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# BREEDING BIRD COMMUNITIES AND NEST PLANT SELECTION IN CHIHUAHUAN DESERT HABITATS IN SOUTH-CENTRAL NEW MEXICO

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ABSTRACT.—We examined the significance of arroyo-riparian habitat to birds in the Chihuahuan Desert of south-central New Mexico. Nests (N = 620) of 27 species were monitored during 1993–1995. Twenty-three species nested in arroyos and 20 species nested in uplands. Northern Mockingbirds (*Mimus polyglottos*), Rock Wrens (*Salpinctes obsoletus*), and Verdins (*Auriparus flaviceps*) nested most frequently in arroyos. Black-throated Sparrows (*Amphispiza bilineata*), Northern Mockingbirds, and Scott's Orioles (*Icterus parisorum*) nested most frequently in uplands. Nest density in arroyos was more than twice that of uplands (0.64 nests/ha versus 0.27 nests/ha). Nest success and predation rates did not differ between arroyos and uplands for Black-throated Sparrows, Northern Mockingbirds, and Crissal Thrashers (*Toxostoma crissale*). Nest predation was the primary cause of mortality to eggs and nestlings in both habitats. Torrey yucca (*Yucca torreyi*), javelina bush (*Condalia warnockii*), and little-leaf sumac (*Rhus microphylla*) were the most frequently used nest substrates, even though these shrubs were among the lowest in density. Maintaining this habitat and protecting sparse shrub species used as nest substrates may have long term importance in managing Chihuahuan Desert bird communities. *Received June 23, 1996, accepted December 5, 1996.*

Populations of some Neotropical migrants have declined over the last 20–30 years (Finch 1991). A significant reason for these declines is thought to be caused by loss of habitat on both breeding and wintering grounds (Wilcove and Whitcomb 1983, Robbins et al. 1989). In order to conserve populations of Neotropical migrants, as well as resident species, it is necessary to understand not only their habitat requirements, but their demographic patterns as well (Martin 1992). Such understanding may provide insight into the evolutionary and ecological factors that influence their fitness (Martin and Geupel 1993). However, for some species in North America, little information exists about basic habitat requirements, reproduction, and survival (Martin 1993, Martin and Geupel 1993).

In this study, we focus on several questions to expand the understanding of ecological factors influencing populations of Neotropical migrants and resident birds in arroyo-riparian and surrounding upland habitat in the Chihuahuan Desert. We hypothesize that breeding bird richness and nesting success is higher in arroyo habitat than in the xeric upland habitat and that birds show disproportionate use of all nesting species of shrubs.

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Our objectives were (1) to determine the composition of the breeding bird communities in both arroyo and upland habitat; (2) to compare nesting success in both habitats and (3) to evaluate nesting plant preferences and life history information.

## METHODS

*Study site.*—Our study area is located 22 km northeast of Orogrande, Otero Co., New Mexico, on the McGregor Range, on the Fort Bliss Military Reservation. The main portion of Fort Bliss rests in the Tularosa Basin surrounded by the San Andres, Franklin and Organ mountains on the west and the Sacramento and Hueco mountains on the east. Elevation of the site ranges from 1276 m to 1512 m. Rainfall averages between 20.3 to 25.4 cm annually (Budd et al. 1979). Approximately 65% to 80% of the annual rainfall occurs from June to September (Shreve 1942). The predominant arroyo vegetation is little-leaf sumac (*Rhus microphylla*), desert willow (*Chilopsis linearis*), apache plume (*Fallugia paradoxa*), and brickell bush (*Brickellia laciniata*). Arroyos are classified here as riparian habitat since they contain plant associations different from those of the adjacent upland, even though they may not contain flowing water for many years (Ohmart and Anderson 1986). The vegetation in adjacent uplands is desert scrub (Shreve 1942) or bajada. Dominant shrubs include whitethorn acacia (*Acacia constricta*), mesquite (*Prosopis glandulosa*), creosote bush (*Larrea tridentata*), and tarbush (*Flourensia cernua*). Torrey yucca (*Yucca torreyi*), soaptree yucca (*Y. elata*), and banana yucca (*Y. baccata*) are found in clumps throughout the uplands. Grasses and forbs throughout the area are dominated by *Aristida* spp., black grama (*Bouteloua eriopoda*), bush muhly (*Muhlenbergia porteri*), broom snakeweed (*Guterrezia sarothrae*), and Gordon's bladderpod (*Lesquerella gordoni*).

