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Foliage Preference and Habitat Utilization by Migrating Warblers

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FOLIAGE PREFERENCE AND HABITAT UTILIZATION
BY MIGRATING WARBLERS

by

John Calvin Stiner

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
April 1977

ACKNOWLEDGEMENTS

I would like to thank Doctor Richard Brewer for his special counsel throughout this study and Doctors Joseph Engemann and Clarence Goodnight for their suggestions and comments. I am also grateful to the staff of W. K. Kellogg Forest for the assistance they rendered. A note of appreciation goes to my wife, Edie, for her cheerful encouragement throughout all phases of this study. The vegetational analysis was funded by a grant from the Upjohn Company of Kalamazoo.

John Calvin Stiner

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Western Michigan University, M.A., 1977
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CHAPTER I

INTRODUCTION

J. F. Parnell (1969) conducted a study in North Carolina over two spring periods in which he observed a number of warbler species and determined their preferences for pine, mixed pine-deciduous, and a variety of deciduous areas. He concluded that a species will select its breeding foliage during migration if available, and if not, as was the case with several spruce breeders, very little selection will occur. He also recorded the foraging zone of each species and found a consistency with the tree parts utilized on the breeding grounds. In fact, he felt that habitat niche (foraging zone) may be more important than habitat (vegetation) for most species.

W. K. Kellogg Forest, located in Kalamazoo County, Michigan, presents a unique opportunity to determine the vegetational preferences of migrating birds. Plots of spruce, pine, and deciduous vegetation are readily available to the birds and accessible to the observer with a minimum of time and travel. Parnell's general conclusions were tested for thirteen warbler and two kinglet species. With spruce present, Parnell's belief that the breeding foliage would be selected by spruce breeders if available, could be examined. Several more spruce species than he observed were included in this study. Michigan is approximately 400-500 miles north of North Carolina. The data of the two studies were compared to see if selection might change over the course of migration. Parnell dealt only with spring behavior.

At Kellogg Forest some fall preferences were established to note any deviation from the spring and to help in determining the factors governing selection during migration. Parnell felt that niche was independent of vegetation type and so combined data from the different vegetations for each species. In this study the observations in the different areas were kept separate for comparison.

Until Parnell, little or no standardized observations had been taken of the vegetational preferences or foraging zones of migrant birds. Most quantitative studies have been conducted in the breeding season or winter. However, general observations of migration are available from various sources. Two that Parnell cited were Stewart and Robbins (1958) and Chapman (1907). They, along with Trautman (1940), Roberts (1932), Stoner (1932), Barrows (1912), and a few comments from other sources such as Bent (1953 and 1949), were compared to the results obtained at Kellogg Forest.

The maintenance of the same foraging zone, noted by Parnell on the breeding grounds and during migration, has been demonstrated at other times of the year. Lack and Lack (1972), MacArthur (1958), Skutch (in MacArthur 1958), and Eaton (1953) found winter and summer behavior to be essentially the same. Morse (1968) saw no change through the course of the breeding season. The vegetational preferences and foraging behavior noted at Kellogg Forest were related to the results of studies and observations made during the breeding season and in the winter.

CHAPTER II

STUDY AREAS

Data were gathered from four plots located in the Michigan State University's W. K. Kellogg Forest found in Kalamazoo County, Michigan just north of Augusta (in the S W 1/4 of Sec 22 and the N W 1/4 of Sec 27 of Ross Township, T 15, R 9 W).

Much of the 602 acres of the forest was previously farmland that became badly eroded due to poor agricultural practices and was no longer fit for that use when acquired by Michigan State in the early 1930's. The University, through its forestry division, planted many different species of trees in both pure and various mixed stands. Also, an existing 18.21 hectare cutover woodlot was allowed to proceed in its natural order of succession.

During the spring and fall of 1973, three study areas were censused; the 18.21 hectare tract of oak-hickory woods, a 4.05 hectare plot of red pine (*Pinus resinosa*), and a 0.3 hectare rectangle of Norway and white spruce (*Picea abies* and *Picea glauca*). Early in the spring of 1974, a second spruce area was added to the others for observation; a 1.02 hectare mixture of Norway, white, and black spruce (*Picea mariana*).

Oak-hickory Area

This was the one naturally seeded area of the four. The canopy trees, categorized as having a diameter at breast height (dbh) of

13.0 cm and above, possessed a density of 301 trees per hectare. The main species of the canopy were, in order of decreasing density, black oak (*Quercus velutina*), white oak (*Quercus alba*), red oak (*Quercus rubra*), sweet pignut hickory (*Carya ovalis*), red maple (*Acer rubrum*), and sassafras (*Sassafras albidum*) as shown in Table 1. (Methods for obtaining vegetational data are described in the following section.) These species comprised 92% of the canopy individuals. Black oak dominated in all categories of Table 1 except mean dbh, with a density of 87.3 trees per hectare, a basal area of 8.85 square meters per hectare, and an importance value of 91.7. Red oak led in mean dbh with a value of 44.9 cm. The basal area of the six species was 20.1 square meters per hectare. The canopy height was 80-100 feet as determined by an Abney level.

The subcanopy trees, categorized as having a dbh between 4.0 and 12.99 cm, possessed a density of 511.8 trees per hectare. The main species, in order of decreasing density, were flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), red maple (*Acer rubrum*), white oak (*Quercus alba*), and black cherry (*Prunus serotina*) as shown in Table 2. Dogwood also led in importance value with a figure of 68.6. Red maple had the highest basal area with 0.52 square meters per hectare and white oak the largest mean dbh with 8.7 cm.

The shrubs and herbs (plants less than 4.0 cm dbh) arranged in order of decreasing relative frequency of occurrence in 100 randomly placed square meter plots were Schreber's aster (*Aster schreberi*), gray dogwood (*Cornus racemosa*), naked flowered tick-trefoil (*Desmodium nudiflorum*), hepatica (*Hepatica acutiloba*), red maple (*Acer rubrum*),

false Solomon's-seal (*Smilacina racemosa*), sassafras (*Sassafras albidum*), wild geranium (*Geranium maculatum*), mapleleaf viburnum (*Viburnum acerifolium*), and prickly gooseberry (*Ribes cynosbati*). The leading relative frequency, by Schreber's aster, was 12.4% (Table 3).

While the more xeric black and white oak still dominated in the oak-hickory area, red oak in the canopy and red maple in both the canopy and understory suggested succession towards a mesic condition.

Pine Area

The 4.05 hectare red pine (*Pinus resinosa*) area was quite homogeneous with only one tree of the canopy, a black cherry measuring 37 cm in diameter, not of the species. The pines were all planted in 1932 and were all in the same height range of 55-65 feet. The density was 809.4 trees per hectare and the mean dbh 26.5 cm. The basal area per hectare was 83.3 square meters.

No understory existed in the 4.0—12.99 cm dbh range with the exception of a few scattered black cherries. The ground cover was greatly aggregated with dense, almost impenetrable, growth in one area and nothing but pine needles covering the forest floor in another. The main shrub and herb species in order of decreasing relative frequency of occurrence in 80 randomly placed square meter quadrats were black raspberry (*Rubus occidentalis*), sassafras (*Sassafras albidum*), Virginia creeper (*Parthenocissus quinquefolia*), blackberry (*Rubus allegheniensis*), common pokeberry (*Phytolacca americana*), grape

(*Vitis* sp.), black cherry (*Prunus serotina*), and deadly nightshade (*Solanum dulcamara*). The highest frequency, exhibited by black raspberry, was 17.04% (Table 4).

Spruce Areas

The original spruce area was very small. It lay in the shape of a rectangle about 100 meters long and 30 meters wide comprising a total area of about 0.3 hectare. Two canopy species were present: Norway spruce (*Picea abies*) occupying the southern 1/3 of the plot and white spruce (*Picea glauca*) the northern 2/3. The density was 400 trees per hectare, the canopy forming a complete cover and greatly restricting light penetration. The result of this was no under-story or ground cover of any significance. The mean dbh of the spruce was 25.8 cm and the basal area 41.15 square meters per hectare. The trees were all planted in 1939 and stood 65-75 feet high.

The second spruce area covering 1.02 hectares was larger and more heterogeneous than the first. Besides the Norway and white spruces, it contained black spruce (*Picea mariana*), European larch (*Larix decidua*), and a few deciduous trees. Norway spruce was the original species planted in 1932 but black and white were added in 1936 and 1937 to fill in where individuals had failed. Also in the spring of 1937 European larch was planted along the eastern edge of the tract. Since that time a few deciduous trees have managed to invade the area and grow to canopy size. Although there were several openings in the area, for the most part it was quite closed. The total density of the canopy was 601 trees per hectare. This, combined

with the fact that many of the trees retained their dead lower branches made penetration of certain sections of the area a difficult task.

The 580 spruces were 65 to 75 feet in height with a mean dbh of 23.5 cm while the 44 larches along the east side were 70 to 80 feet high and averaged 32.4 cm in dbh. Thirty-three deciduous trees were present in the canopy; 14 black cherries, with an average dbh of 21.3 cm, 14 American elms (*Ulmus americana*) with a dbh of 16.95 cm, 4 trees-of-heaven (*Ailanthus altissima*) 16.7 cm dbh, and one buckhorn (*Rhamnus cathartica*) with 17.2 cm dbh. As in the first spruce area there was no understory or ground cover of any significance.

CHAPTER III

METHODS

Vegetational Analysis

Canopy and subcanopy trees of the oak-hickory area were sampled using the point-centered quarter method (Cottam and Curtis 1956). A grid, consisting of 54 points, was laid out in five lines spaced 66 meters apart with the 10 to 12 points in each line located at 40 meter intervals. Twenty-five points were selected at random and four trees sampled at each point for each of two size categories, trees 4.0—12.99 cm dbh and trees 13.0 cm dbh and above. Recorded for each tree were species, dbh, and point-to-plant distance. Total density and basal area were calculated for both the canopy and understory, and for each species relative density, relative dominance, relative frequency, importance value, basal area, and mean dbh were tabulated (Tables 1 and 2).

Shrubs and herbs were sampled by placing a square 10 x 10 meter quadrat at each of the points selected for the point-centered quarter sampling so that the point comprised the southwest corner of the square. At each corner of the 10 x 10 meter square was a 1 x 1 meter quadrat. The presence of all species under 4.0 cm dbh was recorded and relative frequencies for both the 10 x 10 and 1 x 1 meter squares calculated (Table 3). The purpose of using both sized quadrats was to aid in showing tendencies that any of the species might have toward aggregation. Since at one point there were one 10 x 10 meter

quadrat and four 1 x 1 meter quadrats, a species with a high relative frequency in the 1 square meter quadrats and low frequency in the 100 square meter quadrats would be dense and conspicuous where it occurred but absent in other portions of the forest. Conversely, a high 10 x 10 meter frequency and a low 1 x 1 meter frequency would indicate a more complete presence throughout the woods without dominant or conspicuous concentrations. Inclusion of both sized quadrats more accurately depicts the distribution of the herbs and shrubs covering the area.

The pine area canopy was also sampled using the point-centered quarter method. A 24 point grid was constructed comprised of four rows spaced 48 meters apart, the six points of each at 30 meter intervals. Twenty points were selected at random. Basal area and density of the canopy were determined. Since the pine area was so homogeneous, it was not necessary to deal with two sizes of trees or to calculate relative values for different species. Herbaceous and shrub cover were sampled in the same manner as in the oak-hickory plot (Table 4).

The first spruce area was a small pure stand and uniform as far as genus and age were concerned. A few representative trees were measured to determine mean dbh and a visual count of the rows allowed for a density estimate. In the second spruce area the actual numbers of spruce, larch, and each deciduous species were determined and mean dbh calculated for each. No understory, shrubs, or herbaceous cover were present in either plot.

Bird Census

Birds were censused for three seasons; the springs of 1973 and 1974 and the fall of 1973. In the spring of 1973 data were collected on 15 days between April 24 and June 1. The censusing was begun earlier the next spring on March 28 to include spring information on kinglet behavior and continued until June 3. This included 26 days of observation. The fall data were gathered between September 6 and November 18 on 21 separate days. The last warblers were seen October 18, but the time period was again extended for kinglet observation.

About 95 hours were spent in gathering warbler data, 74 in the two spring periods and 21 in the fall (Table 5). During the two spring periods the pine area was visited 16 times, the deciduous area 29, and the spruce area 19. There were 10 fall visits to the pine area, 13 to the deciduous, and 6 to the spruce.

In the spring of 1974 it was noted that warblers frequently occurred in a spruce plot not far from the original spruce area observed in 1973. Since this appeared to conflict with the little, if any, preference the warblers were showing for the original spruce plot, the second spruce area was added for observation. Beginning on May 3 the original area was visited 5 times in the spring of 1974 (3 hours) and the newer area 9 times (10 hours) (Table 5). The data of the two spruce areas were analyzed both collectively and individually.

The periods for kinglet observation amounted to 22.5 hours in the fall of 1973, with 10 visits to the pine area, 16 to the deciduous, and 8 to the spruce, and 48.38 hours in the spring of 1973, with 11

pine, 21 deciduous, and 14 spruce visits, respectively (Table 5). Kinglet and warbler data were gathered simultaneously, of course, during a part of both seasons.

Censusing was done in the forenoon usually beginning after 6:00 and before 8:00. The time of day was kept uniform to eliminate any movement by the birds to areas where food was more available in the afternoon or evening (Orians and Horn 1969). Each area was examined until it was felt that the birds present had been thoroughly recorded. Identification by sound was utilized as well as by sight. The much larger size of the deciduous area necessitated that a greater amount of time be spent there to ensure thorough coverage (Table 5). Data were calculated in birds per hour to equalize this difference between the vegetational areas. As many of the areas were visited on a given day as time would allow. This varied from two of the vegetation types to all three.

Standardized observations (Hartley 1953; Gibb 1954) were used to record information about a bird, in an effort to assess habitat utilization by each species. Recorded were the date, time of day, species, sex and age, if possible, activity (singing, foraging, etc.), species of plant being utilized, location of plant in the canopy, sub-canopy, or understory, height of bird from ground, relative position on plant by fourths (upper 1/4, lower 1/4, etc.), location on plant--trunk, large branch (over 2 cm in diameter), small branch (0.6 to 2 cm in diameter), twig (under 0.6 cm in diameter), or foliage--and whether the plant, or portion of it where the bird was located, was dead or alive. Knowledge of the height of the canopy was used to

estimate the heights of the birds. Sample measurements with an Abney level showed this to be accurate to within 5-10 feet. In later analysis the height data were broken into ten-foot intervals. Only one observation per individual for a given activity was recorded within a 15-minute time span. Standardized observations were also taken of six non-warbler and kinglet species with very similar foraging zones to evaluate interactions between them and the species of this study during migration.

Since the presence of a warbler or kinglet species was recorded by sound as well as by sight, the number of standardized observations taken to assess habitat utilization often did not equal the amount of times a species was counted present for purposes of foliage preference determination. This was especially true for such species as the Ovenbird which are heard much more readily than seen. Also, it was not always possible to record a complete set of standardized observations for a given bird. Whatever data were recorded were made use of. When it was only possible to record heights, relative height and a canopy, subcanopy, or understory status were assigned if enough clues for a reasonable inference were available. The number of observations pertaining to each aspect of habitat utilization are included for each species in Table 11.

The spring and fall standardized observations were compared for three species. The seasonal data of the deciduous area were combined for two of those species and the data of all three areas for the third. The remaining eleven species had only the spring observations utilized. The data of each sex were also combined. While Morse (1968) found

that the males of certain warbler species forage somewhat higher than the females, there is little difference in the part of the tree utilized.

The time spent in each study area was totaled for each season, and birds per hour for each species calculated. The probability of a species occurring at random in the individual study areas was also determined in birds per hour for each season. The number of hours involved in determining these values were the total hours of observation in each area on the dates from the first sighting of the species in Kellogg Forest to the last in each season. The difference between the random value and that of actual observation was tested for significance at the 5% level using the chi-square test to indicate preference or lack of it for any of the vegetation types.

The recommended smallest expected number for any class when using the chi-square has traditionally been 5 or 10. Cochran (1952), however, noted that in some situations this value can be as low as $1/2$ for one expectation if all others are above 5, and that where all values are below 5, fair accuracy is still maintained provided that each is at least 2. A later paper by Snedecor and Cochran (1967) dropped the required expected value even farther by stating that the chi-square test is accurate enough if all expectations are at least 1. The data collected in this study were considered adequate for analysis when it met the requirements laid down by Snedecor and Cochran.

In the spring and fall periods of 1973 the majority of species were not sighted enough to warrant statistical analysis of vegetation

preference; however, in the spring of 1974, all species were with the exception of one (Table 6). The spring 1974 data were analyzed separately and with the spring of 1973 combined. The combination served to increase the number of observations and lower the possibility of error inherent in drawing conclusions from small sample sizes. The fall data, with one exception, were kept separate since migrants are known to frequent different vegetations in the spring and fall. The lone exception was the American Redstart, not commonly seen in this study, which only reached statistical validity after a combination of all three study periods. This was done only after Bent (1953), Chapman (1907), Stewart and Robbins (1958), and several other sources were carefully searched and no mention of any change in preference from spring to fall for this species found.

For comparison of abundance between the warbler species (Table 7), birds per hour were determined from the total amount of time spent gathering warbler data in each season. The values for the Golden-crowned and Ruby-crowned Kinglets were derived in the same manner as the bird per hour values for foliage preference determination, the amount of time being set from the first day of sighting of each species to the last. This seemed more feasible for the kinglets since the Golden-crowned migrates earlier in the spring and later in the fall than the Ruby-crowned. While they coincided fairly well in the fall period of this study, for the most part they existed in two different time periods in the spring of 1974. The various warbler species overlapped greatly throughout the migration periods. Separation of the time into units for each species would

serve to indicate how spread out or concentrated the migration of each species was rather than the relative abundance sought for in this instance. The kinglet totals (Table 8) follow the same pattern as that of the warblers, the time involved being the cumulation for both species.

CHAPTER IV

RESULTS

Vegetational Preference

Thirteen species of warblers and both kinglets were observed with enough frequency, during at least one of the three seasons of study, to warrant statistical analysis of foliage preference (Table 6). Three species were adequately represented in the spring of 1973, two in the fall of 1973, and fourteen in the spring of 1974. One species, the American Redstart, reached the minimum acceptable level only when the data from all three seasons were combined.

The warblers totaled 139 observations in the spring of 1973, 39 observations in the fall of 1973, and 233 observations in the spring of 1974 (Table 7). The number of warblers per hour for each season was 4.25, 1.87, and 5.67, respectively. Thirty-five Golden-crowned and Ruby-crowned Kinglets were seen in the fall of 1973, and 27 in the spring of 1974, averaging 1.55 and 0.56 birds per hour, respectively. This gave a total of 411 warbler and 62 kinglet observations from which foliage preferences were determined.

The Ovenbird was the most recorded warbler in the spring of 1973 (Table 7), while the Black-throated Green predominated in the fall of 1973 and spring of 1974. The Golden-crowned Kinglet was recorded six times as often as the Ruby-crowned Kinglet in the fall of 1973 but was observed only slightly more often in the spring of 1974.

The deciduous area had the highest number of warbler observations and warblers per hour in two seasons and overall; however, the second spruce area had the highest birds per hour value in the spring of 1974 (Table 8). The greatest number of kinglet observations were also taken in the deciduous area; however, the spruce area contained the most kinglets per hour in the fall of 1973 and overall, while the pine area led in the spring of 1974.

All of the warbler species present in each spring, twelve in 1973 and thirteen in 1974, were sighted in the deciduous area (Table 9). Nine of the ten species recorded in the fall occurred there. The original spruce area contained two of twelve species in the spring of 1973, two of ten in the fall of 1973, and four of thirteen in the spring of 1974. The second spruce area possessed eleven of thirteen species in the spring of 1974. Two of twelve species were present in the pine area in the spring of 1973 and seven of thirteen in the spring of 1974. No warblers were sighted in the pine area in the fall of 1973. Both kinglets occurred in all three vegetations during the two seasons they were present.

The Black-throated Green was the warbler recorded in the most areas over the three seasons of study occurring nine out of ten possible times (Table 9). The Ovenbird was second with seven. The Ruby-crowned and Golden-crowned Kinglets were essentially equal.

In the spring of 1974 the original spruce area of the study yielded 3.67 warblers per hour. The second spruce area, added that spring, yielded 6.15 (Table 8). Of the thirteen warbler species analyzed in the spring of 1974, four were found in the original area

and twelve in the second (Table 9).

In the spring, six species of warblers--the Black-throated Green, Nashville, Blue-winged, Bay-breasted, Cape May, and Blackburnian--statistically displayed no preference for any of the three foliage types (Table 6). However, the author feels the last two species may be demonstrating selection (see Discussion). The Golden-crowned and Ruby-crowned Kinglets also revealed no spring preference. Two warblers--the Magnolia and Tennessee--exhibited a tendency towards spruce while the Myrtle Warbler leaned towards the deciduous. No species individually selected the pine. The Chestnut-sided Warbler showed a deciduous preference in the spring of 1974 but exhibited no selection when the spring data were combined. The Black-and-white Warbler demonstrated the opposite, exhibiting no preference in the individual springs but a deciduous preference with the data combined. The American Redstart, with all three seasons combined, gave no indication of preference.

Two species had sufficient samples for determination of fall preference. The Black-throated Green Warbler showed no selection, as in the spring, while the Golden-crowned Kinglet, also lacking a spring preference, occurred most often in the spruce.

Habitat Utilization

The standardized observations taken to assess habitat utilization during migration are summarized in Tables 10 and 11. Table 10 lists the occurrence of each species in the various strata of the deciduous area, while Table 11 records for each species, by vegetation

type and strata, its percent of occurrence in the categories of height, relative height, and location on tree. Observations of singing birds are presented apart from those of other activities in Table 11.

Only three species contributed significant data on habitat utilization in the fall period. These were the Black-throated Green and Black-and-white Warblers in the deciduous area and the Golden-crowned Kinglet in all three vegetations. All three species were analyzed using the chi-square test and revealed no significant difference in the deciduous area between spring and fall foraging heights (Figure 1) or the other categories of habitat utilization (Table 12). The Black-and-white Warbler did exhibit a slight increase in height in the fall, which was reflected in the higher quarter 4 and twig values, and the Golden-crowned Kinglet was noted more frequently on foliage in that season. The Kinglet, while not seen enough in each season to allow statistical comparison of spruce and pine behavior, exhibited no apparent differences in utilization, except a possible tendency to forage lower in both areas in the fall. The spring and fall observations are combined for these three species in Tables 10 and 11. All other species have only the spring data included.

Strata

The canopy, subcanopy, and understory divisions of the strata were essentially only meaningful in the deciduous area. The spruce plot lacked the lower two and, while the pine area possessed scattered locations of understory, warblers and kinglets were only recorded

in the canopy. No warblers or kinglets were seen on the ground in the spruce area. The presence of Ovenbirds in the pine area indicate that the ground layer was utilized by at least this one species; however, the bird was only observed while singing. Therefore, all records of warblers and kinglets in the pine or spruce areas were for the canopy.

In the deciduous area 75% of the warblers were recorded in the canopy, 19% in the subcanopy, 4% in the understory, and 2% on the ground. Fifty-four percent of the kinglets were recorded in the canopy, 39% in the subcanopy, and 7% in the understory.

Nine species of warblers were observed 66% or more of the time in the deciduous canopy (Table 10). Only the Magnolia Warbler noted 50% of the time in the subcanopy, the Golden-crowned and Ruby-crowned Kinglets located equally in the canopy and subcanopy, and the Ovenbird did not show a preference for the deciduous canopy. The Ovenbird, when singing, favored the subcanopy and, when engaged in other activities, the understory and ground layers. The remaining two species, the Cape May Warbler and American Redstart, lacked sufficient data for a determination of preference.

No particular tree species seemed to be favored by any of the warbler or kinglet species in the deciduous area.

Height

Seventy-one percent of the warbler observations in the deciduous area were made 21 to 60 feet above the ground with the greatest percentage of birds (22%) occurring at the 41-50-foot level (Table 13).

The spruce area was quite similar with 79% of the birds observed in the 21-60-foot range, the greatest percentage (29%) again occurring from 41-50 feet. In the pine area 83% of the warblers were sighted 40-60 feet above the ground, the greatest amount (65%) occurring, as in the previous areas, from 41-50 feet.

Ninety-six percent of the kinglet observations in the deciduous area were made 1-60 feet above the ground, the peak percentage (25%) occurring both at 1-10 and 21-30 feet (Table 13). Eighty-two percent of the kinglets in the pine area occurred equally from 11-40 feet. Eighteen percent were recorded over 40 feet, none below 10 feet. In the spruce area 77% of the observations were under 30 feet with a peak of 33% occurring from 21-30 feet.

The height range in which each species occurred 66% or more of the time for a given activity and vegetation type is presented in Figure 2. Five or more observations were required of each activity in each area. The species are arranged by vegetation allowing description and comparison of each species' vertical zone of utilization in the three major habitats. Thirteen species are presented in the deciduous area, five in the spruce, and one in the pine. Fourteen of the fifteen species have a foraging range presented for at least one vegetation type, three have a range presented for two, and one species has the range estimated for all three. The American Redstart lacked sufficient data in all areas for any range determinations. Four species, the Ovenbird, Black-throated Green, Chestnut-sided, and Tennessee Warblers, were sighted enough in song to allow a range estimate for that activity.

From Figure 2 three height groupings were established, a low group located 30 feet under, a high group ranging 41 feet and above, and a middle group, overlapping the other two in various degrees. The low group included the Golden-crowned Kinglet in the spruce areas and the Magnolia Warbler, Ruby-crowned Kinglet, and the Ovenbird (in activities other than singing) in the deciduous. Within this group the Ovenbird occurred only in the 0-10-foot category while the two kinglets and Magnolia Warbler ranged from 0-30 feet.

The high group consisted of the Blackburnian and Tennessee Warblers in the deciduous area and the Tennessee (in song) and Cape May Warblers in the spruce. The Cape May and Tennessee spruce samples were small but the Cape May occurred only in the 40-60-foot range, while the Tennessee was sighted only once below 50 feet (Table 11). In the deciduous area the Blackburnian ranged from 40-80 feet, the Tennessee from 40-85.

The middle heights of the deciduous area were occupied by seven species of warblers and the Golden-crowned Kinglet, while three species of warblers ranged in the mid-zone of the spruce area. The Golden-crowned Kinglet was also located in the mid-zone of the pine area. Four species occurred from 10-60 feet, the Blue-winged and Black-and-white Warblers and the Golden-crowned Kinglet in the deciduous area and the Bay-breasted Warbler in the Spruce. Five warblers ranged from 20-60 feet, the Bay-breasted, Myrtle, and Black-throated Green (foraging and in song) in the deciduous and the Magnolia and Tennessee (foraging) in the spruce. Two species ranged 10-40 feet, the Ovenbird (in song) in the deciduous and the Golden-

crowned Kinglet in the pine. The Chestnut-sided and Nashville Warblers foraged from 10-50 and 30-60 feet, respectively, while the Chestnut-sided sang from 20-40 feet in the deciduous area.

As can be seen, the Tennessee and Magnolia Warblers and the Golden-crowned Kinglet foraged at somewhat different heights in the two or more areas they frequented. All three occurred in the mid-zone of the spruce area. In the deciduous area, however, the Tennessee ranged high and the Magnolia Warbler and the Golden-crowned Kinglet low. The Bay-breasted Warbler remained at the same level in both vegetations. The Golden-crowned Kinglet occurred somewhat lower in the pine than in the spruce.

The Ovenbird and Tennessee Warblers sang in a higher zone than they foraged in, while for the Black-throated Green Warbler the two zones remained the same. The song range of the Chestnut-sided Warbler occurred within its foraging zone. Figure 3 demonstrates that the mean song height and corresponding standard deviation ranged above that of the foraging area for these four species.

Relative height and location on tree

The parameters of relative height and location on tree are illustrated schematically in Figures 4-22. The data were taken from Table 11. The darkened zone of the figures represents the area of greatest concentration in both relative height and location. The double hatching denotes the highest concentration in one category and the single hatching rounds out the shaded area to include 66% of the observations in each category. At least five observations of each

parameter were required for each figure. Thirteen species are represented, five in the spruce area (Figures 4-8), one in the pine (Figure 9), three in the deciduous subcanopy (Figures 10, 13, and 21), and nine in the deciduous canopy (Figures 11, 12, 14-20, and 22). Only four species lacked sufficient data to be represented in the deciduous canopy or subcanopy--the Ruby-crowned Kinglet, American Redstart, Cape May, and Magnolia Warblers. The Tennessee and Bay-breasted Warblers appear in both the spruce and deciduous canopies, the Black-throated Green Warbler in the deciduous canopy and subcanopy, and the Golden-crowned Kinglet in all three canopies and the deciduous subcanopy. Two species--the Black-throated Green Warbler in the deciduous and the Tennessee Warbler in the spruce--possessed adequate data to represent the bird in song as well as foraging. The Ovenbird is illustrated in song only.

The majority of the species occurred primarily in the middle sections (2 and 3) of the canopy: the Magnolia, Bay-breasted, and Tennessee Warblers in the spruce (Figures 4, 5, and 7); the Golden-crowned Kinglet in the pine (Figure 9); and the Golden-crowned Kinglet and Black-throated Green, Bay-breasted, Myrtle, Blackburnian, Chestnut-sided, Blue-winged, Tennessee, and Black-and-white Warblers in the deciduous (Figures 11, 12, 14-17, 19, 20, and 22, respectively). The Nashville Warbler ranged through the upper three quarters of the deciduous canopy (Figure 18). The Cape May Warbler, with just a small sample, indicated a preference for at least the upper half of coniferous trees (Table 11 and Figure 6), while the Golden-crowned Kinglet predominated in the lower quarters of the spruce area and

deciduous subcanopy (Figures 8 and 10). The Black-throated Green Warbler was recorded most often in the second quarter of the deciduous subcanopy (Figure 13), but like the Ovenbird (Figure 21) probably frequented quarters 2-4.

The Bay-breasted and Tennessee Warblers ranged through the same quarters in the spruce and deciduous areas (Figures 5, 7, 14, and 20), while the Golden-crowned Kinglet ranged lower in the spruce and deciduous subcanopy (Figures 8 and 10) than in the deciduous canopy and pine (Figures 9 and 11).

The quarter where the Black-throated Green Warbler foraged with the greatest frequency was also where it most often sang (Figure 12). The Tennessee sang in the quarter above that of its greatest foraging concentration (Figure 7). These results concur with those of Figure 2.

Listing the location of the species from the outside of the tree inward, in the spruce area, the Cape May Warbler occurred 66% or more of the time in the foliage (Figure 6). The Bay-breasted and Tennessee Warblers were noted on foliage, twigs, and small branches and the Magnolia Warbler on foliage, twigs, and small and large branches (Figures 5, 7, and 4, respectively). The Golden-crowned Kinglet was recorded most often on twigs and small branches in both the spruce and pine areas (Figures 8 and 9).

In the deciduous canopy, the outermost species were the Chestnut-sided, Blue-winged, and Tennessee Warblers (Figures 17, 19, and 20) occurring 66% or more of the time on twigs. The Golden-crowned Kinglet and Black-throated Green, Blackburnian, and Nashville Warblers

were noted most often on twigs and small branches (Figures 11, 12, 16, and 18), while the Bay-breasted and Myrtle Warblers were spread over twigs and small and large branches (Figures 14 and 15). The Black-and-white Warbler was the innermost species frequenting large branches and trunks (Figure 22). In the deciduous subcanopy the Golden-crowned Kinglet occurred most on foliage and twigs (Figure 10), the Black-throated Green Warbler frequented twigs (Figure 13), and the Ovenbird sang from small and large branches (Figure 21). The Ruby-crowned Kinglet and American Redstart samples were too small to reveal preference for certain tree zones.

The Golden-crowned Kinglet showed great similarity between the three vegetations favoring twigs and small branches in the spruce, pine, and deciduous canopies; however, it occurred somewhat farther out in the deciduous subcanopy on foliage and twigs (Figures 8, 9, 10, and 11). The Bay-breasted Warbler did not differ greatly between areas favoring foliage, twigs, and small branches in the spruce and twigs, small branches, and large branches in the deciduous (Figures 5 and 14). The Tennessee Warbler, also predominating on foliage, twigs, and small branches in the spruce, was more restricted in the deciduous to just twigs (Figures 7 and 20). The Black-throated Green Warbler exhibited a slight difference between the deciduous canopy and subcanopy frequenting twigs and small branches in the former and twigs in the latter (Figures 12 and 13). It favored twigs and small branches in the deciduous canopy while foraging and in song (Figure 12).

The area or zone utilized by the most species in the deciduous

area was twigs in the third quarter. Eight of eleven species exhibited this. In the spruce area three of five species predominated in the foliage of the third quarter.

Habitat Utilization by Non-Warbler and Kinglet Species

Habitat utilization by several species with closely related foraging areas to the warblers and kinglets was also examined. The Red-eyed Vireo and Black-capped Chickadee were studied for possible interactions with any warbler or kinglet species while the White-breasted Nuthatch, Red-breasted Nuthatch, Downy Woodpecker, and Brown Creeper were analyzed more specifically to determine their relationships to the Black-and-white Warbler. Table 14 gives the strata information and Table 15 the other aspects of habitat utilization for these species.

Spring and fall data are combined in Table 15 for the White-breasted Nuthatch in the deciduous canopy and the Red-breasted Nuthatch and Black-capped Chickadee in the pine area. The spring and fall data were analyzed for each using the chi-square test and no significant difference was demonstrated in height, quarter, or location on tree. These species in other vegetations or strata and the other three species have data presented for one season only.

From the data of Table 15 profiles were constructed for each species to enable comparison of their foraging areas to those of the warblers. Hopefully, possible overlap and exclusions would be revealed. Five of the six species were represented in the deciduous canopy (Figures 23-28) and the White-breasted Nuthatch and Black-capped

Chickadee in the deciduous subcanopy (Figures 29 and 30). The chickadee was illustrated in the spruce and pine canopies as well (Figures 31 and 32). The Red-breasted Nuthatch was pictured only in the pine (Figure 33). The White-breasted Nuthatch was recorded enough in the deciduous canopy to present a foraging profile both with and without the presence of the Black-and-white Warbler (Figures 26 and 27).

The Red-eyed Vireo, Brown Creeper, White-breasted Nuthatch, and Downy Woodpecker all demonstrated a preference for the deciduous canopy (Table 14). The Black-capped Chickadee was noted most often in the canopy in the spring but predominated in the undergrowth in the fall.

The White-breasted Nuthatch was recorded over 70% of the time from 20-60 feet in the deciduous canopy, both with and without the Black-and-white Warbler present (Table 15). Statistical analysis showed the height not to differ significantly in the two situations. In the subcanopy the nuthatch was noted 80% of the time under 20 feet. The Red-eyed Vireo was seen only above 30 feet in the deciduous canopy, while the Downy Woodpecker and Brown Creeper indicated very general height ranges. The Black-capped Chickadee was noted 70% or more of the time above 20 feet in the deciduous, spruce, and pine canopies. In the deciduous subcanopy it occurred 70% of the time under 10 feet. The Red-breasted Nuthatch was recorded 85% of the time from 20-50 feet in the pine.

Statistical analysis revealed a significant difference in the tree quarters inhabited by the White-breasted Nuthatch when the Black-and-white Warbler was present as opposed to absent (Figures 26 and 27).

The nuthatch was recorded most often in the middle two quarters of the canopy when alone (Table 15) and in the lower two with the Black-and-white present. The nuthatch favored the lower three quarters of the deciduous subcanopy (Figure 29). The Red-eyed Vireo predominated in quarter three of the deciduous canopy (Figure 23), the Brown Creeper indicated no selection between quarters one through three (Figure 24), and the Downy Woodpecker inhabited quarters two and three (Figure 25). The Black-capped Chickadee was recorded most in the mid two quarters of the deciduous canopy (Figure 28), the lower two of the deciduous subcanopy (Figure 30), the upper two of the pine area (Figure 32), and throughout the height of the spruce trees (Figure 31). The Red-breasted Nuthatch predominated in the mid two quarters of the pine (Figure 33).

No difference in location in the deciduous canopy was demonstrated statistically by the White-breasted Nuthatch in the presence or absence of the Black-and-white Warbler. The trunk was selected most in both cases as in the deciduous subcanopy; however, the nuthatch was not as confined to the trunk in the warbler's absence (Figures 26, 27, and 29). The Red-eyed Vireo occurred on twigs and small branches in the deciduous canopy (Figure 23), the Brown Creeper was only noted on the trunk (Figure 24), and the Downy Woodpecker occurred equally on the trunk and large branches (Figure 25). The Black-capped Chickadee was recorded most often on twigs and small branches in the deciduous subcanopy and pine area (Figures 30 and 32). It occurred on foliage and twigs in the spruce area (Figure 31) and on foliage, twigs, and small branches in the deciduous canopy (Figure

28). The Red-breasted Nuthatch inhabited the trunk and large branches of the pine area (Figure 33).

No changes in the foraging position of the Black-capped Chickadee were apparent in the presence or absence of the migrant warblers or kinglets; however, the sample was small.

