vegetation affected the abundance of the species in both vegetative types; thus, it can be seen that structure, not the species of the vegetation, was the most significant.

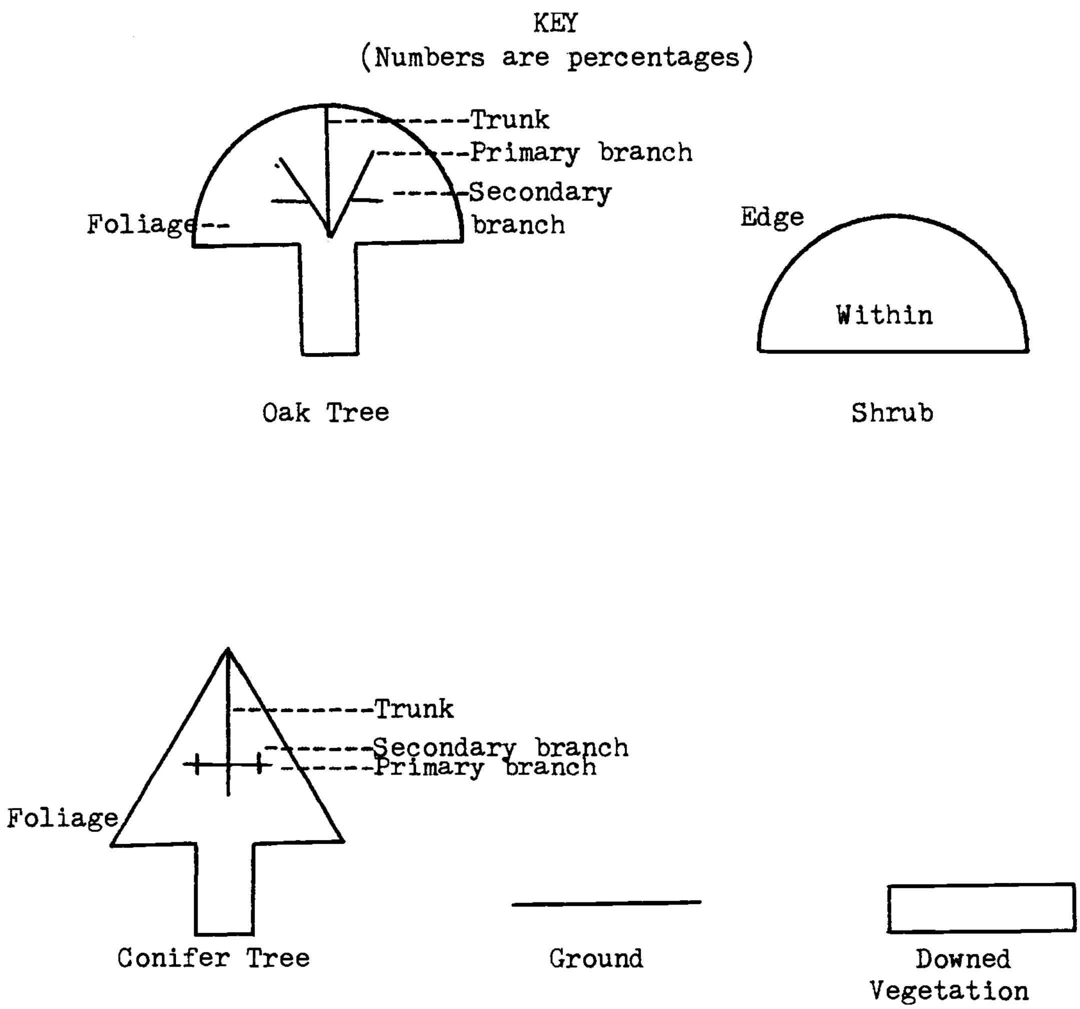
F. Habitat Utilization

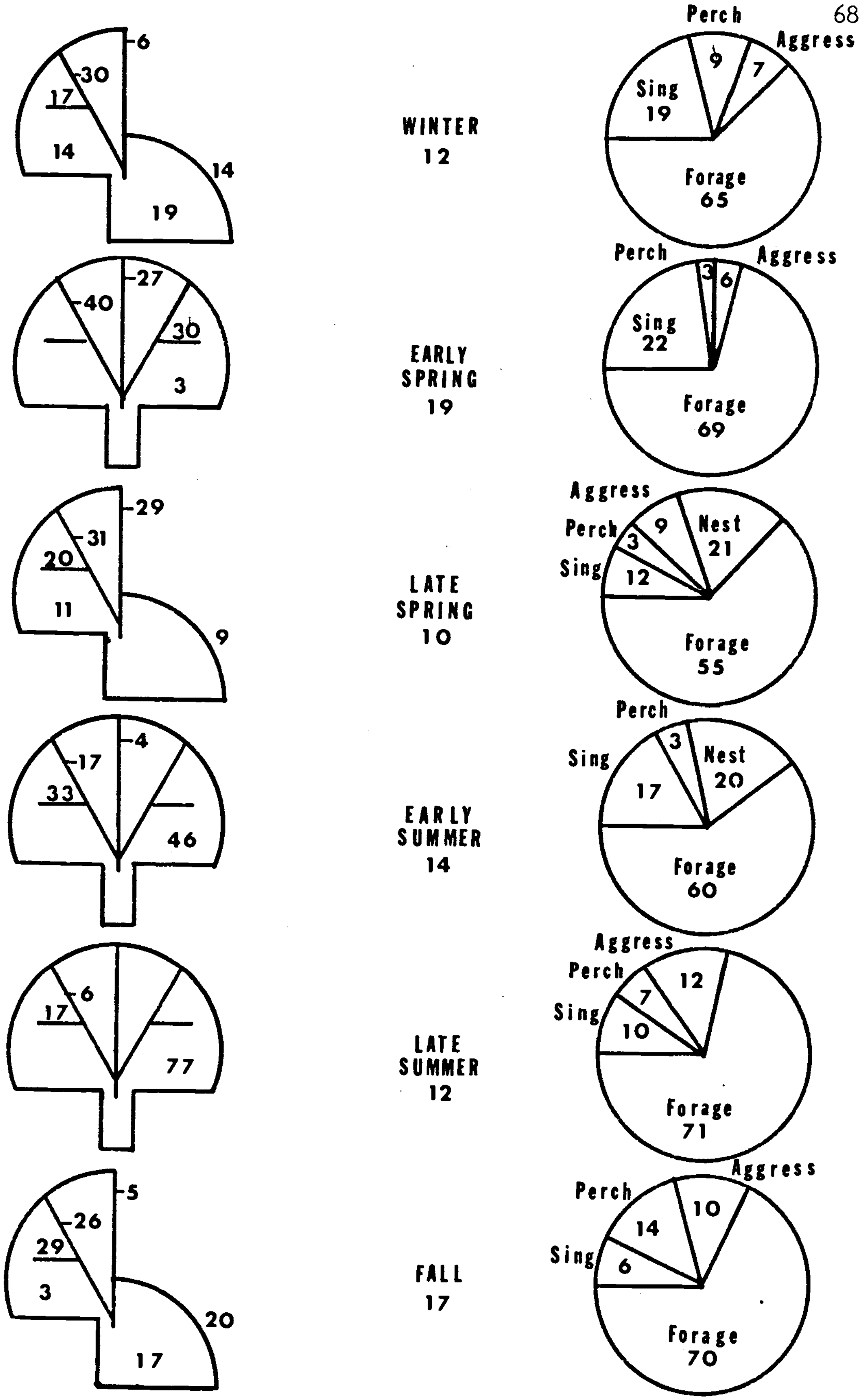
Figures 8 to 17 present seasonal summaries of the selected bird species' activity and utilization of the habitat. Foraging was the major component of the activity of all species at all periods of the year. During the nesting period, the proportion of time spent in foraging decreased, as did the time singing.

The chickadees, towhees and juncos devoted part of their time to perching, while creepers and nuthatches seldom ceased foraging. Food did not seem that difficult for the creepers and nuthatches to obtain; however, they may have needed to expend more energy in breaking the bark or probing in the crevices to find food. It is shown in the food section that creepers and nuthatches were more selective in size and type of diet.

Black-capped Chickadees were most frequently observed in oak trees (Figure 8). During the late spring and summer, a large proportion of their time was spent on the foliage which was otherwise absent from the oak stands. The Black-capped Chickadees seemed to move about in the vegetation and take food wherever it could be found.

Figure 8. Habitat utilization by Black-capped Chickadee. Numbers under seasons indicate sample size.





WINTER
12
6
30
17
14
14
19
Perch
Aggress
9
7
Sing
19
Forage
65
EARLY SPRING
19
27
40
30
3
Perch
Aggress
3
6
Sing
22
Forage
69
LATE SPRING
10
29
31
20
11
9
Aggress
Perch
9
3
Nest
21
Sing
12
Forage
55
EARLY SUMMER
14
4
17
33
46
Perch
3
Nest
20
Sing
17
Forage
60
LATE SUMMER
12
6
17
77
Aggress
Perch
12
7
Sing
10
Forage
71
FALL
17
5
26
29
3
20
17
Aggress
Perch
10
14
Sing
6
Forage
70

Figure 9. Habitat utilization by White-breasted Nuthatch.
Key as in Figure 8.

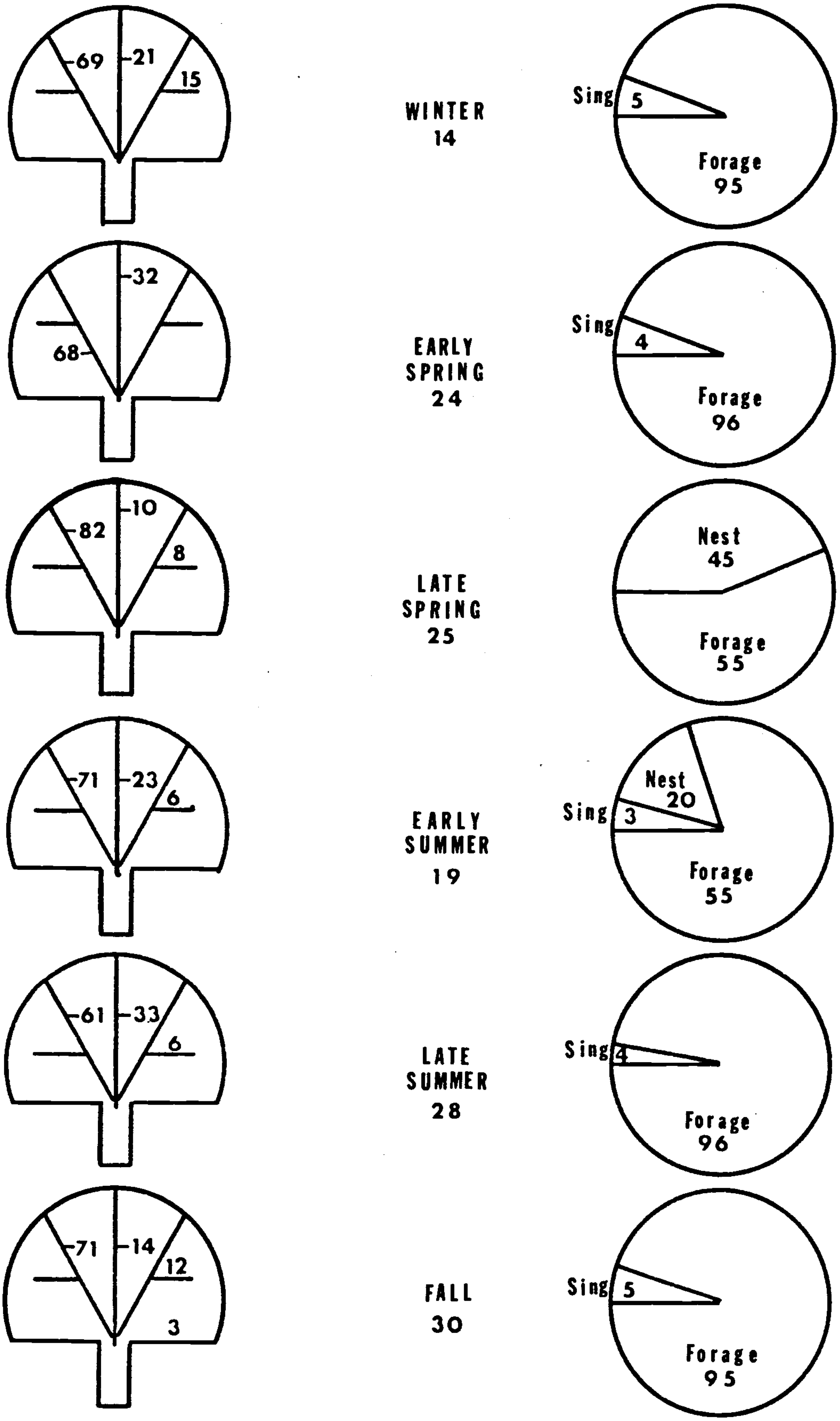
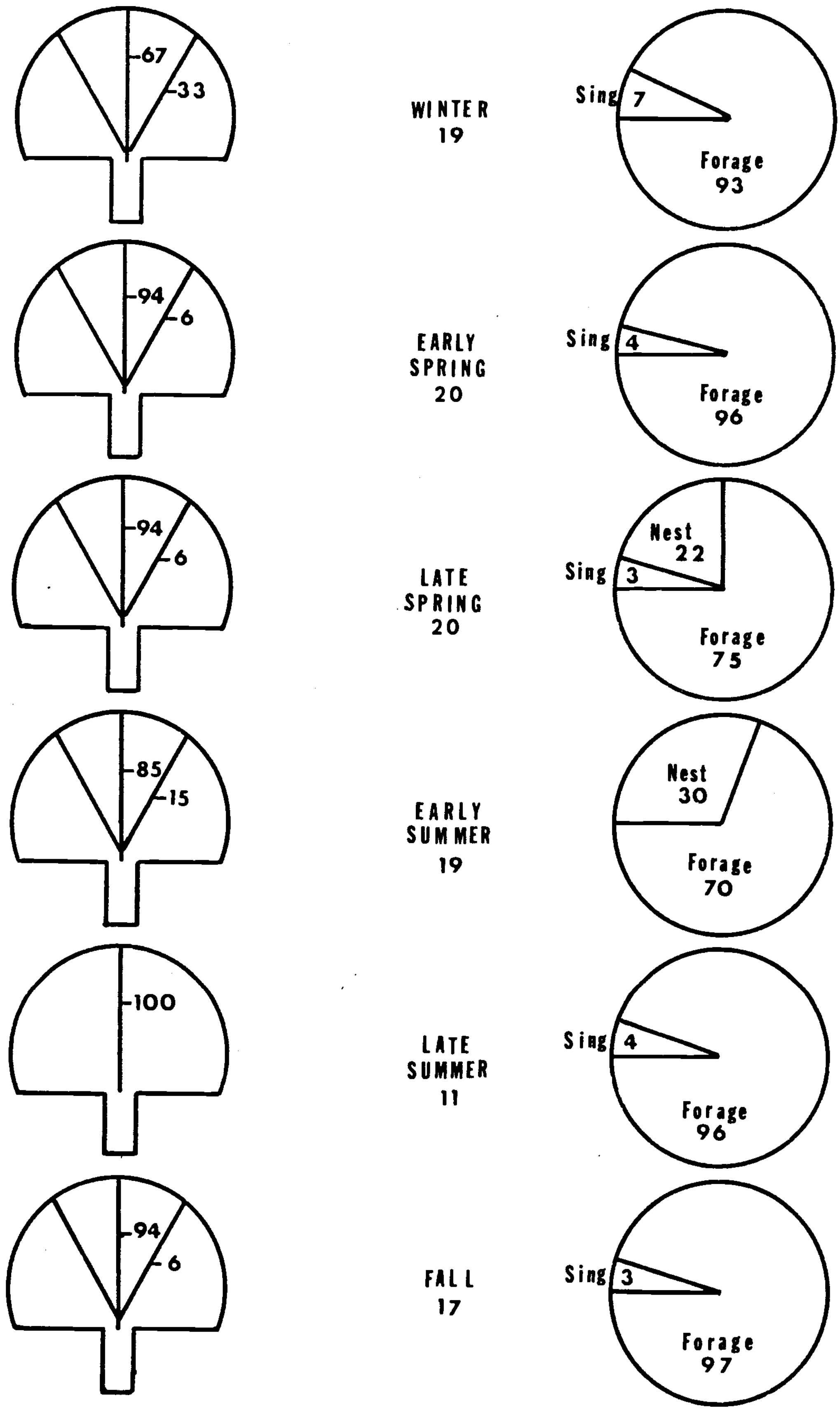