We chose eight arroyos for our study plots based on the presence of (1) a well-defined gravel channel, (2) obligate arroyo plants (i.e., apache plume and brickell bush), (3) a band of arroyo vegetation that averaged between 30–50 m wide and at least 1400 m in length, and (4) compatibility with proposed military activities and access. We chose adjacent uplands for comparison (on one side of the arroyo) based on the lack of intersections with other major arroyos and continuity of cover within a 44.8 ha area. The sample plots were 56 ha (1400 × 400 m) and consisted of a combination of arroyo and upland, of which arroyo habitat comprised approximately 20% (11.2 ha; 1400 × 80 m).

*Nest searching.*—We began nest searching the first week of May in 1993, 1994 and 1995. We found nests by following adults carrying nesting material or food, flushing adults from nests, and actively searching for nests in possible nesting sites (i.e., large yuccas). We proportioned time spent nest searching equally between habitats and visited plots every other day to ensure that nesting cycles and causes of nest failure were documented accurately. When checking a nest, we recorded which adults, if any, were present, nest contents (e.g., number of eggs/young, cowbird eggs), and fate of nest (e.g., fledged, abandoned, depredated, failure due to weather, and other). If no adults were observed for five or more consecutive checks and the contents of the nest remained unchanged, we assigned a fate of deserted. If all eggs or young were gone before the anticipated time of incubation or nestling stage was complete, we assigned a fate of depredated.

*Vegetation sampling.*—We sampled vegetation at a total of 256 points in each habitat, following guidelines proposed by James and Shugart (1970). Points were selected systematically with a 5-m radius circle centered on each point. Within this circle, we counted all shrubs and yuccas. We also used five, 1 m diameter circles around each point and counted the number of forbs (e.g., broom snakeweed) and grasses rooted in the circle.

*Analysis.*—We calculated nest success for those species with ten or more nests per habitat,

using the modified Mayfield Method (Mayfield 1975, Hensler and Nichols 1981) and the program Micromort (Heisey and Fuller 1985). A nest was considered successful if one or more young fledged. We used ANOVA to compare nest densities between habitats and *t*-tests to compare clutch sizes and mean numbers of young fledged between habitats. We used the program Contrast (Sauer and Williams 1989), which utilizes a modified Chi-square statistic, to compare survival and predation rates between arroyos and uplands for species with at least ten nests in each habitat. We used Kendall's coefficient of rank correlation (Sokal and Rohlf 1981) to rank correlate numbers of nests with densities of shrub species used in both habitats. We also used Kendall's coefficient of rank correlation to rank correlate numbers of Black-throated Sparrow and Northern Mockingbird nests with densities of shrub species used. These two species were the only species to have adequate sample sizes to perform rank correlation analyses. All analyses were performed at $\alpha \leq 0.05$.

## RESULTS

We found a total of 620 nests of 27 species during 1993–1995 (Table 1). Of these 27 species, 16 were non-migratory (59.3%), nine were neotropical migrants (33.3%), and two were short distance migrants (7.4%) (Finch 1991). Of all non-migratory species, 37% nested most frequently in arroyos, 37% nested most frequently in uplands, and 25% nested about equally in both habitats. Six of nine Neotropical migrant species (66.7%) and both short distance migrant species nested more frequently in uplands.

Twenty-three species nested in arroyos and 20 species nested in uplands (Table 1). Northern Mockingbirds, Rock Wrens, Verdins, and Crissal Thrashers were the most frequently nesting species in arroyos. Black-throated Sparrows, Northern Mockingbirds, Scott's Orioles, and House Finches were the most frequently nesting species in uplands. Nest density in arroyos (0.64 nests/ha) was significantly greater than in uplands (0.27 nests/ha) ($P = 0.002$). Peak nest initiation of all species combined, occurred between 18 and 24 May in each year.