CHAPTER V

DISCUSSION

Differences occurred in the foliage preferences shown in individual springs and with the springs combined for the Chestnut-sided and Black-and-white Warblers (Table 6). The Ovenbird differed in preference between the springs of 1973 and 1974. These were probably all due to the small sample sizes involved. Even with the inconsistencies, the author feels that a deciduous preference is indicated by the Chestnut-sided and Black-and-white Warblers and an avoidance of spruce shown by the Ovenbird for the spring period. The Cape May and Blackburnian Warblers statistically demonstrated no preference in Kellogg Forest. However, a coniferous preference was ascribed to the Cape May and pine avoidance to the Blackburnian. The author's reasoning is presented in the individual discussions of the two birds.

Black-and-white Warbler

Vegetational preference

Migration. The Black-and-white Warbler, with the data of the two springs combined, exhibited a deciduous preference in Kellogg Forest (Table 6). Parnell (1969) found it to occur commonly in most forests, but did state that it showed a tendency to increase in numbers in deciduous growth. Also his birds per hour value for the oak-hickory areas was three times that of the pine. Stewart and Robbins (1958) recorded it in both deciduous and coniferous forests, usually

with a partly open canopy. Stoner (1932) observed it, in the spring, in old willows, mixed woods, and even around houses. Chapman (1907) noted the latter, finding it in lawn and orchard trees. Bent (1953) in the fall saw it feeding on dead and dying trees and shrubs. Trautman (1940), in Ohio, found it in larger lowland and upland woods with a profuse shrub layer.

A strong preference for one particular vegetation was not revealed by the above authors. While all noted it in deciduous vegetation, Stewart and Robbins (1958), Parnell (1969), and possibly Stoner (1932) indicated that it frequents coniferous vegetation as well. Parnell (1969) stated that the trunk and large branch feeding may restrict the bird less to certain vegetations than the foraging adaptations of some other species.

Breeding. Griscom and Sprunt (1957) wrote that the Black-and-white Warbler always breeds in deciduous areas. Lack and Lack (1972) placed it in open and secondary growth in deciduous woods. Chapman (1907) observed it generally distributed throughout deciduous woodlands. However, Thayer (in Chapman 1907) also found it in mixed vegetation. He rarely saw it in dense spruce forest but, instead, in scrubby second growth. Burns (also in Chapman 1907), in Pennsylvania, noted it from timbered upland down to swampy thickets, wherever there was a sufficient undergrowth of saplings. Stewart and Robbins (1958) observed it to breed in the same vegetation that was frequented in migration, various deciduous and coniferous forests, usually with a partly opened canopy. Kendeigh (1945a) found it most common in or near forest edge and in abandoned fields where a good stand of

trees had developed. When in forests, the bird occurred about equally in deciduous and mixed plots. Bent (1953) reported nests in both deciduous and coniferous areas. Morse (1970), in a Maine mixed area, recorded it foraging 75% of the time on conifers.

Several authors specifically mentioned deciduous vegetation (Griscom and Sprunt 1957, Lack and Lack 1972) while others also included conifers (Stewart and Robbins 1958, Bent 1953) or at least mixed vegetation (Thayer in Chapman 1907, Kendeigh 1945a). The Black-and-white Warbler seems to prefer somewhat open wooded areas rather than deep forest (Lack and Lack 1972, Thayer in Chapman 1907, Stewart and Robbins 1958, Kendeigh 1945a). This, plus the fact that Thayer (in Chapman 1907) actually noted it to avoid dense spruce growth, may explain the scarcity of the bird in the spruce area of Kellogg Forest. Thayer (in Chapman 1907) in the breeding season and Trautman (1940) in migration indicate the importance of saplings or a shrub layer to the ground-nesting bird. Possibly, the well-developed understory of the deciduous area in Kellogg Forest was an attractant. This, coupled with the fact that deciduous vegetation is a common breeding foliage, may explain the preference shown in this study. The pine area was relatively barren beneath the canopy and may not have been as attractive. Also competitive interaction with the Red-breasted Nuthatch may have been a deterrent (see Relationship to non-warbler species). The heavy coniferous foraging in a mixed area, described by Morse (1970), is discussed under the section just mentioned with reference to the Downy Woodpecker.

Winter. Lack and Lack (1972) in Jamaica found the Black-and-white Warbler in all types of forest. Skutch (1957) reported that it occurred in the rain forests at higher levels in Central America but was not restricted to heavy woods. In Bent (1953) Skutch recorded it in heavy forest, more open woods, second growth with scattered trees, and shade trees on the wintering grounds.

Habitat utilization

Migration. The Black-and-white Warbler, in the deciduous area of Kellogg Forest, was seen almost exclusively in the canopy (Table 10) from 10-60 feet (Figure 2). It predominated in the second quarter of the trees and foraged mainly on the trunk and large branches (Figure 22). Spring and fall foraging heights were essentially the same (Figure 1). Trautman (1940) saw the Black-and-white most often on the trunks and large branches of medium to large trees. A few occurred in large shrubs or saplings. It ranged from 3-40 feet above the ground. Bent (1953) also reported it on trunks and large limbs, but stated that it was at home on smaller twigs too. In the fall he noted it on the trunks and low branches of dead or dying trees. Forbush (1939) wrote that it hops along lower limbs in woodlands. Parnell (1969) recorded it 54% of the time in the canopy and 46% in low trees, predominating on the trunk in both strata. It foraged from 15-30 feet and sang from 21-36 feet.

The trunk and large branch foraging of this study agrees well with the observations of others, and the occasional occurrence on smaller twigs mentioned by Bent (1953) matches the small branch and twig values of Figure 22. The concentration in the canopy was supported

somewhat by Trautman (1940); however, Parnell (1969) found it almost equally in the subcanopy. His and Trautman's actual heights and the references of Forbush (1939) and Bent (1953) to low branch foraging indicate the bird extended somewhat higher in Kellogg Forest.

Breeding. Griscom and Sprunt (1957) categorized the Black-and-white's foraging range as medium. Kendeigh (1945b) noted that it often sang exposed at or near the top of an isolated tree. Next to dead vegetation, Morse (1970) recorded the Black-and-white most often low (under 30 feet) in coniferous and mixed areas in Maine.

Griscom and Sprunt (1957) matched best with the height frequented in this study and Kendeigh (1945b) indicated that the bird can range high. Morse (1970) placed it lower than it occurred in Kellogg Forest.

Kendeigh's (1945a) category for the Black-and-white Warbler was tree trunks. Griscom and Sprunt (1957) were not specific, listing limbs, trunks, and leaf clusters. In a coniferous area and on coniferous vegetation in a mixed area, Morse (1970) found the bird slightly more in the "in" category than on the trunk. (His categories were tip, out, in, and trunk. These categories will be referred to throughout the remainder of the paper.) On the deciduous vegetation of the mixed area, it occurred slightly more on the trunk. The bird thus maintains a trunk and large branch preference throughout the migratory and breeding periods.

Winter. Skutch (in Bent 1953) reported that the Black-and-white Warbler foraged in the same manner on the wintering grounds as up north. In agreement are MacArthur (1958) who observed it in Costa

Rica creeping on trunks and branches from 0-35 feet and Lack and Lack (1972) who noted it creeping up and along trunks, branches, and twigs of all sizes in Jamaica. MacArthur's (1958) height range of 0-35 feet matched well with Morse (1970) in the breeding season (under 30 feet) and Trautman (1940) during migration (3-40 feet).

Relationship to non-warbler species

The Downy Woodpecker frequented the same zone of the tree as the Black-and-white Warbler, in the deciduous area of Kellogg Forest (Figures 22 and 25). Anderson and Shugart (1974) also indicated that they prefer the same type of forest since the Downy is abundant where there are a lot of saplings. The attraction of the Black-and-white to understory has already been discussed. Morse (1967c) noted the Downy Woodpecker to obtain much of its food from deeper within the bark than the Brown-headed Nuthatch and Pine Warbler, where the three overlapped foraging zones during the winter. This may be the case at Kellogg, with the Downy foraging deeper than the Black-and-white Warbler. Deeper foraging may not be enough to eliminate competition, however, and may be of limited importance at this time of year. Jackson (1970) observed more subsurface feeding by the Downy in the winter, when Morse (1967c) conducted his study, than at other seasons. The strong coniferous and deciduous tendencies by the Black-and-white Warbler and Downy Woodpecker, respectively, in a Maine mixed area (Morse 1970), may indicate a degree of mutual exclusion. In that study they utilized the same portions of the tree although the Black-and-white did forage more on dead vegetation and the Downy more on

the trunks of live timber. At Kellogg Forest two differences in foraging were noted between the Downy and the Black-and-white. The Downy utilized the subcanopy more (Tables 10 and 14) and was not seen on small branches and twigs in the canopy (Figures 22 and 25). There may also be a difference between the two species in the quarter preferred, but the samples were too small to tell. These factors, plus the ability of the Downy to forage deeper, may allow the species to avoid competition and to coexist in the deciduous area of Kellogg Forest.

The White-breasted Nuthatch also foraged in a similar position to the Black-and-white Warbler. Profiles were constructed of it in the deciduous canopy both with and without the Black-and-white Warbler present (Figures 26 and 27). It can be seen to shift downward quarterwise and may move in somewhat in the presence of the warbler. The phenomenon of retracting inward was noted in the presence of the Red-breasted Nuthatch by Stallcup (1968) in a pine area. His interpretation of the White-breasted Nuthatch's behavior differed though. He felt it voluntarily moved inward in the non-breeding season with the effect of allowing the Red-breasted Nuthatch to fill in the vacancy. When the White-breasted expanded its zone in the breeding season, the Red-breasted was expelled from the area. Willson (1970) observed no change from the winter tree type, feeding site, or height inhabited by the White-breasted Nuthatch, with the influx of spring migrants. Statistically the height ranges utilized by the nuthatch at Kellogg Forest both with and without the Black-and-white Warbler did not differ (Table 15). The question arises of how the nuthatch

could shift downward in quarter (which was statistically significant) and yet remain essentially at the same height. If the Black-and-white Warbler does exert a certain dominance over the nuthatch, the warbler may claim a certain zone of each tree. It primarily inhabited zones 2 and 3 (Figure 22). The nuthatch, rather than drop in height, may have been forced off lower trees but still could maintain the same height in larger trees where zones 2 and 3 were located higher. It is, however, possible that some recording peculiarity could be responsible for the difference. The effect then of the Black-and-white Warbler on the White-breasted Nuthatch, if any, is not clear.

The Red-breasted Nuthatch could be a potentially greater competitor of the Black-and-white Warbler than the White-breasted Nuthatch, since it is more versatile and covers a greater portion of the warbler's foraging zone. It extends out more on small branches than the White-breasted Nuthatch (Bent 1948) and searches for food on the surface of the bark as well as chipping it away in the manner of the latter (Stallcup 1968). The Red-breasted Nuthatch was restricted almost exclusively to the pine area of Kellogg Forest while the Black-and-white Warbler rarely occurred there. The two birds foraged in very similar zones in their respective vegetations (Figures 22 and 33). Therefore, besides the lack of understory already discussed, competition may be another factor in the low occurrence of the Black-and-white Warbler in the pine area.

The Brown Creeper is another possible competitor of the Black-and-white Warbler. Although not occurring in Kellogg Forest at the same time the warbler was present, it too is a trunk forager (Figure

24). Two factors that may help to isolate it from the Black-and-white on the breeding grounds and the other three species just discussed, are its peculiar bill that allows it to obtain food from the trunk that the others miss (Morse 1967c) and its ability to forage along the underside of a horizontal branch (Bent 1948). However, Morse (1967c) felt that it avoided the White-breasted Nuthatch in the pine forests of Louisiana, so there may still be considerable overlap.

Morse (1970) found the Black-and-white Warbler to become very aggressive in the late summer in Maine. At this time it exerted more influence on the Black-capped Chickadee than any other species. The chickadee foraged more peripherally in coniferous vegetation and spent more time on deciduous growth in a mixed area in the warbler's presence. In the deciduous canopy at Kellogg Forest the two species overlapped most on small and large branches (Figures 22 and 28). In the warbler's presence the chickadee appeared to behave no differently than when the warbler was absent. However, since the sample was small, the author can only say that the aggressiveness of the Black-and-white Warbler towards the Black-capped Chickadee may be restricted to the breeding grounds.

Summary

The Black-and-white Warbler selected the deciduous area of Kellogg Forest (Table 6). This may be due to the presence of a well-developed understory in that area combined with its being a common breeding foliage. The absence of the bird from the pine area may have been due to the relative lack of understory and competition from the

Red-breasted Nuthatch. The spruce area, possibly, was too dense for the Black-and-white which is reported to prefer more open woods.

The warbler basically stays on the trunk and large branches and frequents the same heights throughout the migratory, breeding, and winter periods. The data from Kellogg Forest agreed except that the bird was noted to forage somewhat higher in this study than in others.

The foraging behavior of five potential competitors of the Black-and-white Warbler in the Kellogg Forest were described and compared to that of the warbler. In a study by Morse (1970) the Downy Woodpecker and Black-and-white Warbler may have demonstrated mutual exclusion. In Kellogg Forest, the Downy foraged more in the subcanopy than the Black-and-white, not as much on small branches in the canopy, and possibly probed deeper. The White-breasted Nuthatch foraged in a lower quarter of the tree but did not drop in height and possibly was more restricted to the trunk in the presence of the Black-and-white Warbler. The Red-breasted Nuthatch could be a more severe competitor of the warbler than the White-breasted Nuthatch, since it is more versatile and covers more of the Black-and-white's foraging zone. They frequented different vegetation types in Kellogg Forest. The Brown Creeper possesses a few peculiar qualities that may enable it to avoid competition with the above species. The Black-capped Chickadee overlapped foraging zones somewhat with the Black-and-white Warbler. The late summer aggressiveness of the warbler towards the chickadee, on the breeding grounds, may not be maintained during migration.

Blue-winged Warbler

Vegetational preference

Migration. No vegetational preference was exhibited by the Blue-winged Warbler in Kellogg Forest (Table 6). Stewart and Robbins (1958) indicated a deciduous tendency, noting it most often in floodplain and swamp forest and occasionally in other deciduous types. Trautman (1940) found it chiefly on brushy and wooded hill-sides facing east and south and occasionally in scattered second growth timber with high brush.

Breeding. The Blue-winged Warbler breeds primarily in deciduous areas, the nest often placed in a clump of herbs. Clement and Gunn (in Griscom and Sprunt 1957) assigned it to deciduous forest in Canada. Chapman (1907) found that it did not usually inhabit deep woods but occurred mostly in bordering second growth with weedy openings. Burns (in Chapman 1907) observed it in open swampy thickets, upland clearings, neglected pasture, and fence rows where grass and weeds had not been choked out. Bent (1953) found nests in rather open situations such as wood borders and old pasture.

Thus, Stewart and Robbins (1958) observed the bird to select the breeding foliage in migration. Their findings, plus the well-developed herb and shrub layer in the deciduous area at Kellogg, would seem to make it choicest for the warbler. The sample of this study was small and that may be responsible for the lack of preference.

Habitat utilization

Migration. In the deciduous area of Kellogg Forest the Blue-winged Warbler was recorded only in the canopy (Table 10) foraging in the second and third quarters on twigs (Figure 19). It ranged from 10-60 feet (Figure 2). No observations in the literature were found for comparison.

Breeding. Griscom and Sprunt (1957) categorized the warbler as a medium forager. Bent (1953) stated that it obtained its food from weed patches, underbrush, and the lower branches of trees. Chapman (1907) wrote that it foraged in a deliberate style, without much fluttering, like a vireo. Burns (in Chapman 1907) noted that it perched near the top and well out in the open, on branchlets of a tree or sapling, to sing.

The height range of this study (10-60 feet) and the even occurrence in the second and third quarters of the trees (Figure 19) agree well with the medium assessment by Griscom and Sprunt (1957). Bent (1953), however, indicated a preference for lower levels. The only mention of branch size was by Burns (in Chapman 1907) who placed it out on branchlets to sing. That would seem to agree somewhat with the twig foraging observed in this study. Although birds do not necessarily always forage where they sing, the Blue-winged Warbler does forage while it sings (Chapman 1907). Chapman's comparison of the Blue-winged to a vireo may or may not place it on somewhat larger branches.

Summary

Stewart and Robbins (1958) noted the Blue-winged Warbler to inhabit the breeding foliage during migration. In Kellogg Forest no vegetative preference was shown. This possibly was due to the small sample size. In this study the Blue-winged foraged at the same general height recorded by Griscom and Sprunt (1957) on the breeding grounds. Bent (1953), however, placed it lower in the breeding season.

Tennessee Warbler

Vegetational preference

Migration. The Tennessee Warbler demonstrated a spruce preference in Kellogg Forest (Table 6). A coniferous preference was not noted in migration by other authors and several even recorded a deciduous tendency. Stewart and Robbins (1958) observed it in various deciduous woods and Stoner (1932) saw it in deciduous treetops in the spring. Forbush (1939) found it wherever there were trees, not only in woods but in cemeteries, orchards, and yards as well. Trautman (1940) observed it in woodlands in the spring and in smaller trees, thickets, and weedy fields in the fall.

Breeding. The Tennessee Warbler breeds in a variety of situations. In Maine and New Hampshire, Brewster (in Faxon 1889) noted it to breed in larch swamps or on mountainsides, but almost always in conifers. In New York, however, Merriam (in Chapman 1907) reported it to generally prefer hardwoods and Thayer (also in Chapman 1907) in New Hampshire, found it in mixed deciduous growth, big elms,

and blossoming apple trees. In British Columbia, Norris (1902) observed the Tennessee nesting in clumps of aspen and Norway pine. Griscom and Sprunt (1957) reported it in somewhat open spruce woods with a herbaceous ground cover. Forbush (1939) found it breeding in damp woods. In New Brunswick, Bowdish and Philipp (1916) recorded nests around open areas in spruce and fir woods where the bigger trees had been lumbered out. Harrington (in Bent 1953) found nests on the borders of black spruce bogs in Ontario, and Henderson (also in Bent 1953) observed the Tennessee to breed mainly in poplar woods in Alberta. MacArthur (1958), in his study of the spruce warblers, noted it to feed on deciduous vegetation.

As with another ground nester, the Black-and-white Warbler, low cover for the nest may be more important than the species of trees overhead. However, generally the Tennessee Warbler is accepted to be a spruce nester (Peterson 1947, Robbins, et. al., 1966) and if considered as such would have selected the breeding foliage at Kellogg Forest.

Winter. The Tennessee Warbler was one of three coniferous breeders that did not frequent conifers in Jamaica (Lack and Lack 1972). Skutch (in Bent 1953) observed it in coffee plantations in Central America and reported that it was the only warbler to eat bananas on the wintering grounds. In Griscom and Sprunt (1957), he reported that it occurred in rain forest at higher elevations but was not restricted to heavy woods.

MacArthur (1958) saw the bird foraging on deciduous vegetation in spruce forests of the north and Lack and Lack (1972) noted it to

frequent deciduous growth on the wintering grounds. Thus, it seems quite at home in non-coniferous vegetation and the deciduous preference in migration noted by several authors (Stoner 1932, Stewart and Robbins 1958) supports this. However, at Kellogg Forest, where the spruce was more available than at most other points along the migratory route, the bird chose the breeding foliage. This is in agreement with Parnell (1969).

Habitat utilization

Migration. The Tennessee Warbler foraged from 20-60 feet on foliage, twigs, and small branches and sang from 40-80 feet in the spruce area at Kellogg Forest (Figures 2 and 7). In the deciduous area it foraged predominantly in the canopy (Table 10) on twigs from 40-85 feet (Figures 2 and 20). In the spring Stoner (1932) and Roberts (1932) observed the Tennessee Warbler well up in the topmost branches of the trees while Trautman (1940) noted it in the upper half of tall trees during migration. Both Roberts (1932) and Trautman (1940) felt it dropped in the fall occurring frequently in smaller trees, thickets, and weedy fields.

Thus, the spring height observations of other authors agree well with the deciduous data and the spruce song data of this study.

Breeding. Griscom and Sprunt (1957) classified the Tennessee Warbler as a medium forager. They observed the male to sing from 5-30 feet either on top of a young conifer or near the end of a branch partway up a larger tree. Chapman (1907) noted it to sing perched on a high dead branch. MacArthur (1958) recorded it from 0-40 feet.

Therefore the bird occurred lower on the breeding grounds than at Kellogg Forest. This may be expected since it nests on the ground. It may have foraged lower in the spruce area of Kellogg, since that is the breeding foliage. The high foraging in migration may occur mainly in non-breeding or deciduous foliage. Chapman's (1907) observation of high singing matched the behavior in the spruce area where the Tennessee sang above the foraging level (Figure 3).

King (in Bent 1953) saw most food being taken from among the terminal foliage. With its small bill the Tennessee was able to get small insects the bigger birds could not. MacArthur (1958) noted it to hop along branches. King's observations agree with the large foliage and twig values in the spruce and deciduous areas of this study, respectively (Figures 7 and 20). MacArthur implied a somewhat different behavior. Instead of concentrating at the end of a branch, the bird occurred more equally along its length. In the spruce area of this study the bird did frequent twigs and small branches as well as foliage (Figure 7), but in the deciduous area there was very little recording inside the twig zone (Figure 20).

Winter. MacArthur (1958) in Costa Rica observed the Tennessee Warbler from 0-50 feet hopping along the branch. Lack and Lack (1972) in Jamaica noted it to take insects off of both small and large leaves. MacArthur thus found it to exhibit the same behavior he noted in the summer, and Lack and Lack observed it out on the end of branches as recorded by King (in Bent 1953) and displayed in this study. MacArthur (1958) did observe the bird a little higher than in the breeding season, a behavior reported in this and other migratory studies.

Summary

The Tennessee Warbler selected the spruce area of Kellogg Forest, its general breeding foliage, as predicted by Parnell (1969). Other migratory and winter data revealed no coniferous preference. This, too, was predicted by Parnell; since the breeding foliage was rare or absent in most cases, no strong selection of any vegetation would be made.

The bird foraged higher in the deciduous area of Kellogg Forest than on the breeding grounds. This was noted by other migratory observers. In the spruce area it sang high and foraged somewhat lower. The lower foraging may reflect a more normal breeding behavior elicited by the breeding foliage. King (in Bent 1953) and Lack and Lack (1972) saw the bird located at the ends of branches in the summer and winter. MacArthur (1958) noted it more along the branches in both seasons. The data of this study agreed with King and Lack and Lack for the most part.

Nashville Warbler

Vegetational preference

Migration. At Kellogg Forest no preference was shown for any of the three vegetations by the Nashville Warbler (Table 6). Forbush (1939) saw it wherever there were trees or bushes and wrote that its favorite haunts were neglected fields and bushy wood edges. Roberts (1932) also found it in almost all bushy and wooded places, in the fall noting it in treetops and weedy fields. Stoner (1932) felt it

preferred coppices of small growth springing up in cut and burned-over areas along wood edges, but observed the bird visiting taller trees and mixed forest as well. Stewart and Robbins (1958) noted it in swamp forest, floodplain forest, and rich moist upland woods. Trautman (1940) found it most numerous in tall woodland trees in the spring and also in taller bushes and saplings in the fall.

The lack of preference in Kellogg Forest, then, matched well with the general occurrence noted by other authors. The Nashville Warbler may prefer shrubs and small trees over any certain plant species (Roberts 1932, Forbush 1939).

Breeding. Griscom and Sprunt (1957) noted the Nashville in two different situations. At the northern part of its breeding range it nested in sphagnum bogs with a sprinkling of conifers, while farther south it occurred in open stands of early second-growth forest where deciduous vegetation mingled with fir. Stewart and Robbins (1958) observed it in bushy cutover spruce bogs, while Wing (1933) found it in spruce and cedar swamps. Thayer (in Chapman 1907) wrote that it could be called Birch Warbler since it was most common in old fields and mountain pastures half covered by small gray birch. He noted that it did not favor dark spruce woods nor big mixed timber, but even there it could be found where there were openings with smaller deciduous growth. In defining the bird's beat he put it mainly in deciduous trees. Brewster (1906) recorded it breeding in dry, somewhat barren tracts covered with gray birch, oak, red cedar, or scattered pitch pine. Stanwood (in Bent 1953) saw it breeding in deciduous growth that had sprung up where evergreens had been cut,

never straying far from evergreen woods and always building the nest in gray birch. Pitelka (1940) found it breeding in oak-hickory woods with fair undergrowth in Illinois and in spruce and cedar bogs and sandy woods of aspen, birch, and Norway pine in northern Michigan. Kendeigh (1945a) observed it singing and feeding in both coniferous and deciduous vegetation.

Thus, there are references to breeding in both deciduous and coniferous areas. The bird is a ground nester so a suitable nest site may depend more on the presence of low growth than on the species composition of the canopy.

Habitat utilization

Migration. In this study the Nashville Warbler foraged primarily in the deciduous canopy (Table 10), from 30-60 feet (Figure 2), on twigs and small branches (Figure 18). Trautman (1940) noted it in the upper half of large trees in the spring and in the mid-section of tall trees and on taller bushes and saplings in the fall. Barrows (1912) observed it well up in the trees during migration. So the 30-60-foot range in Kellogg matches well with at least the spring observations of other authors. The bird may forage lower in the fall.

Breeding. Griscom and Sprunt (1957) classified the Nashville as a medium forager. Kendeigh (1945a and 1945b) described its beat as dry sunlit ground and saw it singing from 15-30 feet along forest edge. Thayer (in Chapman 1907) observed it from the ground to the tops of lower trees, the song perch being located in the upper story

of those trees. Bent (1953) wrote that it foraged mainly in the lower story of open woodlands and more often in low trees and shrubs around forest borders.

Thus, the Nashville Warbler occurred lower on the breeding grounds than at Kellogg Forest and other points along the migratory route (Barrows 1912, Trautman 1940). Like the Tennessee Warbler, another ground nester, it may be restricted to the lower levels of the forest only in the breeding season. There was nothing in the literature to compare with the twig and small branch feeding observed in Kellogg Forest.

Summary

No vegetational selection was shown by the Nashville Warbler at Kellogg Forest (Table 6). This agreed with other migratory sources. The bird appeared, rather, to seek out low trees and shrubs. In the breeding season, also, that seemed more important to the bird than the species of trees. Like the Tennessee Warbler, another ground nester, it foraged higher in spring migration than during the nesting period, frequenting the upper half of the canopy. In Kellogg Forest it foraged on twigs and small branches.

Magnolia Warbler

Vegetational preference

Migration. In this study the Magnolia Warbler exhibited spruce selection (Table 6). Stewart and Robbins (1958) noted the bird in various deciduous and coniferous stands, most often in those with an

understory. Stoner (1932) observed it in larger mixed and hemlock woods, Barrows (1912) in orchards and gardens, and Forbush (1939) in deciduous as well as coniferous areas once the trees had leafed out. Brewster (in Chapman 1907) noted the Magnolia in damp places such as thickets and in upland pines in the spring and on hillsides of scrub oak and scattered birch in the fall.

There are a few instances of a coniferous preference from the aforementioned authors (Stoner 1932; Forbush 1939; Brewster, in Chapman 1907); however, the bird certainly was not averse to using other foliage. Forbush (1939) points out the possibility that the spruce tendency may lessen in the latter stages of the migratory period as the deciduous trees leaf out. However, this would not explain the bird's absence from the pine area at Kellogg Forest which is also evergreen. The observations of Stewart and Robbins (1958) raise the question of why a stronger deciduous preference was not shown since the deciduous areas of Kellogg Forest composed the one area with a substantial understory.

Breeding. All authors mention conifers, and almost all mention spruce. In fact, Thayer (in Chapman 1907) said the bird should be named Spruce Warbler. He found it breeding in second-growth spruce woods, especially in combination with upland pasture in New Hampshire. Bent (1953) listed fir and spruce and in New York and Pennsylvania, a preference for hemlock. Cruickshank (1956) found nests only in spruce and fir in Maine. Stewart and Robbins (1958) noted the bird in hemlock, red spruce, and mixed mesophytic stands with a coniferous understory. Kendeigh (1945a) stated that the flat horizontal sprays

of a conifer are needed to support the Magnolia's nest. Morse (1968) found the bird in disturbed areas--deciduous, mixed, or coniferous--more so than in spruce forests. Morse (1970), in Maine, noted the bird foraging 75% of the time on conifers in a mixed area.

The literature then concurs very closely in most instances with the preference observed in this study. This would support Parnell's (1969) hypothesis.

Winter. In Jamaica, Lack and Lack (1972) noted the Magnolia Warbler in trees with broad, thin leaves. It was one of three coniferous breeders observed not to prefer conifers there. This agrees with the frequency of non-coniferous foraging noted by other authors during migration.

The lack of specific preference in migration, noted by several other authors, is in agreement with Parnell (1969) who felt that if the breeding foliage were not available, the bird would show little preference for any vegetation. Over most of the Magnolia's migratory range, spruce and hemlock are either absent or restricted to mountaintops and isolated bogs. In Kellogg Forest the Magnolia had the option of choosing spruce and did. Also, in New York, where hemlock was common, Stoner (1932) noted a preference for it.

The Magnolia Warbler may also be attracted by low trees or an understory layer. This was indicated by Stewart and Robbins' (1958) migratory and breeding observations, Thayer's (in Chapman 1907) observations in the fall, Morse's (1968) mention of its occurrence in disturbed areas where lower vegetation would exist than in the spruce forest, and possibly Lack and Lack (1972) although the winter areas

were not described in detail. Bent (1953) and Kendeigh (1945b) mentioned the Magnolia's tendency to avoid dense forest and the fact that it haunts the lower level of woods. MacArthur (1964) proposed that the vertical profile of the vegetation in an area may be more important to a bird than the species of plants. This may explain some of the non-coniferous winter and migratory observations. However, when spruce itself is present, as in this study, the attraction for a preferred profile may be preempted. Thus, the bird selected the spruce rather than the deciduous area in Kellogg Forest. It is not surprising that the pine area was not frequented since it neither is a breeding foliage nor possessed a significant understory.

Habitat utilization

Migration. In this study the Magnolia Warbler exhibited two different behaviors. It was a subcanopy bird in the deciduous area ranging from 0-30 feet in height (Table 10 and Figure 2) and in a small sample occurred predominantly on small branches (Table 11). In the spruce area it occurred from 20-60 feet in the canopy and frequented foliage, twigs, and small and large branches (Figures 2 and 4). The deciduous behavior matched well with that of other authors. Trautman (1940) noted the Magnolia chiefly in the shrub layer of forests but sometimes in the upper branches of tall trees. Parnell (1969) recorded it 77% of the time in low trees. Bent (1953) mentions that it avoided taller treetops in the spring preferring lower levels. In the spruce area of this study, the bird occurred higher than was indicated by other authors.

Parnell (1969) placed the Magnolia Warbler in the inner crown. The small branch observations from the deciduous area at Kellogg and the small and large branch values of the spruce area would fall in that zone. (His categories were top, inner, and lower crown.) However, in the latter area the bird extended outward also.

Breeding. Griscom and Sprunt (1957) categorized the Magnolia as a medium forager, ranging from 10-45 feet; however, they mentioned Saunders calling it a treetop warbler in New York. Thayer (in Chapman 1907) described the beat of the Magnolia as from the tip to the lower branches of second-growth spruce. Bent (1953) stated that the bird preferred low hemlock thickets and haunted the low levels of the forest, while Kendeigh (1945a), though listing the bird's range as 10-45 feet, classed it as a low-level evergreen inhabitator. Morse (1967a, 1967b) noted the Magnolia to forage lower than the Black-throated Green Warbler and recorded it from 0-45 feet in the first study.

Griscom and Sprunt's (1958) medium height classification agrees well with the spruce data of this study, although their figures were somewhat lower. This may apply to Thayer (in Chapman 1907) and Morse (1967b) also. Kendeigh (1945a) and Bent (1953) classed the bird as low, agreeing with the deciduous results of this study. Thus, the deciduous behavior agreed with some authors and the spruce, to a degree, with others. Referring back to MacArthur's (1965) vertical profile, discussed in the section on vegetative preference, the Magnolia's attraction for spruce may override its attraction for understory if spruce is available. Since an understory is absent from the

spruce area of this study, the normal height of the Magnolia may be altered somewhat and its range extended upward. While Morse (1967a) stated that the Black-throated Green Warbler was located above the Magnolia, they occurred in the same height range in the spruce area of this study (Figure 2). Since the Black-throated Green is not selecting any one foliage in Kellogg Forest and may not be displaying territorial aggression at this time of year, there may not be the downward pressure on the Magnolia that exists in the breeding season. This, too, may result in the upward extension of the Magnolia in the spruce area. In the deciduous area a subcanopy and understory were present allowing the bird to behave normally. Also, it may not be able to take advantage of the lessened pressure as in the spruce area. Morse (1970) noted that the Golden-crowned Kinglet was more restricted in its feeding zone on deciduous vegetation than coniferous since it is adapted to foraging in conifers.

Thayer (in Chapman 1907) reported that the Magnolia Warbler was seen less on outer twigs than the Black-throated Green Warbler, sticking to the inner recesses of the spruce clumps. Parnell (1969) found it in the inner crown in all strata. Morse (1967b) noted it 10% of the time on spruce tips and 46% on twigs. Morse (1970) in the conifers of a mixed area recorded it 30% of the time in the "tip" category and 25% in the "out" category. In the deciduous trees of the mixed area he found it to frequent "tips".

In this study the Magnolia appeared to forage inside the Black-throated Green in the deciduous subcanopy, the normal breeding relationship noted by Thayer (in Chapman 1907) and Morse (1967b). (See

Table 11 and Figure 13). The preference for small branches matched well with Parnell's (1969) results. Morse (1970) found the bird out more on "tips" in deciduous vegetation. In the spruce area, while foraging frequently in the inner tree, the bird predominated on the "tips" differing with the observations of Morse (1967b) and Thayer (in Chapman 1907, see Figure 4). Interestingly, the 30% "tip" and 25% "out" figures from Morse (1970) correspond well with the foliage and twig values of the spruce area in this study (Figure 4). The bird may be out farther in the spruce area of Kellogg Forest due to a lack of pressure from the Black-throated Green, as discussed in relation to height. In Morse (1970) the similarity of the Black-throated Green and Magnolia's foraging zones was noticeable. The data were taken from a mixed area where competitive pressure may be less than in a pure stand, the diversity of the environment allowing species to avoid overlap and confrontation more easily. Thus, in Morse (1970) and this study, where pressure on the Magnolia Warbler may have been lessened, the resulting behavior was very similar. The reason the Magnolia did not move outward in the deciduous trees may also be the same as that hypothesized for height- -the bird is better adapted to spruce and thus more restricted in the deciduous vegetation.

Winter. Lack and Lack (1972) found that the Magnolia Warbler feeds in the same zone in the winter as in the summer, frequenting the lower half of trees. This concurs with the migratory data of other authors and the deciduous data of this study, as well as with the breeding behavior observed by Bent (1953) and Kendeigh (1945a).

Summary

In this study the Magnolia Warbler selected the spruce area, just as Parnell (1969) predicted a spruce breeder would if given the opportunity in migration. Other authors, while at times finding a coniferous preference, suggest that areas with an understory or small trees may be attractive to the migrating and wintering Magnolia as well. Where spruce itself was available, as in this study, the desire for low vegetation may be preempted. The spruce bond may weaken when deciduous trees leaf out.

The Magnolia behaved as in the breeding season in the deciduous area at Kellogg Forest and in other migratory and wintering observations. In the spruce area of this study the bird foraged higher and out farther than in the breeding season. Possibly there is less pressure from other species in the non-breeding season and the bird, being adapted to conifers, was able to extend its feeding zone. Also, an understory was absent in this area, and the Magnolia's height may have been altered.

Cape May Warbler

Vegetational preference

Migration. The Cape May Warbler was not observed frequently in this study. The small sample yielded no significant differences in foliage preference (Table 6). However, the bird was only seen once in the deciduous area in ten sightings and may have been selecting conifers. Only one other source reported a coniferous preference

in migration. Stewart and Robbins (1958), while seeing it in various forests, noted a general preference for young pine. Butler (in Chapman 1907) saw it in oak woods and shade and fruit trees; Forbush (1939) observed it in the trees and shrubs around houses as much as in the woods; Barrows (1912) mentioned a preference for trees in blossom; and Trautman (1940) noted it in remnant swamp forest and flowering fruit trees.

Breeding. The Cape May Warbler is a spruce breeder. All nests reported by Bent (1953) were in that foliage. Griscom and Sprunt (1957) placed it in fairly open coniferous woods with a good percentage of mature spruce. Maynard (in Chapman 1907) found it in coniferous trees in Maine. These were probably spruce also. The author could find no records in the literature of nesting in pine by the Cape May Warbler. Thus, the possible coniferous preference shown in this study would agree partially with the breeding foliage. If a larger number of observations were made at Kellogg Forest, a preference for spruce over pine may have been revealed.

Winter. The Cape May Warbler was not noted to frequent conifers in Jamaica, but instead to inhabit deciduous growth (Lack and Lack 1972). It was one of three northern coniferous breeders to do so. Bond (1957) saw little preference in the West Indies, except an avoidance of rain forest. Eaton (1953) observed it usually around bromeliads or trees in flower in Cuba. Maynard (in Bent 1953), also in Cuba, reported the same behavior. Barbour (also in Bent 1953) noted a tendency for scrub growth and thickets around gardens in the Bahamas.