69
21
15
WINTER
14
Sing
5
Forage
95
32
68
EARLY
SPRING
24
Sing
4
Forage
96
10
82
8
LATE
SPRING
25
Nest
45
Forage
55
71
23
6
EARLY
SUMMER
19
Nest
20
Sing
3
Forage
55
61
33
6
LATE
SUMMER
28
Sing
4
Forage
96
71
14
12
3
FALL
30
Sing
5
Forage
95

Figure 10. Habitat utilization by Brown Creeper in Oregon white oak. Key as in Figure 8.



-67
-33
WINTER
19
Sing 7
Forage
93
-94
-6
EARLY
SPRING
20
Sing 4
Forage
96
-94
-6
LATE
SPRING
20
Nest
22
Sing 3
Forage
75
-85
-15
EARLY
SUMMER
19
Nest
30
Forage
70
-100
LATE
SUMMER
11
Sing 4
Forage
96
-94
-6
FALL
17
Sing 3
Forage
97

Figure 11. Habitat utilization by Rufous-sided Towhee in Oregon white oak. Key as in Figure 8.

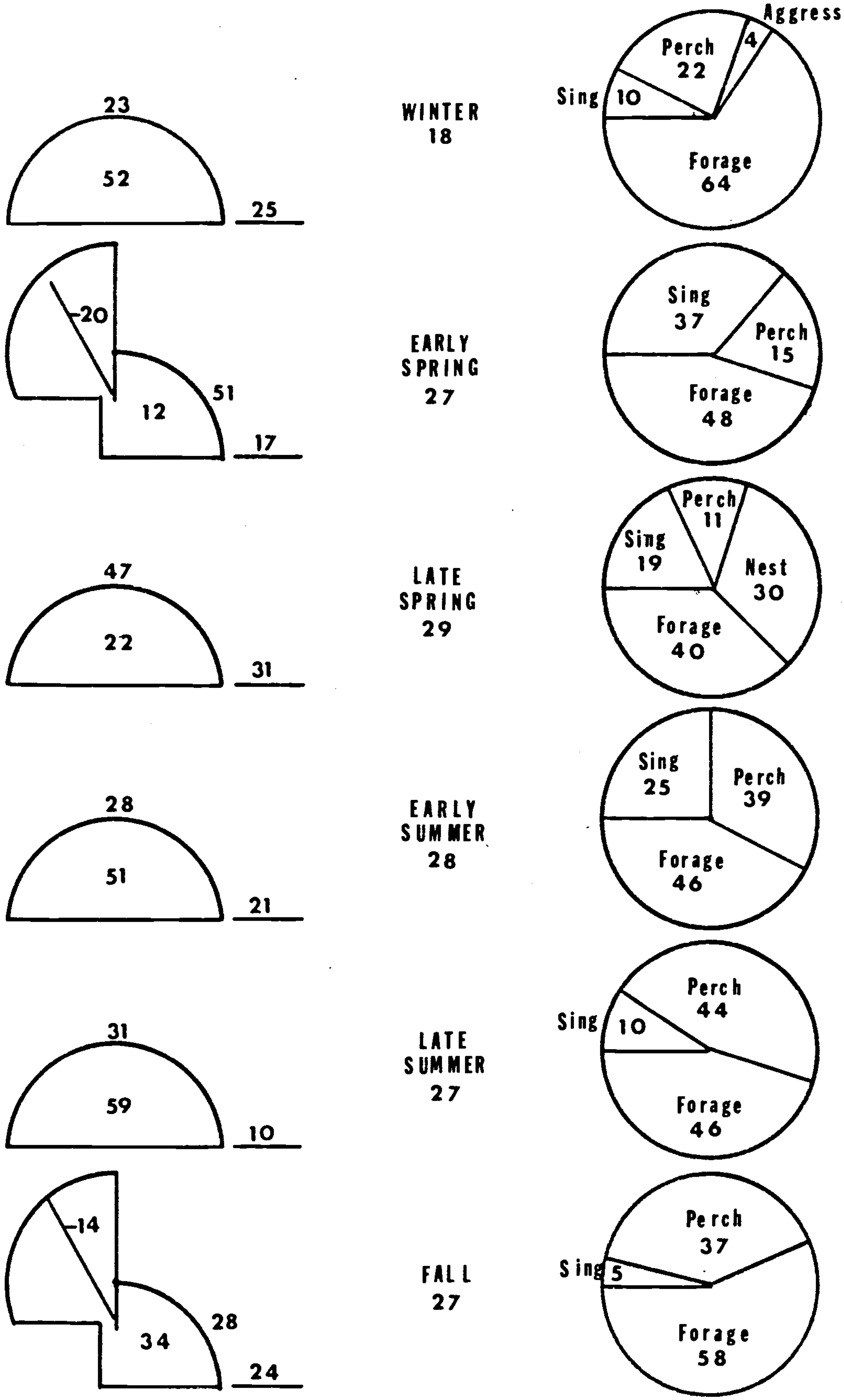
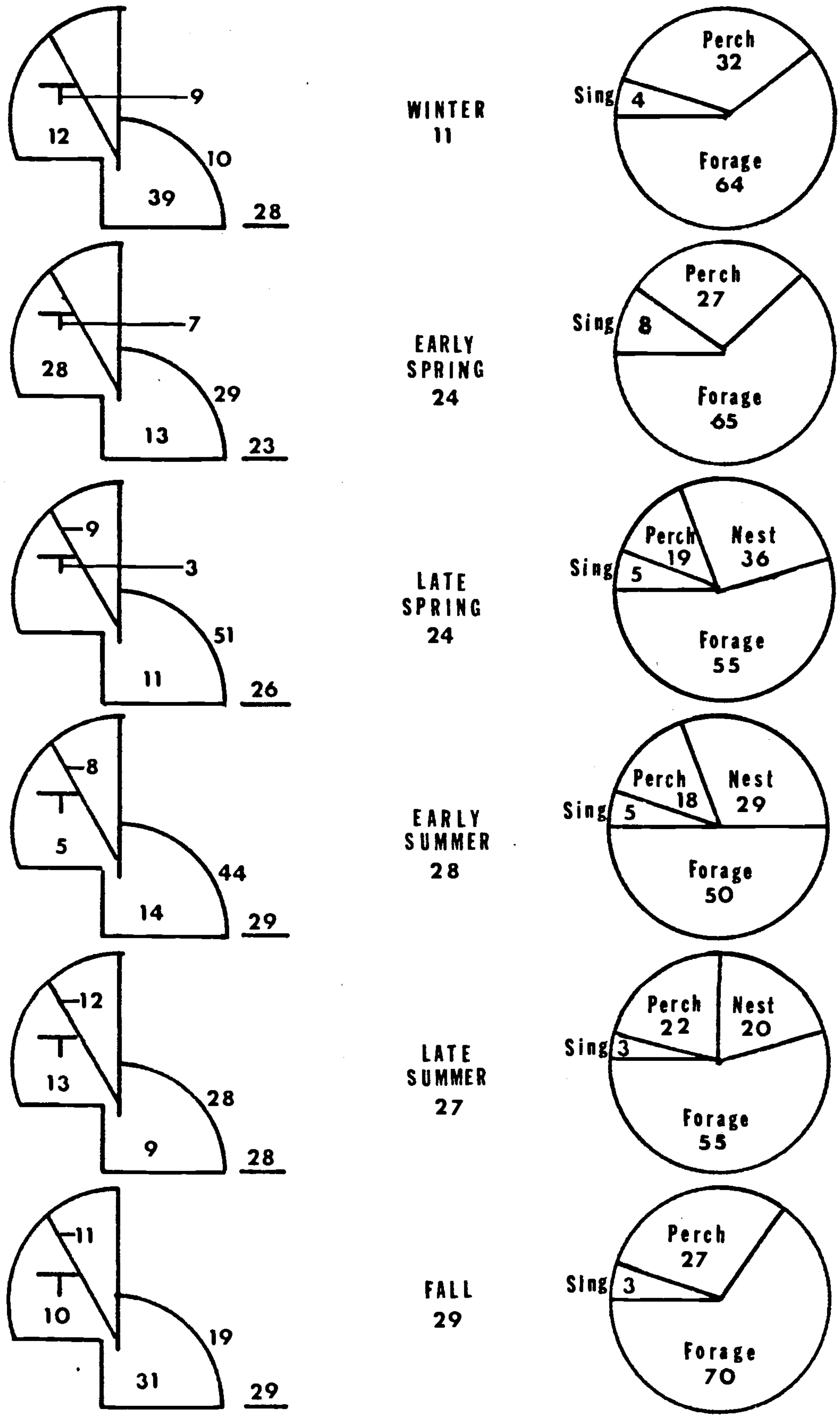

23
52
25
WINTER
18
Aggress
4
Perch
22
Sing
10
Forage
64
-20
12
51
17
EARLY
SPRING
27
Sing
37
Perch
15
Forage
48
47
22
31
LATE
SPRING
29
Perch
11
Sing
19
Nest
30
Forage
40
28
51
21
EARLY
SUMMER
28
Sing
25
Perch
39
Forage
46
31
59
10
LATE
SUMMER
27
Perch
44
Sing
10
Forage
46
-14
34
28
24
FALL
27
Perch
37
Sing
5
Forage
58

Figure 12. Habitat utilization by Oregon Junco in Oregon white oak. Key as in Figure 8.



9
12
10
39
28
WINTER
11
Perch
32
Sing
4
Forage
64
7
28
29
13
23
EARLY
SPRING
24
Perch
27
Sing
8
Forage
65
9
3
51
11
26
LATE
SPRING
24
Perch
19
Nest
36
Sing
5
Forage
55
8
5
44
14
29
EARLY
SUMMER
28
Perch
18
Nest
29
Sing
5
Forage
50
12
13
28
9
28
LATE
SUMMER
27
Perch
22
Nest
20
Sing
3
Forage
55
11
10
19
31
29
FALL
29
Perch
27
Sing
3
Forage
70

Figure 13. Habitat utilization by Chestnut-backed Chickadee. Key as in Figure 8.

