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ECOLOGICAL DISTRIBUTION OF THE GRAY-BREASTED JAY: THE ROLE OF HABITAT[1]

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Abstract. Habitat relationships of Gray-breasted Jays (*Aphelocoma ultramarina*) in southwestern New Mexico were investigated to determine what factors might account for the abrupt termination of this species' range. Habitat variables at 38 sites along a 150 km north-south transect were measured and subjected to multivariate analysis. Patterns derived from this analysis were used to develop a discriminant function based on jay presence or absence. Results indicate that Gray-breasted Jays are tied closely to the densities of mast-producing tree species, and that not all sites seemingly capable of supporting jays are occupied.

Key words: Aphelocoma ultramarina; *habitat selection; distribution patterns; discriminant function analysis; mast production; oaks.*

INTRODUCTION

The availability of suitable habitat is considered an important factor in determining species distribution patterns, and its importance relative to other factors such as competition often can be inferred if, for example, changes in a species' distribution pattern coincide with demonstrable changes in habitat structure. One such example is provided by the cooperatively breeding Gray-breasted (formerly Mexican) Jay (*Aphelocoma ultramarina*) of the southwestern United States. The northwestern limit of the distribution of this jay is the Mogollon Rim of southwestern New Mexico and central Arizona (Pitelka 1951). A north-south transect across the rim reveals a striking habitat gradient, with mixed pine-oak and desert grassland associations found at the bottom of the rim replaced by juniper-piñon and ponderosa pine zones as elevation increases. Along the same transect, the presence of Gray-breasted Jays abruptly terminates, suggesting a change in some ecological factor or factors important in determining this species' presence or absence (Marshall 1957).

Here I examine the role of habitat as a possible factor influencing the distribution of Gray-breasted Jays in southwestern New Mexico. I sampled a variety of habitat parameters to determine what changes in habitat structure are correlated with the northern distributional limit of this jay, examining in particular the relationship between jay presence and mast producing tree species. Although this study emphasized the role of habitat in determining distribution patterns of Gray-breasted Jays, the presence of the congeneric Scrub Jay (*A. coerulescens*) throughout the study area provided opportunity to examine the possible role of competition in determining the distribution pattern of Gray-breasted Jays.

METHODS

STUDY AREA AND DETERMINATION OF JAY PRESENCE OR ABSENCE

Data for my study were collected in southwestern New Mexico along a 150 km north-south transect that covered the western slope of the Gila Mountains and the adjacent Burro Mountains. Vegetation in this region can be categorized as desert scrub and grassland, mixed pine-oak associations, or high mountain forest (see Lowe 1964 for detailed descriptions). Mixed pine-oak associations at the northern end of the sample transect are restricted to canyon bottoms and washes that are separated by expanses of desert scrub, creating a mosaic of habitat types. At the southern end of my sample transect, the pine-oak associations are less fragmented, and larger, more continuous patches of habitat are found. Elevation of the study sites ranged from 1,500 m in the south to 2,100 m in the north.

Preliminary data were collected in August 1981, during which nine sites known to be occupied by Gray-breasted Jays were examined and qualitative observations on jay habitat use patterns were gathered. These observations suggested that Gray-breasted Jays occupied the mixed pine-oak associations found in canyons and washes, and rarely ventured onto the surrounding desert scrub or high mountain forest. This information was used to select 40 potential study sites from aerial photographs and a U.S. Forest Service map of the Gila National Forest, 20 north and 20 south of the known distributional limit of the jay. No sample sites were placed in high mountain forest or desert scrub since Gray-breasted Jays

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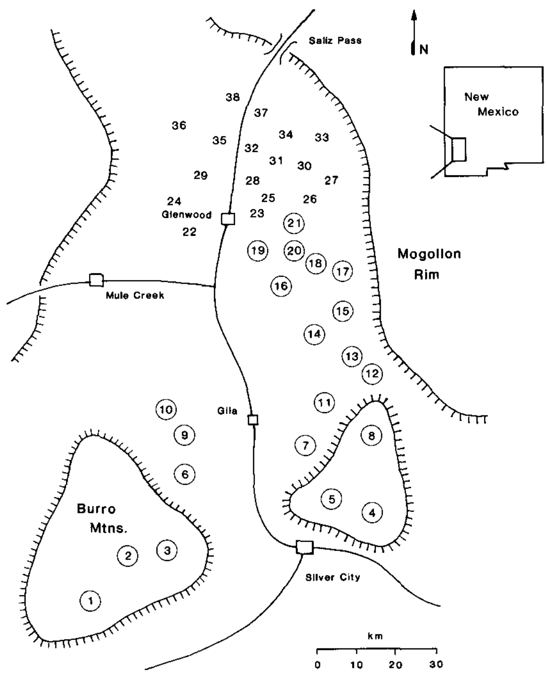

FIGURE 1. Location of sample sites in southwestern New Mexico. Glenwood represents the known northernmost limit of the distribution of Gray-breasted Jays in New Mexico. Circled numbers indicate sites occupied by the jays during summer 1982.

do not occupy these habitats. Two sites eventually were eliminated because of problems of access.