In arroyos, Black-chinned Hummingbirds achieved the greatest nest success of the five species with sample sizes adequate for analysis (Table 2). For four species, predation accounted for the greatest loss of nests; for Canyon Towhees abandonment accounted for the greatest losses. In uplands, Northern Mockingbirds achieved the highest nest success of the eight species with sample sizes adequate for analysis (Table 2). Again, predation accounted for the greatest loss of nests. Nest success and predation rates did not differ between arroyos and uplands for Black-throated Sparrows ($\chi^2 = 2.621$, 1 df, $P = 0.106$ and $\chi^2 = 1.481$, 1 df, $P = 0.224$, respectively), Northern Mockingbirds ($\chi^2 = 0.261$, 1 df, $P = 0.610$ and $\chi^2 = 0.268$, 1 df, $P = 0.605$, respectively), and Crissal Thrashers ($\chi^2 = 1.126$, 1 df, $P = 0.289$ and $\chi^2 = 0.718$, 1 df, $P = 0.397$). These three species were the only ones with sample sizes large enough to compare between habitats, although the scale and proximity of these habitats make comparing productivity difficult. We believe snakes were the primary nest

TABLE 1

TOTAL NUMBER OF NESTS FOUND FOR ALL SPECIES, BY HABITAT, ON THE MCGREGOR RANGE, FORT BLISS, TEXAS IN 1993–1995

| Species | Total | Arroyo | Upland |
|---|---|---|---|
| Black-throated Sparrow (*Amphispiza bilineata*)[a] | 141 | 12 | 129 |
| Northern Mockingbird (*Mimus polyglottos*)[b] | 113 | 31 | 82 |
| Scott's Oriole (*Icterus parisorum*)[c] | 48 | 2 | 46 |
| House Finch (*Carpodacus mexicanus*)[a] | 35 | 9 | 26 |
| Crissal Thrasher (*Toxostoma crissale*)[a] | 33 | 17 | 16 |
| Verdin (*Auriparus flaviceps*)[a] | 31 | 19 | 12 |
| Loggerhead Shrike (*Lanius ludovicianus*)[a] | 28 | 7 | 21 |
| Rock Wren (*Salpinctes obsoletus*)[a] | 23 | 22 | 1 |
| Western Kingbird (*Tyrannus verticalis*)[c] | 23 | 1 | 22 |
| Canyon Towhee (*Pipilo fuscus*)[a] | 19 | 12 | 7 |
| Ash-throated Flycatcher (*Myiarchus cinerascens*)[c] | 18 | 9 | 9 |
| Common Nighthawk (*Chordeiles minor*)[c] | 16 | 0 | 16 |
| Cactus Wren (*Campylorhynchus brunneicapillus*)[a] | 15 | 8 | 7 |
| Mourning Dove (*Zenaida macroura*)[a] | 14 | 0 | 14 |
| Black-chinned Hummingbird (*Archilochus alexandri*)[c] | 10 | 10 | 0 |
| Black-tailed Gnatcatcher (*Polioptila melanura*)[a] | 10 | 2 | 8 |
| Blue Grosbeak (*Guiraca caerulea*)[c] | 8 | 8 | 0 |
| Common Poorwill (*Phalaenoptilus nuttallii*)[c] | 8 | 0 | 8 |
| American Kestrel (*Falco sparverius*)[a] | 5 | 5 | 0 |
| Greater Roadrunner (*Geococcyx californianus*)[a] | 5 | 5 | 0 |
| Say's Phoebe (*Sayornis saya*)[c] | 5 | 3 | 2 |
| Phainopepla (*Phainopepla nitens*)[b] | 4 | 1 | 3 |
| Lesser Nighthawk (*Chordeiles acutipennis*)[c] | 3 | 0 | 3 |
| Rufous-crowned Sparrow (*Aimophila ruficeps*)[a] | 2 | 1 | 1 |
| Barn Owl (*Tyto alba*)[a] | 1 | 1 | 0 |
| Ladder-backed Woodpecker (*Picoides scalaris*)[a] | 1 | 1 | 0 |
| Pyrrhuloxia (*Cardinalis sinuatus*)[a] | 1 | 1 | 0 |
| Total number of nests | 620 | 188 | 432 |

[a] Non-migrant (year-round resident)

[b] Short-distance migrant (absent from the study area during some part of the year, but winters primarily within the United States).