According to other migratory and wintering sources, the Cape May Warbler showed no tendency to select coniferous foliage in the non-breeding season. Only the pine preference in migration, noted by Stewart and Robbins (1958), supported the interpretation of this author. Parnell (1969) would expect no strong preference to be shown for any vegetation over most of the migratory range since the breeding foliage is generally rare or absent. However, the Cape May is somewhat more versatile than most warblers. Along with its flycatching ability, it possesses a semitubular tongue for nectar feeding and a liking for fruit. Rather than displaying no preference in migration, it tended to seek out orchards and blossoming trees. In a sense, it leads a dual existence; haunting the higher outer portions of spruce in the breeding season and frequenting the flowers and fruits of gardens and orchards at other times of the year. When the opportunity to forage in spruce during migration did present itself at Kellogg Forest, the Cape May selected conifers. This was at least partly in accordance with Parnell (1969).

Habitat utilization

Migration. In the spruce area of Kellogg Forest the Cape May Warbler foraged on foliage in the third quarter of the trees (Figure 6) from 40-60 feet above the ground (Figure 2). Several other authors also reported high foraging. Roberts (1932) saw it mainly in the treetops as did Forbush (1939) in the autumn. Thayer (in Chapman 1907) reported that it acted much like the Blackburnian. However, Trautman (1940) in the spring observed it from the base to the top of dying

trees, Butler (in Chapman 1907) reported that it kept in the lower branches in oak woods or upon high bushes and small trees, and Chapman (1907) saw it feeding in weedy fields in Florida. So not all observers noted a preference for the upper tree.

Parnell (1969) recorded the Cape May Warbler much more in the inner than the top of the crown in the canopy and equally on both in the low trees. This does not agree with the heavy foliage preference in the spruce area of this study, but much of Parnell's data may have been from deciduous sources. Most of the migrant warblers in this study foraged more peripherally in spruce than in deciduous vegetation.

Breeding. The heights at which the bird occurred on the breeding grounds are much more consistent with the results of this study. Griscom and Sprunt (1957) categorized it as high although noting it to drop occasionally. Bent (1953) reported all nests up near the top of spruces and cited from Brewster the bird's habit of singing from the highest pinnacle of a giant spruce or fir. Maynard (in Chapman 1907) stated that it lived in the top of high conifers and MacArthur (1958) observed it to feed more consistently in the tree-tops than any of his species except the Blackburnian Warbler. MacArthur also noted the Cape May to move vertically instead of horizontally, keeping to the outside of the tree. This matches very well with the strong foliage preference obtained in this study (Figure 6).

Winter. Lack and Lack (1972) observed the Cape May Warbler in the upper level of deciduous trees in Jamaica, a similarity in height to this study and the breeding grounds. It was also noted to

forage in the same manner horizontally as described by MacArthur (1958) in the breeding season. However, Bond (1957) recorded the bird in lower as well as upper tree levels in the West Indies and the flower feeding in gardens and plantations mentioned previously (Eaton 1953; Maynard and Barbour, both in Bent 1953) would place the Cape May at a lower level than was noted by Lack and Lack.

In the winter in Jamaica and at Kellogg Forest the Cape May Warbler foraged at a similar height and manner as on the breeding grounds. Other migratory and wintering observations showed the Cape May to behave differently. The similarity of behavior at Kellogg Forest to that of the breeding grounds may be due to the bird still being in coniferous vegetation. The similarity in Jamaica may be due to great competitive pressure (Lack and Lack 1973, see also Black-throated Green Warbler) causing the Cape May to retreat to that foraging zone for which it is best adapted. In other vegetations and areas the behavior was not so stereotypic although a preference for treetops in migration was still noted by several authors.

Summary

Statistically the Cape May chose none of the three vegetations at Kellogg Forest. The author believes, however, that it may have been selecting conifers. This would agree, at least partially, with Parnell (1969). The frequency in the pine area may be due to the small sample size. A coniferous preference was not noted from other migratory (with one exception) or wintering sources where spruce was

absent or restricted. Rather the bird appeared to select fruit and flowering trees.

The Cape May Warbler at Kellogg Forest foraged as in the breeding season, probably because it was still in coniferous vegetation. In the winter in Jamaica it did also, possibly a result of competition. In other vegetations and areas in the non-breeding season its flycatching ability, semitubular tongue, and liking for fruit released it from its rather narrow zone of occurrence on the breeding grounds.

Myrtle Warbler

Vegetational preference

Migration. A deciduous preference was shown by the Myrtle Warbler in Kellogg Forest (Table 6). Other observers saw no preference in migration. Trautman (1940) found it in almost every type of habitat, Stewart and Robbins (1958) noted it in various forest types and Parnell (1969) detected no selection, although the highest birds per hour values occurred in two deciduous categories, beech and oak-hickory forests. The first (beech) had a value almost twice as high as the third (a pine-oak mixture).

Breeding. The Myrtle Warbler is a coniferous nester. Chapman (1907) and Bent (1953) spoke generally of conifers, although Harrington (in Bent 1953) mentioned white pine in Ontario. Cruickshank (1956) found nests in spruce and fir in Maine. Morse (1971) noted the Myrtle to use deciduous vegetation about as much as predicted by chance on some small Maine islands. However, Morse (1970) in a mixed

area of Maine noted the Myrtle to forage 99% of the time on conifers.

Winter. Stewart and Robbins (1958) in Maryland found the Myrtle in floodplain forest, swamp forest, and red cedar thickets. Allison (in Chapman 1907) observed it in open woods, usually not coniferous, in Louisiana. Also in Louisiana, Morse (1967c) noted it about 70% of the time on deciduous and 30% on pine growth in a mixed area, while Morse (1970) noted approximately 50% deciduous usage in a pine area and 45% deciduous in a mixed stand. Bond (1957) in the West Indies found little restriction in habitat.

The coniferous preference of the breeding season was not carried over into the other parts of the year. No preference was found by other authors in migration and in several instances a deciduous preference was exhibited in the winter. The Myrtle, then, may be restricted to conifers in the breeding season only because of mechanics such as nest support. When foraging, it may select food source rather than vegetation type. The frequency of foraging on deciduous vegetation in the breeding season, noted by Morse (1971), supports this. However, Morse (1970) may indicate the opposite, the foraging being done almost entirely on conifers. The lack of coniferous selection by the Myrtle Warbler in Kellogg Forest agrees with other migratory data and the deciduous preference exhibited is not surprising in light of the winter observations. Parnell's (1968) birds per hour values may also reveal a deciduous preference in migration. The deciduous area at Kellogg may present a more plentiful source of food to the Myrtle than the spruce or pine.

Habitat utilization

Migration. In the deciduous area of Kellogg Forest the Myrtle Warbler favored the canopy (Table 10) ranging from 20-60 feet (Figure 2) and concentrating on twigs, although occurring also on small and large branches (Figure 15). Thayer (in Chapman 1907) noted it everywhere--high and low, from the ground and low bushes to the treetops. Roberts (1932) stated that it was very active during migration spending much time probing crevices in the bark, flycatching, and hunting on or near the ground. Ficken and Ficken (1962) also observed it on the ground and foraging on tree trunks. Parnell (1969) recorded the Myrtle 53% of the time in the canopy and 40% in low trees. It foraged from 24-38 feet and sang from 14-26. The bird occurred fairly evenly between the inner, top, and lower crowns.

The Myrtle Warbler appeared to forage higher at Kellogg Forest than was noted by other authors, with fewer observations on the ground (Roberts 1932, Ficken and Ficken 1962) or in the subcanopy (Parnell 1969). The trunk foraging recorded by Ficken and Ficken (1962) was not observed in this study.

Breeding. Griscom and Sprunt (1957) classified the Myrtle as medium in height although mentioning that it would feed almost anywhere. MacArthur (1958) stated that it had the widest feeding zone of the five species in that study and quoted Kendeigh's distribution of the ground to the tops of trees. However, most of the ground foraging did not occur until food was being obtained for the young. Morse (1967b) observed it from 0-45 feet and with Morse (1971 and 1967a) placed it below the Black-throated Green in the tree. In

Morse (1970) the Myrtle predominated in the "low" category (30 feet and under) in both spruce and mixed areas.

The height classification of Griscom and Sprunt (1957) agrees with the behavior noted in this study. If most ground feeding in Kendeigh (in MacArthur 1958) and Morse (1967b) did not occur until the young were being fed, their height ranges may not deviate greatly from the results of this study. The Myrtle did not feed below the Black-throated Green in Kellogg Forest as in Morse (1967a, 1967b, and 1971) but occurred at the same height (Figure 2). A lessening of competitive pressure in migration, as discussed with other species, may be a factor here. Also the two species may not behave the same in deciduous as in spruce vegetation.

In the spruce forest the Myrtle Warbler exists by utilizing space not claimed by the Black-throated Green, Magnolia, and Black-burnian Warblers (Morse 1969). It maintains a constant low population with large individual territories. In accordance, the Myrtle had the least specialized and most flexible feeding habits of the five species in MacArthur's (1958) study and, as mentioned, the largest height range. It foraged nearly equally in tangential, radial, and vertical directions with no correlation being found between the insect species eaten and any particular area of the tree. Bent (1953) noted the Myrtle mostly on large branches, while Morse (1971) saw it most often on small limbs (his other categories were tip and large). Morse (1970) found the Myrtle slightly more often in the "out" category than on "tips" in a Maine spruce area, whereas on the coniferous vegetation of a mixed area it preferred "tips". Morse (1967b)

did not support a strong "tip" preference since the Myrtle was seen to compete less with the Parula Warbler (a foliage gleaner) than some other warbler species. He observed it pretty evenly on tips, small twigs, and the proximal part of branches. Griscom and Sprunt (1957) alluded to a tip or twig preference stating that the Myrtle prefers sunny outer branches.

Besides Bent (1953), most of the observations placed the Myrtle out on tips and twigs. The large twig figure of this study (Figure 15) corresponds well with those results although the bird did frequent small and large branches and therefore agreed somewhat with Bent also. Perhaps the flexibility mentioned by MacArthur (1958) is exhibited here. The low tip (or foliage) values of this study may be due to recording differences between deciduous and coniferous vegetation or there may be a tendency to forage less peripherally in deciduous vegetation.

Winter. Lack and Lack (1972) saw only a few individuals in Jamaica. They suggested that the Myrtle might compete with the Black-throated Green and Cape May Warblers, but it is bigger and did not feed as frequently in terminal twigs. Its feeding behavior was the same as that described by MacArthur (1958) in the summer. Morse (1970) reported it in Louisiana predominating in the "out" category in deciduous, mixed, and pine areas. In all of those but the pine of the mixed area it foraged low (under 30 feet). In the system of categories devised by Morse (tip, out, in, trunk) the "out" corresponds well to the twig bracket of this study with possibly some overlap into the small branch range. Therefore, both Morse (1970)

and Lack and Lack (1972) agree with the concentration on twigs and a degree of small and large branch foraging that was noted in Kellogg Forest. Heightwise, however, the bird foraged higher in Kellogg than was observed by Morse (1970).

Summary

In Kellogg Forest the Myrtle Warbler selected deciduous vegetation instead of the coniferous foliage in which it breeds. Other authors saw no coniferous preference in migration. Several noted a deciduous preference in the winter. The bird may be restricted to conifers only for purposes of nest building. At all other times, with its general feeding habits, the Myrtle may simply go to wherever the best food sources are.

The Myrtle appeared to forage higher at Kellogg than was noted by other authors in migration and on the breeding grounds. Griscom and Sprunt (1957), however, classified it as medium and MacArthur (1958) stated that most ground feeding did not occur until young were being fed. Most breeding data placed the Myrtle on foliage and twigs. In Kellogg Forest it frequented twigs but not foliage and ranged in somewhat farther. This may be due to differences in the recording of data between the spruce and deciduous vegetation or the bird may behave differently in each. The Myrtle also ranged high when compared to winter data but otherwise foraged the same.

Black-throated Green Warbler

Vegetation preference

Migration. No preference was demonstrated by the Black-throated Green Warbler in Kellogg Forest (Table 6). This agrees well with the observations of other authors. Forbush (1939) observed the bird in all kinds of trees during migration. Stewart and Robbins (1958) noted it in various deciduous types, and Stoner (1932) observed it often in hardwoods during the spring. Chapman (1907) stated that it occurred almost anywhere, a coniferous preference not being exhibited until the breeding grounds were reached.

Breeding. The Black-throated Green is generally a coniferous nester although it will forage and occasionally nest in deciduous vegetation. Stewart and Robbins (1958) listed hemlock, mixed deciduous-coniferous, and mixed deciduous growth as breeding foliages. Chapman (1907) stated the bird usually nested in conifers, although at times would select an alder or birch. Thayer (in Chapman 1907) specified white pine. Bent (1953) associated it with pine, however mentioning that at higher altitudes and latitudes it became a spruce and fir nester. He felt that it did so only because of the unavailability of pine, citing the experience of Knight in Maine. Bent also gave examples of nests in deciduous trees. Kendeigh (1945a) found the Black-throated Green to prefer hemlock and occur only infrequently on deciduous vegetation. Griscom and Sprunt (1957) noted it in remnant stands of mature pine, hemlock, and maple while Cruickshank (1956), in Maine, located nests almost exclusively in conifers. In

the Great Smoky Mountains National Park the Black-throated Green nests in hemlock at lower and spruce-fir at higher elevations (Stupka 1963). Morse (1970) observed the Black-throated Green foraging 40% of the time on deciduous vegetation in a mixed area in Maine. Morse (1971), on small islands, recorded it on deciduous foliage about as much as would be expected by chance.

The occasional nesting in deciduous vegetation mentioned by several authors and the frequency of foraging in deciduous growth revealed by Morse (1970 and 1971) make the lack of preference shown in this study appear very reasonable. The ability to adapt to the changing flora of the central Allegheny Mountains, as discussed by Brooks (1940), may be further evidence of the Black-throated Green's flexibility. The selection of pine over spruce, discussed by Bent, was not demonstrated here.

Winter. Lack and Lack (1972) noted that in the lowlands of Jamaica the Black-throated Green fed in trees with small leaves. In the mountains, it and the Yellow-throated Warbler selected pine, and it was the only warbler to frequent juniper. Thus, it appears that, at least in the mountains, a coniferous preference is demonstrated in winter. Possibly, in the lowlands the small-leaved deciduous trees physically resemble coniferous foliage to the warbler.

Lack and Lack (1972) supply clues for this return to the breeding foliage in Jamaica. They indicate that the resources of Jamaica are finely divided among the birds in the winter. For example, on the forest floor the Swainson's Warbler probes in the leaf litter for food while the Ovenbird picks insects from the surface of the

leaves. The fact that the Yellow Warbler, a resident, is forced into the mangroves when the wintering warblers appear points to a high level of competition. Each species, resident and winter visitor, seems to have a specific, individual zone in which it feeds. In the lowlands the Black-throated Green Warbler frequents small-leaved trees in secondary woods, feeding at the tips of branches. The Prairie Warbler, the most common leaf gleaner in the lowland forest, except for good secondary woods, prefers this same type tree and also feeds at the ends of branches. The Black-throated Green does forage higher than the Prairie, but the fact that it is found much more in the mountains than the lowlands, where the Prairie Warbler occurs, may indicate that it has been forced out by this species. In the mountains it frequents pine with the Yellow-throated Warbler and juniper by itself. Even in the pine, the feeding zones are finely divided, the Black-throated Green picking insects off the tips of the needles and the Yellow-throated removing them from the bases. Strong competition in Jamaica, therefore, may be forcing the Black-throated Green to retreat to the foliage for which it is best adapted--conifers.

Habitat utilization

Migration. In this study the Black-throated Green Warbler was primarily a canopy bird, occurring from 20-60 feet in height in the deciduous area (Table 10 and Figure 2). It was noted most frequently on twigs and small branches in this strata while in the subcanopy it occurred more exclusively on twigs (Figures 12 and 13). The height

range for song was the same as that used in foraging although the average song height was higher (Figures 2 and 3).

Trautman (1940) recorded the Black-throated Green mainly in the upper parts of trees. Roberts (1932) noted that it did not confine itself to treetops before the deciduous vegetation leafed out, while Forbush (1939) wrote that the Black-throated Green obtained insects from the lower branches to the tops of trees. Forbush (1939) probably agrees best with the medium height obtained in this study, although there is no contradiction with the other authors. The preference for the upper tree mentioned by Trautman and Roberts may be reflected in the third quarter of the canopy and the fourth quarter of the subcanopy having the highest values even though the Black-throated Green ranged pretty evenly throughout the mid-heights of both strata (Figures 12 and 13).

Breeding. Thayer (in Chapman 1907) observed the Black-throated Green from the tops of mid-sized trees to the bottom branches. Bent (1953) wrote that most of the bird's time was spent gleaning in the treetops. MacArthur (1958) observed it at mid-levels while Kendeigh (1945a) noted it from 20 to 60 feet and categorized it as a mid-level evergreen inhabitator. Griscom and Sprunt (1957) placed the Black-throated Green at medium heights, although stating it would occasionally range higher. In Morse (1967b) it ranged from 0 to 65 feet, and in Morse (1970) most often under 30 feet.

There are some rather striking agreements in height between this study and others. Kendeigh's (1945a) height range corresponds exactly to Figure 2 and both he, Griscom and Sprunt (1957), and

MacArthur (1958) categorized the bird as medium in height. Chapman's (1907) description is not dissimilar. The top limit in Morse (1967b) was also about 60 feet; however, the bottom limit extended to the ground. This may have occurred at the time young were being fed and competition for resources was most severe. The low height noted in Morse (1970) may have been caused by the presence of the Blackburnian Warbler combined with the relatively low height of the forest (about 66 feet). The Blackburnian, which forages above the Black-throated Green, shows a high level of aggression towards it and may keep it from expanding upwards (Morse 1967a). Bent (1953) wrote that the Blackburnian is subdominant to the Black-throated Green and only occurs with it in large old trees where a gap can exist between the feeding zones of the two. However, the trees observed by Morse were not particularly high and the ability of the Blackburnian to establish itself may indicate that if the Black-throated Green is dominant, it is not totally so. The treetop preference mentioned by Bent (1953) and the commonness of high foraging alluded to by Chapman (1907) and Griscom and Sprunt (1957) may be reflected in the high quarter three canopy and quarter four subcanopy figures, as discussed under the previous section on migration.

MacArthur (1958) wrote that the Black-throated Green was the only warbler of his study to sing frequently while feeding. This corresponds well with the synonymous song and forage ranges of this study (Figure 2). Griscom and Sprunt (1957) noted the bird to sing at intermediate and upper levels in the forest, shifting upward from the medium foraging height. In this study the Black-throated Green

also sang at intermediate levels and the average song height was above that of foraging (Figure 3). However, the bird did not seem to extend as far up to sing as in Griscom and Sprunt. Possibly the deciduous area of Kellogg Forest is open enough to allow the Black-throated Green to drop somewhat to sing, a behavior noted by Griscom and Sprunt.

Knight (in Bent 1953) wrote that the Black-throated Green Warbler obtained its food from the limbs and foliage of evergreens and that it spent much of its time gleaning foliage in the tops of coniferous and deciduous trees. MacArthur (1958) stated that it liked the mats and buds of white spruce and moved tangentially around the tree, staying within that zone. Morse (1971), on spruce vegetation, recorded the bird most often on small branches, as opposed to large branches and tips. Morse (1967b) recorded the bird 38% of the time on twigs and 26% on tips in a spruce area. He found that it used tips more than any of the other *Dendroica* Warblers present including the Magnolia, Myrtle, and Blackburnian. In Morse (1970) the "tip" and "out" categories were very equal in the spruce area and on spruce growth in the mixed area. In the deciduous vegetation of the mixed area it occurred most frequently on "tips".

The concentration on small branches in the spruce area noted by Morse (1971) agrees well with the twig figures of the deciduous canopy and subcanopy in this study (Figures 12 and 13). (He had only three categories--tip, small branch, and large branch--as opposed to the four of this study.) Morse (1967b), Morse (1970), Knight (in Bent 1953), and MacArthur (1958) all appear to have the

bird out farther than was observed in Kellogg Forest. However, in the case of the subcanopy, the heavy twig figure may point to a simple difference in the recording of data between coniferous and deciduous vegetation. In the canopy the fair small and large branch figures indicated the Black-throated Green did forage in on the tree farther than the other authors observed.

Winter. MacArthur (1958), in Costa Rica, noted the Black-throated Green Warbler to hop across branches rather than along them, maintaining the same tangential movement exhibited in the breeding season. Lack and Lack (1972) found the bird to behave the same in the winter as in the summer. They recorded it usually at the tops or out on tips of taller trees in the lowlands. In the upland pines it picked insects off the tips of the needles while the Yellow-throated Warbler got those at the needle bases. So again, as in the breeding season, the Black-throated Green was out on the periphery of the tree.

Summary

The Black-throated Green Warbler demonstrated no preference for any foliage in the spring or fall while migrating through Kellogg Forest. This is not surprising since the bird nests commonly in spruce and pine, occasionally in deciduous vegetation, and frequently forages in deciduous growth during the breeding season. However, it appears that in the winter a coniferous preference reestablishes itself, at least in the uplands of Jamaica. This may be due to a greater amount of competition than is experienced during the

migration period.

The heights frequented in this study agree well with other migratory observations and the breeding behavior. In the deciduous subcanopy the Black-throated Green foraged as in the breeding season, utilizing the end of branches. However, in the canopy the bird seemed to forage in somewhat farther.

Blackburnian Warbler

Vegetational preference

Migration. Statistically no vegetational preference was revealed by the Blackburnian Warbler in this study (Table 6). However, the fact that it was never seen in the pine area leads the author to suspect that the Blackburnian may have been avoiding the pine. Several other authors support this contention while one does not. Stewart and Robbins (1958) noted it in various deciduous types and Stoner (1932) believed it was partial to hardwoods. Bent (1953) stated that it frequented treetops in deciduous forests. Brewster (1906) noted a decided preference for hemlock and white pine in Massachusetts. Trautman (1940), in Ohio, observed it most often in larger remnant swamp forests.

Breeding. A strong spruce and hemlock preference was indicated by all sources. Stewart and Robbins (1958) placed it in red spruce, hemlock, white pine, and mixed mesophytic stands. Thayer (in Chapman 1907) observed that in New Hampshire it particularly liked hemlock and haunted deep mixed growth; while in Minnesota, Preston (also in Chapman 1907) found that it favored black spruce. Kendeigh (1945a)

noted it only rarely in deciduous growth and stated that it was the most strictly confined to hemlock of all species in that region. Bent (1953) recorded it in deep evergreen woods dominated by spruce, fir, and hemlock. In New York and Pennsylvania hemlock was the favorite vegetation, while in Massachusetts Brewster (1888) found it wherever there were spruce in numbers, whether mixed or pure. Brewster also noted that in Massachusetts it shunned the extensive tracts of white pine that the Black-throated Green Warbler preferred. Stupka (1963) in the Smokies found it breeding in spruce-fir forests on the highest summits. Cruickshank (1956), in Maine, found nests in spruce and fir while Morse (1970), in a mixed area, recorded the bird foraging at least 65% of the time on conifers.

A contradictory picture is presented of the bird's behavior in migration. One author (Brewster 1906) saw it seek out the breeding foliage (hemlock), while several others did not (Stewart and Robbins 1958, Stoner 1932). In this study there was no greater preference for spruce than for deciduous growth. Thus, at Kellogg Forest, at least, the Blackburnian Warbler did not follow Parnell's (1969) hypothesis.

The pine data are confusing. While Brewster (1906) found a preference for it and hemlock during migration, in an earlier study (1888) he observed that extensive tracts of pine were avoided in the breeding season. Only Stewart and Robbins (1958) mention pine as a breeding foliage. Therefore, in light of the deciduous preference noted by several authors in migration, only single references to breeding and migrating in pine, and Brewster's (1888) comment of pine

avoidance during the breeding season the author's interpretation of pine avoidance in Kellogg Forest does not seem unfeasible. During this study the pine area of Kellogg Forest had the lowest number of warblers per hour and, with the exception of the first spruce area, the lowest number of total warblers (Table 8). The possible reasons for this are discussed under "Comparison of the Study Areas at Kellogg Forest".

Habitat utilization

Migration. In Kellogg Forest the Blackburnian Warbler foraged in the upper portions of the deciduous canopy, ranging from 40-60 feet (Table 10 and Figure 2). It was recorded most often in the third quarter of the trees frequenting twigs and small branches (Figure 16). This preference for the upper tree was noted by other authors. Bent (1953), Forbush (1939), and Stoner (1932) all commented on the Blackburnian's selection of treetops during migration. Roberts (1932) stated that it occurred chiefly in treetops but could be found elsewhere, too, and Trautman (1940) observed it in trees from 10-60 feet and occasionally in taller thickets.

Breeding. Griscom and Sprunt (1957) categorized the Blackburnian as high and noted that it often sang perched at the summit of a tree. Chapman (1907) wrote that it spends most of its life high above the ground. Kendeigh (1945a) observed it from 35-75 feet and defined its beat as the top level of evergreens. Cruickshank (1956), in Maine, found all nests above 40 feet and Morse (1967b) found the bird to forage from 35-65 feet. Morse (1970) noted the Blackburnian to forage

high (over 30 feet) in a coniferous area but in a mixed area it foraged most often under 30 feet, both in coniferous and deciduous foliage. Morse (1967a, 1967b) observed the Blackburnian to forage above the Black-throated Green Warbler.

The heights observed at Kellogg Forest agree well with those of other authors. Kendeigh's (1945a) figures of 35-75 feet are especially close, and Cruickshank's (1956) minimum nest height matches the bottom value of Figure 2. The Blackburnian did range higher than the Black-throated Green in the deciduous area, as observed by Morse (1967a, 1967b; see Figure 2). So, with the exception of Morse's (1970) observations in a mixed area, the Blackburnian appears to maintain itself in the upper tree throughout the breeding season and migration. It is not known if this is also true of winter.

MacArthur (1958) found the Blackburnian to be intermediate between the Black-throated Green and Bay-breasted Warblers in its horizontal use of the tree. It moved outward from the base of branches to the tip, overlapping the zones of both species. The Bay-breasted stayed more to the shady interior, while the high percentage of Araneida and Homoptera in the Black-throated Green's diet showed that it foraged out farther than the Blackburnian, which ate mostly Coleoptera. Morse (1967b) also commented that the Blackburnian worked the tips of branches less frequently than the Black-throated Green. He recorded the Blackburnian foraging 20% of the time on spruce tips, 49% on small live twigs, and 15% on the proximal part of branches. Morse (1970), in a spruce area, noted it 47% in the "out" and 36% in the "tip" categories. In a mixed area of the same study he observed

it more often on "tips" than "out" in coniferous vegetation and slightly more so in deciduous.

Comparison of twig, small, and large branch values for the Blackburnian and Black-throated Green Warblers in the deciduous canopy at Kellogg shows the Blackburnian to forage in farther, the same relationship described by MacArthur (1958) and Morse (1967b) in the breeding season (Figures 12 and 16). The 47% figure by Morse (1970) for the "out" category in the spruce area and the 49% small live twig figure from Morse (1967b) correspond well to the 44% twig figure of this study (Figure 16). However, the 39% small branch and 17% large branch values in Kellogg Forest indicate that the Blackburnian foraged in farther in the deciduous vegetation of this study. Morse (1970) especially had the Blackburnian out farther in the coniferous vegetation of a mixed area where it predominated on "tips". However, the fact that in that area the Blackburnian foraged essentially in the same zone and at the same height as the Black-throated Green Warbler indicates a possible deviation from the normal behavior and relationship of the two species. As discussed with the Magnolia Warbler and its similarity of foraging to the Black-throated Green in the same area, a mixed area has a greater diversity of feeding sites than a pure stand. This may reduce competition and result in less restriction to certain zones or heights.

Summary

The Blackburnian Warbler seemed to avoid the pine area of Kellogg Forest. It did not discriminate between the deciduous and spruce

areas. Other authors found it regularly in deciduous vegetation during migration while Brewster (1906) alone felt it preferred pine (and hemlock). Brewster (1888) wrote that it avoided pine in the breeding season in Massachusetts and only one source listed pine as a breeding foliage. The reason for the avoidance at Kellogg is not understood although scarcity of food is one possibility. The lack of discrimination between the deciduous and spruce areas contradicts Parnell's (1969) hypothesis that the breeding vegetation will be selected.

The bird's preference for the upper tree in the breeding season was continued throughout migration. The normal foraging relationship with the Black-throated Green Warbler was also maintained. However, the Blackburnian appears to forage in farther on the deciduous trees of Kellogg Forest than on the spruce and deciduous growth of the breeding grounds.

Chestnut-sided Warbler

Vegetational preference

Migration. A deciduous preference was shown by the Chestnut-sided Warbler in Kellogg Forest (Table 6). Stewart and Robbins (1958) also noted it in various deciduous areas. Trautman (1940) saw it most often in the dense shrub layer of swampy woodlands and to a lesser extent in the shrubs of upland woods, thickets, and fencerows.

Breeding. The Chestnut-sided Warbler constructs its nest in low bushes, saplings, or briars (Chapman 1907). This can be seen in the bird's choice of breeding habitat. Forbush (1939) wrote that it did not favor deep woods but preferred neglected or cutover land with

an abundance of thickets. Its increase in numbers since Audubon's time has been due to the cutting of forests and the resultant increase in scrub and second-growth. Kendeigh (1945a) stated that it avoided dense forest, finding it in open shrubby fields. Brewster (1906) noted that as a rule it avoided evergreens although in late summer in mixed flocks it sometimes entered pine tracts. He found the bird breeding on woods borders, in neglected fields, along streams, and beside country roads. Stewart and Robbins (1958) observed it in brushy cutover oak-chestnut, mixed mesophytic, and northern hardwood stands.

With the well-developed shrub layer in the deciduous area of Kellogg Forest and the evergreen avoidance noted by Brewster (1906), the selection of the deciduous area at Kellogg is not surprising.

Winter. Skutch (in Bent 1953) found the Chestnut-sided Warbler wherever trees grew fairly close together in Central America. That included forest, coffee plantations, and trees along streams flowing through farmland. In Griscom and Sprunt (1957), Skutch reported that it occurred in rain forest at higher elevations but was not restricted to heavy woods.

Habitat utilization

Migration. In the deciduous area at Kellogg Forest the Chestnut-sided Warbler foraged primarily on twigs in the canopy (Table 10 and Figure 17). It foraged from 10-60 feet and sang from 20-40 feet (Figure 2). Parnell (1969) found it lower, occurring equally in the canopy and low trees, and possibly on larger branches, predominating on

the inner crown. Roberts (1932) observed it in treetops during the fall.

Breeding. Griscom and Sprunt (1957) called the Chestnut-sided low ranging although they observed it to extend upward occasionally. Thayer (in Chapman 1907) described its beat as from the ground to the tops of small deciduous trees. MacArthur (1958) observed it from 0-30 feet. Forbush (1939) found it to be normally a bird of shrubbery and lower tree branches. Kendeigh (1945a and 1945b) usually recorded it foraging within ten feet of the ground. It sang higher, from the tops of bushes or the lower branches of trees, sometimes up to 30 feet. Bent (1953) noted it to mainly glean the foliage of shrubbery or low plants. He seldom saw it seek food on the ground.

Thus, the bird was located higher at Kellogg Forest than on the breeding grounds. The Chestnut-sided Warbler forages while it sings (Chapman 1907). This may explain the location of the singing zone within the foraging zone in this study (Figure 2). However, Kendeigh (1945a) stated that the bird primarily sang when it rose to heights around 30 feet. The average song height was above that of foraging in Kellogg Forest (Figure 3). Bent's (1953) description of foliage feeding during the breeding season may concur with the twig dominance in this study.

Winter. Skutch (in Bent 1953) observed the Chestnut-sided Warbler foraging in treetops, usually well above the ground, in Central America. He felt it was the one warbler that acted differently in the winter, spending more time in high trees (in MacArthur 1958). MacArthur's (1958) own results placed it higher in the winter, extending

from 0-50 feet as opposed to 0-30 feet on the breeding grounds. It foraged in the same manner in both seasons, the principal activity being hopping.

The extension of the foraging zone upward in Kellogg Forest from that observed on the breeding grounds was supported by other sources. Roberts (1932) indicated high foraging during migration as did Skutch and MacArthur on the wintering grounds. Even Parnell (1969) found it utilizing vegetation below the canopy only 50% of the time in migration which must be less than on the breeding grounds. Thus, the bird seems to range higher in the non-breeding season. Being a low nester, it may be restricted to low heights only in the summer.

Summary

The Chestnut-sided Warbler nests in deciduous shrubs. It selected the deciduous area at Kellogg Forest. The bird appears to forage higher both in migration and in the winter than on the breeding grounds. Otherwise, the behavior seems similar.

Bay-breasted Warbler

Vegetational preference

Migration. No one vegetation was preferred by the Bay-breasted Warbler in Kellogg Forest (Table 6). One other source agreed. Barrows (1912) noted little apparent preference for any particular growth in migration. All other authors reported a coniferous preference, at least in the spring. Griscom and Sprunt (1957) observed it in all

kinds of woods but felt there was a preference for conifers. Stewart and Robbins (1958) recorded it in various forest types, noting a tendency toward young pine stands in the spring. Brewster (in Chapman 1907) saw it in dense woods of white pine, hemlock, or other conifers in the spring and frequenting gray birch and dense swampy maple woods in the fall. Forbush (1939) observed the Bay-breasted, in the spring, usually in dense coniferous or mixed woods.

Breeding. The Bay-breasted Warbler is generally a coniferous nester, predominantly in spruce. Knight (in Bent 1953) reported it to nest in swampy evergreen or mixed growth in Maine, while Allen (also in Bent 1953) placed it in damp coniferous woods in New Hampshire. Most of Bent's (1953) nest records were in spruce. Cruickshank (1956) located only four nests in Maine but all were in fir or spruce. Griscom and Sprunt (1957) placed the Bay-breasted in evergreen or mixed forests on mountain slopes or with the nest in spruce, hemlock, birch, or other trees, and even shrubs on lower ground.

The lack of selection in this study does not agree with the coniferous tendency noted by most other authors in the spring or the coniferous preference shown on the breeding grounds. The discrepancy is unexplained.

Habitat utilization

Migration. The Bay-breasted Warbler foraged in a similar manner in the spruce and deciduous areas of Kellogg Forest. It occurred from 10-60 feet in the spruce and 20-60 feet in the deciduous (Figure 2) and predominated in the third quarter of both areas (Figures 5 and

14).

Griscom and Sprunt (1957) observed the Bay-breasted to visit all parts of the trees and bushes, occasionally coming to the ground, and noted that it appeared more on lower branches than in the breeding season. Trautman (1940) recorded it most often in the upper half of larger trees, especially in the spring, and occasionally in taller thickets. Bent (1953) and Forbush (1939) noted it to move through the treetops in the fall with the Blackpoll Warbler. Stoner (1932) also placed it in the higher treetops although stating that it will come lower. Forbush (1939) observed the Bay-breasted to search among the foliage and twigs for food.

While the Bay-breasted was a canopy bird in the spruce and deciduous areas at Kellogg (Table 10) and predominated in the third quarter of both (Figures 5 and 14), it did not range as high as several authors indicated. Rather, it appeared somewhat lower, as stated by Griscom and Sprunt (1957) and frequented the mid-levels of the trees (Figure 2). The foliage and twig gleaning noted by Forbush (1939) agrees well with the spruce data of this study (Figure 5). The Bay-breasted foraged mainly on twigs in the deciduous area; however, it also frequented the inner portions of the tree (Figure 14).

Breeding. Griscom and Sprunt (1957) classified the Bay-breasted Warbler as a high forager that occasionally ranges lower. They stated that it would drop from the treetops to sing if there were openings in the canopy. Gunn (in Griscom and Sprunt 1957) noted a different behavior in Ontario, the bird preferring the mid-level of the conifers and conspicuously avoiding the treetops. MacArthur (1958) even

dropped the bird farther, stating that of the five species in that study, the Bay-breasted had the lowest foraging zone.

The observations of Gunn support the heights occupied at Kellogg Forest. Griscom and Sprunt (1957) mentioned that the Bay-breasted forages lower in migration. The relatively open canopy of the deciduous area may also account for the lower heights, since the bird would not have to rise so far to sing. While it is foraging data that are being compared from this study with Griscom and Sprunt, the Bay-breasted does sing while feeding (Chapman 1907). This would not be a factor in the spruce area since the canopy is closed. Possibly inter-specific competition was more severe in MacArthur's (1958) study than elsewhere, accounting for the low height at which he found the Bay-breasted Warbler.

Griscom and Sprunt (1957) observed the Bay-breasted feeding deliberately, passing from branch to branch by hops or short flights. Occasionally it was more active and flitted about terminal twigs. MacArthur (1958) described it as moving radially from the inside of the tree outward. While the bird regularly worked from the base of the limbs out to the tips, most of the time was spent in the interior. It rarely hovered, usually staying away from the buds at the ends of the spruce mats. It was the most restricted of his five species.