From 28 May to 2 August 1982, I examined the 38 remaining sites (Fig. 1) in detail to determine the presence or absence of Gray-breasted Jays during the breeding season, and to sample habitat. Presence, as defined here, included location of a nesting effort within 0.5 km of the sample site or use of the sample site by a flock of jays. Nests were located by using tape-recorded playbacks of calls to attract members of the group and then following individuals back to the nest tree. Factors used to define use included behavioral observations suggesting a nesting effort (e.g., stick carrying), foraging at the sample site, and observations of intra- and inter-specific interactions suggesting possible establishment of breeding territories. The study sites were visited again in December 1982 to determine if jays were still present.

HABITAT SAMPLING AND ANALYSIS

I sampled attributes of vegetation structure at 30 randomly chosen points within each sample site. The point-centered quarter method (Cottam and Curtis 1956) was used to estimate tree and shrub densities. Parameters recorded on trees and shrubs included species, point to species distance (m), diameter at breast height (DBH; cm), tree height (nearest m), and lower canopy height (nearest m). Species sampled included trees and shrubs greater than 1 m in height. Coefficients of variation of DBH, tree height, and lower canopy height, based upon all sample points, were calculated and used as measures of relative site heterogeneity (Rotenberry and Wiens 1980).

TABLE 1. Habitat variables and characteristics measured at each sample plot.

Variable code	Description
OAKS	*Quercus grisea, Q. emoryi, Q. undulata, Q. turbinella, Q. hypoleucoides, Q. gambelii*; number per 0.6 ha
OMAST	*Pinus ponderosa, P. edulis*; number per 0.6 ha
NMAST	*Juniperus deppeana, J. monosperma, Platanus wrightii, Prosopis juliflora, Juglans major*; number per 0.6 ha
CVCANHT	Coefficient of variation of canopy height
CVTREEHT	Coefficient of variation of tree height
CVDBH	Coefficient of variation of tree diameter at breast height
EXPS	Sample site exposure; see methods
ELEV	Elevation (m) at sample site
PLIT	Percent litter
PBARE	Percent bare ground/rock

Initially, I calculated parameter estimates for each tree species encountered at a site. Because tree species composition and frequency changed over the length of the transect, it became necessary to lump similar tree types into categories to avoid problems associated with the creation of a sparse matrix of sample estimates. Categories created in this manner included one for *Quercus* spp., other mast producing species, and one for nonmast-producing species (Table 1).

Variables describing ground cover (percentages of litter, grasses/forbs, and ground/bare rock, based on all sample points), distance to nearest water, whether the water was intermittent or available year-round, and site exposure and elevation also were estimated or measured. As most sample sites were located in canyons or washes, site exposure was determined from a down-slope compass bearing made parallel to the direction of the canyon or wash and scored in the following manner: 315–45° = 1; 45–135° = 2; 135–225° = 3; and 225–315° = 4. Sites with a slope <5% were considered exposed to all directions and assigned a value of zero. Site elevation was obtained from USGS 7.5 min topographical maps. An estimate of the percentage of oaks that produced acorns was made by noting the presence or absence of budding scars on the oaks sampled, and then summing these results by species within each sample site. No attempt

TABLE 2. Comparison of reduced habitat variables at sample sites occupied (P) and not occupied (A) by Gray-breasted Jays. Habitat variables are described in Table 1. See Methods for explanation of *r*.

Habitat variable	Mean ± SE		Range		*r*
	P (*n* = 21)	A (*n* = 17)	P (*n* = 21)	A (*n* = 17)	
OAKS	46.67 ± 6.92	11.10 ± 1.66	13.18–162.14	0–27.63	0.79***
OMAST	8.04 ± 2.39	1.55 ± 0.39	0–43.10	0–4.81	0.29
NMAST	2.76 ± 0.34	31.48 ± 2.81	1.06–7.28	14.51–58.96	−0.86***
CVCANHT	1.42 ± 0.48	1.60 ± 0.93	0.29–2.92	0.11–3.74	0.30
CVTREEHT	2.89 ± 0.73	0.87 ± 0.40	0.43–3.36	0.06–1.42	0.74**
CFDBH	2.24 ± 0.80	0.75 ± 0.21	0.89–3.92	0.41–1.37	0.61*
EXPS	2.47 ± 0.38	2.23 ± 0.26	0–4	0–4	0.42
PBARE	46.33 ± 6.25	47.94 ± 6.71	3–92	8–93	−0.01
PLIT	24.81 ± 4.16	12.41 ± 2.77	0–57	1–40	0.32
ELEV	1,691 ± 26.52	1,775 ± 29.65	1,524–1,905	1,646–2,073	0.54

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

was made to estimate seed production in other mast producing species.