[c] Neotropical migrant (winters in the tropical and sub-tropical latitudes of Central and South America and whose main wintering areas are south of the United States).

predators on all nests, as indicated by the lack of disturbance at the nest site, although some avian species (i.e., Greater Roadrunners) are known to prey on nests and leave little evidence of disturbance. However, avian predators were rare on our sites and for other predators we were unable to collect detailed information on their populations.

Nest parasitism by Brown-headed Cowbirds (*Molothrus ater*) was a source of nest failure for four species. Black-tailed Gnatcatcher (*Polioptila melanura*) nests were the most heavily parasitized of all species; 50%

TABLE 2

PERCENT NEST SUCCESS AND MORTALITY FACTORS FOR TEN[a] NESTING SPECIES IN ARROYO AND UPLAND HABITAT ON THE FORT BLISS MILITARY RESERVATION, FORT BLISS, TEXAS, IN 1993–1995

| Species | N | Exposure[b] | Survival[c] | Predation | Abandoned | Other | Weather | Parasitism |
|---|---|---|---|---|---|---|---|---|
| | | | | Arroyo | | | | |
| Northern Mockingbird | 31 | 481 | 0.50 (0.10) | 0.42 (0.10) | 0.08 (0.07) | 0.0 | 0.0 | 0.0 |
| Crissal Thrasher | 16 | 274.5 | 0.29 (0.10) | 0.53 (0.12) | 0.12 (0.08) | 0.06 (0.06) | 0.0 | 0.0 |
| Canyon Towhee | 14 | 109 | 0.19 (0.11) | 0.30 (0.14) | 0.40 (0.15) | 0.0 | 0.0 | 0.10 (0.10) |
| Black-throated Sparrow | 12 | 113 | 0.13 (0.09) | 0.77 (0.12) | 0.0 | 0.10 (0.09) | 0.0 | 0.0 |
| Black-chinned Hummingbird | 9 | 253.5 | 0.65 (0.16) | 0.23 (0.14) | 0.12 (0.11) | 0.0 | 0.0 | 0.0 |
| | | | | Upland | | | | |
| Black-throated Sparrow | 123 | 1393.5 | 0.29 (0.04) | 0.61 (0.05) | 0.05 (0.02) | 0.01 (0.01) | 0.0 | 0.03 (0.02) |
| Northern Mockingbird | 80 | 1332 | 0.56 (0.06) | 0.36 (0.06) | 0.08 (0.03) | 0.0 | 0.0 | 0.0 |
| Scott's Oriole | 44 | 851 | 0.47 (0.08) | 0.34 (0.07) | 0.15 (0.05) | 0.0 | 0.05 (0.11) | 0.0 |
| House Finch | 26 | 321.5 | 0.20 (0.08) | 0.60 (0.11) | 0.20 (0.09) | 0.0 | 0.0 | 0.0 |
| Loggerhead Shrike | 21 | 384.5 | 0.39 (0.12) | 0.54 (0.13) | 0.07 (0.07) | 0.0 | 0.0 | 0.0 |
| Western Kingbird | 21 | 549.5 | 0.47 (0.11) | 0.43 (0.11) | 0.10 (0.06) | 0.0 | 0.0 | 0.0 |
| Crissal Thrasher | 15 | 258 | 0.47 (0.13) | 0.38 (0.13) | 0.15 (0.10) | 0.0 | 0.0 | 0.0 |
| Mourning Dove | 13 | 151 | 0.15 (0.09) | 0.76 (0.11) | 0.08 (0.08) | 0.0 | 0.0 | 0.0 |

[a] Containing enough nests with adequate exposure days to calculate nest success.
[b] Total number of exposure days.
[c] Percent of nests that fledged at least one young. Numbers in parentheses represents standard error.

of the nests we located contained at least one cowbird egg. In contrast, only 14% of Blue Grosbeak nests, 10% of Black-throated Sparrow nests, and 5% of Canyon Towhee nests were parasitized. All gnatcatcher nests that were parasitized (N = 5) failed to produce young. Each of the species parasitized accepted Brown-headed Cowbird eggs, with the exception of desertion at one Canyon Towhee nest and one gnatcatcher nest.