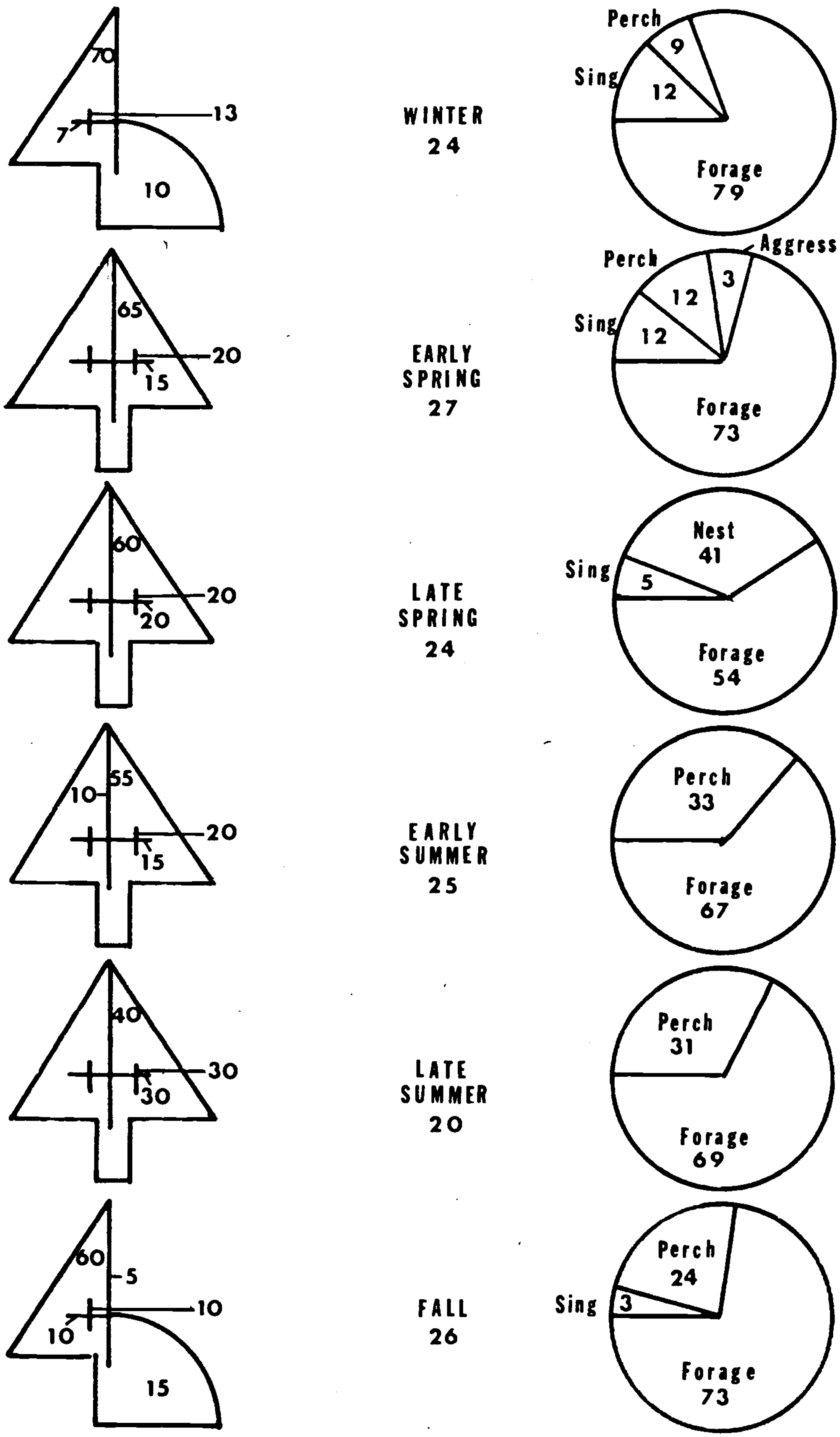

70
7
13
10
WINTER
24
Perch
9
Sing
12
Forage
79
65
20
15
EARLY
SPRING
27
Perch
Aggress
3
12
Sing
12
Forage
73
60
20
20
LATE
SPRING
24
Nest
41
Sing
5
Forage
54
10
55
20
15
EARLY
SUMMER
25
Perch
33
Forage
67
40
30
30
LATE
SUMMER
20
Perch
31
Forage
69
60
5
10
10
15
FALL
26
Perch
24
Sing
3
Forage
73

Figure 14. Habitat utilization by Red-breasted Nuthatch. Key as in Figure 8.

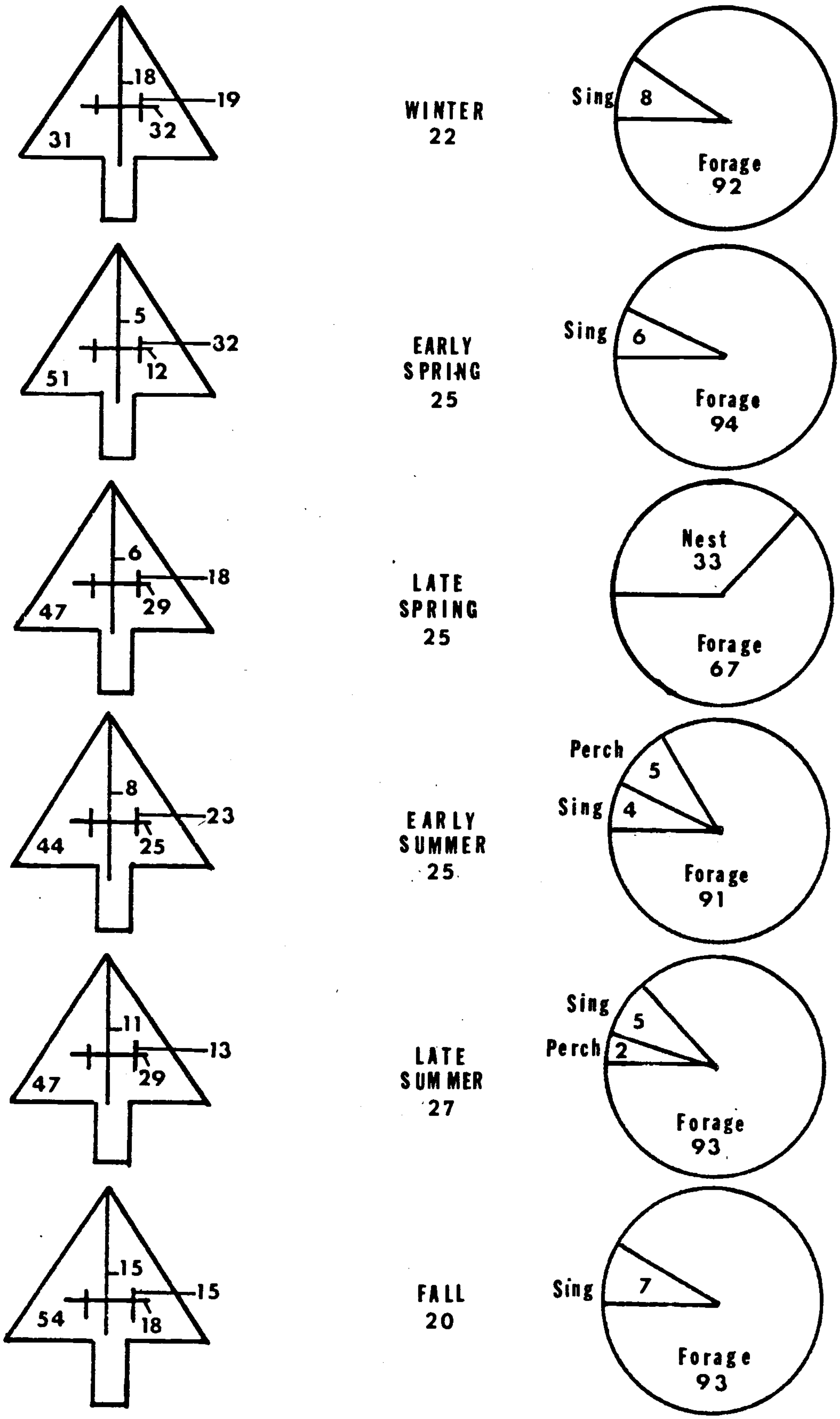

18
19
32
31
WINTER
22
Sing
8
Forage
92
5
32
12
51
EARLY
SPRING
25
Sing
6
Forage
94
6
18
29
47
LATE
SPRING
25
Nest
33
Forage
67
8
23
25
44
EARLY
SUMMER
25
Perch
5
Sing
4
Forage
91
11
13
29
47
LATE
SUMMER
27
Sing
5
Perch
2
Forage
93
15
15
18
54
FALL
20
Sing
7
Forage
93

Figure 15. Habitat utilization by Brown Creeper in conifers.
Key as in Figure 8.

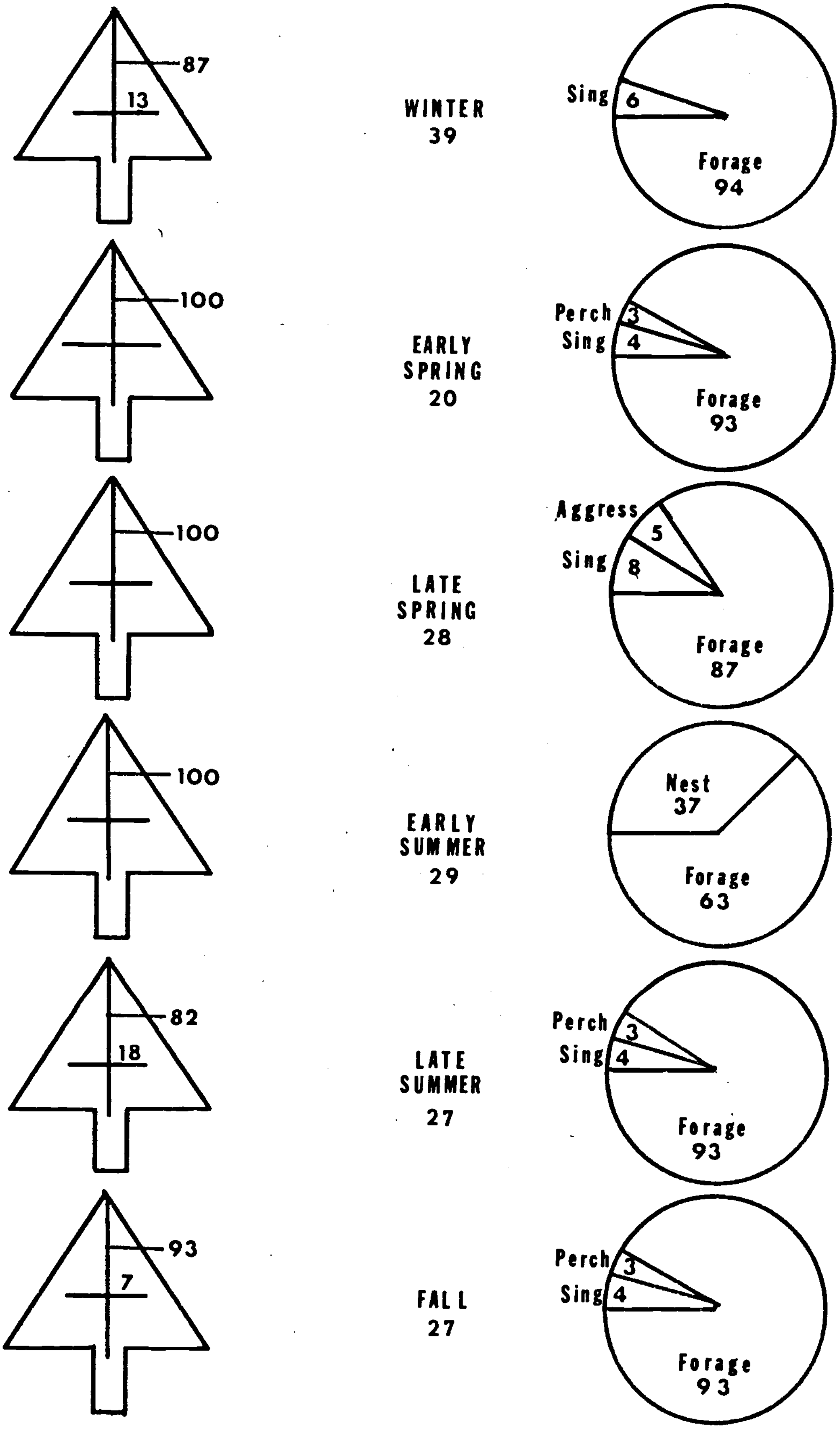

87
13
WINTER
39
Sing
6
Forage
94
100
EARLY
SPRING
20
Perch
3
Sing
4
Forage
93
100
Aggress
5
Sing
8
LATE
SPRING
28
Forage
87
100
EARLY
SUMMER
29
Nest
37
Forage
63
82
18
LATE
SUMMER
27
Perch
3
Sing
4
Forage
93
93
7
FALL
27
Perch
3
Sing
4
Forage
93

Figure 16. Habitat utilization by Rufous-sided Towhee in conifers. Key as in Figure 8.