The broad horizontal foraging zone in the spruce and deciduous areas of Kellogg Forest may reflect radial movement outward as observed by MacArthur (1958). However, the bird did not spend most of its time in the inner tree or show the avoidance of tips in the spruce area as described by MacArthur. The spruce sample was small in this study

and not much weight can be assigned to it; however, the Bay-breasted, like several other warblers, may show less restriction in its foraging during migration due to a lessening of competitive pressure. Griscom and Sprunt (1957) did report occasional tip usage in the breeding season.

Summary

The Bay-breasted Warbler generally breeds in coniferous vegetation, primarily spruce. It preferred no one vegetation in Kellogg Forest. The reason for this lack of selection is not understood since most other observers reported a coniferous tendency during migration, at least in the spring. Barrows (1912), however, also noticed no selection.

The Bay-breasted foraged in a similar manner in the spruce and deciduous areas at Kellogg Forest, although it occurred in somewhat farther in the deciduous vegetation. It frequented the mid-level of the trees, lower than the breeding behavior of Griscom and Sprunt (1957), and higher than that of MacArthur (1958). Griscom and Sprunt did feel that the bird dropped in migration. Gunn (in Griscom and Sprunt 1957), in Ontario, noted the same height preference as this study. In both the deciduous and spruce vegetation at Kellogg the bird was not restricted to the inner tree as described by MacArthur (1958). Less interspecific competition during migration may be a reason.

Ovenbird

Vegetation preference

Migration. The behavior of the Ovenbird at Kellogg Forest seemed to indicate spruce avoidance or pine and deciduous selection (Table 6). Parnell (1969) noted a very similar preference obtaining the highest bird per hour values in pine-hardwood, oak-hickory, and pine areas (with the values all essentially equal). Stewart and Robbins (1958) found it in all types of forest, while Trautman (1940) in the spring saw it principally in larger swamp forests and in the fall in swamp forest and upland woods.

Breeding. The Ovenbird stayed on in Parnell's (1969) area to breed in pine and pine-hickory woods. Stewart and Robbins (1958) observed it in various well-drained upland deciduous areas and in pine areas with a deciduous understory. Eaton (1914) saw a preference for rich deciduous woods but found the bird equally common in mixed growth. Bent (1953) found it in deciduous and coniferous forests, usually nesting where the forest floor was open and leaf covered. Kendeigh (1945a) stated that if the bird occurs in coniferous forest, it may need scattered deciduous trees to provide leaves for nest building. He described its haunts as dry, shaded ground. Griscom and Sprunt (1957) placed it in rather open forests with little underbrush but an abundance of fallen leaves, logs, and rocks. Chapman (1907) reported that in New Jersey it preferred dry, somewhat open, deciduous woods but also low swamp forest with heavy undergrowth. Anderson and Shugart (1974) listed as requirements an open canopy

and subcanopy, with both strata taller than average for that area, and a dense understory.

The pine and deciduous preference demonstrated at Kellogg Forest was consistent with observations in the breeding season. Kendeigh (1945a), Bent (1953), and Griscom and Sprunt (1957) all pointed out the importance of deciduous leaves being present on the forest floor. When the Ovenbird occurred in the pine area of Kellogg Forest, it was almost always near the edge where leaves from adjacent deciduous vegetation had blown over or fallen into the plot. The attraction for a rather open canopy was shown by Chapman (1907), Griscom and Sprunt (1957), and Anderson and Shugart (1974). The tightly closed canopy and the inability of deciduous leaves to penetrate the dense growth of the spruce area in this study may have rendered it unattractive to migrating Ovenbirds. Some individuals stayed on to breed in Kellogg Forest, mostly in the deciduous area.

Winter. Bond (1957) noted little preference in habitat in the West Indies and Lack and Lack (1972), in Jamaica, found it common on the floor of all types of natural forest. Wetmore (1916) reported it in thicket and second-growth forest in Puerto Rico.

Habitat utilization

Migration. In the deciduous area at Kellogg Forest the Ovenbird sang primarily from 10-40 feet on small and large branches in the subcanopy (Table 10, Figures 2 and 21) and foraged from 0-10 feet in the understory and on the ground (Table 10 and Figure 2). Parnell (1969) noted it to forage 3-8 feet and sing from 8-18 feet. His forage heights are close to those at Kellogg, however, the song

height extended much higher in this study. Parnell, with song and forage heights combined, noted the Ovenbird 9.7% of the time in the canopy, 46% in low trees, 22% in shrubs, and 20% on the ground. If the data of Table 10 are likewise combined, the results are strikingly similar. The canopy value would be 4.5%, the subcanopy 54%, understory 22.5% and the ground 18%. The Ovenbird frequented the lower and, somewhat the inner, crown in the canopy and low tree strata in Parnell's study. Although nonspecific, this would not seem to contradict the predominantly small and large branch usage observed in this study.

Breeding. The ground feeding and nesting habits of the Ovenbird are well known and need not be greatly detailed here. Kendeigh (1945a) reported that some food is taken from the lower branches of trees; however, most feeding is done on the ground. Wenger (1970) observed only ground foraging. Griscom and Sprunt (1957) placed the bird in the low height category but indicated that it occasionally ranges upward. Chapman (1907) observed it to sing from the lower branches of trees as did Kendeigh (1945a), who stated that this protects the bird from overhead attack. Kendeigh also noted it to sing on the ground. Barrows (1912) reported ground singing but usually saw the bird perched on a branch at some little height, though seldom at a lofty height or the top of the tree. Wenger (1970) observed the bird singing primarily from 30-40 feet on large branches. Parnell (1969) recorded it predominantly in the lower crown of low trees.

In Kellogg Forest the Ovenbird, at 10-40 feet, appeared to

sing higher than was indicated by Chapman (1907) and Kendeigh (1945a) but the height matched well with Barrows (1912) and Wenger (1970). The predominance of the song perch in the subcanopy agreed with the observations of Parnell (1969) and the small and large branch values did not deviate from the lower crown tendency he observed or the large branch preference noted by Wenger.

Winter. The Ovenbird maintains its ground feeding habit in the winter (Eaton 1953; Skutch and Wetmore, both in Bent 1953; Lack and Lack 1972). In Jamaica the Ovenbird picked insects off the leaf litter, while the Swainson's Warbler probed the litter for food (Lack and Lack 1972).

Summary

The Ovenbird selected the pine and deciduous areas of Kellogg Forest. It breeds in both vegetations. Two factors which seem important on the breeding grounds are the presence of deciduous leaves on the forest floor and a fairly open canopy. The spruce area of Kellogg Forest had neither, and this may be the reason it was avoided. No vegetational selection was observed on the wintering grounds.

The Ovenbird at Kellogg Forest foraged in a similar manner to that noted by other migratory and breeding observers. The song height also agreed with the observations of several authors on the breeding grounds. Winter foraging concurred with that of other times of the year.

American Redstart

Vegetational preference

Migration. With the data from all three seasons combined, the American Redstart indicated no preference for any of the three vegetations in Kellogg Forest (Table 6). Barrows (1912) observed it just about anywhere and Roberts (1932) in the fall noted it wherever there was timber. Stewart and Robbins (1958) found it in various deciduous stands. Trautman (1940) saw it most frequently in larger upland and lowland woods but occasionally in the fall in taller, brushy thickets with no mature trees. Parnell (1969) obtained highest bird per hour values in floodplain and beech forests but recorded no significant difference between those, pine-hickory, and oak-hickory stands.

Barrows (1912) and Roberts (1932) seem to agree with the lack of preference observed in this study; however, Stewart and Robbins (1958) and possibly Parnell (1969) indicate a deciduous preference.

Breeding. The American Redstart is a deciduous breeder. Cruickshank (1956) found 48 out of 50 nests in deciduous vegetation in Maine. Stoner (1932) reported that in the summer it kept to deciduous growth. Morse (1973) noted it to forage on deciduous vegetation more often than would be expected by chance on some small Maine islands. Adult males always chose islands with at least some deciduous vegetation. First-year males were forced to inhabit islands with only spruce growth and had very poor breeding success. Kendeigh's (1945a) category for the American Redstart was secondary deciduous growth. He rarely saw it penetrate the forest proper. Chapman (1907) wrote that

the bird is at home in almost any kind of more or less open deciduous woods but prefers lowland woods with a sapling undergrowth. Trautman (1940) found it in the largest, most mature remnant swamp forest and Stewart and Robbins (1958) in second-growth river, swamp, and flood-plain forest as well as mixed mesophyte and northern hardwoods. Bent (1953) also reported it nesting in mature swamp forest in Ohio and Michigan but found it in mixed coniferous and deciduous as well as hardwood areas in Maine and in areas of considerable pine, hemlock, and spruce growth in New York. In Maine it visited coniferous forests to supplement its diet from deciduous areas. Even in mixed areas, however, the nest was almost always built in deciduous growth.

Though at times utilizing coniferous growth, the American Redstart is a deciduous breeder. Stewart and Robbins (1958) and possibly Parnell (1969) follow the hypothesis of seeking out the breeding foliage in migration. This study, Barrows (1912), and Roberts (1932) do not. The sample of this study was very small, however.

Winter. Wetmore (1916) noted the American Redstart in mangroves, forest growth, coffee plantations and sometimes shade trees.

Habitat utilization

Migration. The sample from this study was too small to reveal much about the American Redstart's foraging habits. The bird was seen most often on twigs in the deciduous area. Parnell (1969) noted it to forage from 17-27 feet and sing from 24-38 feet. It occurred more in the low tree strata than in the canopy, mostly in the inner and lower crown. Thus Parnell seemed to have it utilizing larger branches.

Breeding. Griscom and Sprunt (1957) termed the Redstart's foraging range as medium. Stoner (1932) noted it mainly in the higher parts of trees while Kendeigh (1945b) recorded it singing as high as 40 feet. Ficken and Ficken (1962) observed the male foraging higher early in the season when territory was being established than later in the summer. Chapman (1907) cited Thayer to illustrate ground feeding. Parnell (1969) noted it higher in the breeding season than during migration, occurring in the canopy 52% of the time as opposed to 37%, but again predominating on the inner and lower crown. Bent (1953) reported that besides flycatching, at which the American Redstart is very adept, it gleaned insects from the trunks, limbs, twigs, and leaves of trees. Morse (1973) noted it mostly on small branches. (His categories were large, small, and tip.)

The small branch foraging observed by Morse (1973) seems to support the twig predominance noted in this study, however, the inner crown value of Parnell (1969) would not.

Winter. Eaton (1953) observed it in Cuba from the ground to the tops of trees in pursuit of flying insects. MacArthur (1958) recorded it hawking from 5-50 feet in Costa Rica and stated that it behaved the same as in the summer. Lack and Lack (1972) noted that it was the only warbler in Jamaica that almost totally flycatches to obtain its food. It often flew out just under the canopy, sometimes lower, and even got food off the ground. It also hopped about on leafy twigs. They found their data to compare very favorably to the summer data of MacArthur (1958).

Summary

In this study no preference was shown by the American Redstart, a deciduous breeder. Several other authors agreed (Barrows 1912, Roberts 1932). However, Stewart and Robbins (1958) and possibly Parnell (1969) noted a preference for the breeding foliage. In support of this study, Bent (1953) did point out instances of coniferous foraging in the breeding season.

Morse's (1973) small branch value on the breeding grounds matched the twig predominance noted in this study. Parnell (1969) indicated it used large branches also. In the winter the bird forages as in the summer.

Golden-crowned Kinglet

Vegetational preference

Migration. Enough data were gathered for the Golden-crowned Kinglet to determine preferences in the spring and fall at Kellogg Forest. No preference was shown in the spring while a spruce preference was noted in the fall (Table 6). Other authors concurred with the spring behavior at Kellogg Forest. Stewart and Robbins (1958) found the bird in scrub, pitch, and loblolly pine but also regularly in various deciduous forests. Bent (1949) wrote that it was not confined to conifers in migration but occurred wherever there were trees and bushes, especially the brushier portions of woodlands.

Breeding. The Golden-crowned Kinglet is basically a spruce breeder. In Maine, Knight (in Bent 1949) found the kinglet breeding

in pine, fir, spruce, hemlock, and mixed woods. Saunders (also in Bent 1949) in New York seldom saw the bird in hardwoods during the summer; rather it frequented the tops of tall spruces. Bent (1949), himself, stated that it seemed to prefer more open forests of scattered second-growth spruce. A few birches or firs may be present, but the occurrence of spruce was a necessity for nesting. Brewster (1888) and Durfee (in Bent 1949) did not agree on the height of nesting but both found nests primarily in spruce. Stewart and Robbins (1958) recorded the kinglet only in mature red spruce forest during the breeding season, while Stupka (1963) reported it to be a permanent resident in the high altitude spruce-fir forests of the Great Smoky Mountains National Park. In an area of mixed vegetation in Maine, Morse (1970) recorded almost totally coniferous foraging. Bent (1949) also noted mainly coniferous foraging in the breeding season.

Winter. In Massachusetts Bent (1949) usually found the kinglet in evergreen woods comprised of pine, hemlock, or cedar; however, the bird was not always confined to conifers, frequenting mixed and open woods as well. Morse (1967b and 1970) recorded it predominantly foraging on deciduous vegetation in mixed areas of Louisiana and Maryland. In Maine (1970) he found the bird equally on both vegetations. Trautman (1940) found a few individuals wintering in the densest wild plum and hawthorne thickets. Thus, of the above authors, only Bent found a coniferous preference in the winter and that was not absolute.

With the exception of Bent (1949), it appears from other authors that a coniferous preference is not maintained in the non-breeding

season when spruce is of limited availability. At Kellogg Forest, spruce was available; however, it was only selected in the fall. This would suggest that the Golden-crowned Kinglet may at times go where the food is rather than choosing a certain vegetation. In the spring, the spruce area may be depleted of food due to heavy winter foraging by resident species. In the fall, food may be more abundant there. The factors governing vegetational selection are examined more fully under "Factors Governing Selection" found later in the Discussion.

Habitat utilization

Migration. The Golden-crowned Kinglet was noted frequently in all three areas at Kellogg Forest. In the spruce area it foraged low, from 0-30 feet (Figure 2), occurring primarily in the first quarter on foliage, twigs, and small branches (Figure 8). In the pine area it foraged from 10-40 feet (Figure 2), in the mid-quarters of the tree, most often on twigs and small branches (Figure 9). In the deciduous area the kinglet foraged about evenly in the canopy and subcanopy (Table 10) from 10-60 feet (Figure 2). It predominated in the lowest quarter of the subcanopy on foliage and twigs (Figure 10) and in the middle quarters of the canopy on twigs and small branches (Figure 11). The heavy foliage usage in the subcanopy can be attributed to an instance in the fall when a flock of kinglets was seen gleaning the leaves. Little direct mention is made by other authors of the Golden-crowned Kinglet's foraging behavior during migration.

Breeding. Morse (1967b) observed the kinglet foraging from 0-55 feet in a Maine spruce forest. In both mixed and coniferous areas in Maine, Morse (1970) found it predominantly in the "high" category (above 30 feet). Several authors noted a broad horizontal range. Bent (1949) observed the bird on trunks, branches, and twigs while Forbush (1888) saw it feeding out on the tufts of needles and in on the larger branches and trunks of pine trees. Bent also stated that the kinglet is an excellent flycatcher and occasionally feeds on the ground. Morse (1967b) found it to be a close competitor of the Parula Warbler feeding on the tips of foliage and small dead branches. It worked the inner foliage and dead limbs more than the Parula. He recorded the kinglet at the tips of branches 38% of the time and on small twigs 23%. Morse (1970) recorded a higher "tip" than "out" tendency in coniferous and mixed areas obtaining a 50-20 ratio in the first area and a 37-17 in the second.

Morse's (1967b) height range of 0-55 feet matches well with that noted in the deciduous area at Kellogg Forest; however, in the other two areas of this study the bird occurred lower. Morse (1970) was closer to the deciduous data also. With the exception of the deciduous subcanopy the bird did not appear to be as restricted to the outermost tree portions in Kellogg Forest as observed by Morse (1967b and 1970). Neither was it seen commonly in the innermost tree portions as noted by Forbush and Bent. The difference between Morse (1967b and 1970) and this study may involve a difference in the recording of data.

Winter. Bent (1949) observed the kinglet gleaning from lower tree branches, hovering close to the trunk, and foraging in pine needles on the ground. Morse (1967c) observed it 85% of the time on distal branches in pines. Morse (1970) found it most often on "tips" and in four of the six cases in the "low" height category in the deciduous vegetation of mixed and pine stands in Louisiana, Maryland, and Maine. In the pine vegetation of mixed and pure stands in Louisiana and Maryland, he found it fairly equally in the "tip" and "out" and "low" and "high" categories, while in spruce vegetation in Maine it predominated in the "tip" and "low" categories in mixed and pure stands.

The deciduous observations of Morse (1970) match well with the subcanopy behavior in this study (Figure 10). The bird occurred most often in the outermost tree portions in both instances, and the high occurrence in the first quarter of the subcanopy at Kellogg Forest concurs with the low foraging height noted by Morse. In the deciduous canopy at Kellogg Forest the bird occurred higher and in farther on the tree (Figure 11). The sort of general occurrence noted by Morse (1970) in the pine vegetation seems to match well with the pine data of this study (Figure 9), although the bird was in farther at Kellogg Forest. The spruce heights for both Morse (1970) and this study (Figure 2) are in agreement; however, the bird again seemed to forage in farther at Kellogg.

As mentioned, the low occurrence on the tips of branches by the kinglet in Kellogg Forest may be due to recording differences between this study and Morse (1970). Another possibility exists, however.

Competition between species may be less severe in migration allowing an expansion of the foraging zone. Morse (1970) noted that the Black-capped Chickadee was dominant over the Golden-crowned Kinglet, and when both were present, would push the kinglet outward and lower. In the pine and spruce areas of Kellogg Forest the Golden-crowned Kinglet did not forage outside of the Black-capped Chickadee (Figures 8, 9, 31, and 32). This may indicate a lessened degree of competition. Morse (1970) also found a tendency for the chickadee to forage more peripherally in coniferous vegetation in the presence of the Red-breasted Nuthatch. In the pine area of Kellogg Forest, where both were present, one might expect the outward pressure on the chickadee to in turn force the Golden-crowned Kinglet out even farther. That the chickadee and kinglet occur essentially in the same zone and in farther than in the spruce area (where the nuthatch was uncommon) may be further proof of a less rigid division of resources during migration.

The chickadee did range higher than the kinglet in the spruce and pine areas of Kellogg Forest, however (Figures 8, 9, 31, and 32). Downward pressure by the chickadee may be responsible for the lower kinglet heights than noted by Morse (1967b and 1970) on the breeding grounds. However, the kinglet tends to forage lower in the winter than summer (Morse 1970), so the drop observed at Kellogg could simply be a seasonal phenomenon. In the deciduous area both species frequented the midquarters of the canopy and the lower quarters of the subcanopy (Figures 10, 11, 28, and 30) although the chickadee did appear to forage in somewhat farther than the kinglet.

The Golden-crowned Kinglet is known to compete with the Parula Warbler in the breeding season (Morse 1967b) and probably would with any warbler that forages heavily on the outer tree portions. The kinglet occurred in Kellogg Forest earlier in the spring and later in the fall than the warblers. It foraged in a similar manner and at a similar height to many of the warbler species in their absence. Whether a dominance factor, as with the Black-capped Chickadee, would be involved is not known.

Summary

The Golden-crowned Kinglet selected spruce, the breeding foliage, in the fall at Kellogg Forest. In the spring no vegetational preference was shown. Thus, at times the bird may select for a food source rather than a particular vegetation. Other authors, with one exception, noted little coniferous preference in the non-breeding season, as Parnell (1969) would expect of a migratory spruce breeder.

The Golden-crowned Kinglet may forage lower in the non-breeding season. The heights at Kellogg, except in the deciduous canopy, were more similar to winter observations than to breeding ones. The kinglet may also expand its horizontal foraging range during migration due to a lessening of competition.

Ruby-crowned Kinglet

Vegetational preference

Migration. No preference was indicated by the Ruby-crowned Kinglet at Kellogg Forest (Table 6). Bent (1949) found it almost

anywhere although its favorite haunts were swampy thickets. Stewart and Robbins (1958) observed it in brushy forested areas including pine and deciduous types. Todd (1940) noted it to not be as partial to conifers as the Golden-crowned Kinglet, while Trautman (1940) saw it chiefly in woods, thickets, and brushy fence rows. Thus, other authors seem to support the lack of vegetational preference noted in this study.

Breeding. Bent (1949) stated that the Ruby-crowned Kinglet seemed always to nest in conifers, generally spruce, sometimes fir, and less often western pine. Harrington (in Bent 1949) in Ontario observed it to be a typical bird of black spruce bogs rarely finding it elsewhere in the summer. In Montana, Saunders (also in Bent 1949) noted it to occur in Douglas fir while the Golden-crowned Kinglet frequented spruce.

Winter. Morse (1967c) and Morse (1970) in Louisiana recorded the Ruby-crowned Kinglet utilizing deciduous more so than coniferous vegetation in both mixed and coniferous areas. In the 1967 study the kinglet occurred 70% of the time in the sparse oak subcanopy of a pine area.

The Ruby-crowned Kinglet forages in a very similar manner to the Golden-crowned Kinglet. Morse (1970) noted that in a pine area the Ruby-crowned predominated on deciduous vegetation while the Golden-crowned predominated on pine. This may indicate a degree of mutual exclusion. Morse also noted the Ruby-crowned to react more aggressively towards the Golden-crowned Kinglet than to others of its own kind. In that same study, however, both occurred most on

deciduous vegetation in a mixed area. Saunder's observations during the breeding season in Montana may support the idea of exclusion.

The Ruby-crowned Kinglet is primarily a spruce breeder. Little selection or even a preference for deciduous growth appears to occur in the non-breeding portions of the year when spruce is not available. The deciduous leaning noted at times on the wintering grounds may involve competition with the Golden-crowned Kinglet.

Habitat utilization

Migration. In Kellogg Forest the Ruby-crowned Kinglet occurred equally in the canopy and subcanopy of the deciduous area (Table 10) and was considered a low forager ranging from 0-30 feet (Figure 2). The observations of Trautman (1940) and Bent (1949) placing it frequently in thickets also imply low foraging. Todd (1940) mentioned that it foraged closer to the ground than the Golden-crowned Kinglet.

Breeding. Little reference is made in the literature to the Ruby-crowned Kinglet's foraging range during the breeding season. Bent (1949) reported nests from 2-100 feet. Morse (1967b) noted that it, along with the Golden-crowned Kinglet, foraged in a very similar manner to the Parula Warbler, frequenting the tips of branches.

Winter. Morse (1970) found the kinglet primarily in the "low" category (under 30 feet) in pine and deciduous areas in Louisiana. It occurred most often in the "out" category in the pine and in the "tip" category in the deciduous. Morse (1967c) found it to be almost totally a foliage gleaner.

Thus, in the winter, at Kellogg Forest, and in other migratory

observations, the Ruby-crowned Kinglet foraged low and in the outer tree portions.

Summary

No vegetational preference was noted for the Ruby-crowned Kinglet in this or other migratory studies. This would agree with Parnell (1969) since the breeding foliage is generally not available during migration. In some instances Morse (1967c and 1970) noted a deciduous tendency in the winter. Competition with the Golden-crowned Kinglet could be a factor. The Ruby-crowned foraged in the same manner and at the same height in all seasons of the year.

Comparison with Parnell

Parnell (1969) made three basic statements that were examined in this study:

- 1) With a few minor exceptions the species selected their breeding foliages during migration.
- 2) In the case of spruce breeders, no vegetational selection was shown because that foliage was not present.
- 3) Habitat niche (foraging zone) may be more important than habitat (vegetational type) for most birds.

Power (1971) reanalyzed Parnell's data using more quantitative methods. He found the maintenance of foliage type throughout the spring and post-migratory periods to be very strong. Habitat zone was consistent also but not to as great a degree.

At Kellogg Forest less than half of the species chose the foliage in which they breed (Table 6). None of the three general coniferous

nesters differentiated between conifers and deciduous vegetation. Of the four spruce warblers, two selected the spruce and one preferred conifers. One of the two kinglets, also spruce breeders, selected that vegetation but only in the fall. The Blue-winged Warbler and American Redstart, both deciduous breeders, showed no preference, but that may have been due to sample size. The Ovenbird, Chestnut-sided, and Black-and-white Warblers may have selected for a certain foliage profile or physical appearance rather than kind of vegetation.

The behavior of the spruce breeders in this study was of great interest since Parnell lacked that vegetation in North Carolina. When presented with the opportunity to select spruce at Kellogg Forest, three of the six species did, but the Golden-crowned Kinglet in only one season. Also the Cape May Warbler chose conifers, which with a larger sample might have been shown to be a spruce preference. So actually only two species, the Blackburnian Warbler and Ruby-crowned Kinglet, showed no spruce (or at least coniferous) leaning. The Myrtle and Blackpoll Warblers were used by Parnell as examples of northern breeders that, in the absence of the nesting foliage, demonstrated no selection. Power (1971) disagreed, showing that the Blackpoll actually tended towards wet thicket and oak-hickory. In this study the Myrtle not only did not select the breeding foliage which was available but showed a definite preference for deciduous vegetation.

Three species in this study, the Ovenbird, Chestnut-sided, and Black-and-white Warblers, were described as selecting for a certain foliage profile or physical appearance rather than species of vegetation.

The Magnolia Warbler seemed rather to choose the breeding foliage over its preferred niche, differing with Parnell's statement of the preeminence of the latter. Power noted that the maintenance of habitat niche was significant but not as strong as for foliage type. Several of the species in this study did behave in a similar manner to their actions on the breeding grounds--inhabiting the same strata, foraging at the same heights, and horizontally utilizing the same portions of the trees. The Ovenbird, Black-throated Green, Cape May, and Blackburnian Warblers and the Ruby-crowned Kinglet all were noted to do so. Also the Blue-winged Warbler and American Redstart's activities agreed with at least one, if not all, of the breeding descriptions. The Magnolia acted in a manner similar to its summer behavior in the deciduous area, which had a subcanopy, but not in the breeding foliage, which lack that strata. Three ground nesters and a shrub nester, the Tennessee, Black-and-white, Nashville, and Chestnut-sided Warblers foraged higher in migration than on the breeding grounds, a condition noted by other observers. The Magnolia (in the spruce) and Bay-breasted Warblers, and the Golden-crowned Kinglet expanded their foraging zones at Kellogg Forest possibly in response to lighter competition during migration. The remaining species, the Myrtle, ranged higher in this study than on the nesting grounds. Being an opportunistic forager, this was probably in response to some food source.

Parnell's (1969) three statements, then, were supported to a degree, but not totally, by the species at Kellogg Forest. While some chose the breeding foliage and occupied the same habitat niche,

others did not. A few species expanded their foraging zones, possibly because of less competition or being released from nesting activities.

Comparison of the Areas at Kellogg Forest

The deciduous area at Kellogg Forest had the most warblers per hour in the spring of 1973, the fall of 1973, in total, and was only exceeded slightly by the second spruce area in the spring of 1974 (Table 8). It also had the most species in each of the three seasons (Table 9). One possible reason for the area's popularity was abundance of food. Lack (1954) related population density to food supply. Another reason may have been the more complex foliage profile that the deciduous area presented. While it possessed well-developed canopy, subcanopy, and undergrowth (shrubs and herbs) layers, the spruce areas had only a canopy of like-aged trees and the pine area a monotypic canopy with some sparse understory. MacArthur, MacArthur, and Preer (1962) found the number of species in an area to be proportional to the foliage height diversity while MacArthur (1964) stated that the more equal the amounts of vegetation in the herb, shrub, and tree layers, the greater the number of species present. This certainly described the deciduous area at Kellogg Forest better than the spruce and pine. Colquhoun and Morley (1943), working with birds in the non-breeding season, found the tree and shrub levels (4-35 feet) to be the most important and integrated zones in the forest. Only a few species frequented the canopy (above 35 feet), herb (under 4 feet), and ground layers. Each species requires a patch of vegetation with

a certain profile (MacArthur and MacArthur 1961). In the deciduous area at Kellogg Forest more species had available the verticle niche which they preferred. Parnell (1969) noted the largest number of regularly occurring warblers in floodplain forest during migration. Of all his areas it had the best developed series of strata, thus, the most habitat-niches.

The second spruce area proved quite attractive also, both from a standpoint of birds per hour (Table 8) and species present (Table 9). It is not quite understood why it was preferred so much more than the first spruce plot. The trees in the two areas were planted only a few years apart and were essentially the same height. The second area was somewhat denser than the first (601 trees/hectare to 400 trees/hectare) but both were quite closed, and it seems that if anything, a greater number of species would occur in the more open plot. The second area was larger than the first (1.02 hectare to 0.3 hectare) and located on slightly higher ground. One or both of these features may make it more noticeable to migrants. It was also somewhat more heterogeneous, possessing not only white and Norway spruce, but black spruce, some European larch along one edge, and a few deciduous trees as well. MacArthur, MacArthur, and Preer (1962) found that the variety of plant species does not have a direct effect on the number of bird species present, but if an increase in plant species serves to increase the number of habitat niches in an area, then the bird species will increase. That may be the case in the second spruce area. No super-abundant food source was noted in the second area to explain the preference, but no careful and methodical

investigation of the twigs and foliage was made.

The low population in the pine area at Kellogg Forest is reminiscent of Morse (1970) who noted the same phenomena in longleaf pine stands in Louisiana. He stated that that vegetation supports an extremely low population of insects. He observed birds feed in a deciduous area then fly right through a mixed area to continue feeding in another deciduous plot. The pine vegetation may have been a poor food source in relation to the deciduous at Kellogg Forest also.

The highest birds per hour value for the kinglets occurred in the spruce area in the spring and in the pine area in the fall (Table 8). The possibility of food availability changing in the different areas from season to season is discussed under the Golden-crowned Kinglet.

Preferences for Species of Tree

In the deciduous and spruce areas at Kellogg Forest, the only areas with any variety of trees, no preferences for any particular species of trees were noted. Morse (1970) stated that while Hartley (1953) and Gibb (1954) did find preferences by different birds for different plant species, Brewer (1963) observed the Black-capped Chickadee in Illinois to utilize tree species in relation to their abundance. The latter may be the case here; however, the variety of the two areas was limited. The top three species in each were monogeneric (Table 1 and Chapter II) and the black and red oak of the deciduous area are so similar that to tell the two apart is sometimes difficult.

It is possible that the heavy predominance of canopy sightings in the deciduous area (Table 10) indicated preference by several species for oak-hickory over sassafras, dogwood, and black cherry. Both oak and hickory produce prominent catkins during May and with the accompanying swarms of insects offer a rich food source to migrating birds. Sassafras has insignificant flowers, black cherry blossoms in late May after many of the species have already passed, and the dogwood flowers may not attract the number of insects that the oak and hickory flowers do. Of course, types of food gleanable from leaves, branches, and trunks may also be a factor in strata selection, possibly a more important one in light of the predominance of gleaning over flycatching observed in this study. Parnell (1969) pointed out the affect of a food source during migration when he found warblers to select blue beech (*Carpinus caroliniana*) during an outbreak of small leaf-eating insects on that foliage. Chapman (1907) observed warblers gathering on birches that were much infested with plant lice to the point that the rest of the woods was nearly devoid of migrants. This is not to suggest that species simply flock to where the food is and do not maintain a particular habitat-niche throughout the year (MacArthur 1958, Parnell 1969). A certain degree of flexibility may occur during migration, to take in large or accessible food sources and yet the bird still maintain its foraging identity. Of course, some species such as the Chestnut-sided and Cape May Warblers can act quite differently from their behavior on the breeding grounds. An expansion of the foraging zone was indicated by several of the species at Kellogg Forest (see individual

accounts). It is thought that this was due to a reduction in territorial behavior during migration; however, a large food source would effect the same result by lessening competition.

Heights Frequented at Kellogg Compared to Other Studies

The Ovenbird (in song), Black-and-white, Magnolia (in the spruce), and Myrtle Warblers all ranged higher in Kellogg Forest than was noted in other migratory studies or on the breeding grounds (see individual accounts). Also, Colquhoun and Morley (1943) found the tree (subcanopy) and shrub layers located from 4-35 feet, to be the most important in the forest. At Kellogg Forest the greatest number of birds were observed from 20-60 feet in the deciduous and spruce areas and 40-60 feet in the pine (Table 13). Of course, subcanopy layers were lacking in the latter two. Parnell (1969) agreed with Colquhoun and Morley, recording eleven of the commoner species most often in the low tree category and seven in the canopy. In the deciduous area at Kellogg, all but the Magnolia Warbler, Ovenbird, and two kinglets predominated in the canopy. Parnell obtained 48% of his sightings in low trees and 30% in the canopy. Seventy-five percent of the warblers observed in the deciduous area of this study were recorded in the canopy. Agreement was reached in the strata preferred by five of the seven species common to this study and Parnell. The Black-and-white, Cape May, and Myrtle Warblers were canopy birds in both. (The Cape May was judged by the fact that it did not occur under 40 feet in the coniferous areas at Kellogg and not the isolated deciduous sighting, Table 10.) The

Ovenbird (in song) and Magnolia Warbler frequented the subcanopy. However, of those five species, all but the Ovenbird were found in a much higher percentage in the canopy at Kellogg Forest. (The Cape May may have to be discounted since it may act differently in deciduous vegetation.) The Blue-winged and Chestnut-sided Warblers preferred the canopy at Kellogg Forest while Parnell placed the first in the subcanopy and the second equally in both.

There are several possibilities for the higher recordings at Kellogg Forest. As previously discussed, one or several food sources may have drawn the birds upward. A reduction in the territoriality of species during migration could explain the differences from breeding behavior but would not account for the differences from other migratory data. Physical differences between the areas of this study and others may be a factor. The fact that the Ovenbird was up high mainly to sing and not forage may support this. Also, it is possible that this author may have tended to overestimate heights to a degree. In determining average height, Parnell combined data from various areas since he felt habitat niche was independent of vegetation type. Thus, he may have combined heights from thicket areas and forest serving to lower the average height somewhat. Parnell had several more low-foraging species, explaining some of the difference in the total height and strata percentages. Probably, food source or physical differences between areas were the main reasons for the variance between this study and others.

Difference in Behavior Between Vegetations

Parnell (1969) felt that niche was independent of vegetation type and so combined data from his different areas for each species. The similar behavior of the Parula Warbler in the spruce forests of Maine and the sweet-gum oak forests of Louisiana, as noted by Morse (1967a), supports that belief. The indications of this study were not so clear. Three species had enough foraging data gathered in more than one vegetation to allow niche comparison. The Bay-breasted and Tennessee Warblers frequented both the spruce and deciduous areas while the Golden-crowned Kinglet inhabited the spruce, deciduous, and pine. The Bay-breasted Warbler showed good height agreement between the spruce and deciduous areas (Figure 2); however, it occurred evenly over foliage, twigs, and small branches in the spruce and concentrated on twigs in the deciduous (Figures 5 and 14). The Tennessee Warbler foraged higher in the deciduous than spruce area, the bird extending as high in the spruce but for the purposes of singing (Figure 2). As with the former species, the bird was uniformly spread over foliage, twigs, and small branches in the spruce while mainly utilizing twigs in the deciduous (Figures 7 and 20). The Golden-crowned Kinglet ranged low in the spruce, medium low in the pine, and medium in the deciduous area (Figure 2). The foliage, twig, and small branch figures of the spruce and pine areas matched well, all three being used in each (Figures 8 and 9). In the deciduous subcanopy the kinglet emphasized foliage and twigs while in the canopy it frequented twigs and small branches (Figures 10 and 11).

Thus, there were some similarities between vegetations for all

three species but also some differences. The big difference seems to be between coniferous and deciduous vegetation since the zones inhabited by the Golden-crowned Kinglet in the spruce and pine areas were very similar (Figures 8 and 9). None of the three species utilized foliage in the deciduous canopy, a portion of the tree used frequently in the coniferous plots. This difference could be partly due to recording techniques. The heavy foliage usage by the Golden-crowned Kinglet in the deciduous subcanopy can be attributed to an instance in the fall where a flock of kinglets was observed gleaning the leaves. A bird may not be expected to act exactly the same in different vegetations since there are physical differences between the plants and often different species of birds are present forcing an adjustment in behavior. The samples at Kellogg Forest were not large and maybe these differences were accentuated.