Of the ten most abundant nesting species in both habitats, only one species produced significantly different clutch sizes between arroyos and uplands. Black-throated Sparrows produced a higher mean clutch size ($P = 0.02$) and tended to fledge a greater number of young in uplands ($P = 0.190$) (Table 3). Mean clutch sizes and mean number of young fledged for the other nine species did not differ between habitats. Mourning Doves had the smallest average clutch size and thus fledged the fewest young (Table 3).

Little-leaf sumac and mesquite were used for nesting by the greatest number of bird species, followed by Torrey yucca and javelina bush (Table 4). Torrey yucca, javelina bush, little-leaf sumac, and walls of arroyos were the most frequently used nest substrates of the 26 confirmed nesting species in both arroyo and upland habitats (Table 4). Kendall's coefficient of rank correlation analysis did not reveal a significant correlation between the number of nests placed in a particular shrub species and the abundance of that shrub (Table 5) in either habitat for all bird species combined (tau = −0.0545 and tau = −0.110, in arroyos and uplands respectively).

Nest plant selection appears to be different between Black-throated Sparrows and Northern Mockingbirds. Kendall's coefficient of rank correlation did not reveal a significant correlation between number of sparrow nests placed in a particular shrub species and the abundance of that shrub in uplands (tau = 0.2946). Similarly, mockingbirds showed no preference for a particular shrub species in arroyos (tau = −0.4243). However, Kendall's coefficient did reveal a significant negative correlation for mockingbird nests placed in a particular shrub species and the abundance of that shrub in uplands (tau = −0.740).

## DISCUSSION

Nesting bird species richness on our study area was greater than in previous studies investigating nesting bird communities of Chihuahuan Desert wash and scrub habitat (Raitt and Maze 1968, Naranjo and Raitt 1993). Raitt and Maze (1968) found eight breeding species in a predominately creosote bush upland dissected with arroyos. Similarly, Naranjo and Raitt (1993) found 11 breeding species in three habitats along a bajada that contained a large creosote/grassland component. However, spe-

## TABLE 3

NEST PRODUCTIVITY DATA FOR THE 10 MOST ABUNDANT NESTING SPECIES, BY HABITAT, ON THE MCGREGOR RANGE, FORT BLISS, TEXAS, IN 1993–1995

| | Arroyo | | | | Upland | | | |
|---|---|---|---|---|---|---|---|---|
| | Observed slutch size | | Number of young fledged | | Observed clutch size | | Number of young fledged | |
| Species[b] | Mean | SE[a] | Mean | SE | Mean | SE | Mean | SE |
| Black-throated Sparrow | 2.27[c] (11)[d] | 0.19 | 0.58 (12) | 0.31 | 2.79 (99) | 0.07 | 1.11 (121) | 0.12 |
| Northern Mockingbird | 3.39 (28) | 0.13 | 1.54 (28) | 0.27 | 3.51 (71) | 0.08 | 1.80 (80) | 0.16 |
| Scott's Oriole | 4.00 (1) | — | 2.00 (2) | 2.00 | 3.76 (38) | 0.19 | 1.59 (41) | 0.27 |
| Crissal Thrasher | 2.60 (15) | 0.16 | 0.76 (17) | 0.30 | 2.85 (14) | 0.09 | 0.93 (15) | 0.26 |
| House Finch | 3.20 (5) | 0.37 | 1.16 (6) | 0.60 | 3.94 (17) | 0.18 | 1.07 (26) | 0.31 |
| Loggerhead Shrike | 4.67 (6) | 0.21 | 2.85 (7) | 0.74 | 4.93 (15) | 0.37 | 2.33 (21) | 0.51 |
| Western Kingbird | — | — | — | — | 4.22 (18) | 0.15 | 1.57 (21) | 0.40 |
| Canyon Towhee | 3.29 (7) | 0.18 | 1.58 (12) | 0.48 | 3.00 (4) | 0.58 | 1.29 (7) | 0.52 |
| Mourning Dove | — | — | — | — | 1.92 (13) | 0.08 | 0.46 (13) | 0.24 |
| Black-chinned Hummingbird | 2.00 (9) | 0.0 | 1.00 (10) | 0.30 | — | — | — | — |

[a] Standard error.
[b] Rank determined by total number of nests in both habitats combined.
[c] Significantly different between habitats at ≤ 0.05.
[d] Number of nests where clutch size and number of young fledged were determined.