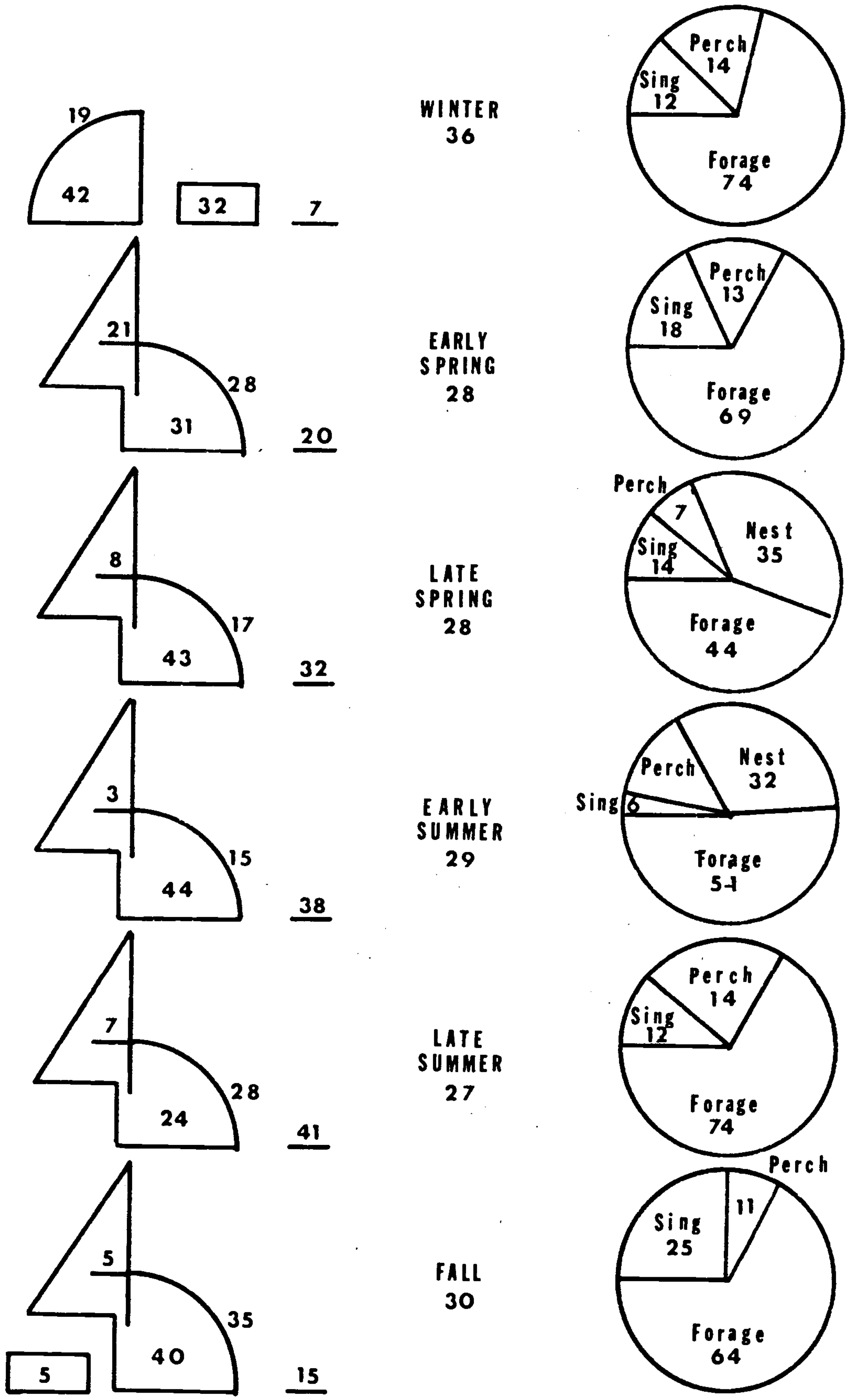
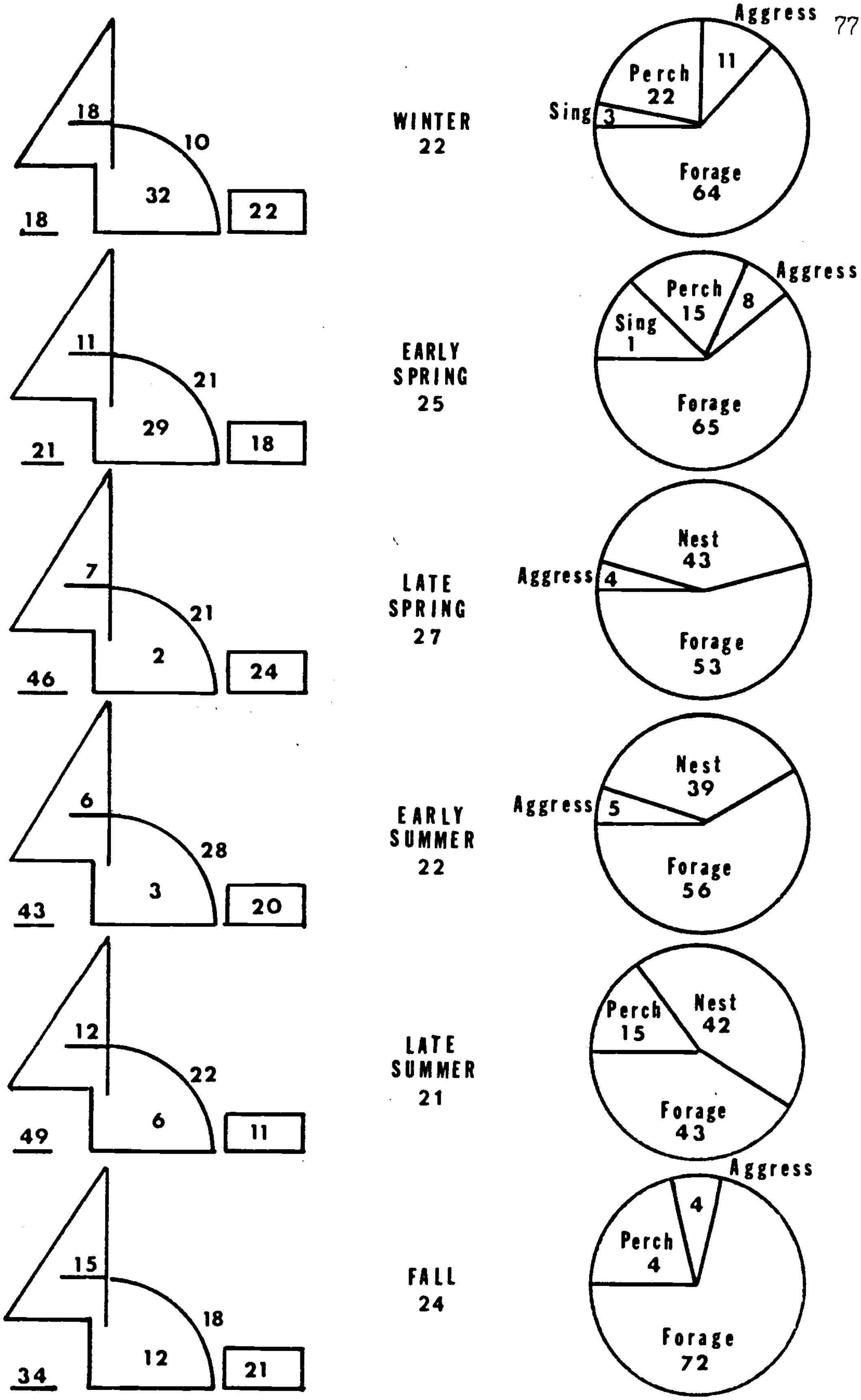

19
42
32
7
WINTER
36
Perch
14
Sing
12
Forage
74
21
28
31
20
EARLY
SPRING
28
Perch
13
Sing
18
Forage
69
8
17
43
32
LATE
SPRING
28
Perch
7
Sing
14
Nest
35
Forage
44
3
15
44
38
EARLY
SUMMER
29
Perch
Nest
32
Sing
6
Forage
54
7
28
24
41
LATE
SUMMER
27
Perch
14
Sing
12
Forage
74
5
35
40
5
15
FALL
30
Perch
11
Sing
25
Forage
64

Figure 17. Habitat utilization by Oregon Junco in conifers. Key as in Figure 8.


18
10
32
18
22
WINTER
22
Aggress
11
Perch
22
Sing
3
Forage
64
11
21
29
21
18
EARLY
SPRING
25
Perch
15
8
Aggress
Sing
1
Forage
65
7
21
2
46
24
LATE
SPRING
27
Nest
43
Aggress
4
Forage
53
6
28
3
43
20
EARLY
SUMMER
22
Nest
39
Aggress
5
Forage
56
12
22
6
49
11
LATE
SUMMER
21
Perch
15
Nest
42
Forage
43
15
18
12
34
21
FALL
24
Aggress
4
Perch
4
Forage
72

During the fall and winter, the chickadees spent 30 to 40 percent of their time on the branches of the many shrubs in the area. During these seasons, the birds were in mixed flocks and moved en mass through an area, some individuals in trees, others on the shrubs.

White-breasted Nuthatches were more predictable in their habitat utilization than the chickadees and foraged in a different area of the tree. During the spring and summer, they spent their time close to the top of the tree, occasionally gleaning material off the foliage, but mostly remaining on the branches. No White-breasted Nuthatches were found in the conifers. Figure 9 indicates that nuthatches spent the greatest proportion of their time on the angular primary branches. Such structure was not available in the conifers and may partially account for the absence of the White-breasted Nuthatch in them.

Brown Creepers were found in all study areas. They spent a large proportion of their time foraging on the main trunks of trees (Figures 10 and 15). Creepers in the oaks foraged at a lower height when the leaves were out (Table 26). Also, they moved off the main trunk more frequently in the winter months.

Rufous-sided Towhees were birds of the ground and low shrubs. When they moved to a tree it was on a primary branch, usually to perch (Figures 11 and 16). Most of the foraging occurred on the ground. This ground foraging was even more frequent during the spring and summer. The only appreciable difference between the pattern of habitat utilization in oak and fir stands was that in the latter, the towhees spent more time perching on the primary branches, while in the oaks perching was mostly on bushes. Towhees were not found in all coniferous stands, apparently the requisites were not present in all areas.

When not nesting, Oregon Juncos flocked and moved through a wide range of habitats. During the breeding season, juncos were found nesting in the grass in both vegetation types, which largely accounted for the high proportion of time spent on the ground. During this period, juncos foraged in the shrubs of the area. In the fall and winter, juncos spent 20 to 30 percent of their time foraging on the ground.

Chestnut-backed Chickadees were most frequently observed in the foliage of the conifers. Foraging was also done on the primary and secondary branches, but the birds seemed to prefer small needles. Chestnut-backed Chickadees were not common in the oaks. Chestnut-backed Chickadees remained in the upper part of the canopy most of the year (Table 26). During the winter, they were occasionally observed on shrubs; however, these shrubs were normally close to small conifers from which the chickadees flew.

Red-breasted Nuthatches were also most abundant in the conifers. About 40 to 50 percent of their time was spent on the foliage. They occurred in the same areas as did Chestnut-backed Chickadees; however, the nuthatches were not found as high as were the chickadees (Table 26). The nuthatches spent more time on the primary and secondary branches than did Chestnut-backed Chickadees. During the winter, nuthatches were frequently observed on the branches and trunks of trees. Red-breasted Nuthatches nested in the trunks of

Table 26. Foraging height ± S.D. and range expressed as percentage from top of tree.

	SEASON											
	Winter		Early Spring		Late Spring		Early Summer		Late Summer		Fall	
	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range
OAK												
Black-capped Chickadee	42± 6	0-50	48± 4	0-60	53± 7	20-70	55± 6	0-70	57± 8	0-70	54± 8	0-70
White-breasted Nuthatch	51± 9	0-50	46± 7	0-60	39± 9	10-55	32± 7	0-40	31± 5	0-40	48± 7	0-60
Brown Creeper	30±18	55-90	48±14	30-80	43±12	40-80	51±19	30-80	54± 7	30-70	48± 7	35-90
CONIFERS												
Chestnut-backed Chickadee	19± 5	0-70	11± 7	0-65	12± 5	10-60	19± 7	5-65	16± 7	5-60	13± 8	0-65
Red-breasted Nuthatch	14± 6	5-60	25±12	5-60	28±11	10-70	31±10	5-70	29± 9	5-70	27±12	5-70
Brown Creeper	44±12	5-70	48±11	10-60	37± 7	10-50	42±12	10-70	40±14	5-60	43±15	20-60

dead conifers. Most nesting trees were 6 to 12 inches in diameter with the nest 30 to 40 feet above the ground.

G. Food Analysis

Food often plays a major role in determining the abundance of bird species since it is the only unsharable, completely utilizable resource (Orians and Collier, 1963). In addition to determining abundance, food may be an important factor in the habitat selection of bird species. Many birds apparently select their habitats on the basis of some "sign stimuli" of the environment (Lack, 1933; Hilden, 1965). The signal received by the bird from the habitat must convey some information concerning food and nest site availability, since ultimately a bird must obtain the necessary food for survival and reproduction from its habitat. One of the first considerations in analyzing these factors must be to determine the diets of the species occurring in an area. Such information may also contribute to clarification of the degree of competition between the species; thus, in order to assess the relationships of the bird species in oak and conifer habitats, diets of the species selected for intensive study were sampled. Tables 27 to 36 present the results of the stomach analyses of these species.

Black-capped Chickadees had a variable diet. In the breeding season, when the greatest variety of food was available, they ate a wide variety of items (Table 27). Beetles in the families Chrysomelidae and Curculionidae were the most common food item. Using the Shannon and Weaver (1949) species diversity calculation, H,

Table 27. Diet of Black-capped Chickadees from oak stand.