The reciprocal of Simpson's (1949) diversity index, $D = 1/\sum_{i=1}^{n} (p_i^2)$, where p_i equals the relative proportion of each tree species, was used to calculate site diversity. Site evenness (E) was calculated from Hill's (1973) ratio $E = D/\exp\left(-\sum_{i=1}^{2} p_i \ln p_i\right)$. Richness was the number of tree species encountered.

All variables were tested for normality and log-transformed when necessary. The arcsine square root was used to transform percentage estimates. Stepwise discriminant function analysis (DFA) was used to characterize the ecological differences between sites occupied and unoccupied by the jay. The point-biserial correlation (Kendall and Stuart 1961) was used to estimate the strength of the relationship between jay presence and site diversity and evenness indices. Stuart's tau-c (Kendall and Stuart 1961) was used to determine the relationship between jay presence and tree species richness values. A significant relationship using either test also represents significant difference between the variables being tested. The level of significance for all tests was 0.05 unless otherwise noted. All analyses were performed using procedures found in the Statistical Analysis Systems Guides (SAS Institutes Inc., SAS Circle, P. O. Box. 8000, Cary, North Carolina 27511).

RESULTS

Active nests were located at 16 of the 21 sample sites occupied by Gray-breasted Jays during summer 1982 (Fig. 1). The remaining five sites met the other criteria used to define Gray-breasted Jay presence, and thus were classified as occupied by the jay. All sample sites south of Glenwood, NM, considered the northernmost location of Gray-breasted Jays, contained evidence indicating use or occupancy by the jay (Fig. 1).

Sixteen of the 19 sample sites were still occupied by the jays in December. Three sites appeared to have been abandoned, and I was unable to return to two sites. Although I do not know if winter and summer flocks were composed of the same individuals, or if the same flocks were present from year to year, the sedentary nature of this jay (Brown 1974) makes it reasonable to assume the same flocks occupy the same site year-round. No differences in habitat between the three abandoned sites and those still occupied in December were apparent.

Site occupancy by Gray-breasted Jays appears related primarily to variables describing tree densities or structure (Table 2). Oak density and two measures of site heterogeneity, the coefficients of variation of tree height and DBH, were significantly greater at occupied sites, while the density of nonmast-producing tree species was significantly less. Densities of other mast producing trees and percent litter generally were higher at occupied sites, although the differences were not significant. Differences among the remaining variables were negligible. Jay presence correlated significantly with the number of oak and other mast-producing species, and the total number of tree species (Table 3). No relationships were apparent between jay presence and site diversity or evenness although trends existed towards increased diversity and evenness at sites occupied by the jay.

Based on budding scars, a slightly higher proportion of oaks at sites occupied by Gray-breasted Jays produced acorns (Table 4). These results should be interpreted with caution, however, because yearly variation in acorn production is greater both within and between oak species, and even by particular trees (Sharp

TABLE 3. Comparison of mean diversity, evenness, and tree species richness indices between sampled sites occupied (P) or not occupied (A) by Gray-breasted Jays. Tree species richness is divided into subsets describing all oak species, and other mast and nonmast-producing species. See Methods for explanation of *r*.

	Mean ± SE		Range		
	P (*n* = 21)	A (*n* = 17)	P (*n* = 21)	A (*n* = 17)	*r*
Diversity	3.23 ± 0.22	2.69 ± 0.12	1.80–5.11	1.92–3.79	0.31
Evenness	4.04 ± 0.23	3.33 ± 0.13	2.67–6.29	2.51–4.33	0.38
Richness					
OAKS	2.80 ± 0.17	1.53 ± 0.18	2–5	0–3	0.75***
OMAST	1.14 ± 0.17	0.53 ± 0.15	0–2	0–2	0.42*
NMAST	2.34 ± 0.12	2.47 ± 0.27	2–4	1–5	−0.08
Total	6.28 ± 0.25	4.53 ± 0.17	4–9	4–6	0.77***

* $P < 0.05$; *** $P < 0.001$.

and Sprague 1967, Goodrum et al. 1971). Of importance is the slightly greater proportion of oaks that produced acorns coupled with a higher density of oaks at sample sites occupied by the jay. This suggests that overall acorn production may have been greater in habitat occupied by Gray-breasted Jays.