Comparison of Behavior Between Seasons

Three of the fifteen species observed at Kellogg Forest were recorded enough in the fall to compare behavior between the two migratory seasons. The Golden-crowned Kinglet, Black-throated Green, and Black-and-white Warblers all foraged the same in both (Figure 1 and Table 12). A search was made of the literature to determine the behavior of other warblers. As with vegetational preference, references to seasonal differences in foraging site were few and fragmentary. Information that allowed definite statements was only found for four species. Roberts (1932) and Trautman (1940) reported that

the Tennessee Warbler drops in height in the fall as compared to the spring. Trautman (1940) noted the Nashville Warbler to extend its foraging zone somewhat lower in the fall. Forbush (1939) and Trautman (1940) indicated the opposite for the Cape May Warbler, observing it to rise in the fall and Trautman (1940) found the Bay-breasted Warbler higher in the spring. Thus, at least a few species seem to alter their behavior in a regular manner from spring to fall. The birds are probably adjusting their foraging range to include the available food sources in each season. This was discussed when the high incidence of spring canopy sightings was suggested to involve the distribution of food. While a bird's behavior may vary somewhat with local conditions, a regular pattern over the migratory range should be possible. With different species of insects being abundant at different times, certain types preferred by a warbler species may be high in the trees in one season and low in another or out on the leaves at one time and in on branches in another. This may be influenced by the fact that the parts of a tree vulnerable to insect attack or available for use vary somewhat throughout the year. In the early spring it is the tender young leaves and flowers, and later may be new twigs, fruits, or buds. As the migrants move northward or southward, their location may coincide with the peak populations of certain insects since both are responding to seasonal phenomena. Chapman (1907) noted the warblers to reach New England in the spring just as the larvae of the gypsy moth are hatching and to return in the fall just as the browntail moth larvae emerge from the egg. In both cases the timing is just right to reap an abundant food supply

and to help out the horticulturist. It is possible that a bird could feed on only a few insect species over a large part of the migratory journey. Thus, if a bird is seen feeding high up in the trees on aphids in upstate New York, a few weeks later he may be seen doing the same thing in Tennessee.

The three species at Kellogg Forest indicated no change between the migratory seasons. Possibly the food sources were located in the same portions of the trees. As mentioned, some species do not deviate as much from the habitat niche on the breeding grounds as others. They may be efficient enough to survive throughout migration on the food taken from a certain zone. Other species may find it more profitable or essential to seek out plentiful sources of food or gather from a variety of zones.

Relationship of the Black-capped Chickadee to the Warblers and Kinglets

Willson (1970) suggested that certain species maintain the same foraging positions, during the invasion of spring migrants, that they held throughout the winter. She observed the White-breasted Nuthatch, Brown Creeper, and three species of woodpeckers. The Black-capped Chickadee occurred throughout the year at Kellogg Forest. Its behavior was recorded before the warblers arrived in the spring and after the kinglets left. No difference in foraging was observed in the presence or absence of either group in the deciduous area. However, the sample was small. The kinglets would not be expected to affect the chickadee's behavior since Morse (1970) found the chickadee to be dominant over the Golden-crowned Kinglet (see individual account

of Golden-crowned Kinglet). On the breeding grounds in late summer Morse (1970) found the Black-and-white Warbler to push the chickadee peripherally. This was not noted in the deciduous area at Kellogg Forest.

In the deciduous canopy of this study the Black-capped Chickadee overlapped strongly with the Black-throated Green, Bay-breasted, Myrtle, and Blackburnian Warblers (Figures 28, 12, 14, 15, and 16, respectively). In the spruce area the foliage and twig feeding by the chickadee was similar to that of the warblers (Figures 31 and 4-8). Warblers were relatively rare in the pine area of this study. In the spring, although occurring frequently in the deciduous area at Kellogg Forest, the Black-capped Chickadee statistically selected pine. Also, it was not often seen in the spruce area when warblers were present. This could be a result of competition with the warblers since the foraging zones were so similar in the spruce and deciduous areas. It does not seem likely that the low warbler numbers in the pine area are an indication of their exclusion by the chickadee, although it may be a factor. A scarcity of food or the area's lack of vertical variety are probably more important.

Relationship of the Red-eyed Vireo to the Warblers and Kinglets

The Red-eyed Vireo overlapped foraging zones with almost all the warbler and kinglet species in the deciduous canopy. It spent almost half of its time on twigs in the third quarter (Figure 23) which was the most frequented zone for the majority of the species. However, there were a few properties which helped to separate it from

the others. No other species had as high a small branch figure except the Ovenbird (Figure 21) which was engaged in singing rather than foraging. It was only seen above 30 feet. All other species except the Blackburnian Warbler ranged at least somewhat lower (Figure 2). It fed in the deliberate style of the vireos and had a larger, more hooked bill. The latter two properties may have enabled it to glean more thoroughly and to utilize somewhat different food sources.

Factors Governing Selection

There are several factors which could govern the vegetation a migrant bird will choose. Some have already been discussed.

Food is one factor. It was postulated as a reason for the dearth of warblers in the pine area of Kellogg Forest. Parnell (1969) with blue beech and Chapman (1907) with birch gave examples of the attraction of a rich food source to migrants. Food abundance may help explain the popularity of the one spruce area over the other in this study.

The foliage profile of an area may influence selection. Each species has a certain vertical niche which it prefers (MacArthur and MacArthur 1961). Parnell (1969) found the most species in the area with the best developed series of strata. The more complex character of the deciduous area at Kellogg Forest may be the reason for the high number of species. Greater internal variety could also be a factor in the selection of the one spruce area over the other.

A third possibility is avoidance of predators or competitors.

The Black-and-white Warbler may have been absent from the pine area at Kellogg Forest due to the presence of the Red-breasted Nuthatch. A pair of Broad-winged Hawks and a pair of Barred Owls nested in Kellogg Forest. Though neither species preys primarily on birds, their presence may have caused the warblers to avoid the pine area. In the pine trees a raptor could conceal itself better than in the deciduous and, because pine prunes itself better than spruce, the bird could swoop down and surprise its prey more easily in the pine. Gulian and Marshall (1968) found Ruffed Grouse to avoid big pines in the winter in favor of fir and spruce due to heavy predation in the former.

A factor not yet mentioned is that of hormonal influence. As the bird moves northward in anticipation of courtship and mating, it is under the influence of androgens in the male and corresponding hormones in the female, and may be attracted to the breeding foliage. If this is the case, the breeding foliage would be selected in the spring rather than in the fall. Other influences would dictate fall selection. Two species had both spring and fall preferences determined at Kellogg Forest. The Black-throated Green Warbler, generally a coniferous breeder, showed no selection in either season. The Golden-crowned Kinglet, a spruce breeder, showed no preference in the spring and chose spruce in the fall. These two species then did not indicate hormonal influence. The findings of other authors were consulted. Stoner (1932) noted the Black-throated Green Warbler to prefer hardwoods in the spring while Chapman (1907) observed no preference. Both support the results of this study. Seasonal preferences

for the Golden-crowned Kinglet were not found in the literature. The Magnolia Warbler breeds in spruce. Brewster (in Chapman 1907) noted it in thickets and upland pines in the spring and in scrub oak and scattered birch in the fall. So, he noted at least a partial coniferous preference in the spring. His observations were made in Massachusetts where spruce itself is of limited availability. The Bay-breasted Warbler is a coniferous nester. Brewster (1906) found it to seek out conifers in the spring and to frequent gray birch and swampy maple woods in the fall. Stewart and Robbins (1958) noted it in young pine stands in the spring and in various forests at other times. This species then behaved as if hormonal influences govern its spring selection.

The tremendous increase of migrants in the fall due to the recent batch of young may force birds to inhabit areas that they would not under conditions of less population pressure in the spring. Trautman (1940) saw the American Redstart spread from woods in the spring to occasionally include brushy areas with no mature trees in the fall. Roberts (1932) found the Redstart just about everywhere in the fall. Trautman (1940) observed the Ovenbird in swamp forest in the spring and in swamp forest and upland woods in the fall. He also noted the Tennessee Warbler to spread from woodlands in the spring to small trees, thickets, and weedy fields in the fall. Roberts (1932) found the Nashville Warbler to include weedy fields in the fall as well as woods. Of course, some of this shifting may be due to relocation of food sources as well as population pressure (see Chapter V, Comparison of Behavior Between Seasons).

In this study a lack of vegetational preference in either season would indicate that, at least in the three areas at Kellogg Forest, foliage profile and competition were not of primary concern. A lack of preference in the spring would further show that hormonal factors were not involved. As mentioned, the Black-throated Green Warbler showed no preference in either season at Kellogg Forest while the Golden-crowned Kinglet exhibited no selection in the spring and a spruce preference in the fall. It appears then that of the possible factors listed above, these two species inhabited any area where they could find food. The other species, with preference determined only for the spring, provided a less complete picture. However, the Ovenbird, Black-and-white, and possibly Chestnut-sided Warblers seemed to select for a certain profile or physical appearance (see individual accounts). The Myrtle chose deciduous rather than its breeding vegetation. While competition cannot be ruled out, the motivational factor probably was food. The species that showed no preference instead of selecting the breeding foliage may primarily be concerned with food also. For those species that did seek out the breeding foliage, hormonal factors may or may not have been the key. Knowledge of their fall preferences would help in determining the governing factors.

CHAPTER VI

SUMMARY

Parnell (1969) reported that most of the warblers he observed chose the breeding foliage in migration. If it was not available, little selection occurred. Fewer than half of the species in this study chose the breeding foliage (Table 6). None of the three coniferous warblers (Myrtle, Black-throated Green, and Bay-breasted) chose conifers and of the three primarily deciduous warblers (American Redstart, Chestnut-sided, and Blue-winged) only one selected the deciduous plot. Of the four spruce warblers (Magnolia, Tennessee, Cape May, and Blackburnian) two showed a spruce preference, one a coniferous preference, and one pine avoidance. The two kinglets (Golden-crowned and Ruby-crowned), both spruce breeders, showed no preference in the spring, but the Golden-crowned demonstrated a spruce preference in the fall. The Nashville Warbler, which breeds in both deciduous and coniferous vegetation, showed no selection.

Factors governing selection during migration could be food availability, foliage profile, population pressure, competition, predation, and hormonal influence. Foliage profile, or the physical appearance of an area, seemed to be of more concern to the Black-and-white Warbler, Ovenbird, and possibly Chestnut-sided Warbler than species of plants. That the Golden-crowned Kinglet selected spruce in the fall rather than spring and the Black-throated Green Warbler chose no vegetation in either season indicate, for those two species,

hormonal influence was not the main factor. They, the Myrtle Warbler which chose deciduous vegetation over coniferous at Kellogg Forest, and other species that showed no preference may be concerned primarily with food availability. Of species that did select the breeding foliage in the spring, hormonal factors may be the key. Knowledge of their fall preferences would be helpful in assessing the main determinants.

Parnell (1969) stated that niche (foraging zone) may be more important to migrants than loyalty to any species of vegetation. Several of the species at Kellogg Forest did forage in a similar manner to that on the breeding grounds. The Magnolia Warbler seemed to choose the breeding foliage over its usual niche. A lessening of competition, aggression, or territorial behavior during migration may allow some species to expand their foraging zone. Also, ground and shrub nesters may be freed to range higher in the non-breeding season.

The deciduous area at Kellogg Forest had the best developed series of strata and contained the most species of migrants. The pine area and the original spruce area were comparatively barren of birds. Besides lack of vegetational diversity, poor food source may have been a factor, as well as lack of cover in the pine and the small plot size of the spruce.

A greater amount of canopy sightings were made for most species in this study than was noted by Parnell. The oak and hickory trees of the canopy may have provided a greater source of food for the migrants than the sassafras, dogwood, and black cherry of the understory.

For those species noted in more than one vegetation, there were both similarities and differences in the behavior exhibited in each. Parnell felt niche was independent of vegetation type. The small samples of this study may have accentuated the physical variation between areas and the adjustments in behavior caused by the presence of different species of birds.

Three species were observed in both the spring and fall. Seasonal differences in their foraging behavior were not apparent. Some differences are reported in the literature for various species. These probably reflect a shift in the position of food sources.

The Black-capped Chickadee did not seem to alter its behavior in the presence of the warblers or kinglets. However, in the spring it occurred predominantly in the pine area, where the warblers were scarce, and was uncommon in the spruce plot, which the warblers utilized heavily. This may suggest a certain degree of avoidance. The Red-eyed Vireo, another possible competitor of the warblers and kinglets, was unique in that it had a higher small branch value than the other migrants, was only seen over 30 feet, and had a somewhat different foraging method and beak structure. The Black-and-white Warbler may affect the White-breasted Nuthatch's foraging position and it and the Red-breasted Nuthatch may be somewhat exclusive. It does not appear to affect the Downy Woodpecker or Black-capped Chickadee.

The results of this study do not totally agree with Parnell. The factors governing selection listed above indicate that selection is a complex matter affected by a variety of influences. The general rule of choosing the breeding foliage, if available and selecting none when it is not, may be an oversimplification.

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Table 1. Characteristics of the oak-hickory canopy.

Characteristics	<i>Quercus velutina</i>	<i>Quercus alba</i>	<i>Quercus rubra</i>	<i>Carya ovalis</i>	<i>Acer rubrum</i>	<i>Sassafras albidum</i>
Density in trees per hectare	87.3	69.2	39.1	39.1	27.1	12.0
Basal area in m ² per hectare	8.9	2.1	6.2	1.9	0.8	0.3
Relative density	29.0	23.9	13.0	13.0	9.0	4.0
Relative dominance	40.2	9.7	28.7	9.0	4.0	1.3
Relative frequency	22.5	21.0	14.0	14.0	10.0	5.6
Importance value	91.7	53.7	55.7	36.0	23.0	10.9
Mean dbh in centimeters	35.6	19.6	44.9	25.2	19.4	17.2

Table 2. Characteristics of the oak-hickory understory.

Characteristics	<i>Cornus florida</i>	<i>Sassafras albidum</i>	<i>Acer rubrum</i>	<i>Quercus alba</i>	<i>Prunus serotina</i>
Density in trees per hectare	133.1	107.5	102.4	66.5	30.7
Basal area in m ² per hectare	0.4	0.3	0.5	0.4	0.1
Relative density	26.0	21.0	20.0	13.0	6.0
Relative dominance	19.6	14.4	23.0	17.7	4.5
Relative frequency	23.0	20.0	18.4	13.8	7.6
Importance value	68.6	55.4	61.4	44.5	18.1
Mean dbh in centimeters	6.5	6.2	8.0	8.7	6.5

Table 3. Relative frequency of the oak-hickory shrubs and herbs.

Species	1 square meter quadrat	100 square meter quadrat
<i>Aster schreberi</i>	12.4	13.1
<i>Cornus racemosa</i>	10.6	12.5
<i>Desmodium nudiflorum</i>	10.4	12.5
<i>Hepatica acutiloba</i>	7.6	11.3
<i>Acer rubrum</i>	7.6	9.4
<i>Smilicina racemosa</i>	5.4	10.6
<i>Sassafras albidum</i>	5.2	8.8
<i>Geranium maculosum</i>	3.9	5.0
<i>Viburnum acerifolium</i>	3.7	6.9
<i>Ribes cynosbati</i>	3.3	5.0
<i>Quercus</i> sp.	3.3	5.6

Table 4. Relative frequency of the pine area shrubs and herbs.

Species	1 square meter quadrat	100 square meter quadrat
<i>Rubus occidentalis</i>	17.0	12.9
<i>Sassafras albidum</i>	14.4	13.7
<i>Parthenocissus quinquefolia</i>	11.1	9.4
<i>Rubus allegheniensis</i>	10.7	9.4
<i>Phytolacca americana</i>	9.6	9.4
<i>Vitis</i> sp.	7.7	8.6
<i>Prunus serotina</i>	6.3	6.8

Table 5. Number of visits and hours spent in each study area in each season for both warbler and kinglet observations.

Area		Spring 1973		Fall 1973		Spring 1974		Total	
		Warbler	Kinglet	Warbler	Kinglet	Warbler	Kinglet	Warbler	Kinglet
Pine	Visits	7		10	10	9	11	26	21
	Hours	3.9		5.8	4.5	4.6	5.7	14.3	10.2
Deciduous	Visits	13		13	16	16	21	42	37
	Hours	26.8		12.4	14.4	23.4	28.5	62.6	42.9
Spruce*	Visits	5		6	8	14 (5,9)	14 (8,6)	25	22
	Hours	2.1		2.7	3.7	13.1 (3.0,10.1)	14.2 (5.9,8.3)	17.8	17.9
Total	Visits	25		29	34	39	46	93	80
	Hours	32.7		20.9	22.5	41.1	48.4	94.7	70.9

*For the Spring of 1974, the first figure is the total for both spruce areas. The numbers in parentheses pertain to the first and second spruce areas respectively.

Table 6. Foliage preference exhibited in each season and with the seasons combined at Kellogg Forest using the chi-square test. Significance (preference shown) = 5.991 and above. Breeding preferences as determined from the literature are listed for comparison.

Warbler and Kinglet Species	Spring 1973	Fall 1973	Spring 1974	Two Springs	All Three Seasons	Migratory Preference	Breeding Preference (from literature)
Black-and-white (<i>Mniotilta varia</i>)	3.72	+	4.23	<u>8.38</u>	-	Deciduous*	Open woods, shrub layer or saplings
Blue-winged (<i>Vermivora pinus</i>)	+	-	1.43	2.80	-	None	Deciduous
Tennessee (<i>Vermivora peregrina</i>)	+	+	<u>13.37</u>	<u>8.26</u>	-	Spruce	Spruce (and other situations)
Nashville (<i>Vermivora ruficapilla</i>)	+	-	2.96	3.85	-	None	Conif. bogs, early second growth decid. forest
Magnolia (<i>Dendroica magnolia</i>)	+	+	<u>7.90</u>	<u>13.48</u>	-	Spruce	Spruce
Cape May (<i>Dendroica tigrina</i>)	-	-	4.04	-	-	Coniferous*	Spruce
Myrtle (<i>Dendroica coronata</i>)	+	+	<u>16.53</u>	<u>13.54</u>	-	Deciduous	Coniferous
Black-throated Green (<i>Dendroica virens</i>)	4.68	3.88	3.62	0.18	-	None (Fall) None (Spring)	Coniferous

Table 6 Continued.

Warbler and Kinglet Species	Spring 1973	Fall 1973	Spring 1974	Two Springs	All Three Seasons	Migratory Preference	Breeding Preference (from literature)
Blackburnian (<i>Dendroica fusca</i>)	+	+	3.33	5.50	-	Pine avoidance*	Spruce and hemlock
Chestnut-sided (<i>Dendroica pensylvanica</i>)	+	+	<u>9.37</u>	5.63	-	Deciduous*	Primarily deciduous (open shrubby areas)
Bay-breasted (<i>Dendroica castanea</i>)	+	+	0.31	1.20	-	None	Coniferous (usually spruce)
Ovenbird (<i>Seiurus aurocapillus</i>)	0.39	+	<u>9.34</u>	<u>9.91</u>	-	Spruce avoidance*	Decid. leaves on ground, open canopy
American Redstart (<i>Setophaga ruticila</i>)	+	+	+	+	1.18	None	Deciduous
Golden-crowned (<i>Regulus satrapa</i>)	-	<u>10.84</u>	0.04	-	-	Spruce (Fall) None (Spring)	Spruce
Ruby-crowned (<i>Regulus calendula</i>)	-	+	0.77	-	-	None	Spruce

+ species present but not in sufficient quantity to be valid statistically.

— indicates a significant value.

* author's interpretation (see text).

Table 7. Total number of observations and birds per hour values for each species in each season.

Species	Spring 1973		Fall 1973		Spring 1974		Total	
	Total obs.	Birds per hr.	Total obs.	Birds per hr.	Total obs.	Birds per hr.	obs.	Birds per hr.
Black-and-white	17	0.52	10	0.48	11	0.27	38	0.40
Blue-winged	11	0.34	-	-	9	0.22	20	0.21
Tennessee	7	0.21	1	0.05	18	0.44	26	0.27
Nashville	11	0.34	-	-	17	0.41	28	0.30
Magnolia	3	0.09	3	0.14	24	0.58	30	0.32
Cape May	-	-	-	-	10	0.24	10	0.11
Myrtle	5	0.15	2	0.10	26	0.63	33	0.35
Black-throated Green	26	0.79	12	0.57	38	0.93	76	0.80
Blackburnian	16	0.49	1	0.05	13	0.32	30	0.32
Chestnut-sided	5	0.15	1	0.05	13	0.32	19	0.20
Bay-breasted	6	0.18	1	0.05	25	0.61	32	0.34

Table 7 Continued.

Species	Spring 1973		Fall 1973		Spring 1974		Total	
	Total obs.	Birds per hr.	Total obs.	Birds per hr.	Total obs.	Birds per hr.	obs.	Birds per hr.
Ovenbird	30	0.92	6	0.29	24	0.58	60	0.63
American Redstart	2	0.06	2	0.10	5	0.12	9	0.09
Warbler Total	139	4.25	39	1.87	233	5.67	411	4.34
Golden-crowned	-	-	30	1.33	15	0.98	45	1.19
Ruby-crowned	-	-	5	0.22	12	0.29	17	0.26
Kinglet Total	-	-	35	1.55	27	0.56	62	0.87

Table 8. The number of warblers, warblers per hour, kinglets, and kinglets per hour recorded in each season for each study plot.

Area	Spring 1973		Fall 1973		Spring 1974		Total	
	Total obs.	Birds per hr.	Total obs.	Birds per hr.	Total obs.	Birds per hr.	obs.	Birds per hr.
Warbler								
Pine	10	2.56	-	-	18	3.94	28	1.96
Deciduous	125	4.67	37	2.98	142	6.07	304	4.86
Spruce *	4	1.92	2	0.75	73 (11,62)	5.58 (3.68,6.15)	79 (17,62)	4.43 (2.20,6.15)
Total	139	4.25	39	1.87	233	5.67	411	4.34
Kinglet								
Pine	-	-	4	0.89	5	0.88	9	0.89
Deciduous	-	-	18	1.25	15	0.53	33	0.77
Spruce*	-	-	13	3.56	7 (5,2)	0.49 (0.85,0.24)	20 (18,2)	1.12 (1.88,0.24)
Total	-	-	35	1.55	27	0.56	62	0.87

*For the spring of 1974 the first figure is the total for both spruce areas. The numbers in parentheses pertain to the original and later spruce areas respectively.

Table 9. Warbler and kinglet species recorded in each study area in each season.

Warbler and Kinglet Species	Spring 1973			Fall 1973			Spring 1974			
	Pine	Decid.	Spruce (original)	Pine	Decid.	Spruce (original)	Pine	Decid.	Spruce (original)	Spruce (added)
Black-and-white		X			X			X		X
Blue-winged		X						X	X	X
Tennessee		X				X	X	X		X
Nashville		X						X	X	X
Magnolia		X			X		X	X		X
Cape May							X	X		X
Myrtle		X			X			X		
Black-throated Green	X	X	X		X	X	X	X	X	X
Blackburnian		X			X			X		X
Chestnut-sided		X			X			X		X
Bay-breasted		X			X		X	X		X
Ovenbird	X	X	X		X		X	X	X	

Table 9 Continued.

Warbler and Kinglet Species	Spring 1973			Fall 1973			Spring 1974			
	Pine	Decid.	Spruce (original)	Pine	Decid.	Spruce (original)	Pine	Decid.	Spruce (original)	Spruce (added)
American Redstart		X			X		X	X		X
Golden-crowned				X	X	X	X	X	X	
Ruby-crowned				X	X	X	X	X	X	X
Total										
Warbler species	2	12	2	0	9	2	7	13	4	11
Species	2	12	2	2	11	4	9	15	6	12

Table 10. Occurrence of each species in the various strata of the deciduous area (expressed in per cent).

Species	Activity	Strata				Total obs.
		C	SC	U	G	
Black-and-white	F	93	7			27
Blue-winged	F	100				6
Tennessee	F	90	10			10
Nashville	F	76	18	6		17
Magnolia	F	37	50	12		8
Cape May	F		100			1
Myrtle	F	91	9			22
Black-throated Green	S	87	12			8
" " "	F	70	30			30
Blackburnian	F	100				19
Chestnut-sided	S	66	33			6
" "	F	75	12	12		8
Bay-breasted	F	86	14			14
Ovenbird	S	10	90			10
"	F		25	42	33	12
American Redstart	F	33		33	33	3
Golden-crowned	F	48	43	4	4	23
Ruby-crowned	F	44	44	11		9

C=canopy, SC=subcanopy, U=undergrowth, G=ground, S=singing, F=foraging and other non-singing activities.

Table 11. Habitat utilization in each vegetation by each species (expressed in per cent).

Species Vegetation	Strata	Activity	Height from ground (in feet)									Relative height (by quarter)					Location in tree					Total obs.			
			0	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	>80	Total obs.	1	2	3	4	Total obs.	Fo	T	S		L	Tr	
Black-and-white Warbler																									
Deciduous	C	F	4	11	21	18	29	7		7	4	28	8	58	21	12	24		12	15	26	47	34		
Blue-winged Warbler																									
Deciduous	C	F				29	57	14				7		43	57		7		100				6		
Tennessee Warbler																									
Deciduous	C	F			10	10	30	30	10		10	10		25	62	12	8		89	11			9		
Spruce	C	S			20			40		40		5		20		80	5	25	50	25			4		
	C	F		17	33		17	33				6	17	33	33	17	6	37	25	25	12		8		
Nashville Warbler																									
Deciduous	C	F		7		7	29	50		7		14	8	15	62	15	13		62	31	8		13		
Magnolia Warbler																									
Deciduous	SC	F		80	20							5		75	25		4		20	80			5		
Cape May Warbler																									
Spruce	C	F					60	40				5			100		5	80	20				5		
Myrtle Warbler																									
Deciduous	C	F			22	18	26	18	11		4	27		36	45	18	22		63	18	18		27		

Table 11 Continued.

Species	Vegetation	Strata	Activity	Height from ground (in feet)								Total obs.	Relative height (by quarter)				Total obs.	Location in tree					Total obs.
				0	0-10	11-20	21-30	31-40	41-50	51-60	61-70		71-80	>80	1	2		3	4	Fo	T	S	
Black-throated Green Warbler																							
	Deciduous	C	S					29	29	29	14	7			86	14	7		57	29	14	7	
		C	F			4	8	19	27	23		19	26	5	38	34	24	21	60	24	16	25	
		SC	F		9	18	45	27				11			44	22	33	9	89	11		9	
Blackburnian Warbler																							
	Deciduous	C	F				11	11	42	21		16	19		24	59	18	17		44	39	17	18
Chestnut-sided Warbler																							
	Deciduous	C	F				17		66	17		6			50	50		6		100		6	
Bay-breasted Warbler																							
	Deciduous	C	F				14	14	36	21	14	14			30	60	10	10		64	18	18	11
	Spruce	C	F			12	25	12	12	25	12	8	14	29	43	14	7	33	33	33		6	
Ovenbird																							
	Deciduous	SC	S		22	22	11	44				9			33	33	33	6		14	57	29	7
Golden-crowned Kinglet																							
	Pine	C	F			27	36	27	9			11	10	40	40	10	10	20	50	30		10	
	Deciduous	C	F						27	45	27	11		27	64	9	11		54	36	9	11	
		SC	F		66		33					9	66		11	22	9	50	37	14		8	
	Spruce	C	F		28	32	16	16	8			25	62	25	12		16	28	39	33		18	

C=canopy, SC=subcanopy, S=singing, F=foraging (and activities other than singing), Fo=foliage, T=twig, S=small branch, L=large branch, Tr=trunk.

Table 12. Habitat utilization in the deciduous area - spring versus fall (expressed in per cent).

Species	Season	Strata				Total obs.	Quarter				Total obs.	Location					Total obs.
		C	SC	U	G		1	2	3	4		F	T	S	L	Tr	
Black-and-white Warbler																	
	Spring	94	6			18	12	56	25	6	16		4	18	29	50	28
	Fall	89	11			9	11	55	11	22	9		38		12	50	8
Black-throated Green Warbler																	
	Spring	70	30			20		30	50	20	20		67	25	8		24
	Fall	70	30			10	10	50	20	20	10		70	10	20		10
Golden-crowned Kinglet																	
	Spring	44	44	11		9	28		57	14	7		50	38	12		8
	Fall	54	46			13	36	21	28	14	14	36	45	18			11

C=canopy, SC= subcanopy, U=undergrowth, G=ground, F=foliage, T=twig, S=small branch, L=large branch, Tr=trunk.

Table 13. Distribution of the warblers and kinglets over the different height increments in each area (expressed in per cent).

Area	Height from ground (in feet)									Total obs.
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	Above 80	
Warbler										
Pine	0	0	6	6	65	18	0	6	0	17
Deciduous	9	10	18	17	22	16	3	5	1	256
Spruce	3	12	22	6	29	22	3	5	0	65
Kinglet										
Pine	0	27	27	27	18	0	0	0	0	11
Deciduous	25	4	25	12	21	12	4	0	0	28
Spruce	22	22	33	6	17	0	0	0	0	18

Table 14. Occurrence of five non-warbler and kinglet species in the various strata of the deciduous area (expressed in per cent).

Species	Season	Strata				Total obs.
		C	SC	U	G	
Downy Woodpecker (<i>Dendrocopos pubescens</i>)	Spring	73	27			15
Black-capped Chickadee (<i>Parus atricapillus</i>)	Spring	58	33	8		24
	Fall	12	25	63		8
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	Spring	77	23			39
	Fall	82	18			11
Brown Creeper (<i>Certhia familiaris</i>)	Spring	100				5
	Fall	100				6
Red-eyed Vireo (<i>Vireo olivaceus</i>)	Spring	87	13			15

C= canopy, SC= subcanopy, U= undergrowth, G= ground.

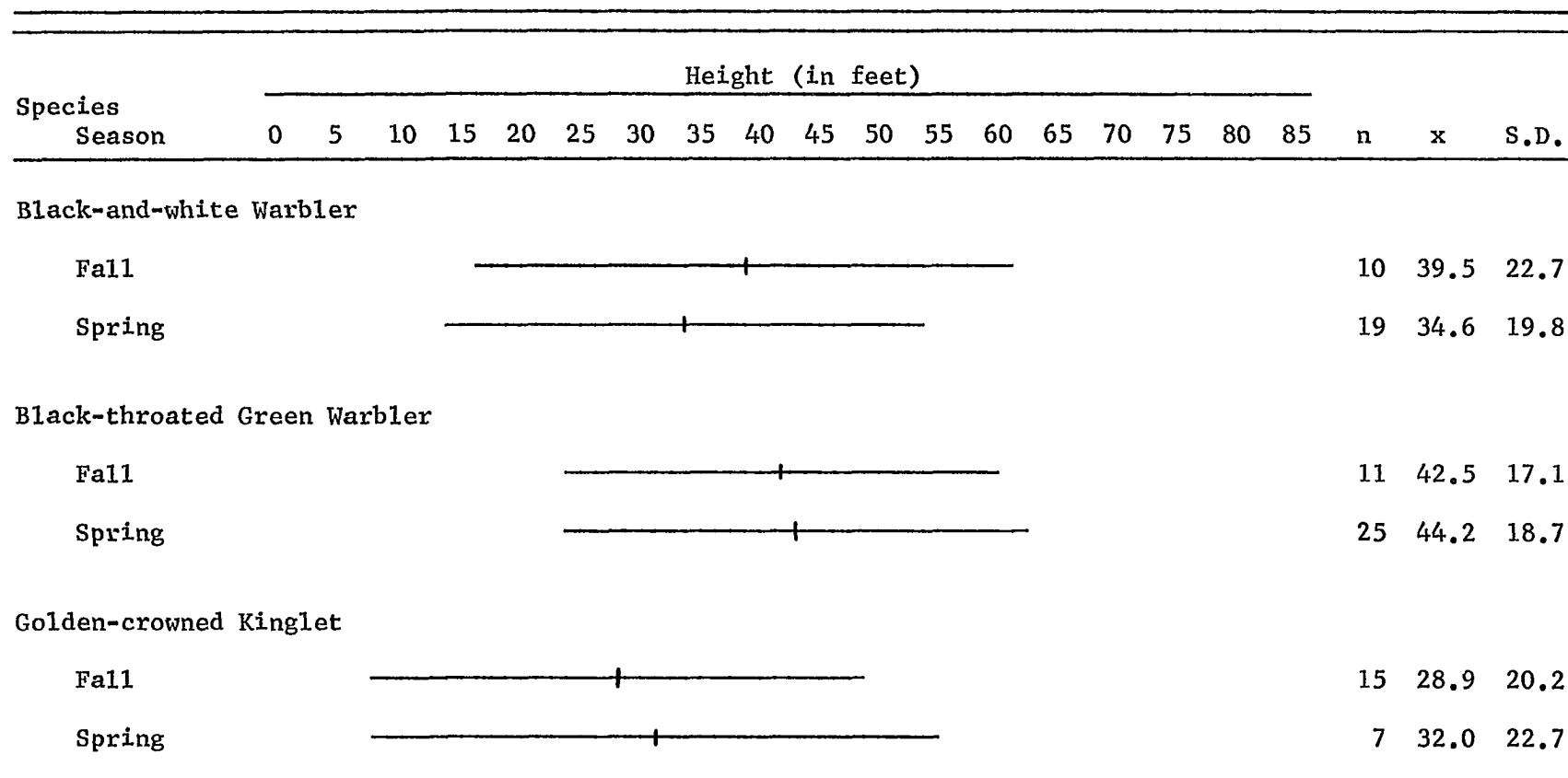
Table 15. Habitat utilization by six non-warbler and kinglet species (expressed in per cent).

Species Vegetation	Strata	Season	Height from ground (in feet)										Total obs.	Relative height (by quarter)					Total obs.	Location in tree					Total obs.
			0	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	>80		1	2	3	4	Fo		T	S	L	Tr		
Downy Woodpecker																									
Deciduous	C	Sp			17	25	17	17	17	8		12		37	50	12	8				50	50	8		
Black-capped Chickadee																									
Deciduous	C	Sp		7	7	21		29	29	7		14	14	36	50		14		54	23	23		13		
	SC	Sp		70	10	10		10				10	43	29	14	14	7		44	33	22		9		
Spruce	C	Sp		18	9	27	27	9		9		11	20	30	30	20	10	40	40	20		10			
Pine	C	Sp/F			9	18	22	40	4	4		22		20	50	30	20	12	40	40	4	4	25		
White-breasted Nuthatch*																									
Deciduous	C ¹	Sp/F		4	14	32	14	27			9	22	30	65		5	20			25	75	20			
	C ²	Sp/F		6	6	18	18	35	18			17	19	44	37		16		12	35	53	17			
	SC	Sp		60	20	10	10					10	33	44	22		9		11	22	66	9			
Red-breasted Nuthatch																									
Pine	C	Sp/F			11	26	22	37	4			27		37	59	4	27	7	4	11	26	52	27		
Brown Creeper																									
Deciduous	C	F		17	17	17	17		17	17		6	29	29	29	14	7				100	6			
Red-eyed Vireo																									
Deciduous	C	Sp					22	11	55		11	9		22	67	11	9		44	55		9			

C=canopy, SC=subcanopy, Sp=spring, F=fall, Fo=foliage, T=twig, S=small branch, L=large branch, Tr=trunk.

*^{C1} is with the Black-and-white Warbler present, ^{C2} with the Black-and-white Warbler absent.

Figure 1. Foraging height in the deciduous area - spring versus fall.



n=number of observations, x=mean height, S.D.=standard deviation. The vertical slash represents the mean height and the long line one standard deviation. The spring data represent a combination of the 1973 and 1974 seasons for the Black-throated Green and Black-and-white Warblers.

Figure 2. Height at which each species occurred 66% or more of the time for a given activity and vegetation type.

Vegetation	Warbler and Kinglet Species	Activity	Height (in feet)																	% of occur.	Total obs.
			0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	
Spruce	Golden-crowned +	F	_____																	78	15
	Bay-breasted +	F			_____															88	8
	Magnolia +	F					_____													86	14
	Tennessee * +	F					_____													87	7
	Cape May	F									_____									100	5
	Tennessee * +	S									_____									80	5
Deciduous	Ovenbird *	F	_____																	100	13
	Magnolia +	F	_____																	67	9
	Ruby-crowned	F	_____																	100	13
	Ovenbird *	S			_____															77	13
	Chestnut-sided *	S					_____													66	5
	Chestnut-sided *	F			_____															81	11
	Blue-winged	F			_____															100	10
	Black-and-white	F			_____															72	31
	Golden-crowned +	F			_____															100	19
	Black-throated Green *	S					_____													86	7
	Black-throated Green *	F					_____													76	37
	Bay-breasted +	F					_____													85	19
	Myrtle	F					_____													84	31
	Nashville	F							_____											71	18
	Blackburnian	F									_____									80	20
	Tennessee * +	F									_____									72	11
Pine	Golden-crowned +	F			_____															90	10

S=singing, F=foraging (and other non-singing activities), +=species with ranges presented for two or more vegetation types, *=species with ranges presented for different activities in the same vegetation.

Figure 3. Song height versus forage height during the two spring periods.

Species	Activity	Height (in feet)																	n	x	S.D.	
		0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80				85
Tennessee Warbler (S)																						
	Forage																			6	37.5	17.6
	Sing																			5	60.0	18.5
Black-throated Green Warbler (D)																						
	Forage																			25	44.2	18.7
	Sing																			8	55.4	13.4
Chestnut-sided Warbler (D)																						
	Forage																			10	30.9	17.6
	Sing																			6	38.8	11.4
Ovenbird (D)																						
	Forage																			8	1.9	2.4
	Sing																			15	27.7	13.5

n=number of observations, x=mean height, S.D.=standard deviation, D=deciduous area, S=spruce area. The vertical slash represents the mean height and the long line one standard deviation.

