PRINCIPAL COMPONENT ANALYSIS OF WOODPECKER NESTING HABITAT

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Biologists have long been able to associate species of birds in a general way, with their characteristic habitats. Yet, for most species few such studies of a quantitative nature have been published. James (1971) used principal component and discriminant function analyses to ordinate breeding habitats of 46 species of breeding birds in Arkansas on vegetational continua. These kinds of analyses enable habitat relationships among a set of different species of birds to be detected and expressed more readily than do univariate techniques. They emphasize the detection of relationships among species rather than attempting to achieve the fine resolution possible in evaluating single species.

We have applied principal component analysis to the nesting habitats of 5 species of woodpeckers: The Downy (*Picoides pubescens*), Hairy (*P. villosus*), Pileated (*Dryocopus pileatus*), and Red-headed (*Melanerpes erythrocephalus*) woodpeckers and the Common Flicker (*Colaptes auratus*). Red-bellied Woodpeckers (*Melanerpes carolinus*) were not abundant in our study area and were not included in the analysis because of an insufficient number of nests. We selected a set of habitat variables that we felt were pertinent to these cavity nesting species. Woodpeckers are unique among the cavity nesters in that they can exercise a choice as to where they excavate. Most other cavity nesters use cavities where they find them.

METHODS

The study area (20 km^2) was located mainly on the upper Craig and Poverty creek drainages, Blacksburg Ranger District, Jefferson National Forest in southwestern Virginia. A small part of the area was on the Virginia Polytechnic Institute and State University farm and consisted of large mature woodlots.

We searched intensively for active woodpecker nests during the springs of 1972, 1973, 1974 to locate as many nests as possible. Stand condition maps of the Ranger District were used to assure that all habitat types were searched. Vocalizations and drumming of woodpeckers were used initially to locate territories. Subsequent movement of the birds was observed to locate nest trees. We felt that the actual location of the nest would yield a more accurate representation of nesting habitat requirements than measurements of only the nesting territory.

At each active nest tree 8 variables were measured: (macrohabitat) basal area and density of stems greater than 7 cm DBH (diameter at breast height) within a 20-m radius of the nest tree, canopy height to crown top, distance from the nest tree to the nearest clearing, (microhabitat) DBH of the nest tree, diameter of the nest tree at the

TABLE 1

CORRELATION MATRIX (r) FOR 8 HABITAT VARIABLES MEASURED AT WOODPECKER NEST TREES

	BA*	DOS	CH	DTC	DNT	PTA	DAN
DOS*	0.27						
CH	0.72**	0.03					
DTC	0.17	0.48**	0.08				
DNT	0.41**	-0.40**	0.57**	-0.18			
PTA	0.27	-0.31	0.52**	-0.28	0.52**		
DAN	0.47**	-0.11	0.37	-0.05	0.61**	0.17	
NH	0.59**	-0.24	0.70**	0.03	0.68**	0.51**	0.39**

* Variable abbreviations are: BA = basal area, DOS = density of stems, CH = canopy height, DTC = distance of nest tree to nearest clearing, DNT = DBH of nest tree, PTA = percent of nest tree alive, DAN = diameter of tree at nest cavity, NH = nest height.

** Significant at = 0.01.

cavity, height of the nest, and a subjective estimate of percentage of live wood in each nest tree.

A correlation matrix was calculated for the 8 habitat variables (Table 1). As would be expected, basal area was highly correlated with canopy height, and DBH of the nest tree was highly correlated with the diameter of the nest tree at the cavity and with height of the nest. Diameter of the nest tree was significantly correlated with almost everything and distance from the nest tree to the nearest clearing was correlated with almost nothing.

Variation within and among these variables was analyzed using the principal component analysis available in Biomedical Computer Programs BMDO1M (Dixon 1974).

RESULTS

We found 19 Pileated, 20 Downy, 13 Hairy, 11 Red-headed, and 29 flicker nests. Over ⅓ of the flicker nests were found in trees left within clearcuts; most of the remaining nests were found on the edges of the old mature woodlots. The 11 Red-headed Woodpecker nests were found in old mature woodlots on the University campus. Nests of the remaining species were more widely distributed.