Sample size:[a] B[b]=12, P=10, W=7.

Order	Family	Frequency[c]			Total Number[d]			% Total Volume[e]			Mean Length[f]		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	2	3	2	2	23	1	3	21	1	2	3
Orthoptera				1			1			5			4
Dermaptera		2			2			3			3		
Hemiptera	Miridae	2	4		2	10		6	8		3	3	
	Pentatomidae			1			1			4			4
Neuroptera	Chrysopidae			1			1			4			4
Coleoptera	Elateridae		4			10			13			3	
	Chrysomelidae	8	10	7	18	28	13	23	35	27	3	4	4
	Curculionidae	8	6	1	18	2	2	26	9	6	3	2	3
	Scolytidae			5			6			7			2
	Unid. larvae	6	4		6	8		5	7		3	3	
Lepidoptera	Phalaenidae	4			4			5			2		
	Geometridae	6			6			19			2		
	Tineidae	4			4			4			2		
	Unid. Larvae	2			2			1			3		
Diptera	(Cyclorrhapha)	4			2			1			2		
	Psychodidae			1			1			5			2
Hymenoptera	Formicidae	2	4		4	6		3	7		2	2	
	Unid.		2			2			2			2	
Unid. Insect		4		1	2		1	3		4	2		2
Plant													
	Cyperaceae			7			165			12			2
	Compositae		4			2			9			1	
Unid. Plant			4	1		9	1		7	6		1	4

[a]Number of individuals sampled in each period.

[b]B=Breeding Season (Late Spring, Early Summer)
P=Post Breeding Season (Late Summer, Fall)
W=Winter Season (Winter, Early Spring)

[c]Number of individuals with this food item.

[d]Total number of whole food items in all stomachs examined of species.

[e]Mean estimate of the volume this food item occupied in all individuals of this species examined during period.

[f]Longest distance in millimeters.

Table 28. Diet of White-breasted Nuthatches from oak stands. (Terms explained in Table 27).

Sample size: B=7, P=10, W=10.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		1	2	9	1	7	23	1	6	14	4	2	2
Collembola			2			3			3			2	
Dermaptera	Forficulidae	6	6	1	18	19	2	29	20	3	4	4	5
Hemiptera	Miridae	1			1			1			3		
	Pentatomidae			5			13			11			2
	Unid.		1			1			1			3	
Neuroptera	Chrysopidae			2			4			7			3
Coleoptera	Carabidae			1			1			5			9
	Staphylinidae			1			1			3			2
	Elateridae		5			12			9			3	
	Larvae	1	9	1	1	26	1	1	17	4	5	3	2
	Buprestidae	1	5		5	13		3	9		4	4	
	Chrysomelidae	3	4	2	6	5	4	13	5	8	4	4	4
	Curculionidae	6	5	8	15	21	19	31	17	13	3	3	3
	Scolytidae	1	4	5	2	4	15	1	4	7	4	2	2
	Unid. Larvae			1			3			2			4
Lepidoptera	Phalaenidae	2	1		9	1		15	1		3	2	
Diptera	Psychodidae			1			2			3			3
	Unid.		2			2			2			2	
Hymenoptera	Formicidae	2	2		3	4		5	4		3	3	
	Unid.			1			1			3			2
Unid. Insect			1			1			1			1	
Plant													
	Cyperaceae			10			278			17			2
Unid. Plant			1			1			1			1	

Table 29. Diet of Brown Creeper from oak stands.
(Terms explained in Table 27)

Sample size: B=5, P=8, W=6.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		1	2	6	1	2	16	1	2	28	2	2	2
Thysanura			2			2			2			2	
Dermaptera	Forficulidae	1	8		2	20		2	33		3	4	
Neuroptera	Chrysopidae			2			4			9			4
Coleoptera	Elateridae(L)[a]	5	2		11	2		36	5		3	3	
	Curculionidae	1	4	2	2	8	4	1	10	8	4	3	4
	Scolytidae	5	8	6	47	26	24	44	45	43	3	3	2
	Unid. Larvae	1			2			2			3		
Lepidoptera	Phalaenidae		2			2			2			2	
	(Frenatae)	1			1			15			3		
Diptera	Psychodidae			2			2			4			3
	Culicidae			2			4			5			3
Hymenoptera				2			4			3			2
Plant													
	Leguminosae	1			2			1			3		

[a]Larvae

Table 30. Diet of Rufous-sided Towhees from oak stands.
(Terms explained in Table 27)

Sample size: B=5, P=8, W=6.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
						Period							
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Gastropoda)			2	6		2	14		5	20		3	3
(Araneida)		1			1			2			3		
Orthoptera	Acrididae		2			2			4			2	
Dermaptera	Forficulidae	2	2		6	2		5	2		5	5	
Hemiptera	Miridae	1			2			4			3		
Coleoptera	Carabidae	5	8	6	11	12	18	26	23	33	6	5	5
	Chrysomelidae	2	6	6	4	20	12	5	17	21	4	4	4
	Curculionidae	3		2	6		4	15		4	4		4
Lepidoptera	Phalaenidae	1			3			7			4		
	Unid. Larvae	2			3			6			3		
Diptera	Tachinidae			2			6			3			3
Hymenoptera	Formicidae	1			1			3			3		
	Unid.	1			1			2			3		
Plants													
	Gramineae	3	6		40	93		14	8		1	1	
	Cyperaceae			6			90			13			1
	Portulacaceae	7			28			5			1		
	Ranunculaceae	1	1		15	59		3	7		1	1	
	Rosaceae		2	4		16	24		4	4		1	3
	Compositae		8			99			26			2	
Unid. Seeds		2	2	4	5	24	24	3	4	2	1	1	2

Table 31. Diet of Oregon Juncos found in oak stands.
(Terms explained in Table 27)

Sample size: B=6, P=8, W=5.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)				3			5			12			2
Dermaptera			4			9			10			3	
Hemiptera	Miridae		2			2			7			3	
Coleoptera	Carabidae			1			1			3			4
	Elateridae		2			4			5			4	
	Chrysomelidae		6	4		10	5		11	24		4	3
	Curculionidae	3			36			23			3		
	Unid.	3			24			7			2		
Lepidoptera	Pselaphidae	3			12			5			3		
	Unid.	3			6			10			3		
Diptera	Psychodidae			1			1			4			2
	Culicidae			2			2			5			2
	Tachinidae			2			2			6			3
Hymenoptera	Formicidae		2			6			4			3	
Plants													
	Gramineae	6	4	5	72	24	61	45	10	7	5	1	1
	Cyperaceae			6			146			24			3
	Ranunculaceae		2			2			2			1	
	Rosaceae	3			87			10			2		
	Leguminosae		4	2		70	49		17	5		3	1
	Compositae		4			99			25			1	
Unid. Plant				2			2			2			3
Unid. Seeds			2	2		2	26		9	8		1	2

Table 32. Diet of Chestnut-backed Chickadees from conifer stands. (Terms explained in Table 27)

Sample size: B=8, P=9, W=12.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	3	8	2	5	19	3	9	12	2	2	1
Dermaptera	Labiidae		3			9			8			4	
Hemiptera	Miridae		4			8			13			3	
	Pentatomidae			2			4			4			1
	Unid.	4			4			5			2		
Homoptera	Membracidae			1			2			3			1
	Aphididae		2			99			5			1	
	Unid.	1			1			1			2		
Coleoptera	Elateridae	1			1			2			3		
	Larvae	3	2		5	2		8	6		3	3	
	Buprestidae	1			1			2			3		
	Coccinellidae			1			3			6			1
	Chrysomelidae	3	4	6	5	8	17	11	12	11	3	3	2
	Curculionidae	4	6	11	10	13	36	16	21	17	4	4	2
	Scolytidae		4	2		11	6		8	7		3	2
	Unid.	2			2			2			3		
	Unid, Larvae		1	1		1	1		1	3		3	1
Lepidoptera	Arctiidae			1			1			3			2
	Phalaenidae	5			8			19			3		
	Geometridae	5			12			22			4		
	Unid. Larvae		3	1		3	1		8	3		2	1
Diptera	Tachinidae			2			4			4			2
Hymenoptera	Formicidae			5			13			6			1
	Unid.			1			1			2			1
	Unid. Larvae		2			6			4			2	
Unid. Insect		2	1		2	2		5	2		2	2	
Plants													
	Gramineae	1	1		1	1		2	1		1	2	
	Cyperaceae			1			29			2			1
	Ranunculaceae	1			1			1			1		
	Rosaceae			3			15			12			1
Unid. Plant				1			29			4			1
Unid. Seeds		1	1	1	1	1	1	1	1	1	3	2	2

Table 33. Diet of Red-breasted Nuthatches from conifer stands. (Terms explained in Table 27)

Sample size: B=10, P=8, W=8.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	1	4	2	1	4	5	2	6	2	3	3
Isoptera		1			1			2			3		
Dermaptera	Labiidae		2			3			7			4	
	Forficulidae	1	2		2	16		2	12			5	5
Hemiptera	Miridae		3			5			13			3	
	Pentatomidae			4			6			4			4
	Unid.	2			2			3			2		
Homoptera		3			4			5			3		
Coleoptera	Elateridae	1			1			2			2		
	Buprestidae	1	1		12	2		4	5		4	3	
	Coccinellidae			7			10			10			5
	Scarabaeidae			1			5			3			5
	Chrysomelidae	10	3	7	21	5	18	24	11	33	4	3	5
	Curculionidae	10	3	8	27	5	20	41	17	21	4	4	5
	Scolytidae		1	4		6	14		3	8		3	4
	Unid.	1			2			1			3		
Lepidoptera	Phalaenidae	3	1		6	1		6	4		3	3	
Diptera	Culicidae			4			5			5			3
	Unid.			1			1			1			2
Hymenoptera	Psammocharidae		1			2			4			3	
	Formicidae	1	4	2	2	18	7	3	22	3	2	2	2
Unid. Insect		2			2			2			2		
Plant													
	Cyperaceae			3			15			6			2

Table 34. Diet of Brown Creepers from conifer stands. (Terms explained in Table 27)

Sample size: B=6, P=5, W=5.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	3	5	2	4	14	3	17	21	3	2	2
Plecoptera				1			1			3			2
Dermaptera	Forficulidae		2			2			9			4	
Hemiptera	Miridae	2			4			7			3		
	Pentatomidae			1			2			5			4
Coleoptera	Elateridae		1			4			4			3	
	Cantharidae	2		1	2		6	3		4	3		2
	Coccinellidae			2			3			5			4
	Chrysomelidae		1			6			4			3	
	Curculionidae		3	2		5	2		14	3		4	3
	Scolytidae	6	5	5	56	11	27	35	44	32	3	3	3
	Unid. Larvae	2			4			7			3		
Lepidoptera	Pyralidae			1			1			2			3
	Phalaenidae	4			6			20			3		
	Unid.	2		1	2		2	3		3	2		2
Hymenoptera	Ichneumonidae			2			5			8			4
	Formicidae	4	1	2	2	4	4	15	6	8	2	4	2
	Apidae			1			1			3			1
	Unid.		1	1		1	1		2	3		3	2
Plant													
Unid.		6			6			7			2		

Table 35. Diet of Rufous-sided Towhees from conifer stands. (Terms explained in Table 27)

Sample size: B=10, P=5, W=5.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	5		2	5		3	9		3	4	
Hemiptera	Miridae	2			2			2			4		
Coleoptera	Carabidae	6	5	4	12	5	10	16	5	18	5	5	6
	Dermestidae	2			20			3			2		
	Chrysomelidae	6	4		18	10		13	12		3	4	
	Curculionidae	8		5	22		20	21		24	4		7
Diptera	Tachinidae			5			10			11			3
	Unid.	2			2			2			4		
Hymenoptera	Formicidae	2	4		2	15		2	14		2	5	
Plant													
	Gramineae		3			99			39			4	
	Cyperaceae			4			98			24			2
	Portulacaceae	2	5		2	72		4	21		1	1	
	Ranunculaceae	2			4			2			1		
	Rosaceae	8		5	28		89	26		23	2		2
	Leguminosae	2			2			4			2		
Unid. Plant		2			2			2			1		

Table 36. Diet of Oregon Juncos from conifer stands.
(Terms explained in Table 27)

Sample size: B=8, P=10, W=10.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)			2			2			2			3	
Orthoptera	Acrididae		4			2			10			4	
Hemiptera	Miridae	3	4		3	4		9	5		3	3	
Homoptera		1			1			1			2		
Coleoptera	Carabidae			2			2			10			4
	Elateridae	1			1			3			2		
	Chrysomelidae	5	6	2	15	10	4	34	10	9	4	3	3
	Curculionidae			2			2			6			4
Lepidoptera	Unid. Larvae	1		2	1		2	3		6	2		4
Diptera	Cuicidae			2			2			5			2
	Trypetidae	1			1			3			4		
	Unid.	1			1			1			3		
Hymenoptera	Formicidae	1	2		2	6		6	5		2	2	
Plant													
	Pinaceae	1	4	10	3	30	99	3	7	26	2	3	1
	Gramineae		8			98			29			3	
	Cyperaceae			6			59			18			2
	Portulacaceae	3	4		28	28		7	10		1	1	
	Rosaceae	1	4	6	5	30	20	6	16	7	1	2	1
	Leguminosae		4			8			4			3	
	Compositae	1			4			10			2		
Unid. Plant		4		6	8		6	14		3	2		2
Unid. Seeds			1	4		2	37		2	10		1	1

the diversity of the diet was calculated for each season (Table 37). The diversity of Black-capped Chickadee food was high during the breeding and post-breeding seasons; however, it dropped during the winter with H being only 20 percent of HMAX. Concentration on spiders and plant seeds largely accounted for this shift.