TABLE 4

THE FREQUENCY OF NEST PLANTS AND OTHER SUBSTRATES BY NESTING BIRDS IN BOTH HABITATS ON THE MCGREGOR RANGE, FORT BLISS, TEXAS, IN 1993–1995

| Nest substrate | Total nests | Arroyo | Upland | Number of species[a] |
|---|---|---|---|---|
| Torrey yucca (*Yucca torreyi*) | 109 | 4 | 105 | 9 |
| Javelina bush (*Condalia warnockii*) | 103 | 13 | 90 | 9 |
| Little-leaf sumac (*Rhus microphylla*) | 61 | 55 | 6 | 11 |
| Arroyo wall | 39 | 34 | 5 | 5 |
| White-thorn acacia (*Acacia constricta*) | 29 | 9 | 20 | 7 |
| Algerita (*Berberis trifoliata*) | 24 | 5 | 19 | 6 |
| *Ephedra* sp. | 24 | 1 | 23 | 5 |
| Mesquite (*Prosopis glandulosa*) | 24 | 15 | 9 | 11 |
| Soaptree yucca (*Y. elata*) | 22 | 4 | 18 | 5 |
| Cholla cactus (*Opuntia imbricata*) | 20 | 9 | 11 | 5 |
| Allthorn (*Koeberlinia spinosa*) | 19 | 3 | 16 | 7 |
| Broom snakeweed (*Gutierrezia sarothrea*) | 16 | 0 | 16 | 2 |
| Creosote bush (*Larrea tridentata*) | 16 | 1 | 15 | 3 |
| Desert willow (*Chilopsis linearis*) | 14 | 14 | 0 | 7 |
| Grasses[b] | 12 | 1 | 11 | 3 |
| Mariola (*Parthenium incanum*) | 12 | 0 | 12 | 3 |
| Banana yucca (*Y. baccata*) | 11 | 0 | 11 | 3 |
| Tarbush (*Flourensia cernua*) | 10 | 1 | 9 | 5 |
| Skeleton-leaf goldeneye (*Viqueria stenoloba*) | 9 | 2 | 7 | 4 |
| Apache plume (*Fallugia paradoxa*) | 7 | 7 | 0 | 5 |
| Tasajillo (*O. leptocaulis*) | 4 | 0 | 4 | 1 |
| Other[c] | 35 | 7 | 28 | 10 |

[a] Includes ground nesting birds that nested within 30 cm of a plant species.
[b] Includes *Aristida* spp., black grama, bush muhly, and plains bristlegrass (*Setaria leucopila*).
[c] Includes plant species with three or fewer nests.

cies richness on our site is significantly lower than in larger, more mesic, riparian habitats in Arizona that contain perennial water and large trees (Carothers et al. 1974, Stamp 1978).

Nesting bird species richness was similar in arroyos and uplands. Rock Wrens, Crissal Thrashers, Northern Mockingbirds, and Verdins were the most frequent nesting species in arroyos. This differs slightly from Raitt and Maze (1968) who found that in southern New Mexico, the most frequently nesting species in arroyos were Verdins and Black-throated Sparrows. Of the 27 confirmed breeding species in our study, nine nested predominantly in arroyos and eight predominantly in uplands. The large number of bird species nesting more frequently in upland habitat is unusual. Raitt and Maze (1968) found that only Black-throated Sparrows and Mourning Doves nested in upland divides between arroyos. However, their study was performed in habitats dominated by creosote bush which