More than 86% of the cumulative total variance was accounted for by the first 4 principal components (Table 2). The first component accounted for 44.9% of the total variance. Most habitat variables were positively correlated with the first component; density of stems and distance to a clearing were the exceptions. The highest correlations were with basal area, canopy height, DBH of the nest tree, and height of the nest. High values on the first component correspond to habitat with high basal area, tall canopy, large DBH nest trees, and nest cavities that are high above the ground. Thus the first component represents, with increasing values, a trend from clearcuts to old mature forests.

TABLE 2

RESULTS OF THE PRINCIPLE COMPONENTS ANALYSIS OF 8 NESTING HABITAT VARIABLES FOR 5 SPECIES OF WOODPECKERS

		Component			
		I	II	III	IV
Percentage of total variance accounted for		44.9	22.8	11.0	8.1
Cumulative percentage of total variance accounted for		44.9	67.7	78.7	86.8
Correlations of components to original variables					
	BA*	0.71	0.53	0.01	0.25
	DOS	-0.25	0.83	-0.08	0.35
	CH	0.84	0.28	-0.24	0.07
	DTC	-0.11	0.77	-0.02	-0.58
	DNT	0.85	-0.23	0.21	-0.15
	PTA	0.66	-0.32	-0.50	0.11
	DAN	0.64	0.06	0.70	0.11
	NH	0.86	0.05	-0.14	-0.26

* Variable abbreviations as in Table 1.

The second component accounted for an additional 22.8% of the total variance (Table 2). This component was negatively correlated with DBH of the nest tree and percent of the tree that was alive, and positively correlated with the remaining 6 variables. Density of stems and distance to a clearing were the variables most correlated with the second component. High values on the second component correspond to a high density of stems and great distances from clearings. The second component emphasizes the relationships between dense forest (weighted on stems, but not on maturity factors such as canopy height and basal area) and cleared areas.

The third component accounted for 11.0% of the total variance. The diameter of the nest tree at the nest cavity (positive correlation) was highly correlated with the third component. The fourth component accounted for an additional 8.1% of the total variance but no single factor made a prominent contribution.

Habitat relationships among the 5 species of woodpeckers can be observed when mean values for each species are plotted on the first 3 components (Fig. 1). As can be seen on the first component axis, Red-headed Woodpeckers preferred to nest in areas of high basal area and tall canopy and to nest relatively high above the ground in trees with great DBH and large diameter at the nest. The Downy Woodpecker preferred to nest in areas with

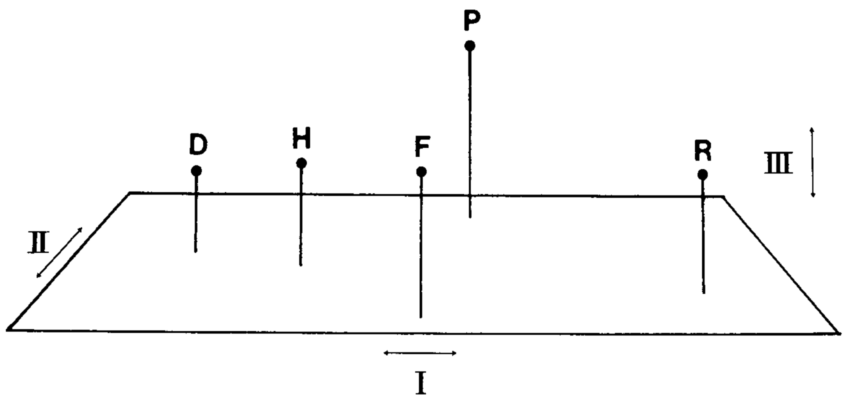

FIG. 1. Three-dimensional ordination of nesting habitat relationships among 5 species of woodpeckers on the first 3 principal components. Contributions of variables to each component are summarized in text. The first component, left to right, represents a change from less mature forest to mature forest. The second component, front to back, represents a change from open areas to dense forests. The third component, low to high, represents a change from small diameter nest cavities to large. Total variance explained by this ordination is 78.7%. (Dots indicate means, D—Downy, H—Hairy, F—Flicker, P—Pileated, and R—Red-headed.)

lower basal area and lower canopy height than the other 4 species of woodpeckers. The Pileated and Hairy woodpeckers and Common Flicker nested in habitat intermediate to the Downy and Red-headed woodpeckers.