Chestnut-backed Chickadees had a high diversity of food items during the breeding season which dropped to 60 to 65 percent of HMAX during the post-breeding and winter seasons. Like the Black-capped Chickadees, they took more plant food during the winter (Table 32).

White-breasted Nuthatches ate a large number of Curculionidae throughout the year. In the breeding and post-breeding seasons, Dermaptera made up a large proportion of their diet. While these birds spent a good part of their time foraging on the trunks and branches of the oaks, the Scolytidae, which are found in large numbers in these areas, did not constitute a significant proportion of their diets. Since Scolitidae are small and are found under the bark, the large bill of the nuthatch may not be suited to extracting the beetles. Diversity of the White-breasted Nuthatch's diet dropped from its highest in the breeding and post-breeding seasons to only about 50 percent of HMAX during the winter, due to concentration on spiders and some seeds.

The food of the Red-breasted Nuthatch reflected its foraging pattern in the foliage of the fir. A large proportion of the diet consisted of Chrysomelidae, Curculionidae and Hymenoptera. Diversity of the Red-breasted Nuthatch's diet remained high throughout the

Table 37. Diet species diversity.

Species	Breeding		Post-breeding		Winter	
	H	H/HMAX	H	H/HMAX	H	H/HMAX
OAK						
Black-capped Chickadee	2.317	0.878	1.850	0.841	0.495	0.206
White-breasted Nuthatch	1.883	0.818	2.175	0.848	1.308	0.523
Brown Creeper	1.027	0.528	1.413	0.679	1.644	0.845
Rufous-sided Towhee	2.093	0.793	1.608	0.698	1.650	0.794
Oregon Junco	1.465	0.818	1.549	0.673	1.518	0.611
CONIFERS						
Chestnut-backed Chickadee	2.328	0.882	1.721	0.652	1.978	0.684
Red-breasted Nuthatch	2.091	0.815	2.003	0.835	2.211	0.922
Brown Creeper	1.405	0.639	0.102	0.491	1.887	0.735
Rufous-sided Towhee	1.879	0.756	0.917	0.570	0.984	0.612
Oregon Junco	1.727	0.720	1.390	0.632	1.605	0.579
PINE						
Pigmy Nuthatch	1.126	0.620	1.744	0.794	2.112	0.762
White-breasted Nuthatch	2.106	0.848	1.324	0.739	2.211	0.802
Red-breasted Nuthatch	1.363	0.760	1.847	0.888	1.978	0.796

Note: in the printed table the column heading "Period" spans the Breeding, Post-breeding and Winter columns.

year (Table 37).

The Brown Creeper's diet reflected its trunk-foraging activity pattern (Figures 10 and 15). Large numbers of Scolytidae and Elateridae were eaten during the breeding season. A shift to Dermaptera in the post breeding season and Araneida in the winter was found in the oaks (Table 29). In the fir, Scolytidae were also important; however, Elateridae were not an important part of the creeper's diet. The remainder of their diet in the firs was seasonally more evenly distributed among other insect groups (Table 34). Food diversity of creepers found in all study areas was higher in the winter than in the breeding and post breeding seasons (Table 37). As the creepers tended to move away from the trunks in the winter, the food supply must not have been sufficient.

Rufous-sided Towhees spent a large part of their time on the ground. Seeds were an important component of their diet in all seasons (Tables 30 and 35). Carabidae beetles also constituted a major part of the diet. The dietary diversity did not change significantly during the year (Table 37).

Oregon Juncos also spent part of their time foraging on the ground; however, most of their food was gleaned from shrubs and trees. Juncos appeared to move more and take a wider variety of the available food than did other species (Tables 31 and 36). They appeared to forage in one area for a while and then move to another. Junco food diversity remained relatively high in the oaks, but declined slightly in the firs from the breeding to the winter seasons (Table 37).

In order to assess the competition potential among these species, I measured five morphological characteristics which could possibly play a role in habitat utilization (Tables 38, 39 and 40). Similarity in bill structure, wing length, or tarsus length could indicate a similarity in ability to obtain food when compared to habitat utilization, food eaten and food size.

Chestnut-backed and Black-capped Chickadees seemed to prefer conifers and deciduous forests respectively. When their morphological structures were compared, the bill characteristics were similar, but mean wing and tarsus lengths were significantly different. These differences may be adaptations to differences in the structure and density of the vegetation in which the species usually forage.

Comparing the primary components of most birds' diet, I found that Chrysomelidae and Curculionidae (Figure 18) formed a greater proportion of the diet of the Chestnut-backed Chickadee than of the Black-capped Chickadee; however, the Chestnut-backed Chickadee selected slightly larger beetles during the breeding and post breeding seasons.

Several studies of the Black-capped and Chestnut-backed Chickadees have indicated marked differences in habitat preferences. The deciduous preferences of the Black-capped Chickadees are well known; however, Smith (1967) found both species living side by side in mixed vegetation on Vancouver Island, British Columbia, and foraging in mixed flocks. Sturman (1968a) showed that the breeding habitats did not overlap in the lowlands of western Washington, but during winter mixed species foraging flocks were common. In such

Table 38. Morphological measurements of birds found in oak stands.

	N	Mean(mm)	S.D.	S.E.
		Black-capped Chickadee		
Bill length	14	9.04	0.40	0.11
Bill width	14	4.37	0.50	0.13
Bill depth	14	4.17	0.48	0.12
Wing length	14	63.80	2.86	0.72
Tarsus length	14	15.70	0.63	0.22
		White-breasted Nuthatch		
Bill length	23	17.42	0.80	0.17
Bill width	23	4.83	0.60	0.13
Bill depth	23	4.12	0.45	0.90
Wing length	23	85.71	2.32	0.48
Tarsus length	22	17.49	0.47	0.10
		Brown Creeper		
Bill length	10	14.95	1.80	0.57
Bill width	10	2.80	0.46	0.14
Bill depth	10	2.70	0.41	0.13
Wing length	9	62.46	3.22	1.07
Tarsus length	10	14.16	0.76	0.24
		Rufous-sided Towhee		
Bill length	11	14.58	0.68	0.21
Bill width	11	7.62	0.76	0.23
Bill depth	11	9.28	0.55	0.17
Wing length	11	86.60	2.84	0.86
Tarsus length	11	25.15	3.24	0.98
		Oregon Junco		
Bill length	11	10.71	0.72	0.22
Bill width	11	5.77	0.51	0.16
Bill depth	11	5.60	0.49	0.15
Wing length	11	72.41	1.70	0.51
Tarsus length	11	19.53	0.41	0.12

Table 39. Morphological measurements of birds found in coniferous stands.

	N	Mean(mm)	S.D.	S.E.
		Chestnut-backed Chickadee		
Bill length	22	8.67	0.59	0.13
Bill width	22	4.15	0.53	0.11
Bill depth	22	3.86	0.45	0.10
Wing length	22	61.62	1.75	0.37
Tarsus length	20	14.74	0.97	0.22
		Red-breasted Nuthatch		
Bill length	23	13.20	0.60	0.12
Bill width	23	4.08	0.48	0.10
Bill depth	23	3.46	0.43	0.09
Wing length	23	66.57	2.59	0.54
Tarsus length	10	14.47	1.20	0.25
		Brown Creeper		
Bill length	10	16.46	1.81	0.57
Bill width	10	3.00	0.55	0.17
Bill depth	10	3.02	0.55	0.17
Wing length	10	64.41	2.17	0.69
Tarsus length	10	14.01	0.79	0.25
		Rufous-sided Towhee		
Bill length	7	14.04	0.80	0.30
Bill width	7	8.44	0.80	0.30
Bill depth	7	9.21	0.33	0.13
Wing length	7	84.93	2.11	0.80
Tarsus length	7	23.61	3.89	1.47
		Oregon Junco		
Bill length	15	10.80	0.58	0.15
Bill width	15	5.63	0.34	0.16
Bill depth	15	6.19	0.50	0.09
Wing length	15	73.35	2.06	0.13
Tarsus length	15	18.74	0.69	0.18

Table 40. Morphological measurements of birds found in pine stand.

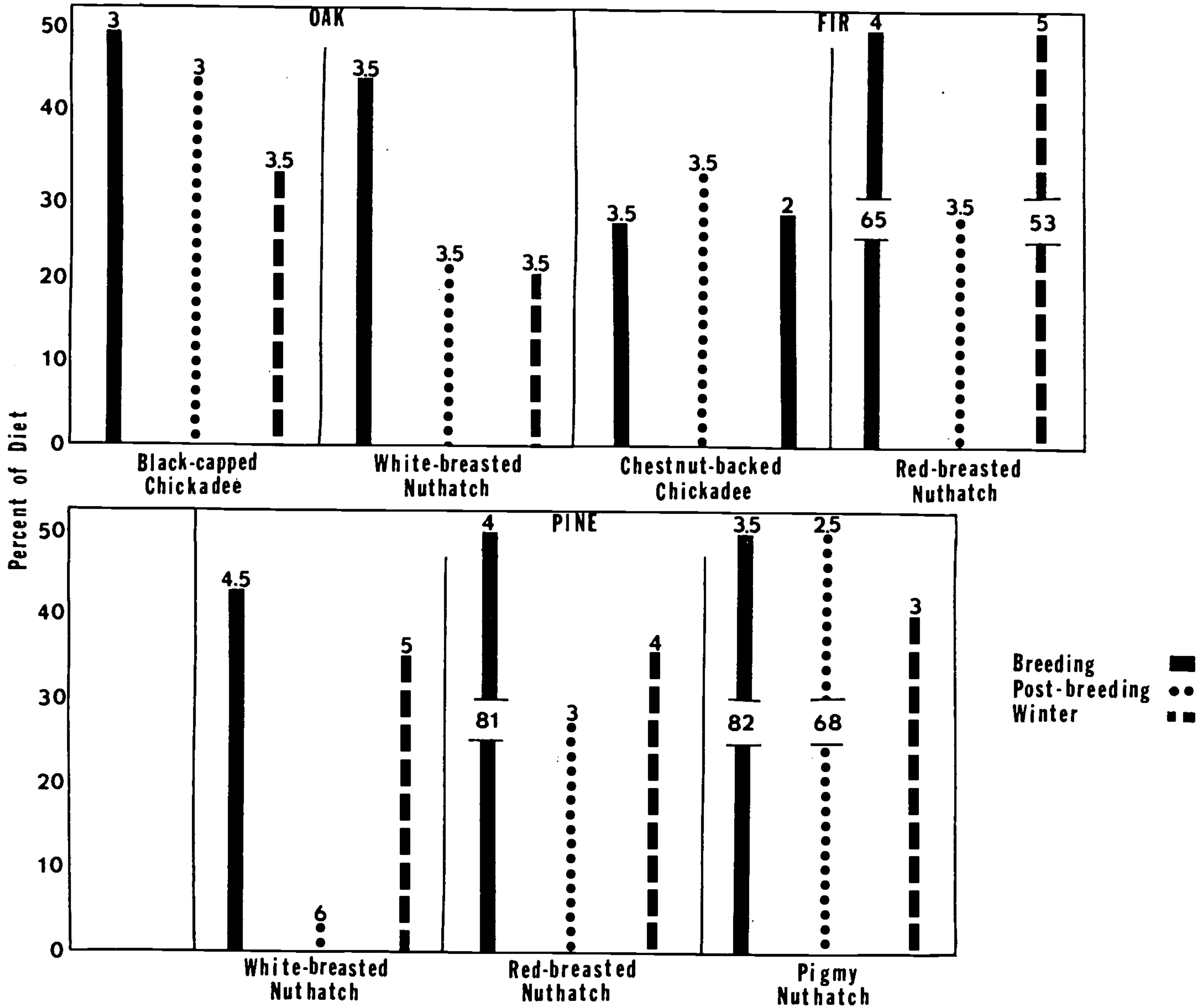
	N	Mean(mm)	S.D.	S.E.
		White-breasted Nuthatch		
Bill length	23	18.51	0.66	0.14
Bill width	23	4.36	0.58	0.12
Bill depth	23	3.59	0.47	0.10
Wing length	22	85.96	3.34	0.71
Tarsus length	22	17.42	0.79	0.17
		Red-breasted Nuthatch		
Bill length	20	12.91	1.18	0.26
Bill width	20	3.69	0.37	0.08
Bill depth	20	3.18	0.29	0.06
Wing length	20	67.98	2.37	0.53
Tarsus length	18	15.49	0.87	0.20
		Pygmy Nuthatch		
Bill length	23	13.31	0.93	0.19
Bill width	23	3.57	0.57	0.12
Bill depth	23	3.36	0.42	0.09
Wing length	22	63.01	2.44	0.52
Tarsus length	23	14.18	0.90	0.19

Table 41. Morphological comparisons of bird species.