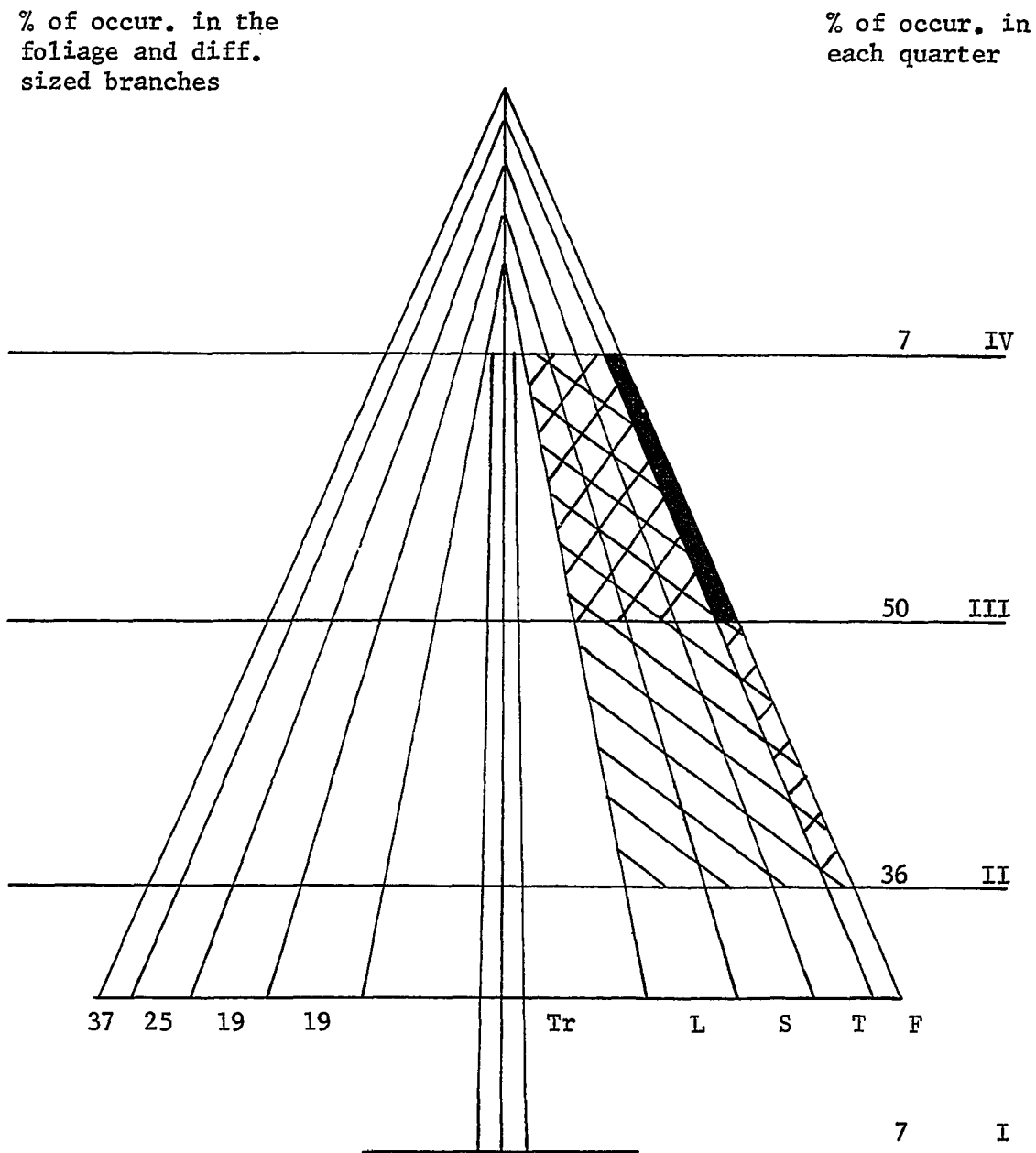


Figure 4. Magnolia Warbler foraging position in the spruce canopy. The darkened zone represents the area of greatest concentration in both relative height and location. The double hatching denotes the highest concentration in one category and the simple hatching rounds out the shaded area to include 66% of the observations in each category. F=foliage, T=twig, S=small branch, L=large branch, Tr=trunk. Sample sizes are found in Table 11.

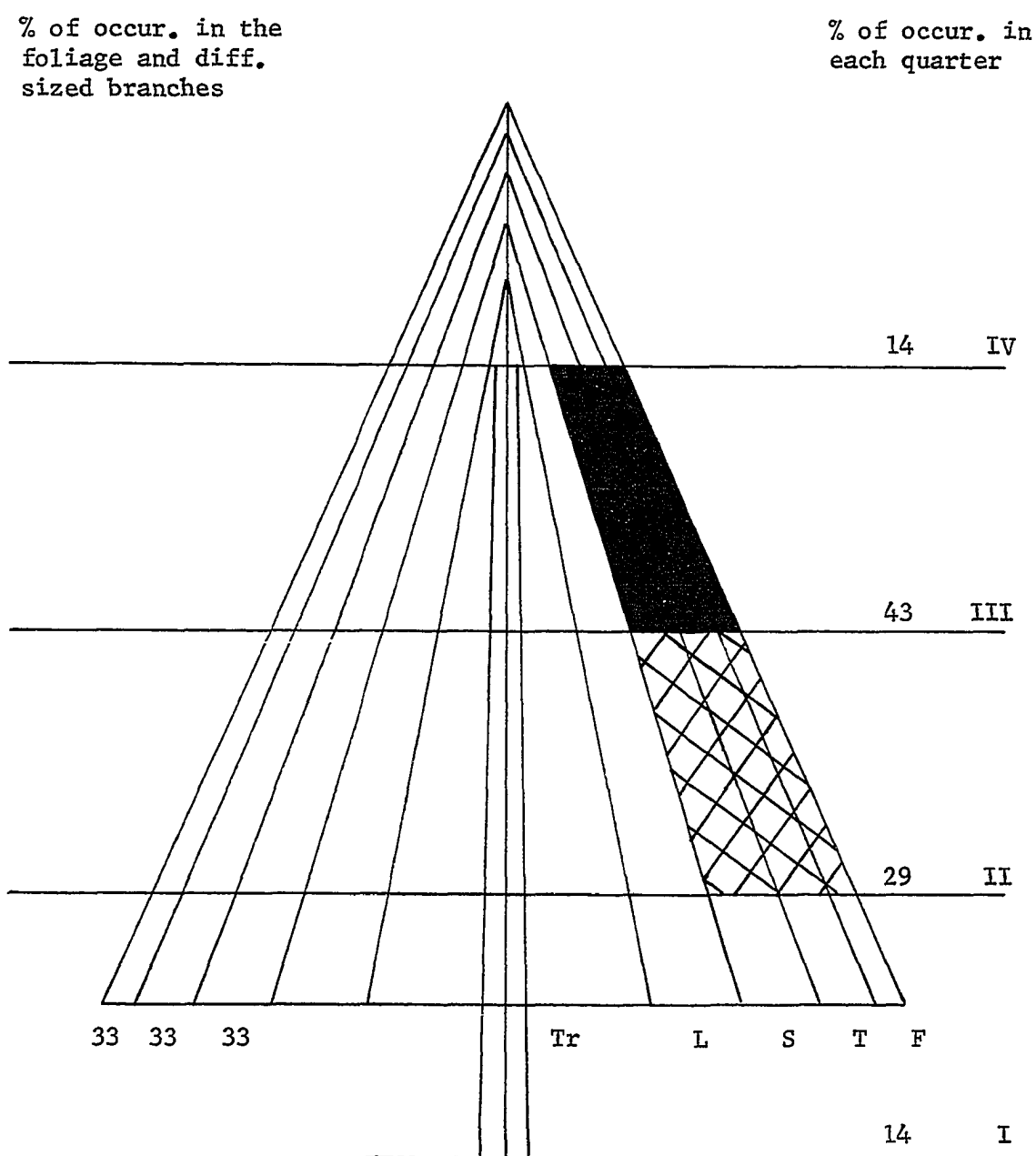


Figure 5. Bay-breasted Warbler foraging position in the spruce canopy. See Figure 4 for explanation of symbols.

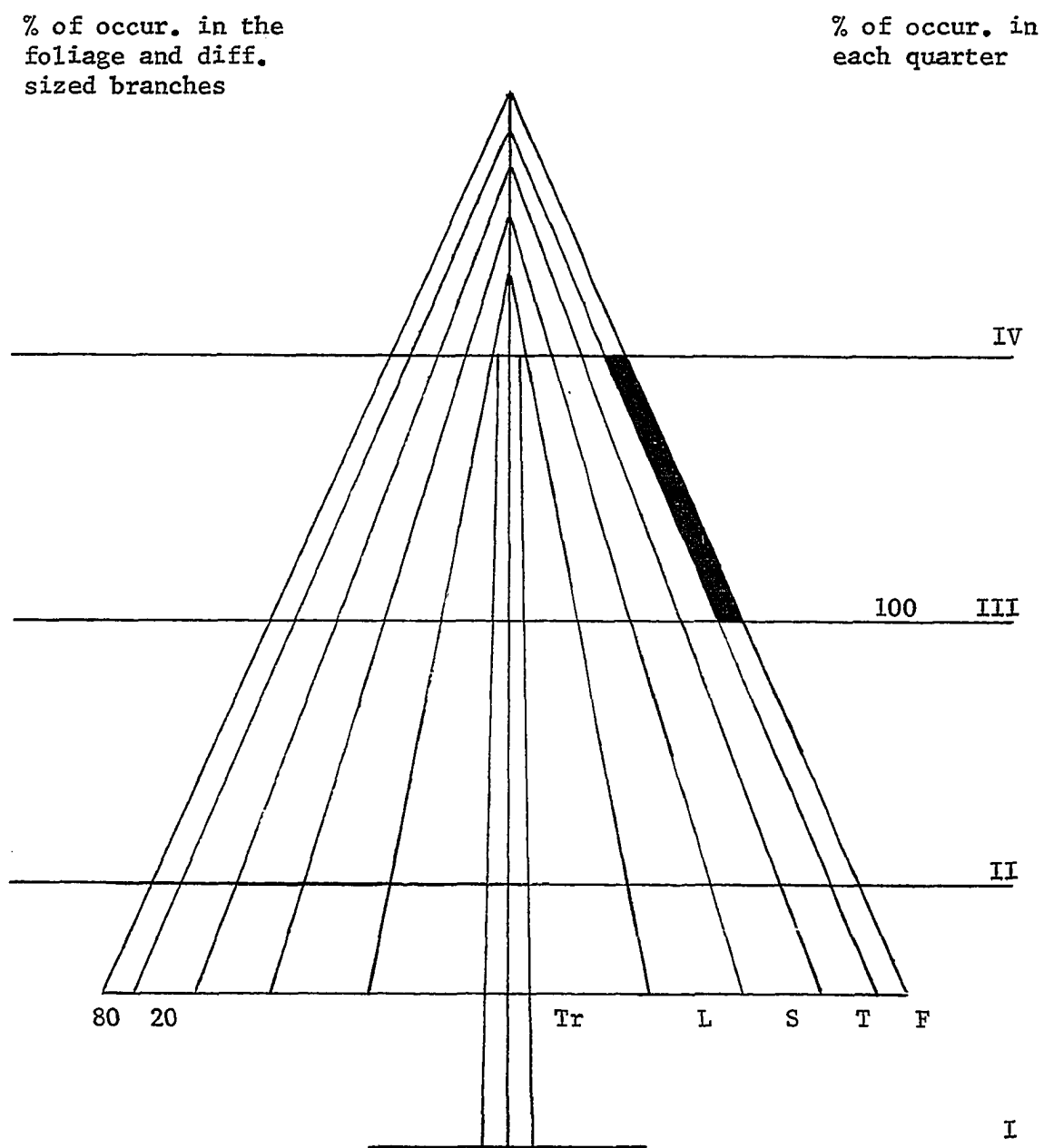


Figure 6. Cape May Warbler foraging position in the spruce canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

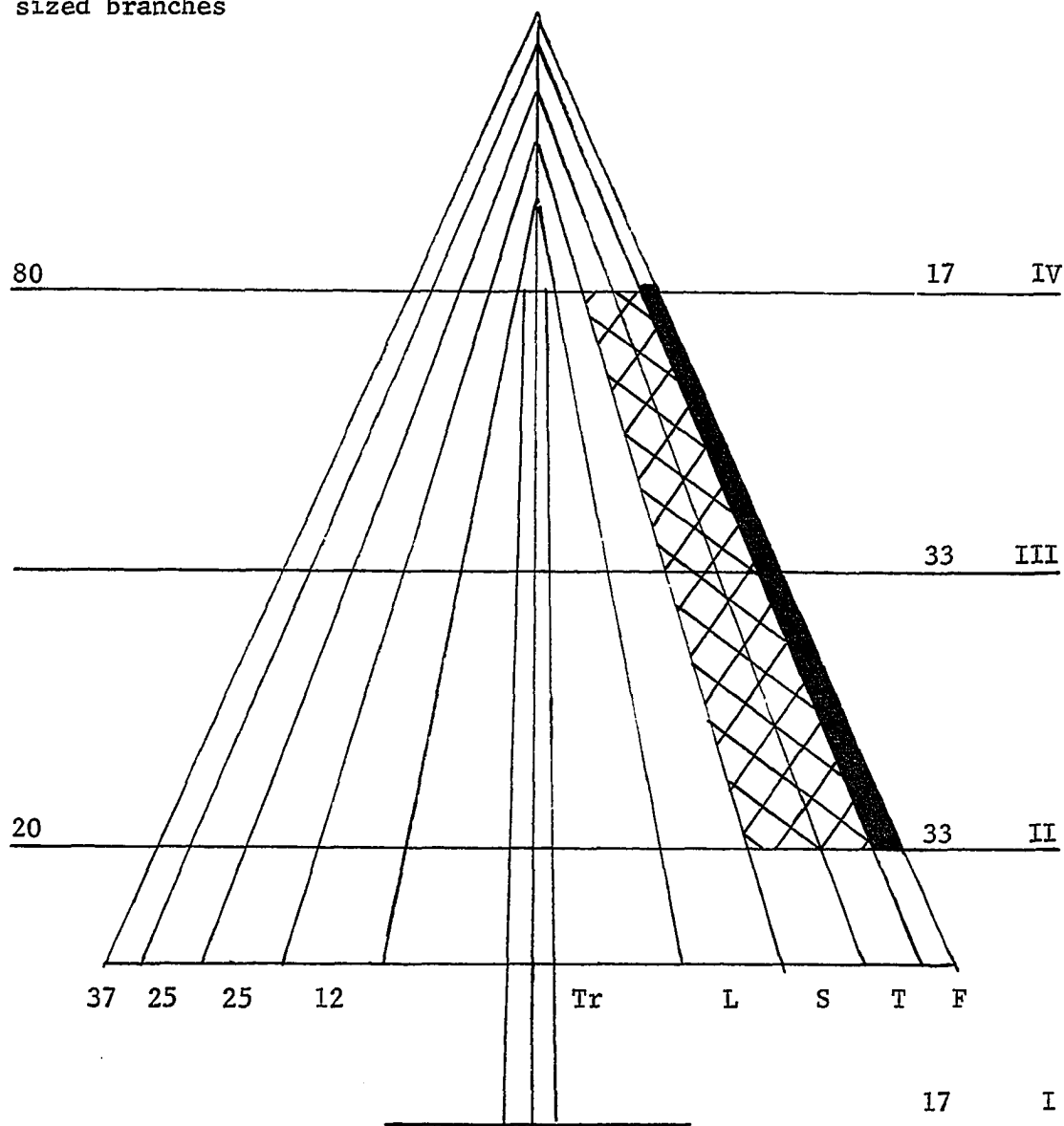


Figure 7. Tennessee Warbler foraging and singing positions in the spruce canopy. Singing position is indicated only by the percent of occurrence in each quarter figures on the left side of the tree. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

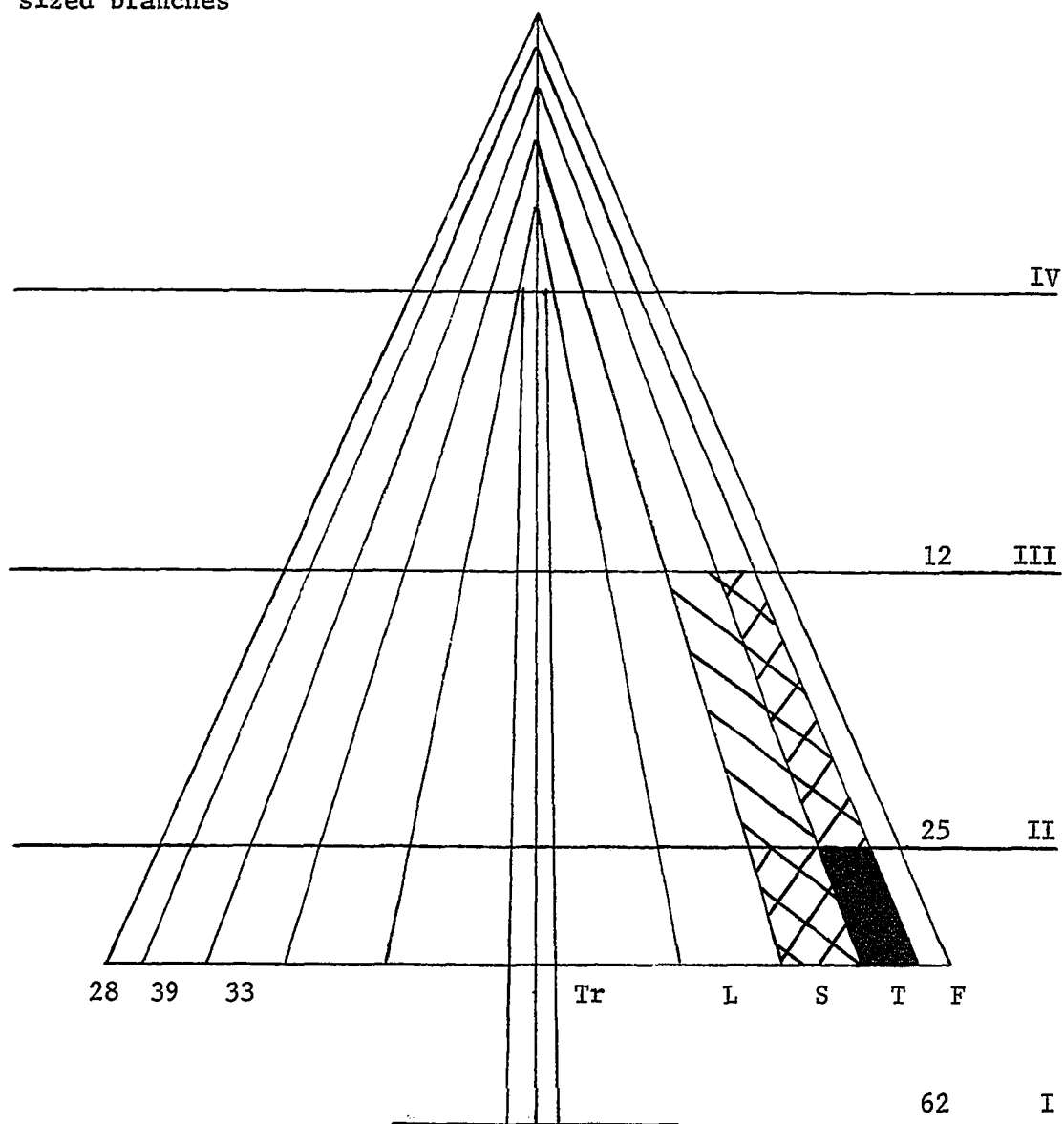


Figure 8. Golden-crowned Kinglet foraging position in the spruce canopy. See Figure 4 for explanation of symbols.

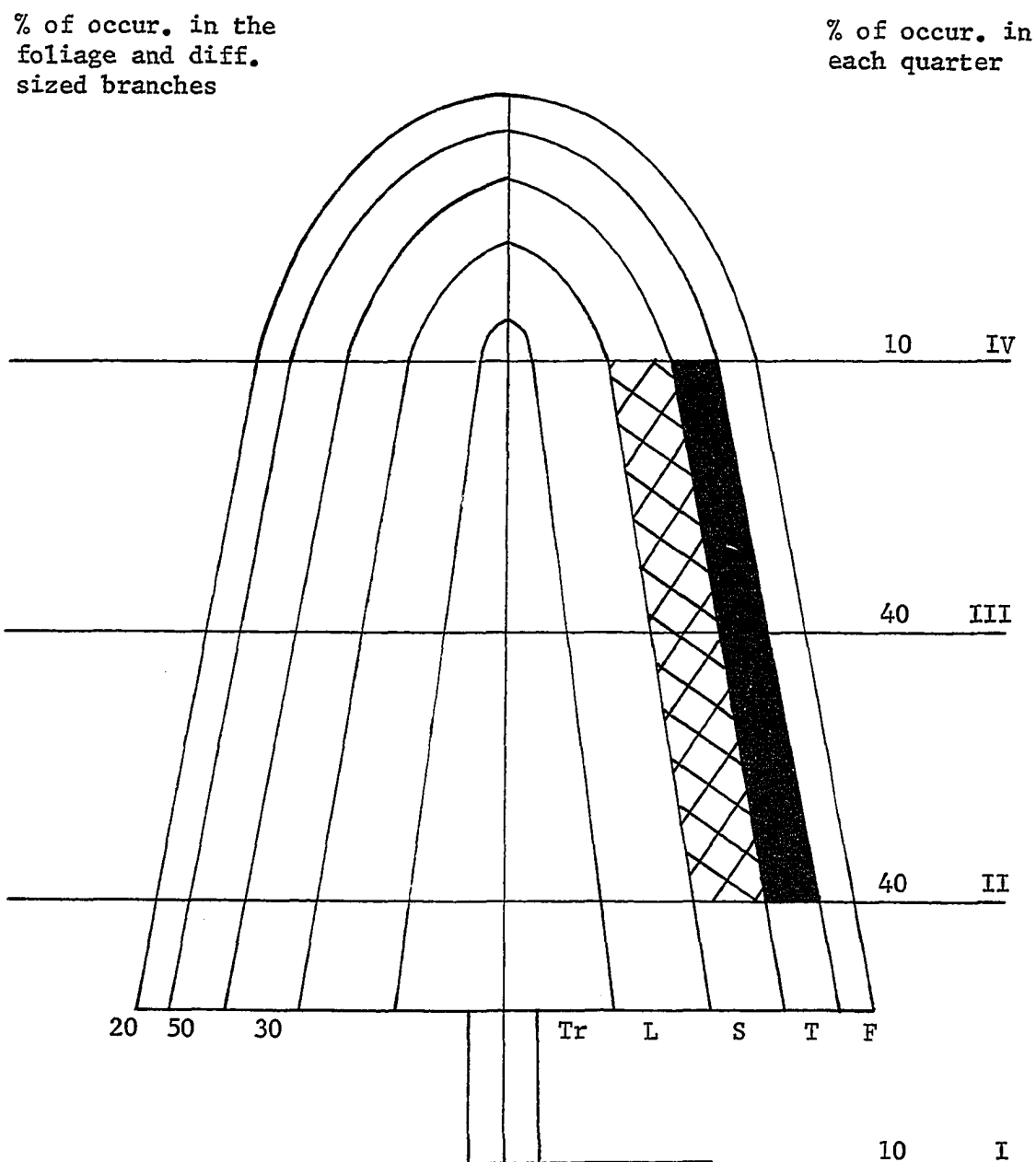


Figure 9. Golden-crowned Kinglet foraging position in the pine canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

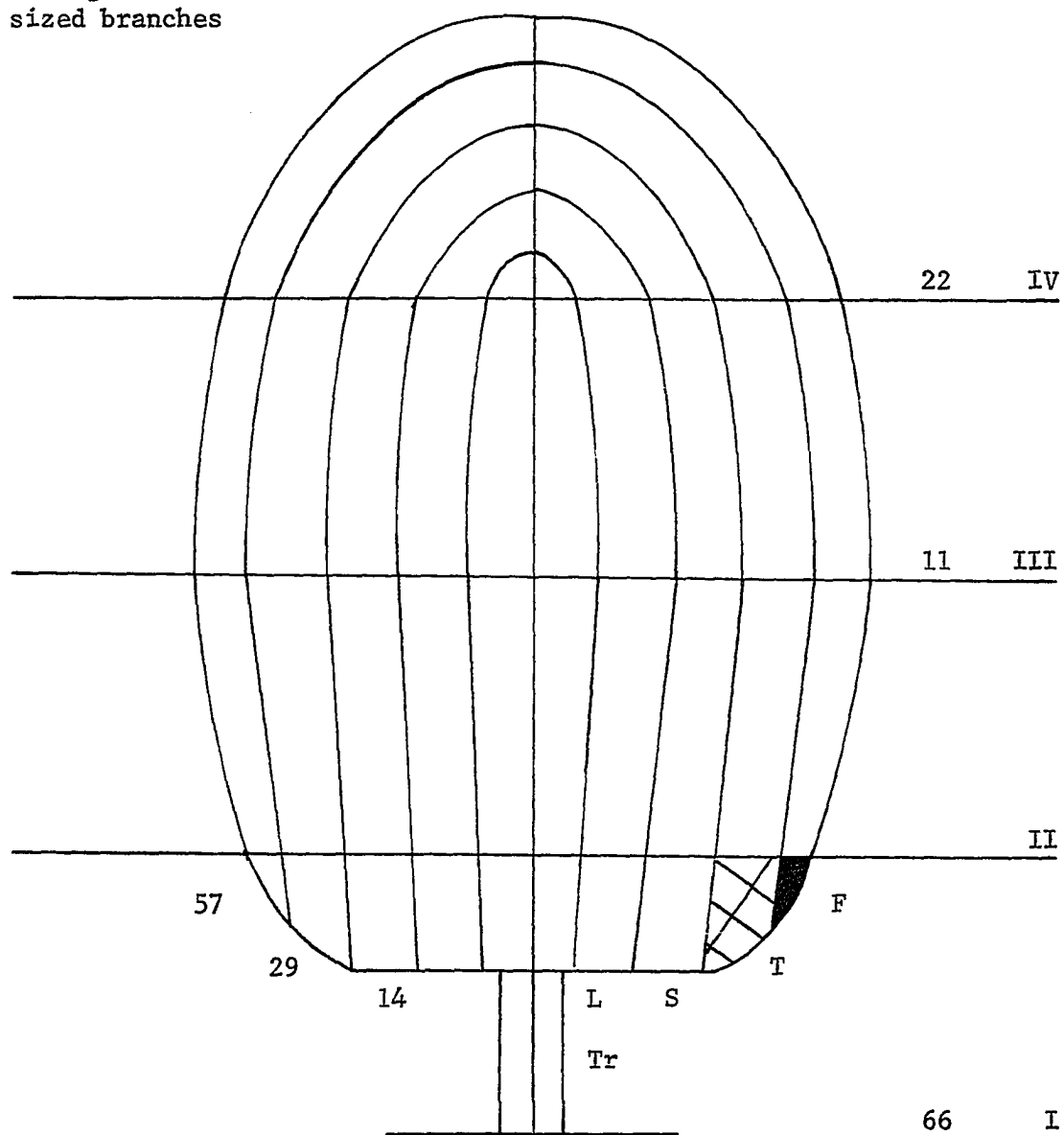


Figure 10. Golden-crowned Kinglet foraging position in the deciduous subcanopy. See Figure 4 for explanation of symbols.

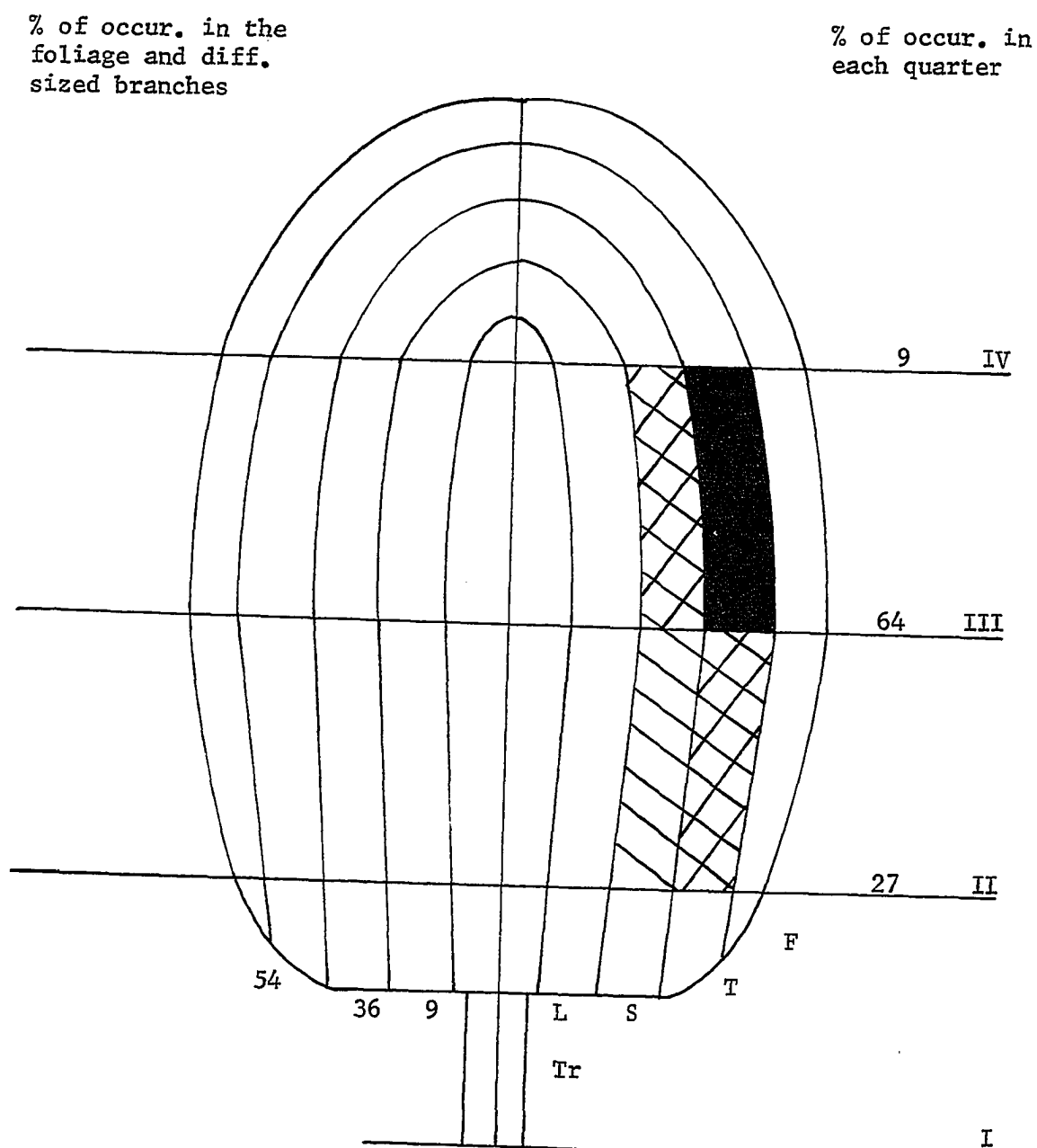


Figure 11. Golden-crowned Kinglet foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

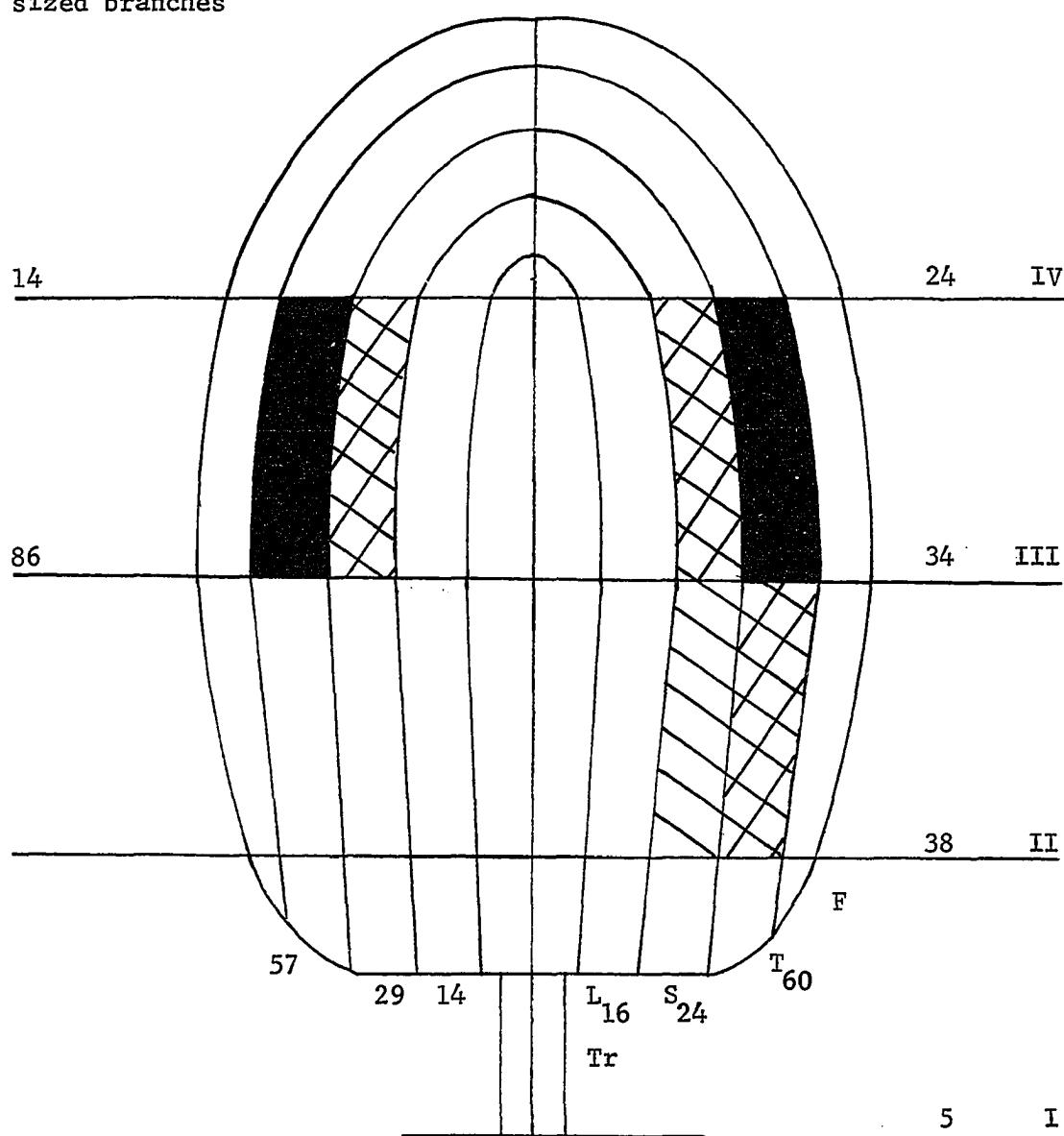


Figure 12. Black-throated Green Warbler foraging and singing positions in the deciduous canopy. The foraging figures are presented on the right, the singing figures on the left. See Figure 4 for explanation of symbols.