On the second component the Pileated, Downy, and Hairy woodpeckers have high values, indicating a preference for nesting areas of high density of stems, while the Red-headed Woodpeckers and the Common Flicker preferred to nest near clearings in areas with a low density of stems (Fig. 1).

On the third component, as the size of the woodpecker increased, so did the diameter of the tree at the place where the nest cavity was excavated (Fig. 1).

TABLE 3

MATRIX OF SIMILARITY VALUES (S) FOR NESTING HABITAT BETWEEN EACH PAIR OF WOODPECKER SPECIES*

	Flicker	Downy	Hairy	Pileated
Downy	.196			
Hairy	.269	.379		
Pileated	.192	.207	.257	
Red-headed	.189	.000	.026	.090

* Higher values represent greater ecological similarity between species (S = complements of average Euclidian distance in hyperspace).

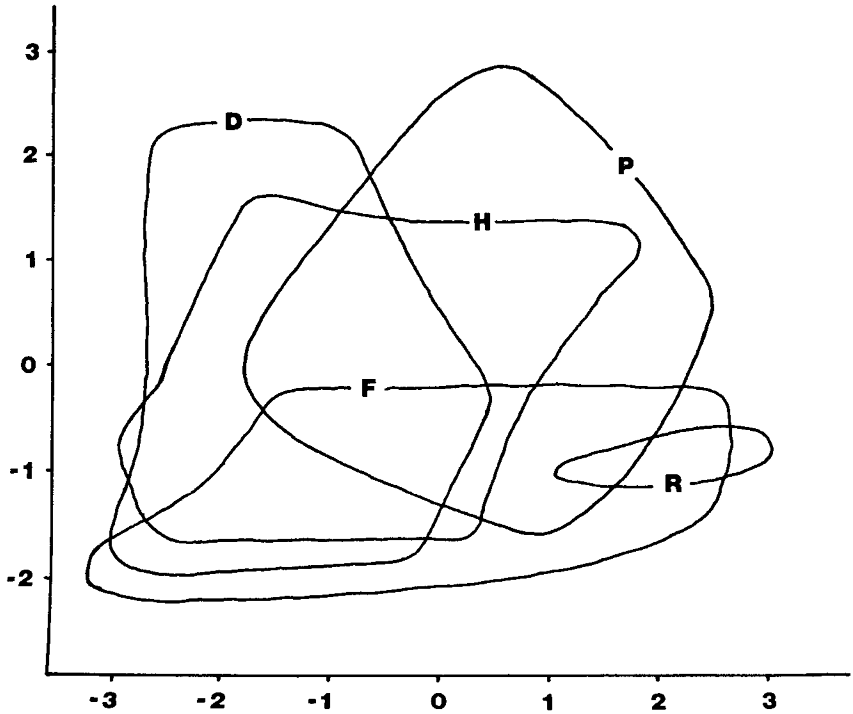

FIG. 2. Two-dimensional ordination of nesting habitat overlap among 5 species of woodpeckers on the first 2 principal components. Contribution of variables to each component is summarized in the text. The first component, left to right, represents a change from less mature to mature forest. The second component, low to high, represents a change from open areas to dense forest. (See Fig. 1 for symbol code.)

A matrix of ecological similarity of nesting habitats for each woodpecker species was calculated using the method described by Power (1971) (Table 3). Higher values in the matrix represent greater similarity among nesting habitats. Red-headed and Downy woodpeckers have the least similar nesting habitats of all the species. The Downy and the Hairy woodpecker had the most similar nesting habitat.

The nesting habitat of each species was plotted on the first 2 principal components and circled to obtain a visual estimation of overlap (Fig. 2). Extensive overlap between the Downy and Hairy woodpeckers is obvious. There is no overlap between the Downy or Hairy and Red-headed woodpeckers. The Pileated Woodpecker and the Common Flicker overlapped with all other species. The habitat area used by the Red-headed Woodpecker was much smaller than the areas used by the other species. This may reflect the limited availability of Red-headed Woodpecker nesting habitat in southwestern Virginia rather than specific nesting habitat requirements.