	t-value	D.F.	P level		t-value	D.F.	P level
	(OAK-FIR) B.C. Chickadee-C.B. Chickadee				(PINE-PINE) W.B. Nuthatch-R.B. Nuthatch		
1[a]	-2.2648	34	0.05	1	-18.8117	41	0.01
2	-1.2468	34	0.3	2	-4.6758	41	0.01
3	-1.9908	34	0.05	3	3.5827	41	0.01
4	-2.6939	34	0.01	4	-20.2975	40	0.01
5	-2.2866	32	0.01	5	-7.2922	38	0.01
	W.B. Nuthatch-R.B. Nuthatch				W.B. Nuthatch-P. Nuthatch		
1	-20.3103	44	0.01	1	-21.8295	44	0.01
2	-4.7069	44	0.01	2	-4.7263	44	0.01
3	-5.1658	44	0.01	3	-1.7662	44	0.01
4	-26.4024	44	0.01	4	-26.0342	42	0.01
5	-11.2186	43	0.01	5	12.8079	43	0.01
	B. Creeper-B. Creeper				(OAK-PINE) W.B. Nuthatch-W.B. Nuthatch		
1	-1.8734	18	0.1	1	5.0414	44	0.01
2	-0.7965	18	0.5	2	-2.6753	44	0.01
3	-1.4785	18	0.2	3	-3.9526	44	0.01
4	-0.7488	18	0.5	4	0.2967	43	0.8
5	0.4348	18	0.7	5	-0.3251	42	0.01
	R.S. Towhee-R.S. Towhee				(FIR-PINE) R.B. Nuthatch-R.B. Nuthatch		
1	1.4698	16	0.2	1	-0.9643	41	0.4
2	-2.1792	16	0.05	2	-3.0029	41	0.01
3	0.3237	16	0.8	3	-2.5703	41	0.01
4	1.4289	16	0.2	4	1.8437	41	0.1
5	0.8742	16	0.4	5	3.1456	39	0.01
	O. Junco-O. Junco				(FIR-FIR) C.B. Chickadee-R.B. Nuthatch		
1	-0.3711	24	0.7	1	-15.5768	43	0.01
2	0.7786	24	0.4	2	0.5067	43	0.7
3	-2.9800	24	0.01	3	3.0742	43	0.01
4	-1.2693	24	0.3	4	0.8062	41	0.5
5	3.5141	24	0.01	5	-7.5358	43	0.01

[a]1=Bill length, 2=Bill width, 3=Bill depth, 4=Wing length
5=Tarsus length

Figure 18. Percentage of total diet represented by Curculionidae and Chrysomelidae. Number above bar indicates average beetle length in mm.


Percent of Diet
OAK
FIR
PINE
Black-capped Chickadee
White-breasted Nuthatch
Chestnut-backed Chickadee
Red-breasted Nuthatch
White-breasted Nuthatch
Red-breasted Nuthatch
Pigmy Nuthatch
Breeding
Post-breeding
Winter
0
10
20
30
40
50
3
3
3.5
3.5
3.5
3.5
3.5
3.5
2
4
65
3.5
5
53
4.5
6
5
4
81
3
4
3.5
82
2.5
68
3

mixed flocks, Chestnut-backed Chickadees foraged near the ends of the branches more often than did Black capped Chickadees. In my study, mixed flocks were not often found, although they did occur infrequently.

White-breasted Nuthatches inhabiting oak stands ate Curculionidae as the major portion of their diets during all seasons. These Curculionidae were larger than those selected by the Black-capped Chickadee.

The Red-breasted Nuthatch in coniferous stands took a larger number of Curculionidae than did the White-breasted Nuthatch in the oaks. When a comparison of the Chrysomelidae and Curculionidae is made (Figure 18), it is apparent that a very large proportion of the Red-breasted Nuthatch food consists of these beetles. This is a much larger proportion than in the Chestnut-backed Chickadee. The size of the beetles selected by the Red-breasted Nuthatch was also generally larger than the beetles selected by the chickadees.

In the Willamette Valley habitat separation between the Red-breasted and White-breasted Nuthatches was quite marked. Differences in foraging areas and food sizes (Figures 9 and 14; Tables 28 and 33) suggested that competition did not occur between the two species. Morphological features of the two species were significantly different (Table 41).

To further examine habitat relationships of the nuthatches, dietary samples were collected in a ponderosa pine habitat where the two species occurred sympatrically with the Pigmy Nuthatch. Table 39 shows that White-breasted and Red-breasted Nuthatches of the pine and those of the valley habitats differ significantly in a number of morphological features; thus, the sympatric relation of these three species in the pine may have caused divergence in body parts. Significant differences were found between White-breasted and Pigmy Nuthatches, and between Red-breasted and White-breasted Nuthatches but not between the Pigmy and Red-breasted Nuthatches in the pine habitat.

Examining the food of the three nuthatches in the pine (Tables 42 to 44) illustrates differences in size distribution of food items taken by these birds. White-breasted Nuthatches take the largest items, followed by the Red-breasted and then the Pigmy Nuthatches. Further, a difference in the preference for Chrysomelidae and Curculionidae was seen (Figure 18). They constituted a high proportion of the Pigmy Nuthatch's diet during all seasons and a very high proportion of the Red-breasted Nuthatch's diet only during the breeding season. The size differential can be seen in comparing the insects taken from these two families. The difference in food procured during the breeding season in the Red-breasted and Pigmy Nuthatches was small. There was probably an abundance of food during this period so that the birds were not restricted in their choice. Competition would more likely occur during the winter when a larger area must be covered to obtain the necessary food (see Hartley, 1953; Stallcup, 1968). Pigmy Nuthatches do move to the bark occasionally, as Psocoptera and Scolytidae were found in their stomaches. White-breasted Nuthatches were most commonly observed on the trunk and large branches of the pine trees. Gizzard contents consisted mainly

Table 42. Diet of White-breasted Nuthatches from pine stands. (Terms explained in Table 27)

Sample size: B=10, P=10, W=10.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		1		3	1		5	2		4	3		1
Psocoptera				1			16			12			2
Dermaptera		7			15			17			4		
Hemiptera	Pentatomidae			9			23			17			3
	Unid.	2			1			1			4		
Neuroptera	Raphidiidae			2			2			4			3
Coleoptera	Cantharidae			1			1			2			2
	Lathridiidae			1			2			3			3
	Elateridae	2	4		9	5		4	10		3	6	
	Scarabaeidae	1			2			3			3		
	Buprestidae	1	9		2	28		3	48		3	4	
	Chrysomelidae	7	1	7	19	4	14	22	3	16	5	6	5
	Curculionidae	2		9	18		18	21		19	4		5
	Scolytidae	3		3	12		8	7		3	3		5
Trichoptera		2		1	5		1	8		2	6		4
Lepidoptera			1			1			2			5	
Hymenoptera	Formicidae	2	8		3	29		11	36		3	3	
	Unid.			1			1			2			4
Plant													
	Gramineae			1			1			2			1
	Cyperaceae			1			10			8			2
Unid. Plant		1	1	1	1	5	1	1	1	6	2	3	1

Table 43. Diet of Red-breasted Nuthatches from pine stands. (Terms explained in Table 27)

Sample size: B=11, P=10, W=12.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)				6			12			8			5
Orthoptera				2			2			4			3
Plecoptera			2			2			5			4	
Hemiptera	Anthocoridae			2			4			4			2
	Pentatomidae			10			34			12			2
Coleoptera	Carabidae		2			12			5			4	
	Cantharidae			2			4			4			3
	Elateridae	3	6		6	6		6	16		3	4	
	Buprestidae		4			4			9			4	
	Scarabaeidae	1	4		2	8		2	18		3	4	
	Chrysomelidae	9	4	8	17	8	50	34	13	19	4	3	4
	Curculionidae	8	4	10	26	8	40	47	14	17	4	3	4
	Scolytidae	3	2	8	5	12	20	7	6	12	4	3	4
Lepidoptera				2			2			4			4
Diptera				4			6			6			3
Hymenoptera	Formicidae	1	4	1	2	20	2	4	12	4	3	3	3
Plant													
	Compositae		2			20			2			1	
Unid. Plant				4			6			6			3

Table 44. Diet of Pigmy Nuthatches from pine stands.
(Terms explained in Table 27)

Sample size: B=12, P=11, W=12.

Order	Family	Frequency			Total Number			% Total Volume			Mean Length		
		Period											
		B	P	W	B	P	W	B	P	W	B	P	W
Animal													
(Araneida)		2	4	3	4	6	6	7	9	7	3	2	3
Psocoptera				1			1			3			2
Hemiptera	Pentatomidae			5			12			11			3
	Unid.		1			1			2			2	
Neuroptera	Chrysopidae			1			1			4			4
Coleoptera	Staphylinidae			1			1			3			3
	Elateridae		3	1		8	1		8	4		2	6
	Buprestidae	1		1	2		2	3		4	3		4
	Chrysomelidae	8	11	5	36	29	13	37	59	13	3	3	3
	Curculionidae	12	4	11	42	6	27	45	9	27	4	2	3
	Scolytidae		1	3		4	4		3	7		2	4
	Unid. Larvae	1	1		2	2		3	2		3	3	
Lepidoptera	Phalaenidae			1			1			3			4
Diptera	Syrphidae			1			4			4			4
	Unid.		1			1			2			3	
Hymenoptera	Icheumonidae			1			1			3			3
	Formicidae	2	2	3	4	4	7	5	5	3	3	2	2
Plant													
Unid.			1	2		1	3		1	4		2	4

of Formicidae, Scolytidae and Curculionidae. A number of Pentatomidae were found in the stomachs during the winter. These insects overwinter under the bark in aggregations (L. Russel, personal communication).

DISCUSSION

The gradient of vegetation analyzed for avifaunal composition in western Oregon includes three seres of plant community succession (Franklin and Dryness, 1969). Succession has been defined by Margalef (1968) as "...the occupancy of area by organisms involved in an incessant process of action and reaction which in time results in changes in both the environment and community." He further stated that during succession there is a trend toward increase in biomass, stratification, complexity, and diversity. Odum (1969) listed four types of diversity which could be observed during succession: species variety, expressed as a species number ratio; equitability, the apportionment of individuals among species; stratification; and biochemical diversity, the increase in diversity of organic compounds such as variety of plant pigments. Each of these components of diversity tends to go from low to high in the successional sequence and theoretically reaches a stable state in the mature or climax stage. In this study, the measure of equitability species diversity was of primary concern.

If we assume that species diversity of the avifauna follows the general trend of species diversity in succession, we should expect the bird species diversity of the study areas to increase in accordance with their successional status. Thus, the fir stands should have a higher diversity than the oak and the hemlock a higher diversity than the fir. Rather, a definite drop in diversity occurred between the oak and fir while only a small rise was noted between the fir and hemlock.

Johnston and Odum (1956) studied the bird populations along a successional gradient in the Piedmont of Georgia and found a biomodal pattern of species abundance; the number of species increased during the early stages of old field succession, declined during early forest stages, and then increased again in the mature forests. Odum (1969) suggested that during succession, an increase in potential niches results from increased biomass, stratification and other consequences of biological organization exceeding the counter-effect of increased size and competition of the organisms. While one would assume that diversity should increase for all species of organisms living in an area, this does not necessarily follow. Essentially the assumption is made that as communities become more complex, it becomes possible for animals to subdivide the area into finer and finer parts, thus reducing the size of the niches. In terms of behavior, the animal has become more stereotyped (Klopfer, 1962). When the niche size is reduced, the range of objects in the environment to which the animal responds by feeding, reproducing, seeking shelter, etc. is reduced. As the oak-fir sequence did not follow the expected trend in diversity in relation to avifauna, several factors must be considered. First, it was possible that a measure of diversity of all organisms of the communities, not just the birds, would have presented the expected increase in diversity with each step in succession. Also, it would be important to measure the total biomass in the vegetative types to see if any change occurred there.

Second, in examining the three stages in succession, some marked differences in vegetation structure were apparent. The oaks had a much denser understory than undisturbed fir and hemlock communities. This might mean that a larger number of species could be accommodated in the more diverse vegetation.

Finally, the mobility of avian population should be considered when calculating diversity. Patchiness in the vegetation may in itself have accounted for part of the irregular distribution of the avian populations; however, each species of bird had a different ability to move through an area. This movement was influenced by features unique to each species.

When comparison is made with the bird species diversity values obtained in other studies, the results for this study are higher than those reported by MacArthur and MacArthur (1961) for eastern deciduous forests, and also exceed those from Puerto Rico and all but the mature and young tropical forests in Panama (MacArthur, Recher, and Cody, 1966). Karr (1968) compared the species diversity in an east-central Illinois strip-mined area during the breeding season and found results in bottom land forests similar to this study. He suggested that the size of the area censused as well as the patchiness in vegetation and patchiness of bird distributions may influence the bird species diversity.

Total populations in the study areas in western Oregon were somewhat higher than the avian populations found in eastern forest communities. Johnston and Odum (1956) found 474 individual birds per 100 acres in southern pine and 448 birds per 100 acres of oak-hickory woods. Twomey (1945) reported 406 birds in an elm-maple forest during breeding season. Kendeigh (1944) found a range of 390 to 570 breeding birds per 100 acres in eight deciduous forests of the eastern United States. Bond (1957) recorded 310 to 386 individuals per 100 acres in the upland forests of southern Wisconsin. The range of 154 to 1112 in my study may have been partly the result of the large number of permanent residents in the Oregon forests. During the breeding season in Oregon, the numbers of individuals in the study areas ranged from 464 to 1112. The upper portion of this range exceeded the totals found in eastern forests.