TABLE 5

DENSITY OF THE 15 MOST FREQUENTLY USED NEST PLANT SPECIES IN ARROYO AND UPLAND HABITAT ON THE MCGREGOR MISSILE FIRING RANGE, FORT BLISS, TEXAS IN 1993–1995

| Species | Arroyo | | Upland | |
|---|---|---|---|---|
| | Stems/ha | SE | Stems/ha | SE |
| Broom snakeweed[a] | 3826.1 | 815.43 | 10,867.4 | 7452.52 |
| Mariola | 6028.5 | 866.67 | 6988.3 | 927.56 |
| Creosote Bush | 1477.2 | 399.08 | 1818.3 | 180.16 |
| Tarbush | 939.5 | 259.88 | 1437.4 | 181.42 |
| White-thorn acacia | 540.1 | 191.61 | 1118.6 | 318.08 |
| Mesquite | 124.8 | 12.63 | 137.8 | 60.45 |
| Banana yucca | 85.0 | 72.87 | 151.7 | 86.61 |
| Little-leaf sumac | 208.9 | 36.29 | 6.0 | 4.32 |
| Mormon tea | 47.2 | 17.04 | 86.5 | 25.61 |
| Allthorn | 5.0 | 2.89 | 5.5 | 2.81 |
| Algerita | 6.0 | 3.01 | 1.0 | 1.00 |
| Javelina bush | 2.5 | 2.49 | 3.0 | 1.25 |
| Soaptree yucca | 4.5 | 1.58 | 0.5 | 0.50 |
| Torrey yucca | 0.8 | 0.39 | 1.79 | 0.62 |

[a] Rank determined by total stem density across both habitats.

is rarely used by birds for nesting (Anderson and Anderson 1946). In contrast, Naranjo and Raitt (1993) found a greater number of bird species on a Chihuahuan Desert bajada than reported by Raitt and Maze (1968) and attributed this difference to the presence of large mesquite and yuccas on their study area.

We believe that the greater diversity of upland shrubs on our study area may explain the larger number of species found nesting there. Of the eight species nesting predominantly in uplands, four build open-cup nests (Scott's Orioles, Western Kingbirds, Black-tailed Gnatcatchers, and Black-throated Sparrows), and four nest on the ground. Scott's Orioles and Western Kingbirds nested exclusively in large Torrey and soaptree yuccas, both of which reach their highest density and tallest stature in uplands. It is, therefore, not surprising that orioles and kingbirds nest almost exclusively in uplands (Dixon 1959, Naranjo and Raitt 1993). Likewise, gnatcatchers nested in large allthorn shrubs that were more abundant in uplands. Black-throated Sparrows nested within 45.8 cm of the ground, and it is likely that more nesting sites were available to them in uplands due to the greater abundance of small, compact shrubs. Other predominant upland nesting species (Common Nighthawk, Lesser Nighthawk, Common Poorwill, and Mourning Dove built little or no nest and laid their eggs predominantly on bare ground. Their presence was prob-

ably due to sparse ground vegetation (i.e., grasses and forbs) and a lower probability of being swept away by running water during rain storms.

Of the nine species nesting predominantly in arroyos, four were cavity nesters and five were open-cup nesters. Rock Wrens, American Kestrels, and Barn Owls nested in holes in high banks of arroyos; thus suitable upland sites were not available. A single Ladder-backed Woodpecker (*Picoides scalaris*) nest was located in a large desert willow, which was only found in arroyo habitat. The other obligate arroyo nesters (Black-chinned Hummingbird, Blue Grosbeak, Greater Roadrunner, Rufous-crowned Sparrow [*Aimophila ruficeps*], and Pyrrhuloxia [*Cardinalis sinuatus*]) appear to be less nest substrate-specific than exclusive upland nesters. The reasons for their exclusive use of arroyos in this study is not clear, although choice of the greater shrub density and taller stature of shrubs found in arroyo habitat may relate to food resources or protective cover for nesting.

Our finding of greater nest density in arroyo habitat concurs with that of Raitt and Maze (1968) and Tomoff (1974). The presence of more dense and large shrubs, again, may offer greater opportunities for nesting and improved concealment from predators.