A rough index of the nesting versatility of each woodpecker species was calculated by summing the variances of each species on each component (the vectors for each component were solved for each species and the variances of these families of values calculated for the respective species) over the first 3 components: Flicker = 5.24, Hairy = 4.14, Pileated = 3.21, Downy = 2.71, and Red-headed = 2.51. The Common Flicker was the most versatile species, by this index, reflecting its ability to nest in conditions varying from mature woodlots to clearcuts, provided that nearby access to open ground was available for foraging. The Red-headed Woodpecker had the lowest versatility and was only found in mature woodlots that lacked a shrub layer and were near clearings.

A short-coming of this technique is that one species might show a great range for one component but be very narrow for one or both of the other components. For example, the Hairy Woodpecker had relatively high variance values on all 3 of the components, while the flicker had high values only on the first and third components, indicating its low tolerance of uncleared areas. The Red-headed Woodpecker had a high variance on only the third component. The Downy and Pileated had high values on the first 2 components and average values on the third component.

DISCUSSION

We believe that the principal component analysis is a valuable tool in evaluating multivariate habitat relations for the 5 woodpecker species. Many of the results were in accord with what is known of the natural histories of these species. General descriptions of Red-headed Woodpecker nesting habitat are abundant. Our results, which indicate that this species prefers areas with high basal area, tall trees, a low density of stems, and an open understory, tend to agree with these previous habitat descriptions (Bent 1939, Stewart and Robbins 1958, Bock et al. 1971, Reller 1972). The open understory and nearness to a clearing (Fig. 1) is compatible with the foraging requirements of this species. Open areas above and on the ground are needed since Red-headed Woodpeckers flycatch and forage on the ground extensively in the summer (Bent 1939, Reller 1972).

Past descriptions depict nesting habitat of the Common Flicker as being diverse (Burns 1900, Bent 1939, Stewart and Robbins 1958). Dennis (1969) thought flickers well adapted to any relatively treeless situation. Our study agrees with all of these observations.

Downy Woodpecker habitat in Maryland was reported as wood margins, open woodland, and forest edge habitat (Stewart and Robbins 1958). Although many of our nests were found in edge type habitats, many were also found in dense stands far from clearings (Fig. 2).

Lawrence (1966) thought that Hairy Woodpeckers could nest in any place where sufficient foraging habitat and a suitable nest tree were present. We found this species to nest over a wide range of basal areas, canopy heights, densities of stems, and distances from cleared areas. Several instances have been reported of Hairy Woodpeckers nesting and foraging in clearcuts (Kilham 1968, Conner et al. 1975, Conner and Crawford 1974).

Hoyt (1957) described Pileated Woodpecker nesting habitat as heavy timber sometimes on mountain slopes, but mainly in moist lowlands such as valleys or bottomland. Kilham (1959) reported Pileated Woodpeckers nesting in swamps in Florida and Maryland. Pileated Woodpeckers in our study typically nested within 75 m of a small stream in stands of high basal area, tall canopy, and usually far from cleared areas. Several reports exist of Pileated Woodpeckers nesting in clearcuts and in forest edge habitat (Bent 1939, Conner et al. 1975).

The large amount of overlap of nesting habitat among some of the woodpeckers in this study (Fig. 2) could be misinterpreted as an indication of competition. Past observations, however, suggest a lack of competition. Lawrence (1966) reported that Hairy Woodpeckers ignored both Common Flickers and Downy Woodpeckers that came near their nest territories. Kilham (1969) reported no agonistic encounters between nesting Hairy and Downy woodpeckers, yet the similarity value between these woodpeckers was the highest (Table 3).

Competition between species might occur only if a resource required by both species is limited. In the past selection favoring a divergence in the size of sympatric populations of Downy and Hairy woodpeckers may have been a factor in reducing competition for nest sites, if any competition existed. Other factors, however, such as foraging technique probably also influenced the evolution of size differences in woodpeckers. A species that fed superficially might not need the larger size and mass of species that fed by excavating through several inches of sound wood to reach arthropod chambers.

It would be difficult to determine if woodpecker nest sites are at present a limited resource. Woodpeckers cannot nest in any tree in a forest, even if the surrounding habitat and diameter and height of the tree are optimum. They require nest trees with fungal heart rots to soften the core of the tree (Conner et al. 1975). A low density of suitably infected trees, especially in forests that are clearcut on a short term rotation, might limit the nest site resource. No data are available at present on the prevalence of heart rots in southwestern Virginia.

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