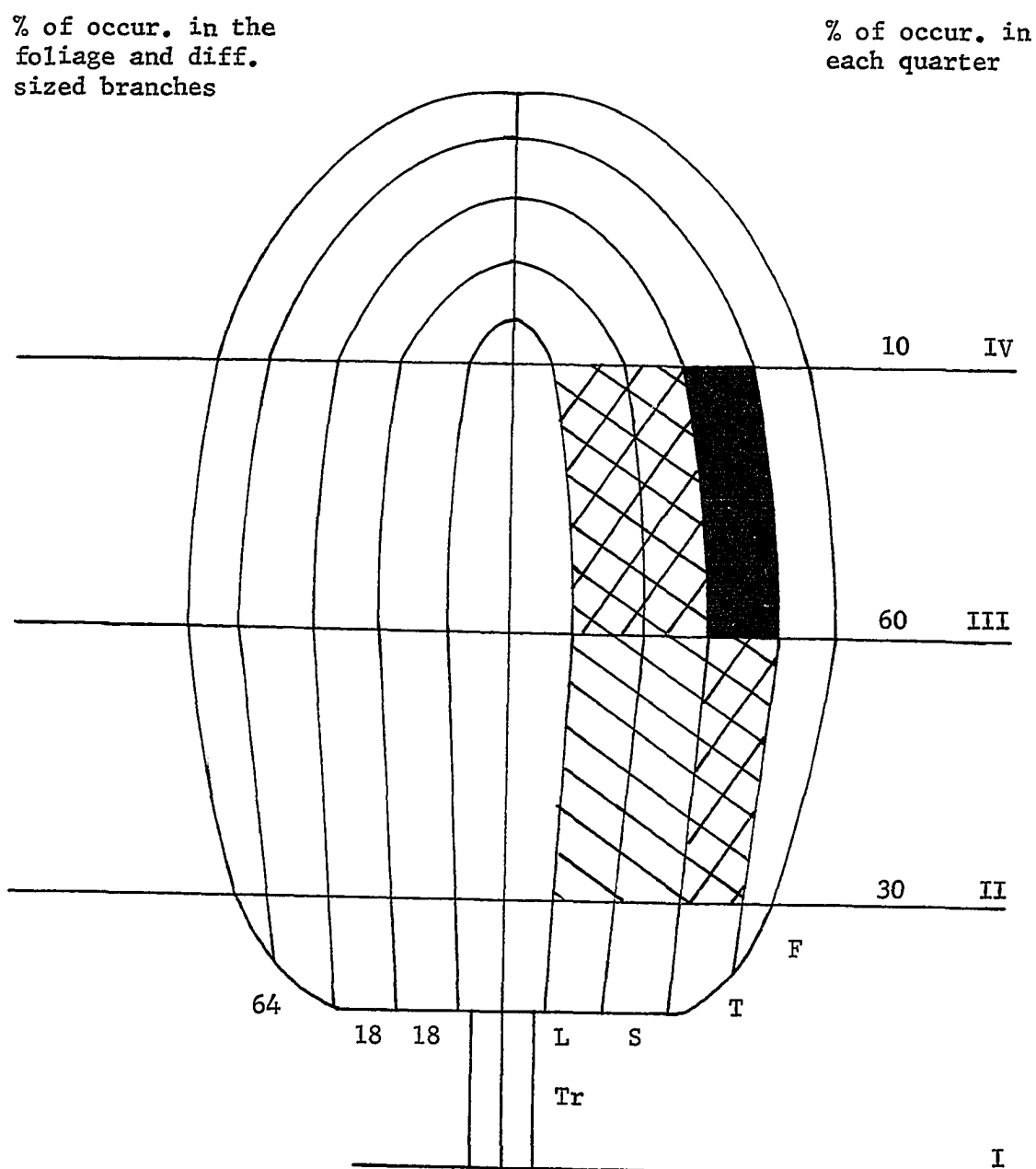


Figure 14. Bay-breasted Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

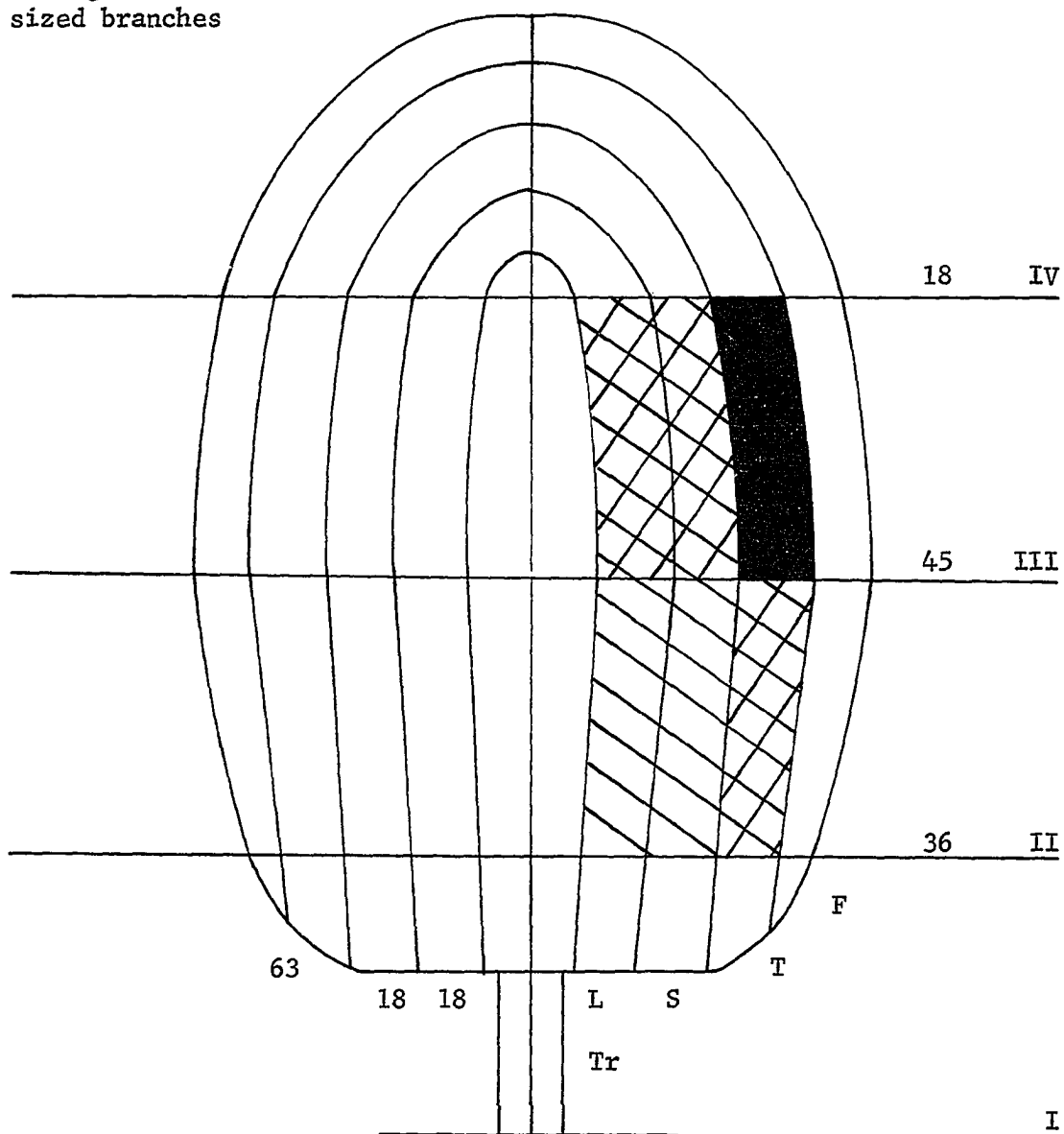


Figure 15. Myrtle Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

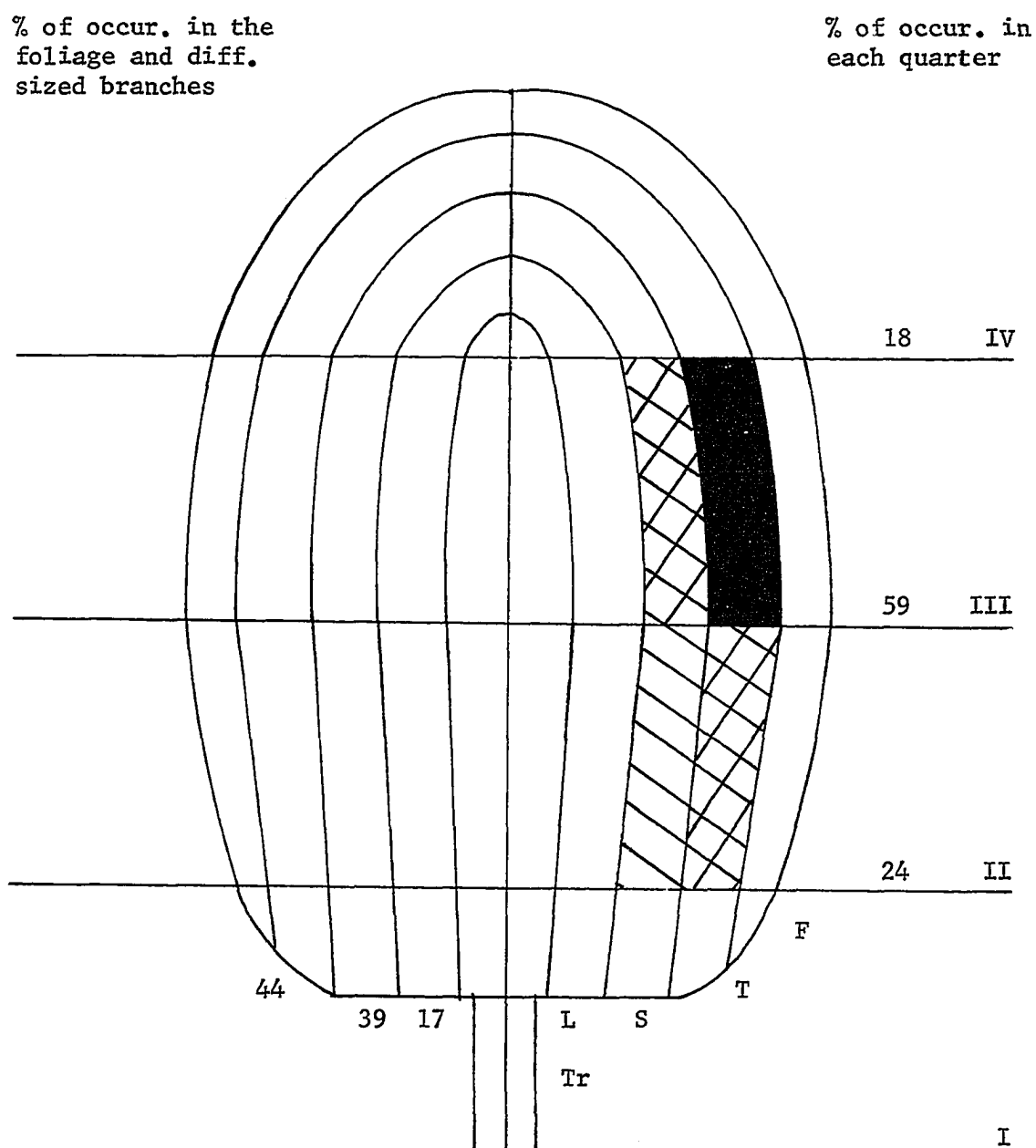


Figure 16. Blackburnian Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

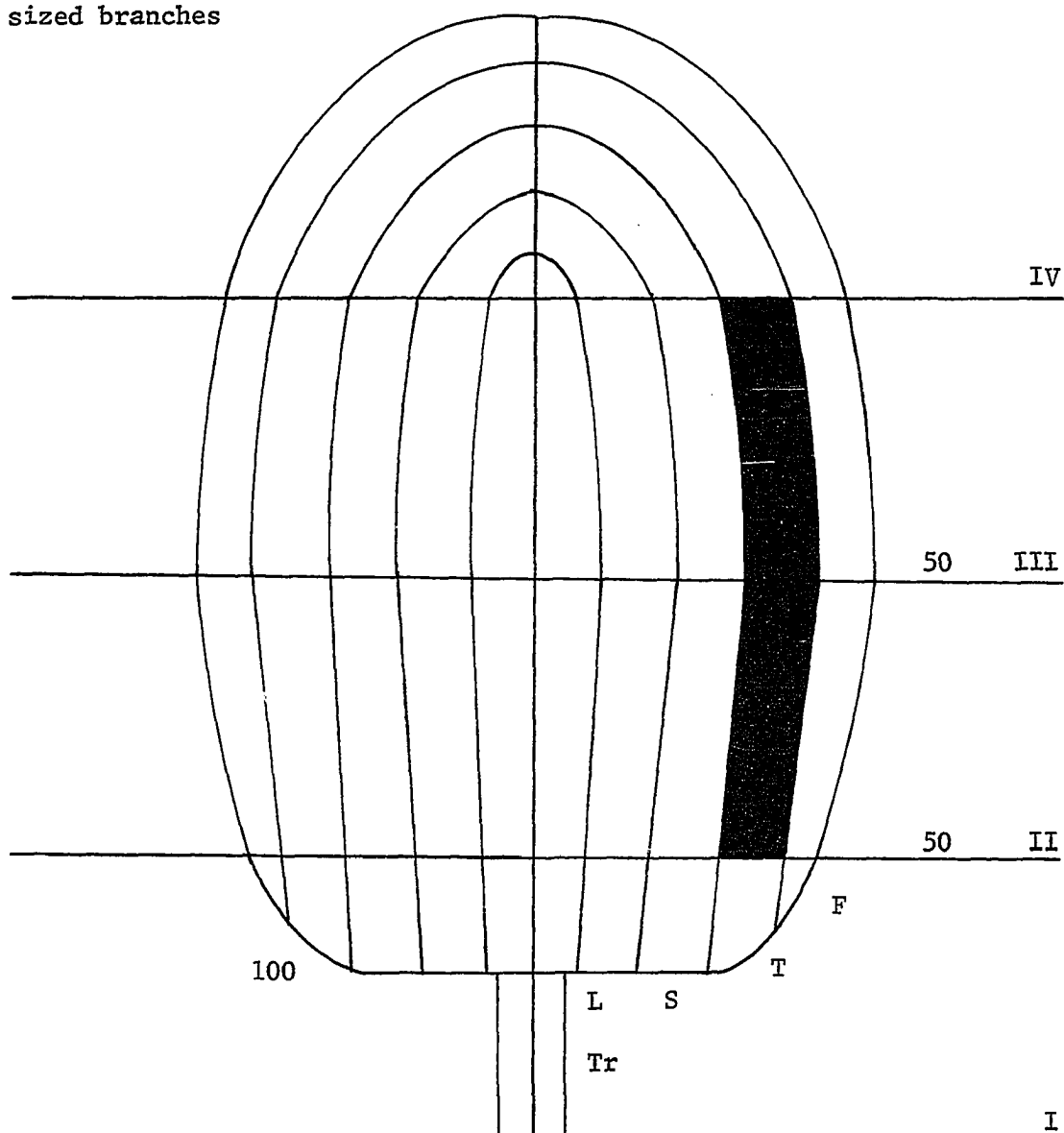


Figure 17. Chestnut-sided Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

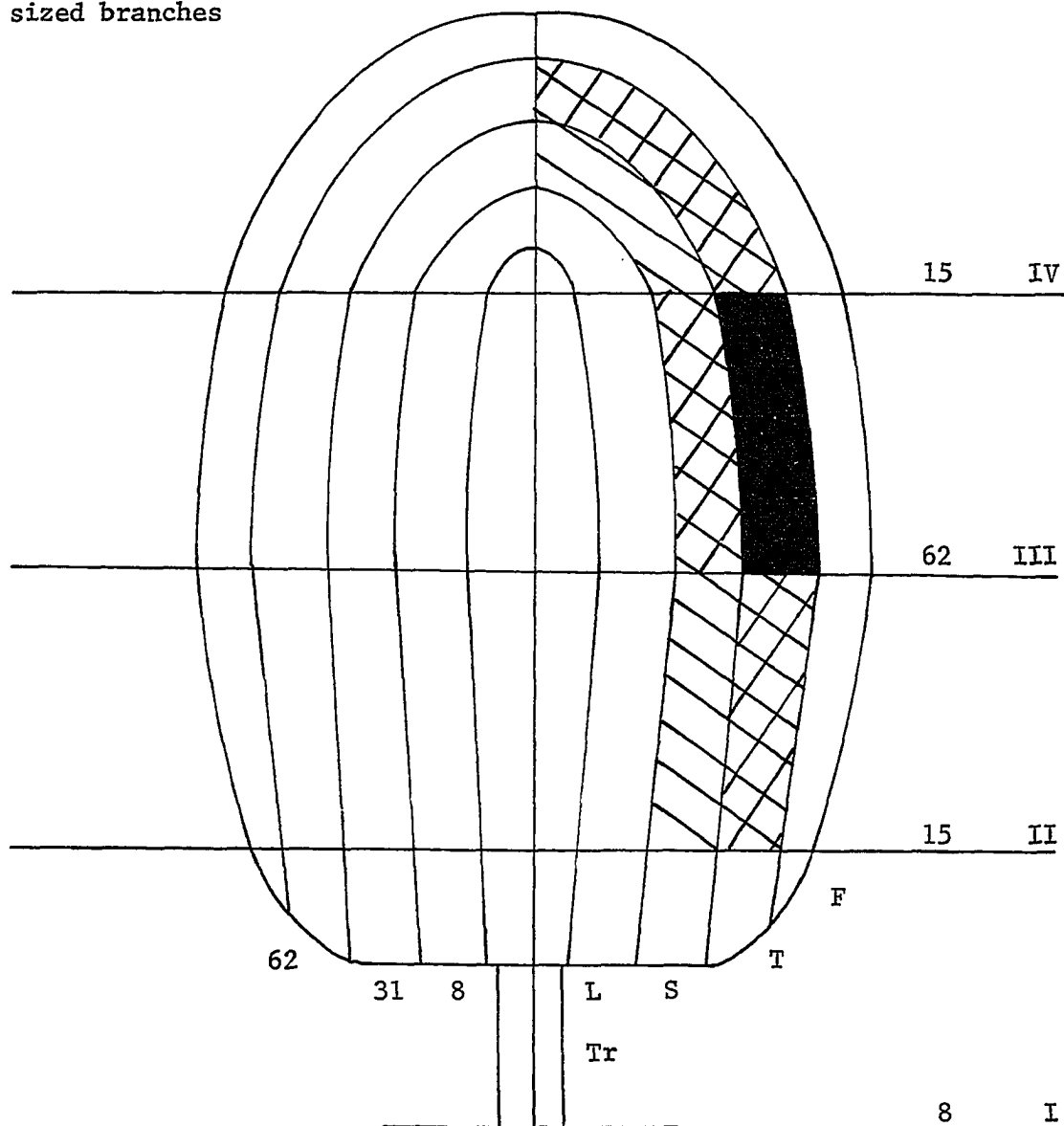


Figure 18. Nashville Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

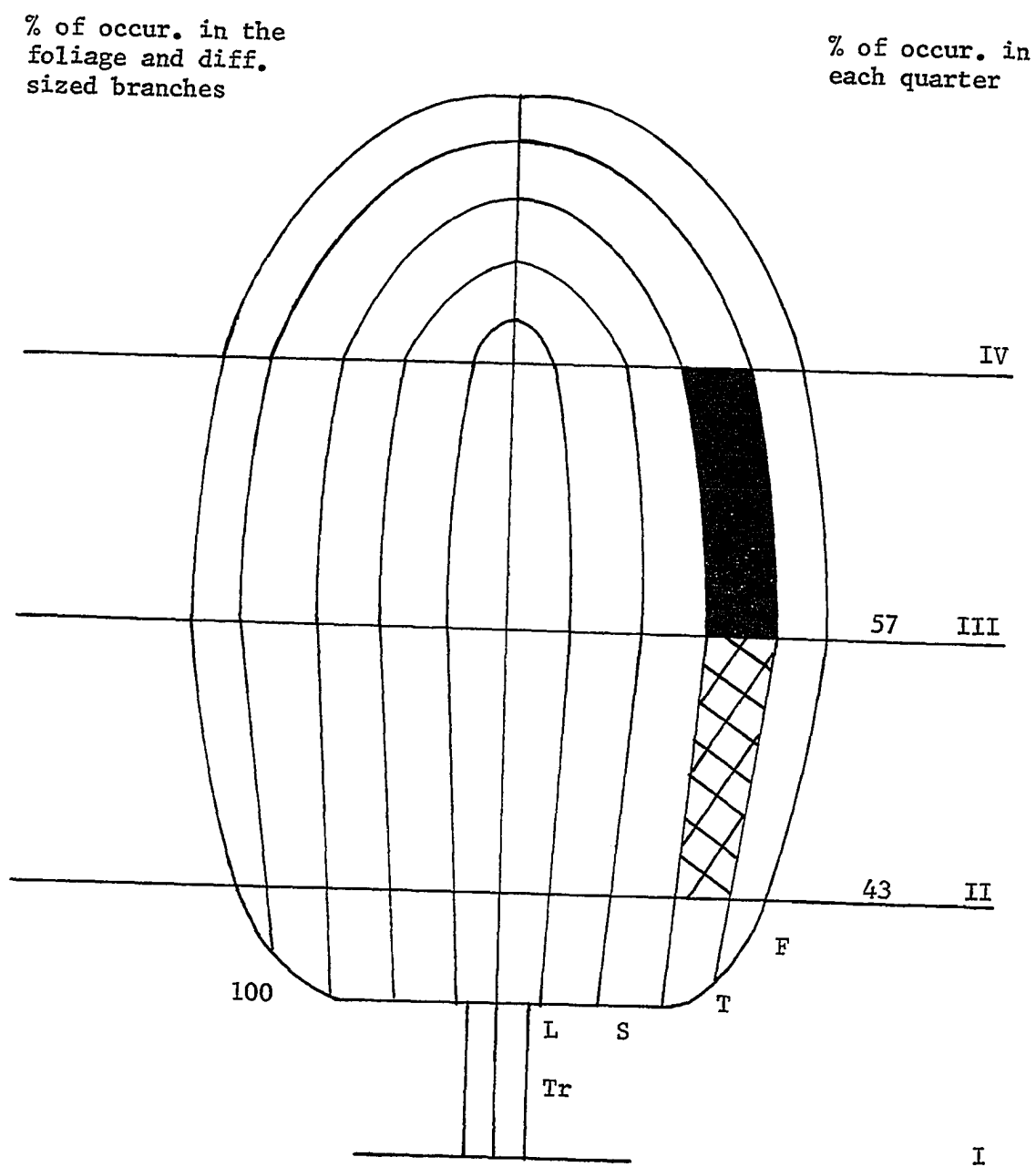


Figure 19. Blue-winged Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

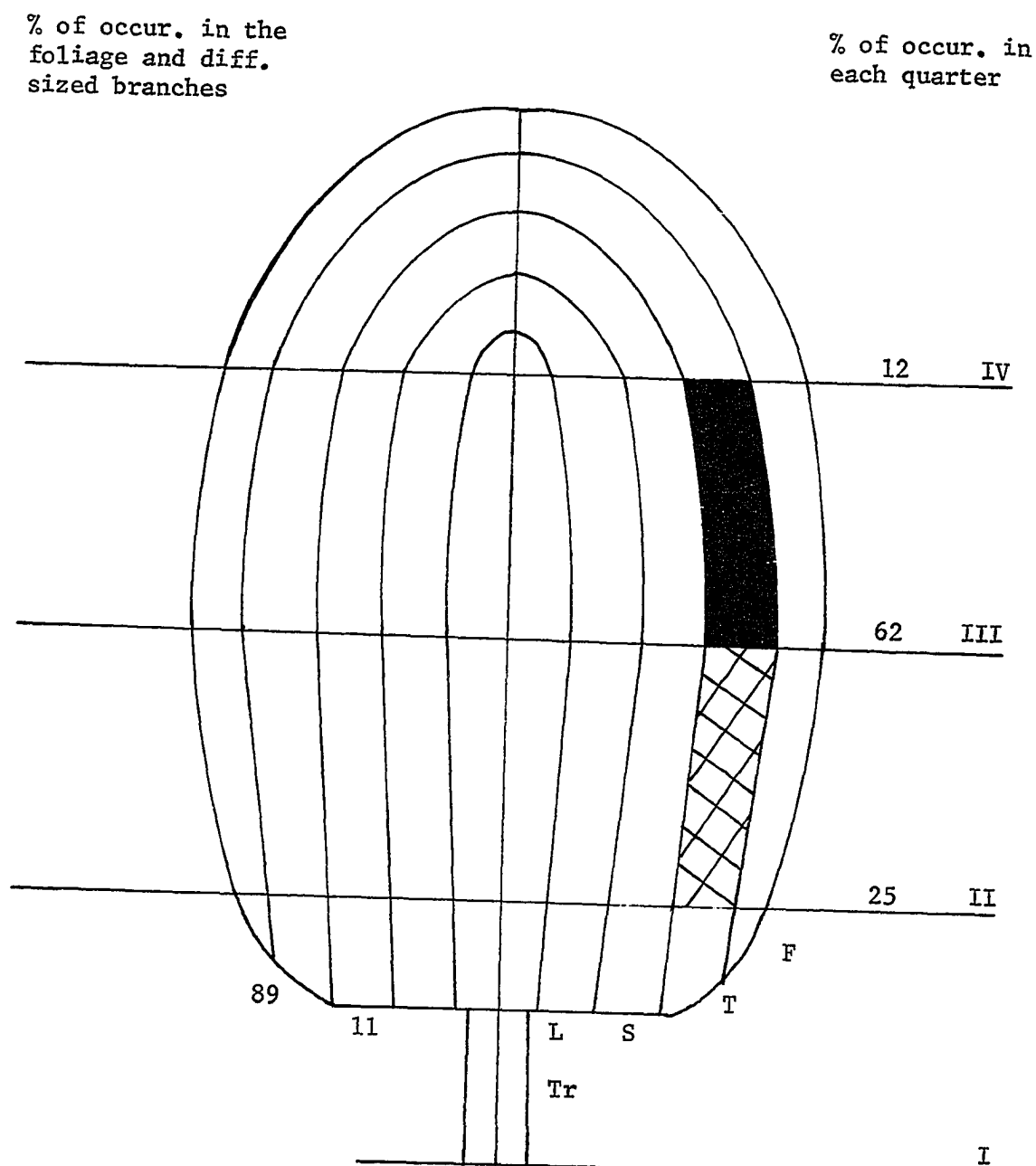


Figure 20. Tennessee Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

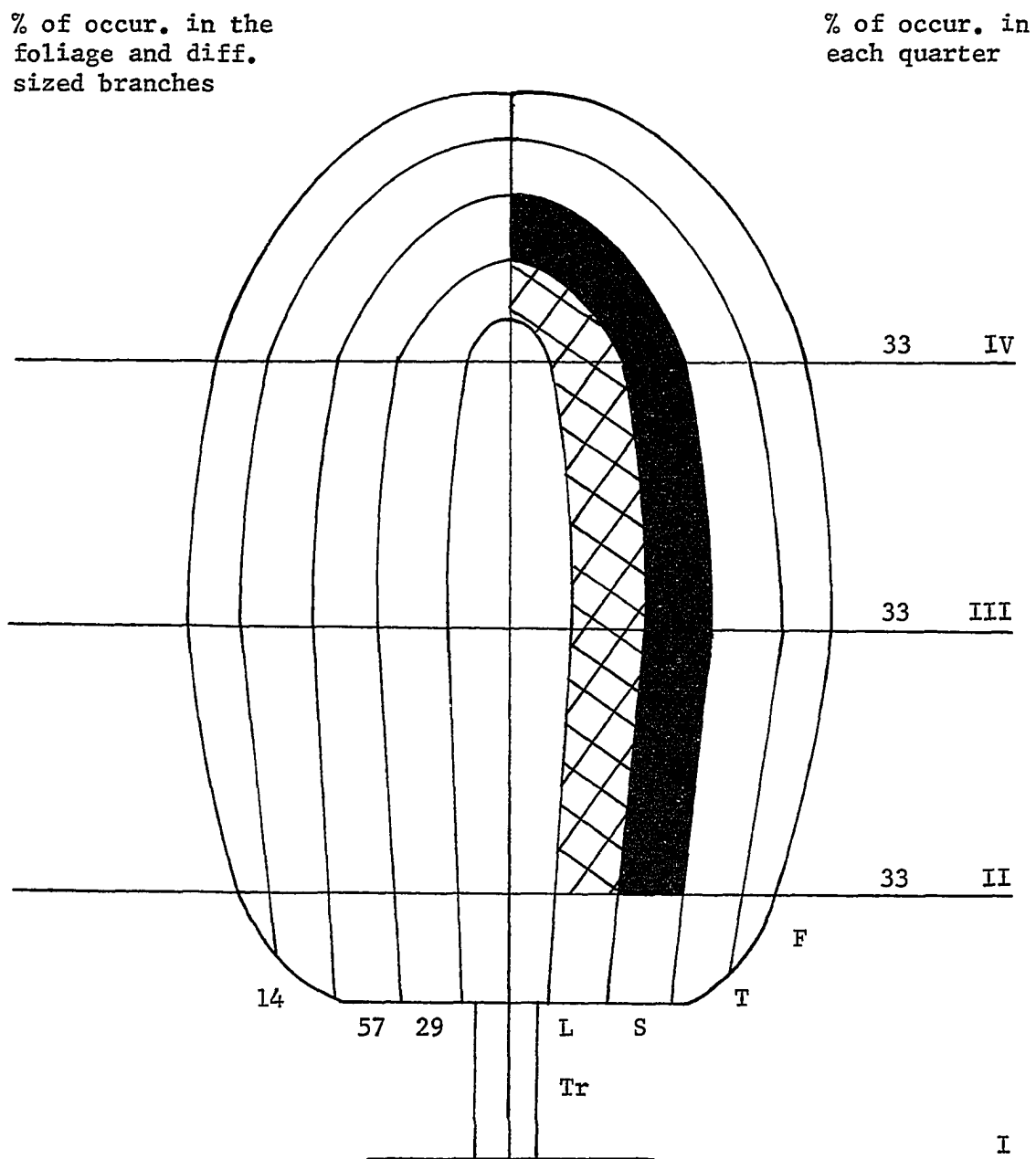


Figure 21. Ovenbird singing position in the deciduous subcanopy. See Figure 4 for explanation of symbols.

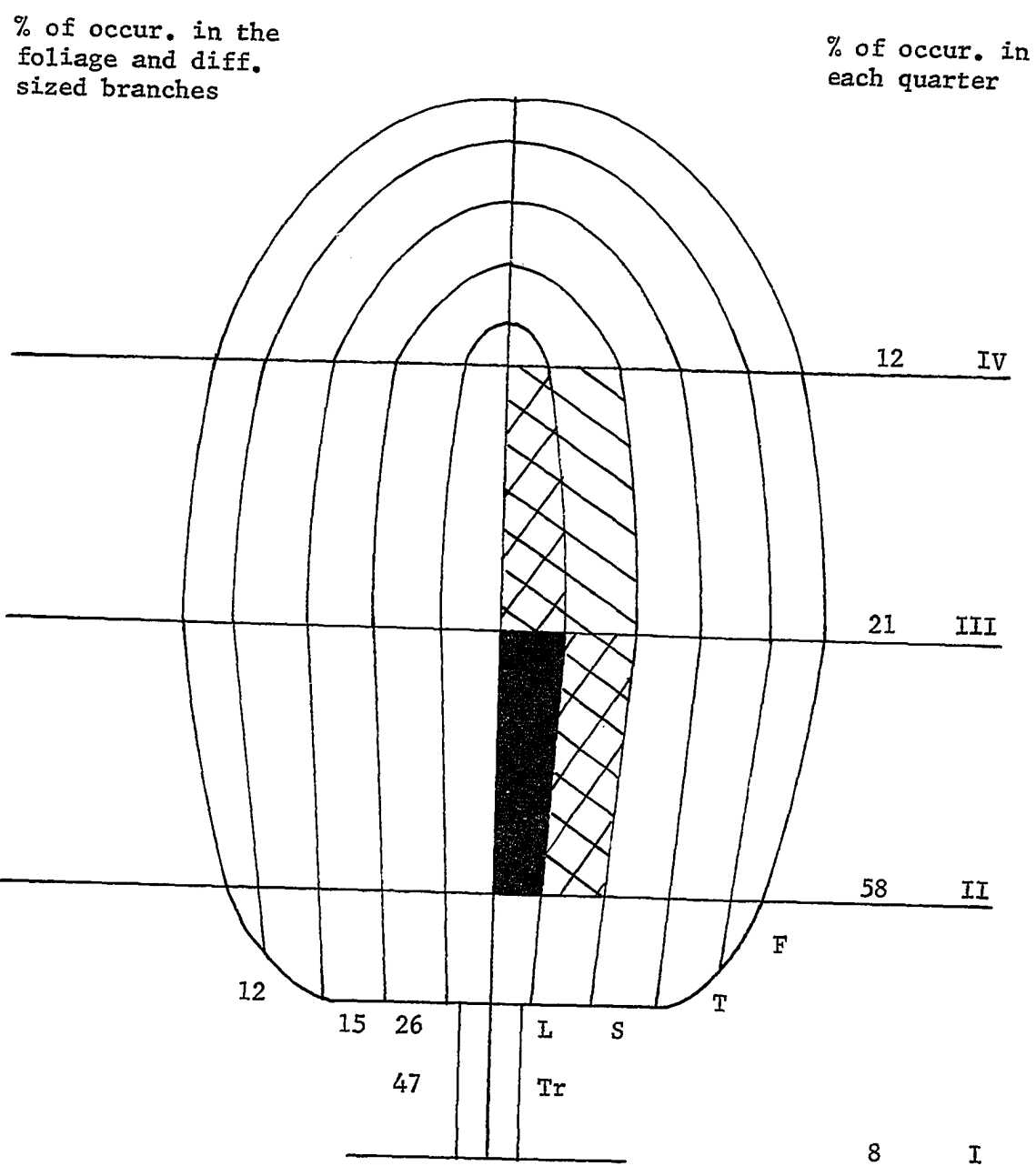


Figure 22. Black-and-white Warbler foraging position in the deciduous canopy. See Figure 4 for explanation of symbols.