Nest success rates for bird species on our study area correspond with those previously reported. Nest success for Northern Mockingbirds in both habitats was similar to success rates previously reported in Tennessee and Florida (Laskey 1962, Joern and Jackson 1983). Black-throated Sparrows achieved nest success rates in uplands similar to those reported by Delesantro (1978) in southern New Mexico. However, nest success for Loggerhead Shrikes in uplands and for Crissal Thrashers in arroyos was lower than those observed for shrikes in southwestern Oklahoma (Tyler 1992) and thrashers of the lower Colorado River (Finch 1982). These differences might be explained in that habitats in Oklahoma and along the Colorado River may offer greater food resources, more lush vegetation, and less severe climate than habitats in this area of the Chihuahuan Desert. Blancher and Robertson (1985) report much lower nest success rates for Western Kingbirds in southeastern Arizona than for kingbirds in uplands on our site. Western Kingbirds in this area of Arizona nested in open riparian habitats in addition to desert habitat where they overlapped breeding areas of Cassin's Kingbirds (*Tyrannus vociferans*). The increased nest density, as well as greater predation rates in the riparian habitat, may explain the differences in nest success between our study areas.

Mean clutch size for Black-throated Sparrows was significantly lower in arroyos than in uplands. Although this may be related to somewhat higher predation rates in arroyos, it suggests that arroyos lack habitat characteristics which are important for successful nesting. If uplands are

the preferred nesting habitat for Black-throated Sparrows, then inexperienced breeding adults may nest in sub-optimal arroyo habitat. This may also account for the smaller clutch sizes. All other species failed to show significant differences in clutch sizes or number of young fledged between habitats, indicating that they are equally adapted to nest in both habitats.

While over 24 species of plants were used for nesting across both habitats, they were not used equally. Little-leaf sumac, mesquite, Torrey yucca and javelina bush were used by the greatest number of bird species, even though these plants were among the lowest in density. In fact, we found no correlation between number of nests and shrub abundance. Thus, the most abundant shrub species were not used most often. Characteristics of these frequently used plant species include dense foliage, stiff branches, spinescent stems, and greater height. Each factor may offer better protection from nest predators by better concealing the nest and making access to the nest more difficult. In addition, these factors may protect nests from extreme environmental conditions (e.g., temperature) by providing more shade and by elevating nests away from the ground.

The three most abundant bird species differed in their selection of plant species for nesting. Black-throated Sparrows nested in 25 different plant species and Northern Mockingbirds nested in 13 different plant species, where as Scott's Orioles nested in only two plant species. Therefore, we classified sparrows and mockingbirds as nest-site generalists and orioles as nest-site specialists. Only mockingbirds displayed a correlation between number of nests and abundance of plant species in uplands. Thus, mockingbirds appeared to be selecting plant species for nesting that were less abundant in the habitat, whereas Black-throated Sparrows did not. Previous studies in Arizona (Tomoff 1974, Vander Wall and MacMahon 1984, Parker 1986) also found that nesting birds selected less abundant plant species as nest substrates. Because mockingbirds are considerably larger than sparrows, they may be more restricted to the larger plant species, which are rarer in the habitat. Black-throated Sparrows, however, are able to utilize the smaller, more abundant plants for nesting. Although we could not perform rank correlation analysis on Scott's Orioles because of sample size restrictions, the two plant species they selected for nesting were among the lowest in density and, thus, clearly a preferred nest substrate. Therefore, our data did not support our hypothesis that all shrub species are used equally; plant species composition, and perhaps ultimately the structural components of those plants, influences nest-site selection for some bird species.

The majority of breeding species (e.g., Western Kingbird, Black-chinned Hummingbird) appear to favor one habitat over the other for nesting, while several (e.g., Northern Mockingbirds, Crissal Thrashers)

nest in both habitats. The higher density of nests and greater number of species nesting in arroyo-riparian habitat illustrate its importance to both resident and Neotropical migrants. Chihuahuan Desert breeding birds appear to be strongly influenced by plant species composition and the presence of suitable nest sites offered by specific plants in both arroyo and upland habitat. Suitable nesting shrubs tend to be those that are spinescent, contain dense foliage, and have stiff branches. The presence of appropriate nest sites offered by little-leaf sumac, mesquite, Torrey yucca, and javelina bush is a key component of breeding bird habitat in this region of the Chihuahuan Desert. Future studies should be directed towards assessing the structural components and location of these plants relative to other shrubs and how this influences nest-site selection.

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