MacArthur (1959) indicated that a very high percent (70-90) of eastern forest species were migratory whereas only 20 to 30 percent of the Oregon forest species were neotropic migrants. My results indicated that 30-55 percent of the birds were summer residents. Oak stands had fewer summer residents (about 35 percent) while the fir and hemlock stands had 50 to 55 percent. Not all summer residents, however, were neotropic migrants. This was particularly true in the conifers where many nomadic birds settled to breed. In the oaks, the greater proportion of the summer residents were neotropic migrants, the Brown-headed Cowbird being one exception. The fact that in the west a lower proportion of the breeding avifauna of an area migrates than in the east may have partially accounted for the relatively high numbers of birds found in the western Oregon forests when compared with eastern studies. The mild winters in the Willamette Valley undoubtedly allowed many bird species to find food during the winter period.

In western Oregon forests, with their rather stable environment and mild winters, a high proportion of the birds are permanent residents. Many of these permanent residents range over a wide area in the forests. The forests themselves are distinct, in that communities of upper story vegetation are separated from each other by narrow ecotones, which contrasts to the many eastern forest communities which share broad ecotones (Kendeigh, 1948). Much of the forest area in Oregon has been disturbed by man through logging and livestock grazing. Natural events such as windfall have disturbed other areas. Thus, there are "gap phases" within the forested areas. In this study, avian community structure did not conform to the plant community outline. There were some birds that might be classified with a deciduous or coniferous community (e.g., Black-capped Chickadee and White-breasted Nuthatch in the former and Chestnut-backed Chickadee and Red-breasted Nuthatch in the latter). Still, most birds did not confine themselves to either type of plant community, as was shown by juncos, creepers and towhees. During the non-breeding seasons, particularly, birds seemed less subjected to the confines of a particular plant community. All of the winter residents in the oaks were found as permanent residents in the conifers. Habitat utilization data indicated that even though a bird remains in a particular form of vegetation (coniferous or deciduous) all year, it may utilize a larger portion of the habitat during the winter (Figures 8, 9, 13 and 14).

Generally most of the western Oregon bird species were opportunistic in their choice of food. In most cases the comparison of dietary H and HMAX showed that H was at least 90 percent of HMAX. The Brown Creeper appeared the most specialized in its selection, particularly in the breeding and post-breeding periods. The Chestnut-backed Chickadee increased its dietary specialization in the winter while the Black-capped Chickadee showed an even more extreme tendency toward winter specialization. This may have contributed to the habitat division seen in the two species. The White-breasted Nuthatch also became more specialized in its diet in the winter, and was not observed in the conifers, while the Red-breasted Nuthatch became more generalized during the winter season and had a broader ecological distribution, occurring commonly in mixed foraging flocks in the oaks as well as the conifers. Both the Red-breasted and the White-breasted Nuthatches were generalized in their diet habits throughout the year in the ponderosa pine where they co-occurred with the Pigmy Nuthatch. The Pigmy Nuthatch, on the other hand, appeared specialized all year. In order to survive sympatrically with the Red-breasted Nuthatch in the pines, the White-breasted Nuthatch took a variety of food, while in the oaks it became more specialized in the winter.

All bird species have physiological and behavioral tolerances which allow them to utilize different niches within the vegetation. Perhaps a better approach to avian population studies could come from Levins (1968). He uses the expressions fine and coarse-grained environment. Using these expressions in a restricted sense, birds which remained in one vegetative type would be coarse-grained species. This group would include the chickadees and nuthatches. On the other hand, birds which moved through more than one vegetation type might be considered fine-grained species. Creepers, towhees and juncos would fall into this group, as would the general ecological category of ground predators.

The shift in the ecological roles of bird species was most apparent in this study when the deciduous and coniferous study areas were compared. The proportion of ground feeders declined in the conifers, but the number of timber searchers increased. Both the foliage and ground-seed eaters decreased with the increase in importance of fir-hemlock. Comparable results were obtained by Salt (1953) when a comparison of three California avifaunas was made in essentially deciduous-coniferous areas.

When the role of the selected species was examined, no change was detectible for those species found in both deciduous and coniferous communities. Oregon Juncos and Rufous-sided Towhees were ground-seed eaters or ground-insect eaters depending on the time of the year. They were not found as frequently in the coniferous as the deciduous forests; however, they occupied the same role in both types of community. Brown Creepers were always timber searchers. This category increased in importance in the conifers as there were a larger number of creepers and an increase in the number of Red-breasted Nuthatches.

It was shown by regression analysis that similar structural features in the coniferous and deciduous stands influenced the abundance of species that were found in both areas. The importance of the vegetation structure in bird habitat preference has been well documented in the literature (summarized by Palmgrem, 1930; Odum, 1945). The attempt then must be made to determine which features of the vegetation have the greatest correlation with the abundance of bird species. This study has shown that important structural features of the vegetation can be correlated with the abundance of species.

The ecology of an area is always changing, partly due to the influence of the animal element. Avian species contribute a bit to or extract a bit from the energy system of the many areas they visit. The habitat utilization pattern and ecological role are essentially the same in each area where the bird is found; however, food does not remain the same as most bird species are opportunistic, taking advantage of differences in prey abundance, within the limits imposed by their physiology, morphology, and behavior.

Seasonally, the forest types of western Oregon are influenced by avian movement. Movement of winter residents into the oaks brings energy exchange with the conifers. Margalef (1968) discusses the balance of energy flow between ecosystem types as being from less mature to more mature. Mixed winter flocks of birds move throughout a large area and become a part of dynamics of each system. Still, many of the birds are permanent residents of the more mature conifers, returning there to breed and thus in a sense confirming Margalef's view. This poses a problem for further study. By following the mixed winter flocks, it would be possible to determine where the greatest portion of time is spent, thus indicating further their contribution to the energy dynamics of the communities.

The influx of migrants which apparently "select" an area due to an abundant supply of food contributes further to the dynamics of forests. The appearance of insects in the spring provides an abundance of food thereby decreasing the necessary movement of avifauna. Birds utilize a small area for nesting and rearing their young in comparison to the broad area covered by foraging during the remainder of the year. Thus, the community affects the movement of the avifauna and the avifauna provide an energy link with other areas.

SUMMARY

The ecological relationships of the avian populations of western Oregon forests were examined on a seasonal basis. Ten study sites were selected in Oregon white oak, Douglas fir and western hemlock stands at the eastern base of the Coast Range near Corvallis, Oregon. Permanent census transects were established in each area.

In order to determine seasonal changes in bird species composition and diversity, variation in the ecological roles of the bird species, their patterns of habitat utilization, and the importance of habitat components in determining the abundance of species, information was gathered on the behavior activity patterns, morphological variation and dietary habits of the bird species, and on the vegetative structure of the stands. Intensive studies were centered on seven permanent resident species, the Black-capped Chickadee, Chestnut-backed Chickadee, White-breasted Nuthatch, Red-breasted Nuthatch, Brown Creeper, Rufous-sided Towhee and Oregon Junco.

Fluctuations of the avifaunal composition in the stands followed six seasons during the year: winter, early spring, late spring, early summer, late summer and fall. The highest total number of individuals in all but one area occurred during the late spring or early summer, when the migratory species were breeding. Diversity of the avifauna was highest in the oak areas during all periods of the year.

Analysis of the ecological roles played by species indicated the importance of foliage, as more than 50 percent of the birds present during all seasons were either foliage-seed or foliage-insect eaters.

The role of any one species remained the same in the several distinct vegetative types.

A stepwise multiple regression analysis was used to correlate the importance of vegetative structural features with the abundance of the species selected for intensive study. Identical structural features were found to influence the abundance of avian species in the oak and conifers.

Most species utilized a broader range of habitat conditions during the non-breeding periods. This was suggested to be correlated with food abundance. Generally, it was found that avian species of the western Oregon forests took what food was available within the area in which they were adapted to forage.

More individuals and species were found in the western Oregon forests than reported for eastern forests. It was suggested that mild winters may account in part for the high number of permanent residents. Because of this large number of permanent residents, the percentage of migratory birds was lower than in eastern forests.

Comparisons between the study areas showed bird species diversity to be higher in oak stands than in the conifers. This is in contrast to the increase in diversity expected in the conifers according to their more mature stage in succession. The dense understory, characteristic of oak stands, may have accounted in part for this difference. Differences in the avian populations of the coniferous study areas were not large. Considerable overlap in avian species present occurred among all fir and hemlock stands. In the areas ecotonal to oak dominated stands, diversity was a little higher than in the surrounding pure stands of both vegetation types.

The avifauna of the western Oregon forests thus does not fit into any specific plant community. The birds move between the different areas seasonally, providing an energy link between the immobile vegetative section.

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APPENDICES

APPENDIX 1

Scientific Names of Bird Species[3]

Turkey Vulture	Cathartes aura
Red-tailed Hawk	Buteo jamaicensis
Blue Grouse	Dendragapus obscurus
Ruffed Grouse	Bonasa umbellus
Mountain Quail	Oreortyx pictus
Ring-necked Pheasant	Phasianum colchicus
Band-tailed Pigeon	Columba fasciata
Great Horned Owl	Bubo virginianus
Vaux's Swift	Chaetura vauxi
Rufous Hummingbird	Selasphorus rufus
Red-shafted Flicker	Colaptes cafer
Pileated Woodpecker	Dryocopus pileatus
Yellow-bellied Sapsucker	Sphyrapicus varius var. ruber
Hairy Woodpecker	Dendrocopos villosus
Downy Woodpecker	Dendrocopos pubescens
Hammond's Flycatcher	Empidonax hammondii
Dusky Flycatcher	Empidonax oberholseri
Western Flycatcher	Empidonax difficilis
Western Wood Pewee	Contopus sordidulus
Olive-sided Flycatcher	Nuttallornis borealis
Gray Jay	Perisoreus canadensis
Steller's Jay	Cyanocitta stelleri
Scrub Jay	Aphelocoma coerulescens
Common Crow	Corvus brachyrhynchos
Black-capped Chickadee	Parus atricapillus
Chestnut-backed Chickadee	Parus rufescens
Common Bushtit	Psaltriparus minimus
White-breasted Nuthatch	Sitta carolinensis
Red-breasted Nuthatch	Sitta canadensis
Pigmy Nuthatch	Sitta pygmaea
Brown Creeper	Certhia familiaris
House Wren	Troglodytes aedon
Winter Wren	Troglodytes troglodytes
Bewick's Wren	Thryomanes bewickii
Robin	Turdus migratorius
Varied Thrush	Ixoreus naevius
Hermit Thrush	Hylocichla guttata
Western Bluebird	Sialia mexicana
Townsend's Solitaire	Myadestes townsendi
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Cedar Waxwing	Bombycilla cedrorum

[3]According to the American Ornithologists' Union. 1957. Check-list of North American Birds, 5th edition.

Hutton's Vireo	*Vireo huttoni*
Solitary Vireo	*Vireo solitarius*
Warbling Vireo	*Vireo gilvus*
Orange-crowned Warbler	*Vermivora celata*
Yellow Warbler	*Dendroica petechia*
Myrtle Warbler	*Dendroica coronata*
Audubon's Warbler	*Dendroica auduboni*
Black-throated Gray Warbler	*Dendroica nigrescens*
Townsend's Warbler	*Dendroica townsendi*
Hermit Warbler	*Dendroica occidentalis*
MacGillivray's Warbler	*Oporornis tolmiei*
Wilson's Warbler	*Wilsonia pusilla*
Brown-headed Cowbird	*Molothrus ater*
Western Tanager	*Piranga ludoviciana*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Lazuli Bunting	*Passerina amoena*
Evening Grosbeak	*Hesperiphona vespertina*
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus mexicanus*
Pine Siskin	*Spinus pinus*
American Goldfinch	*Spinus tristis*
Red Crossbill	*Loxia curvirostra*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Oregon Junco	*Junco oreganus*
Chipping Sparrow	*Spizella passerina*
White-crowned Sparrow	*Zonotrichia leucophrys*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*

APPENDIX 2

Scientific Names of Plant Species[4]

Bracken Fern	*Pteridium aquilinum*
Sword Fern	*Polystichum munitum*
Douglas Fir	*Pseudotsuga menziesii*
Grand Fir	*Abies grandis*
Western Hemlock	*Tsuga heterophylla*
Western Red Cedar	*Thuja plicata*
Red Alder	*Alnus rubra*
Western Hazel	*Corylus rostrata* var. *californica*
Oregon White Oak	*Quercus Garryana*
Golden Chinquapin	*Castanopsis chrysophylla*
Oregon Grape	*Berberis aquifolium* var. *minor*
Ocean Spray	*Holodiscus discolor*
Big Leaf Maple	*Acer macrophyllum*
Vine Maple	*Acer circinatum*
Thimbleberry	*Rubus parviflorus*
Wild Blackberry	*Rubus macropetalus*
Wood Rose	*Rosa gymnocarpa*
Nootka Rose	*Rosa nutkana*
Poison Oak	*Rhus diversiloba*
Common Dogwood	*Cornus nuttallii*
Snowberry	*Symphoricarpos albus*
Ox-eye Daisy	*Chrysanthemum Leucanthemum* var. *pinnatifidum*
Bull Thistle	*Cirsium lanceolatum*

[4]According to Gilkey, H. M., and L. J. Dennis. 1967. Handbook of northwestern plants. Corvallis, Oregon. Oregon State University Bookstore, Inc.