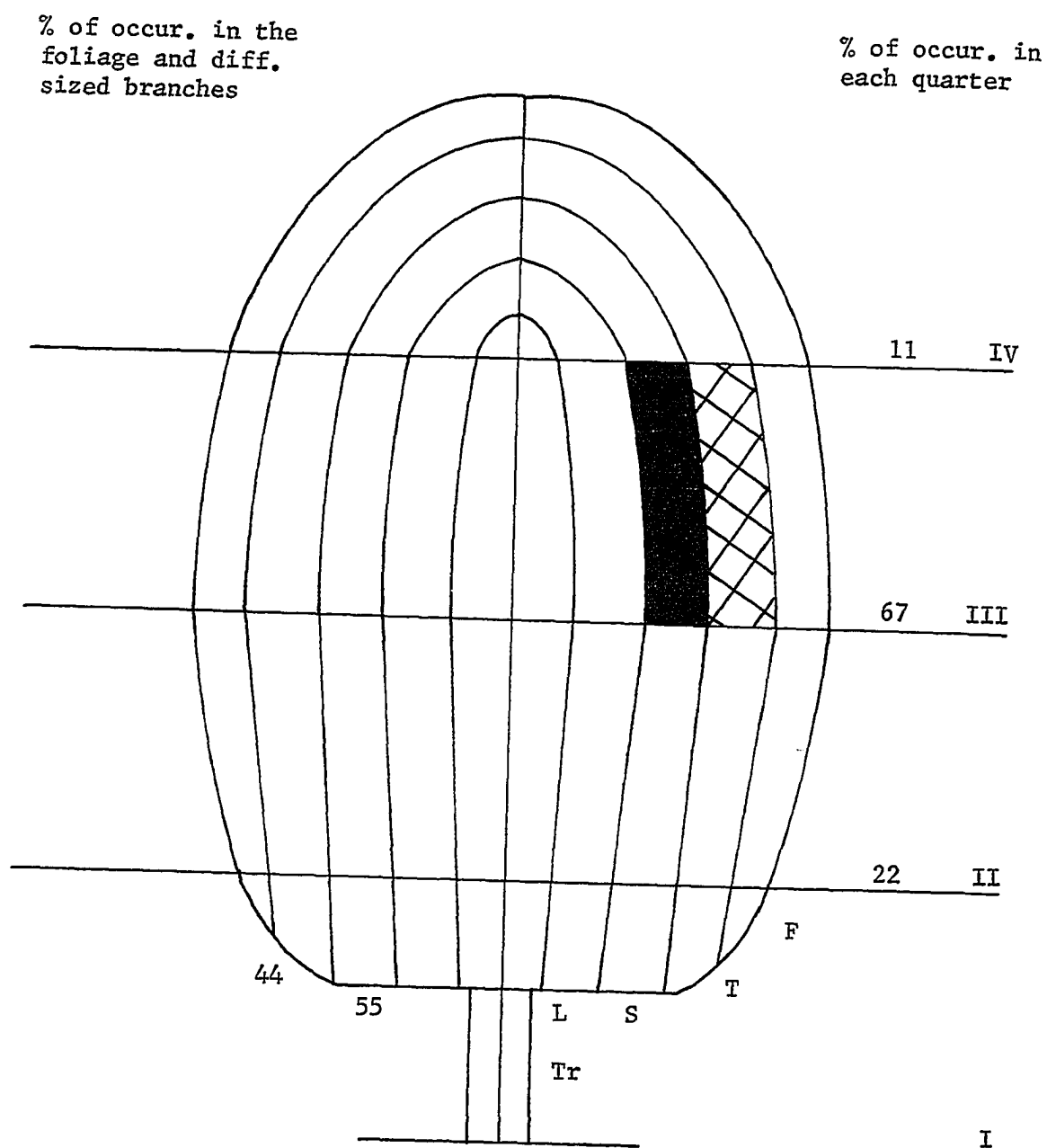


Figure 23. Red-eyed Vireo foraging position in the deciduous canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

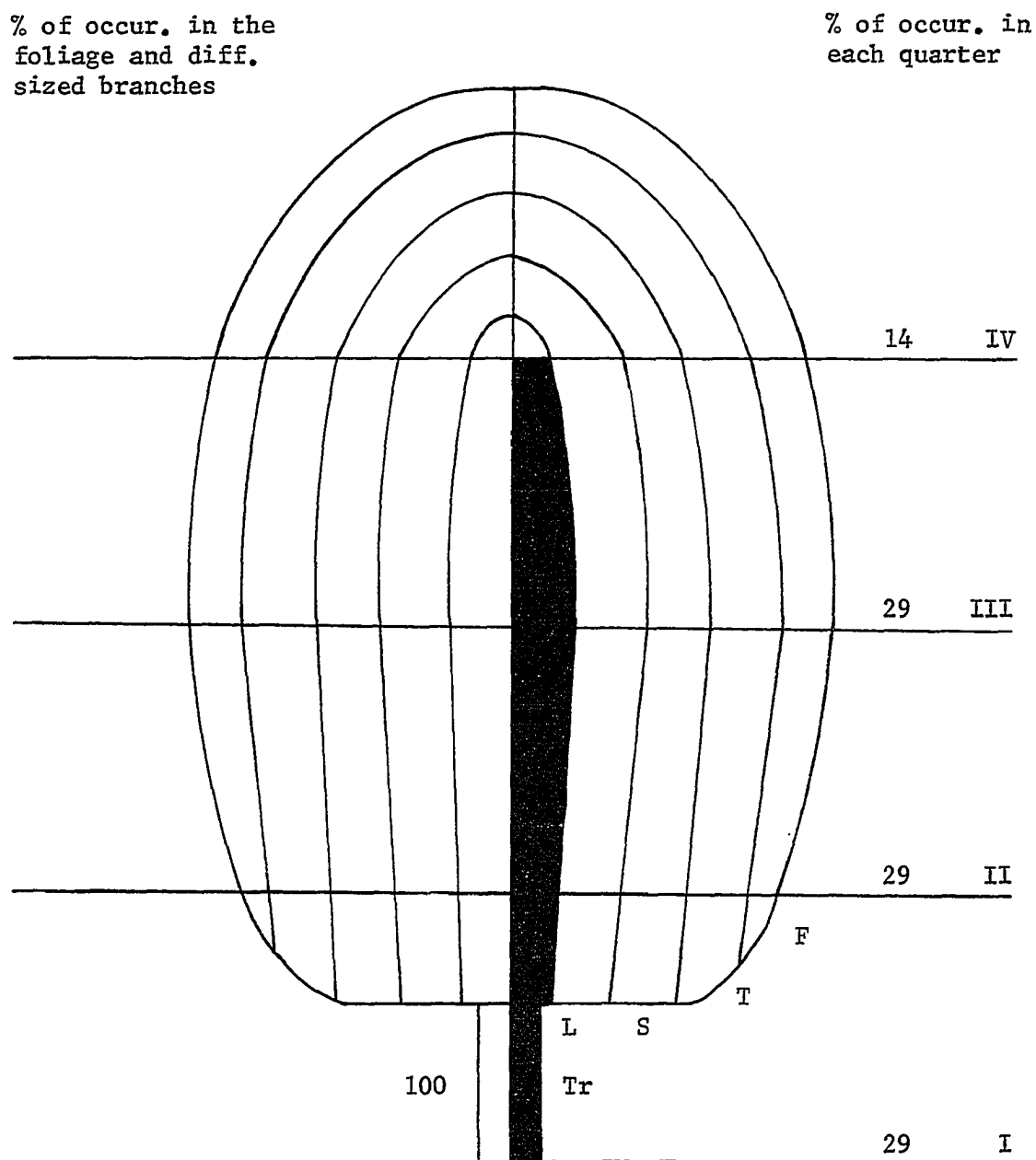


Figure 24. Brown Creeper foraging position in the deciduous canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

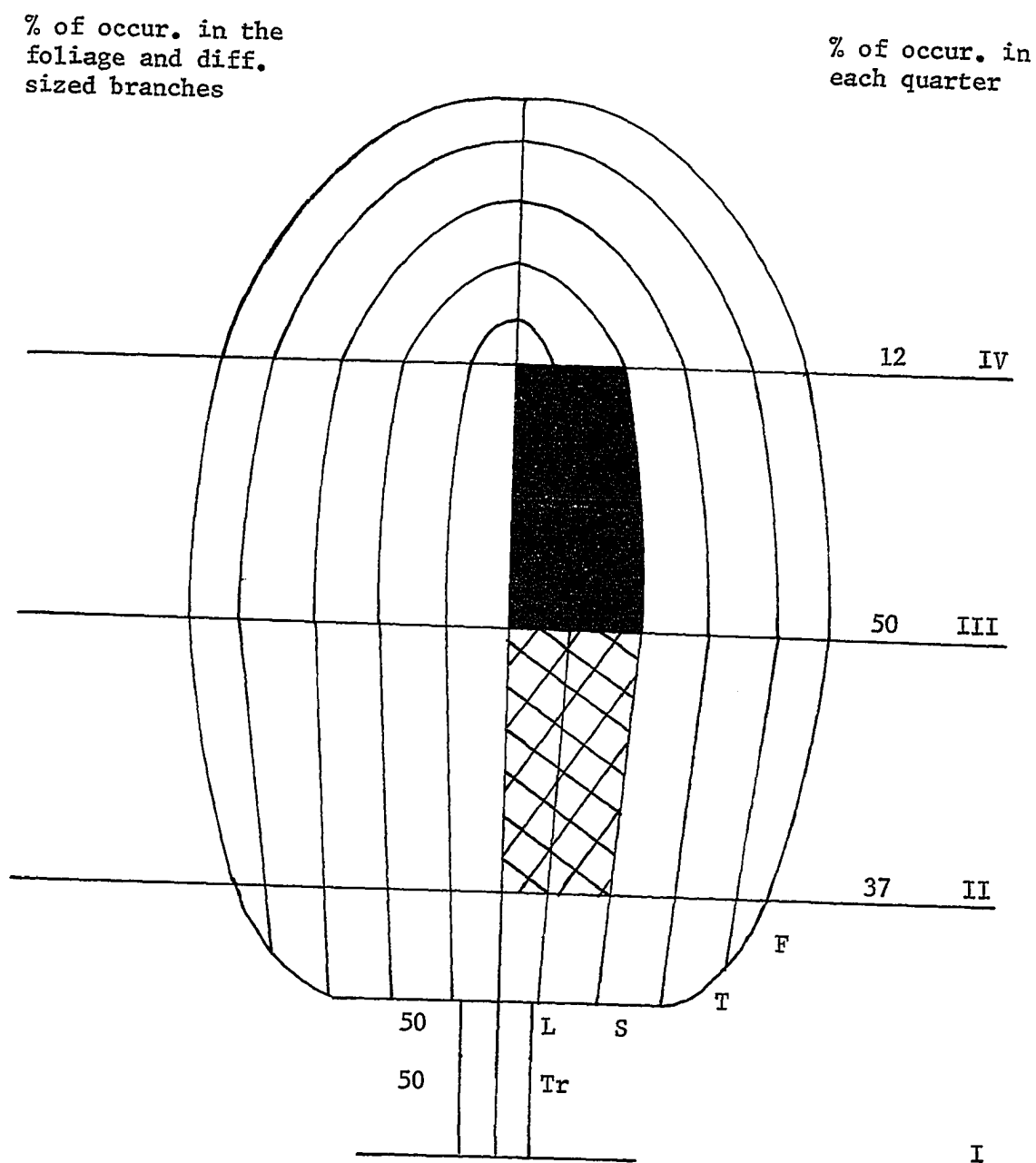


Figure 25. Downy Woodpecker foraging position in the deciduous canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

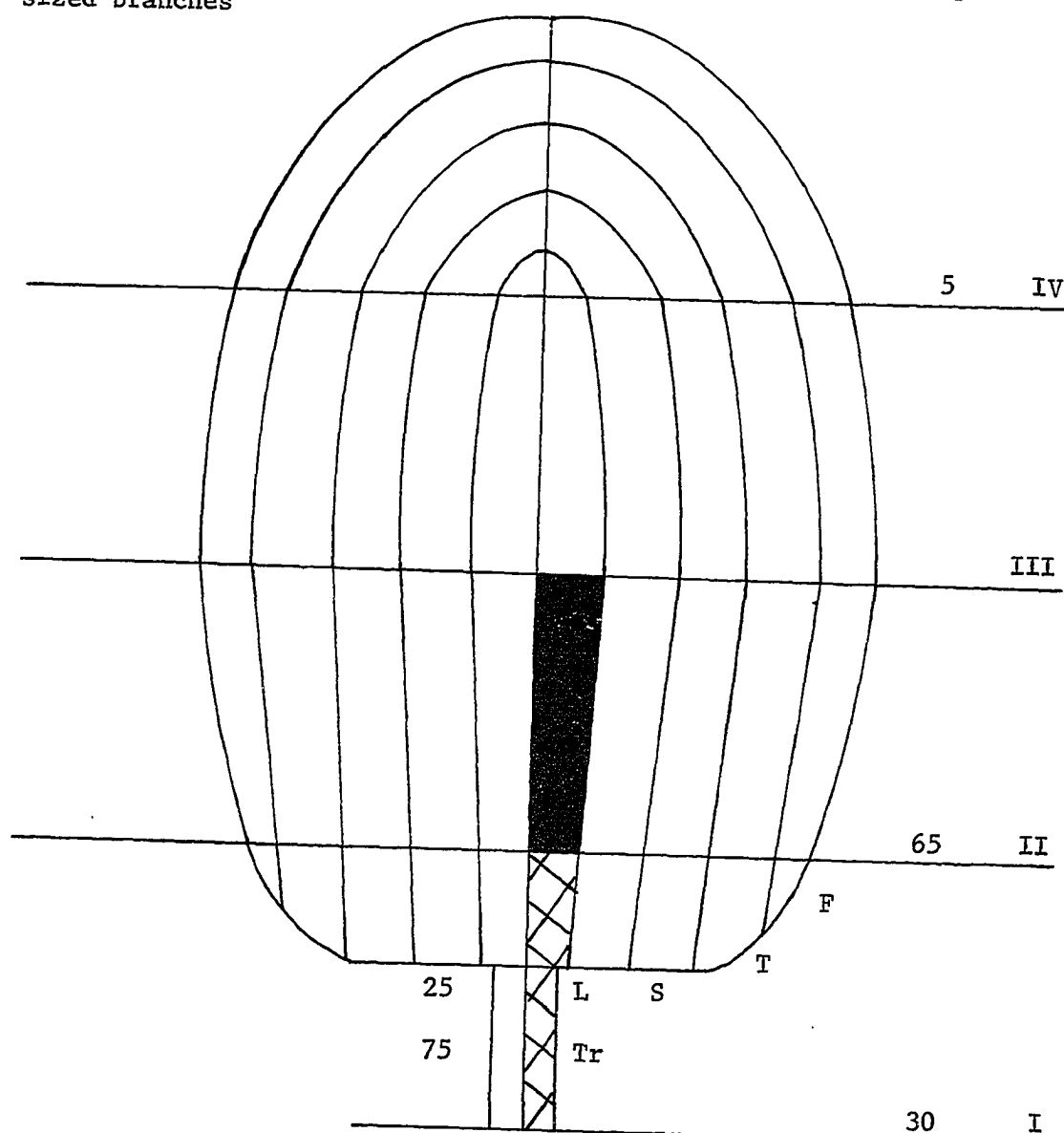


Figure 26. White-breasted Nuthatch foraging position in the deciduous canopy with the Black-and-white Warbler present. See Table 15 for sample size and Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

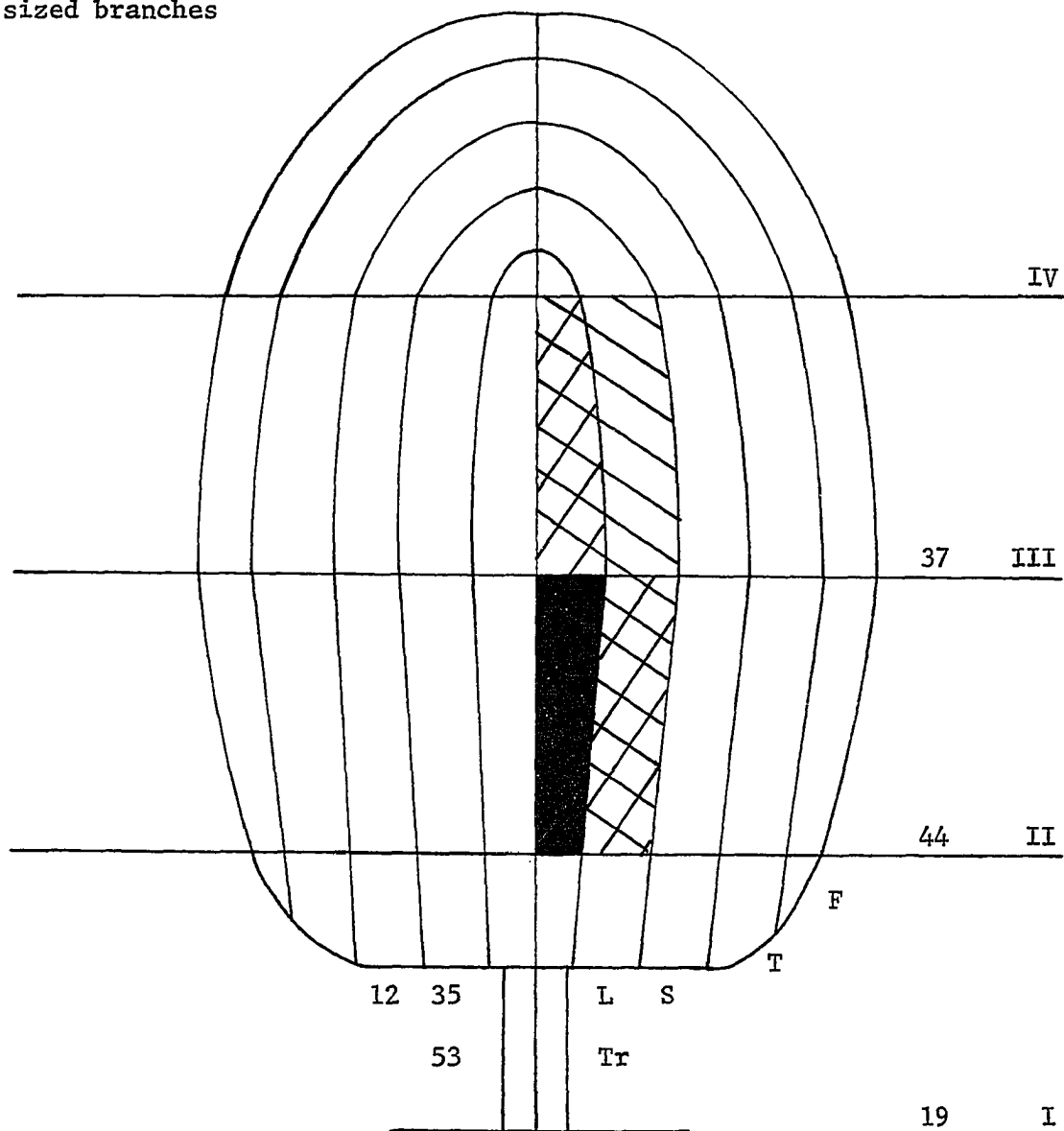


Figure 27. White-breasted Nuthatch foraging position in the deciduous canopy with the Black-and-white Warbler absent. See Table 15 for sample size and Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

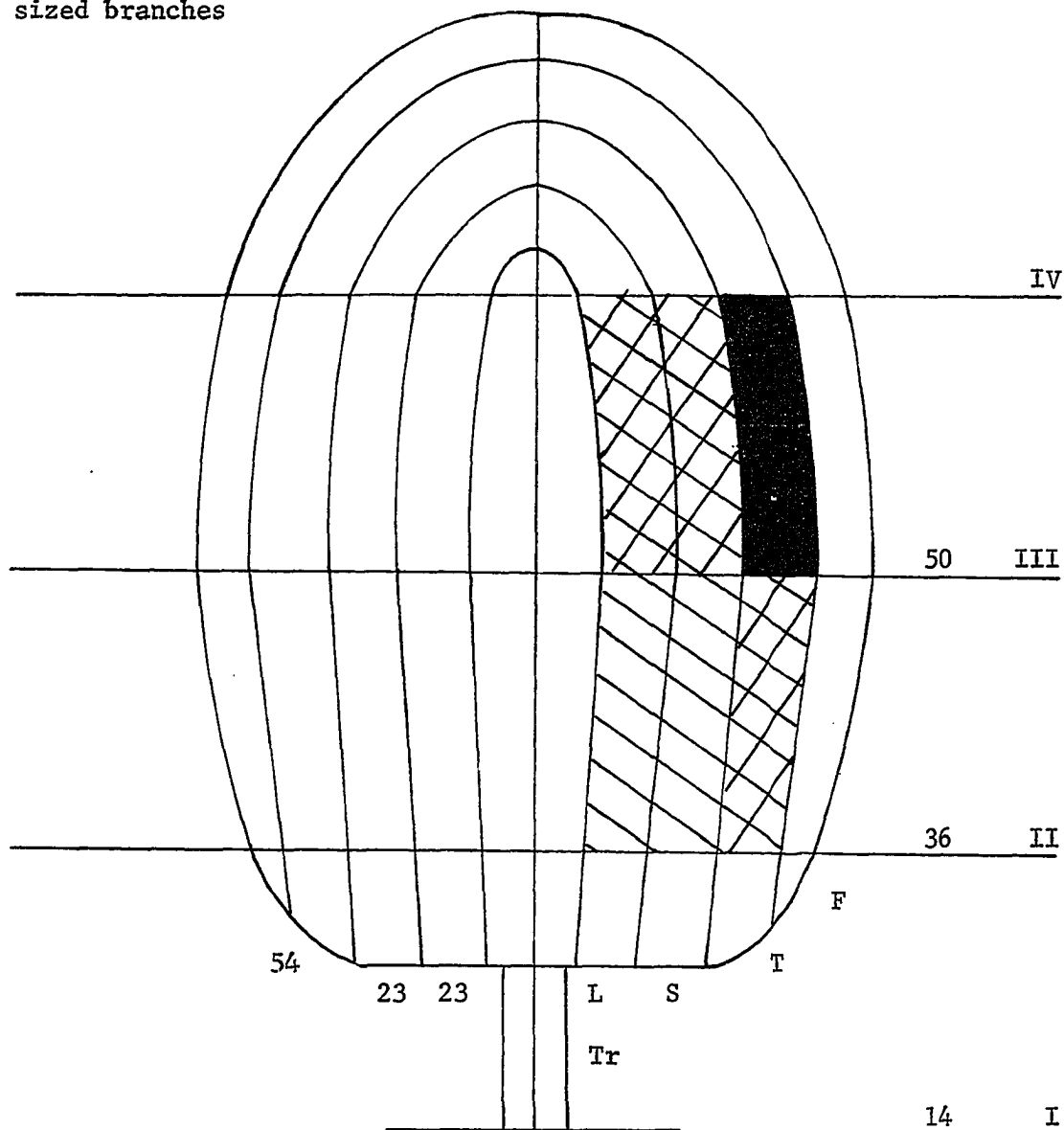


Figure 28. Black-capped Chickadee foraging position in the deciduous canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

% of occur. in the
foliage and diff.
sized branches

% of occur. in
each quarter

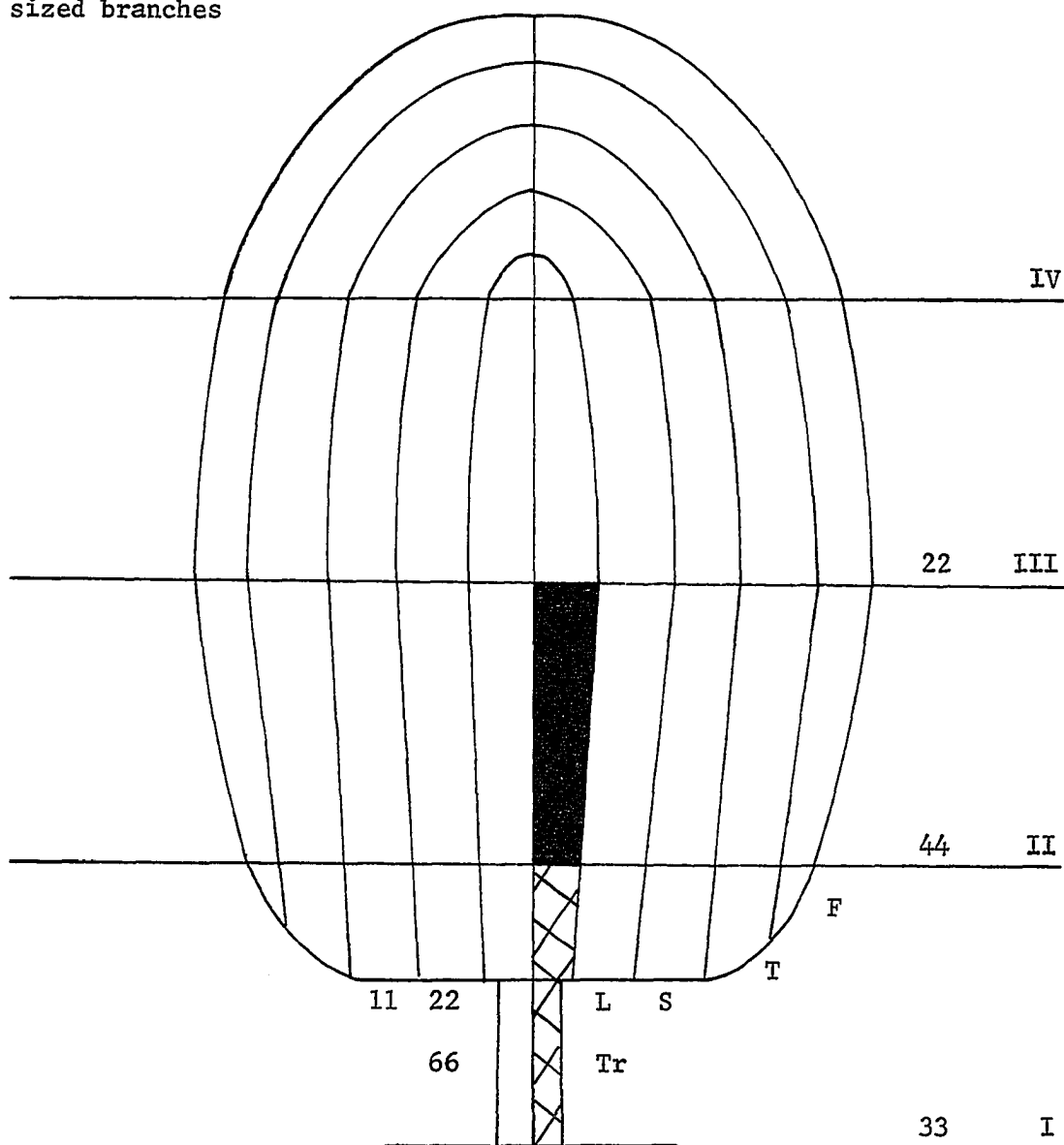


Figure 29. White-breasted Nuthatch foraging position in the deciduous subcanopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

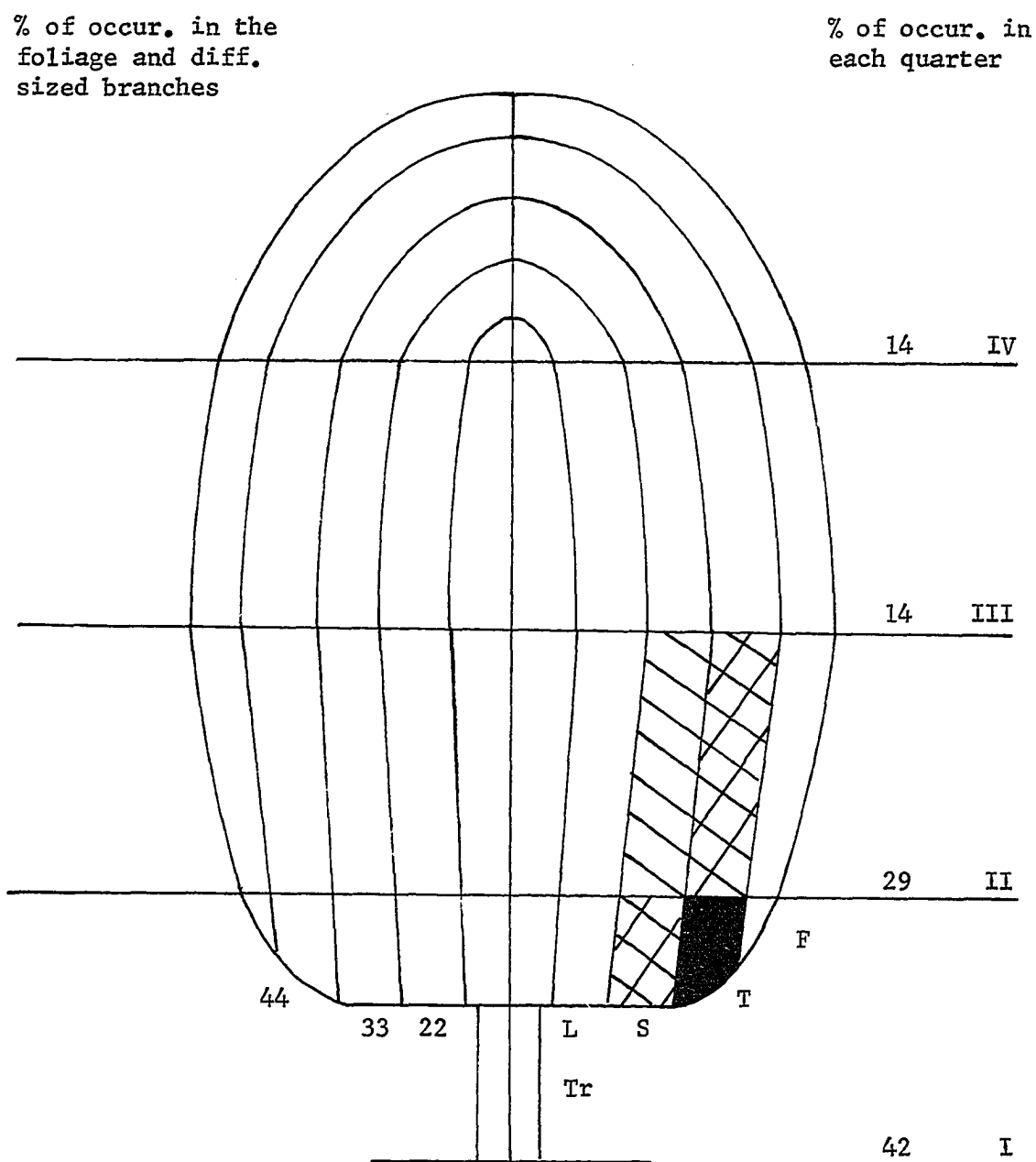


Figure 30. Black-capped Chickadee foraging position in the deciduous subcanopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

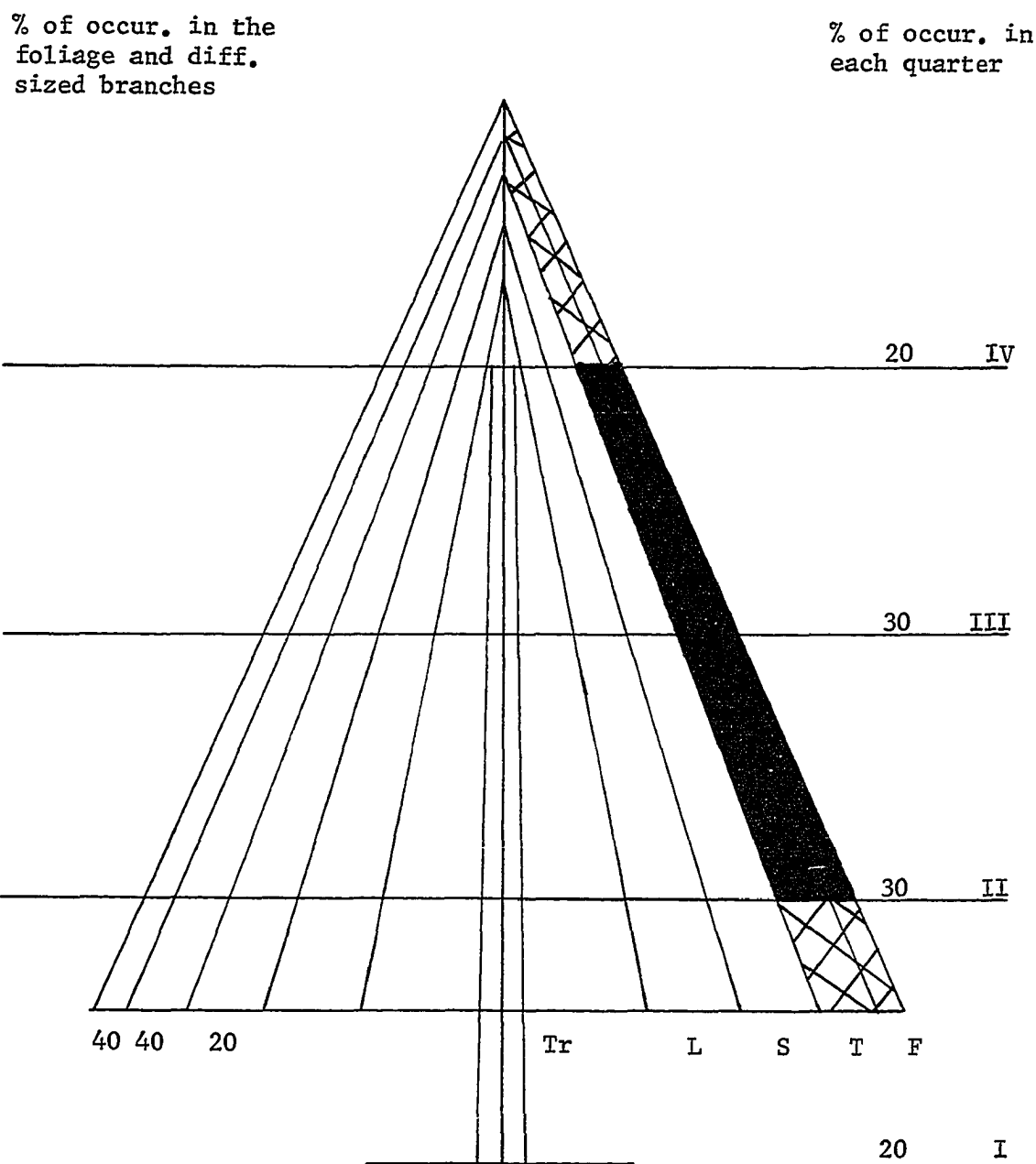


Figure 31. Black-capped Chickadee foraging position in the spruce canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

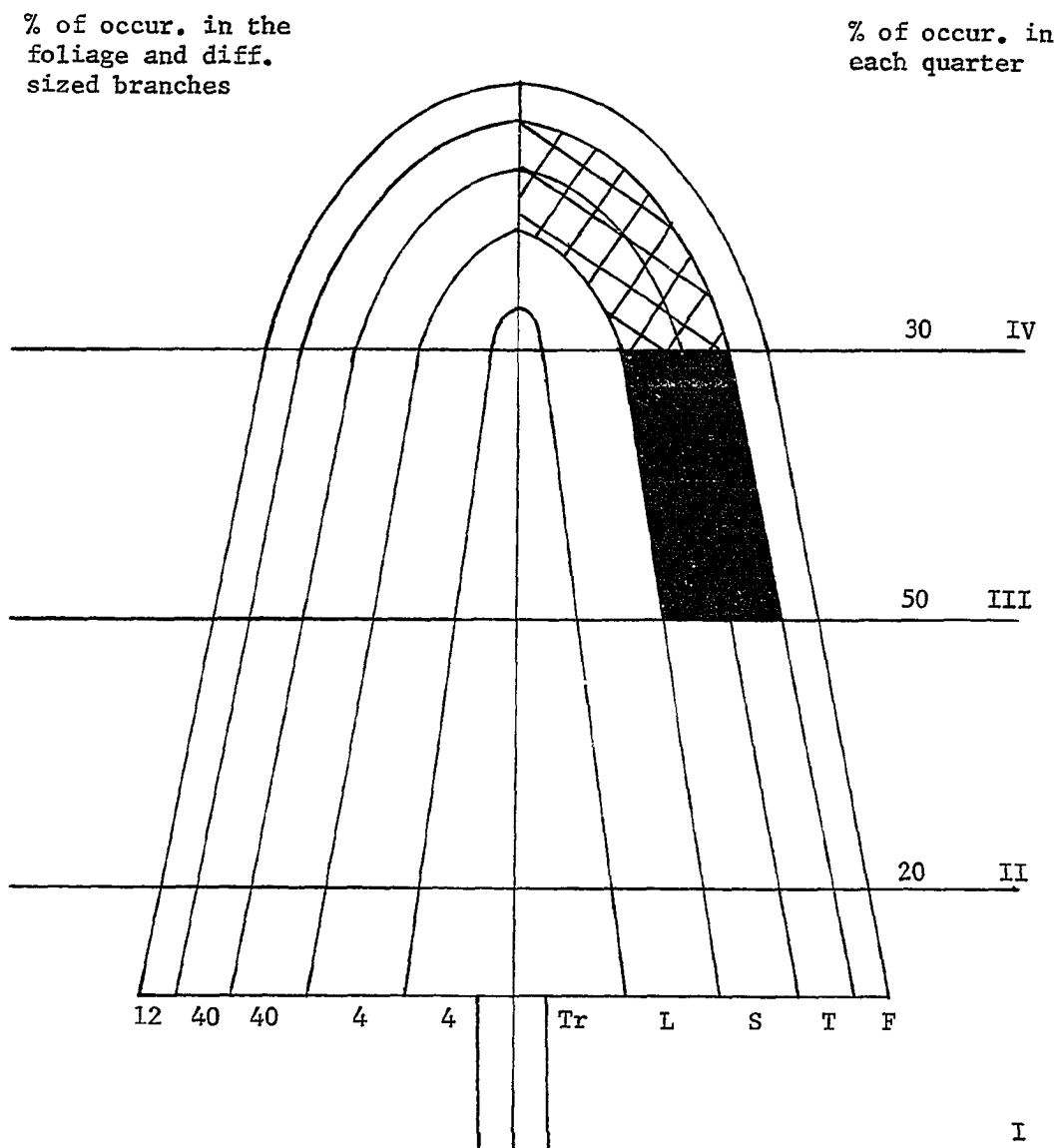


Figure 32. Black-capped Chickadee foraging position in the pine canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.

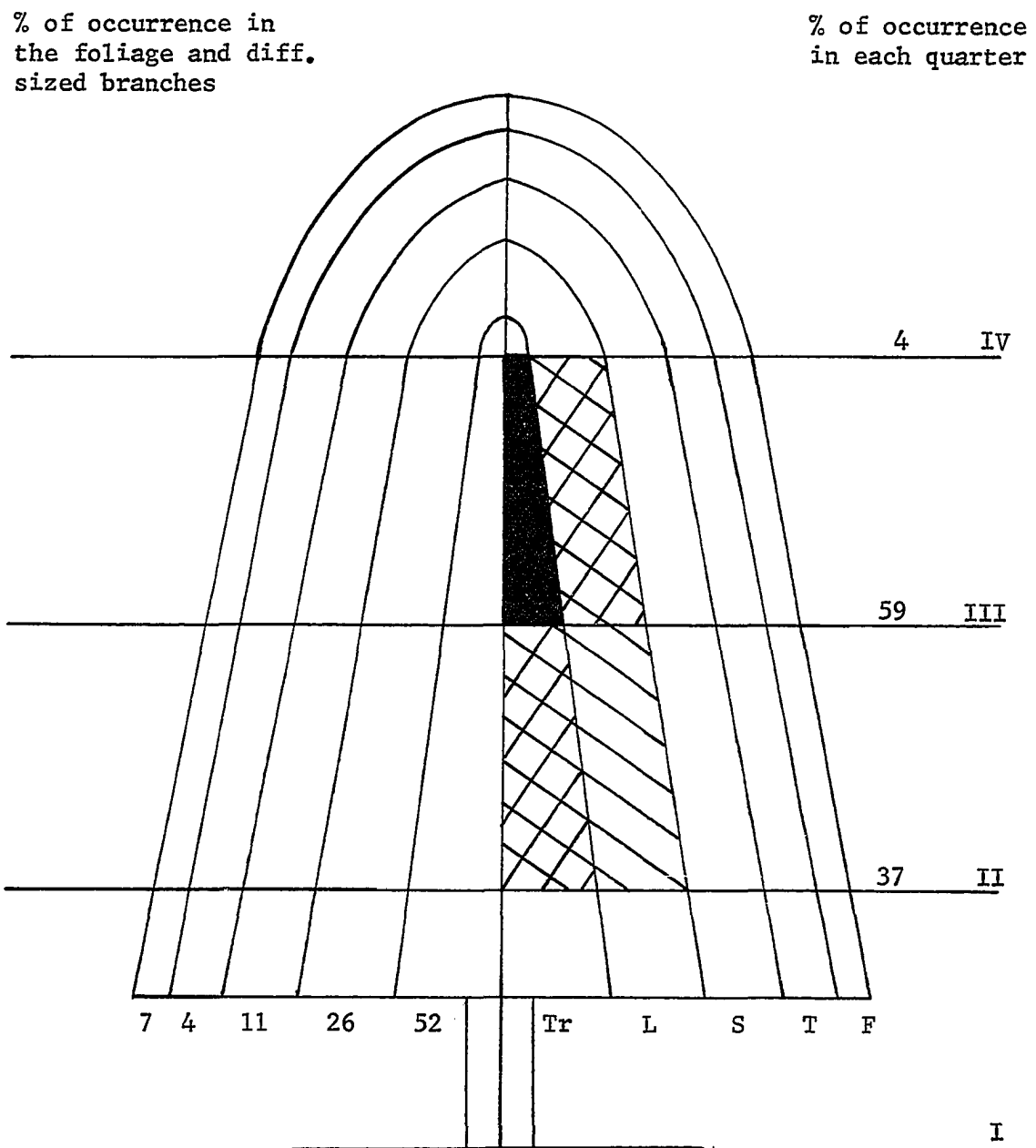


Figure 33. Red-breasted Nuthatch foraging position in the pine canopy. See Table 15 for sample size and Figure 4 for explanation of symbols.