The discriminant function based on the measured habitat variables correctly classified 19 of 21 (90.5%) occupied sample sites as occupied by the jay. Of the 10 variables entered for the analysis, only six met the stepwise criterion ($P < 0.1$) for retention. Oak density was the first variable entered and accounted for a large portion of the model significance, followed by tree height, nonmast-producing tree species, coefficients of variation of DBH and canopy height, and elevation. Reanalyzing the data using only these six variables did not change any sample site classifications. Two sites incorrectly classified as unoccupied (18 and 19) had low densities of mast-producing tree species, which probably accounts for the misclassification. One site (27 lacking jays was classified as occupied.

DISCUSSION

In their examination of the relationship between oaks and the acorn dependent Acorn Woodpecker (*Melanerpes formicivorus*), Bock and Bock (1974) argued that when only a few species of oaks are present, the potential for large annual fluctuations in food availability increases. In some years, insufficient mast is produced in an area to permit over-wintering by the woodpeckers, whereas in other years production is sufficient. Breeding groups may not remain in areas where annual acorn production fluctuates greatly or where yearly production is low. While Bock and Bock's (1974) hypothesis about the relationship between oaks and population stability is generally supported for Acorn Woodpeckers in California and Arizona (Roberts 1979, Trail 1980), attempts to relate it to habitat selection by Gray-breasted Jays are not clear. Whereas Acorn Woodpeckers remain territorial year-round and actively defend acorn storage sites (MacRoberts and MacRoberts 1976, Stacey 1979), the territorial boundaries of Gray-breasted Jays may be more flexible during winter, with groups of jays often foraging outside their breeding territories for food (Hardy 1961, Brown 1963, Westcott 1969). Occupancy of breeding territories may last until mast stores are depleted, at which time the jays would be forced to abandon their territories and search elsewhere for food.

TABLE 4. Proportion of oaks in habitat occupied (P) and unoccupied (A) by Gray-breasted Jays that produced acorns. Mean number of each oak species per 120 sampling points is given in parentheses.

Oak species	Percent of trees producing acorns	
	P (*n* = 21)	A (*n* = 17)
All oaks	78 (106)	71 (27)
Q. emoyri	64 (62)	69 (10)
Q. grisea	81 (17)	77 (16)
Q. undulata	73 (12)	—[1]
Q. turbinella	84 (8)	—[1]
Q. hypoleucoides	79 (7)	—[1]
Q. gambelii	—[1]	68 (11)

[1] Species not encountered.

Brown and Brown (1985) recently examined the relationship between habitat and Gray-breasted Jays farther south in the species' range. Their admittedly qualitative observations suggest that, unlike the results reported here, Gray-breasted Jay distribution patterns in the Chiricahua Mountains of southeastern Arizona are not affected by oak density, diversity, or richness. This lack of any relationship, in part, may be caused by the larger, more continuous nature of the oak-woodland and savannah in Arizona. Here, jays facing a localized food shortage during winter may not have to wander as far to locate alternative foraging sites. In contrast, Gray-breasted Jays near the northern limit of their range in New Mexico occupy fragmented habitat, and a local food shortage during winter is more likely to result in dispersal from the immediate area. Winter movements of this nature may affect jay distribution patterns the following breeding season, whereas Brown and Brown (1985) state little turnover occurs in breeding sites in Arizona.

Gray-breasted Jays in southwestern New Mexico, however, do occupy areas where the number of oak species is high and the density of oaks is low. This kind of habitat is relatively common in the Burro Mountains, located at the southern end of my sample transect, and is more similar to the pine-oak woodland described for Arizona. Although oak density in the Burro Mountains is lower than in sites farther north, oaks are not restricted to canyon bottoms and jays can forage over larger areas to obtain mast. Increased density of oaks may become important toward the northern limit of the jay's range, where mast-producing tree species are largely restricted to canyon bottoms and where jays would have to migrate considerable distances in response to a local food shortage.

The close association Gray-breasted Jays have with particular habitat attributes also may represent separation along habitat lines to reduce competition with similar species (e.g., Cody 1978). One such potential competitor might be the Scrub Jay (*A. coerulescens*), a common species found throughout southwestern New Mexico and one using many of the same resources used by Gray-breasted Jays. Intrusion of this jay into territory occupied by Gray-breasted Jays often led to agonistic interactions. A total of 33 aggressive interactions were observed between Scrub and Gray-breasted Jays, and in all instances the intruding Scrub Jay was chased from the area, apparently as soon it was detected. However, the extent to which Scrub Jays are able to intrude into and remain undetected in habitat occupied by Gray-breasted Jays is unknown, as my observations on intruders were made only after aggressive interactions began. In all my observations, it was clear that Scrub Jays were subordinate to Gray-breasted Jays. Thus, it appears unlikely that Gray-breasted Jays are restricted to the particular habitat they occupy by Scrub Jays; rather, the strong correlations with high densities of mast-producing tree species suggest habitat change rather than competition is the primary factor determining the northern limit of the range of Gray-breasted Jays.

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