BREEDING BIRD DENSITIES, SPECIES COMPOSITION, AND BIRD SPECIES DIVERSITY OF THE ALGODONES DUNES

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The Algodones Dunes, also known as the Imperial Sand Dunes, in Imperial County are considered to be the largest sand dune system in California and one of the largest in the United States (California Division of Mines 1952, Miller 1957). Within the Algodones Dunes are several different habitat types which contribute to the biological uniqueness of the area. Few data are available on the avian community of these dunes. The purpose of this investigation was to determine avian species composition, breeding bird densities, bird species diversity, and plant species diversity in the various habitats associated with the Algodones Dunes.

STUDY AREA

The Algodones Dunes are located in the extreme southeastern portion of California with the southernmost 6.4 km extending into Mexico. The dunes are bordered on the west by East Mesa, on the north by Mammoth Wash, on the east by the Chocolate Mountains and the Cargo Muchacho Mountains, and on the south by the Colorado River Delta. The Coachella Canal lies along the western boundary of the dunes while the Southern Pacific Railroad borders the eastern fringe, eventually intersecting the Coachella Canal to form the northern border.

This dune system is approximately 64.4 km long, varying in width from 4.8 km to 9.7 km, and is oriented in a northwesterly direction. The dunes are long and narrow at the northern tip, extending to a wider, southern base. Dune crests may exceed 90 m although most range between 60-90 m (Westec Services Inc. 1977). Elevation ranges from 33-168 m.

Climate

The Algodones Dunes are located within the Cahuilla Basin, an area of both low rainfall and humidity, and extremely high summer temperatures. Rainfall results from occasional torrential late summer showers or from infrequent light winter rains. Average annual rainfall for Amos, a site on the eastern side of the dunes, is 71.9 mm (Norris and Norris 1961).

Vegetation

Several basic habitat types occur on the Algodones Dunes. A considerable portion of the dunes consists of barren, wind-blown sand form-

ing, in places, steep troughs and peaks. However, much of the area is not devoid of vegetation but contains psammophytic ("sand-loving") species which occur throughout this dune system, some of which are endemic.

Fingers of partially stabilized sand invade the borders of the Algodones Dunes. Within these fingers of land and along much of the periphery of the dunes, Sonoran Creosote Bush scrub, characterized primarily by Creosote Bush, occurs. On the western side of the dunes, stands of almost pure Creosote Bush, some reaching enormous size, are found. Gigantism presumably results from continual water seepage from the unlined Coachella Canal. This vegetation type is referred to as "dense" Sonoran Creosote Bush scrub in this study. Although unusually large Creosote Bushes are also prevalent in the more mesic sites on the eastern dunes border, there are substantial areas of relatively sparsely distributed Creosote Bushes referred to as "open" Sonoran Creosote Bush scrub.

Particularly interesting is the desert microphyll woodland habitat which has a patchy distribution along the eastern dune edge. In these areas the vegetation is luxuriant by desert standards, probably as a result of temporary impounding of runoff water during infrequent rains (Norris and Norris 1961). As water drains from the Chocolate and Cargo Muchacho mountains down the alluvial fans east of the dunes, it is effectively impeded by the large sand mass. This serves as a barrier, thereby creating in some locations a sufficiently mesic environment to permit development of a very dense, lush, desert microphyll woodland. Consequently, this habitat is found on only one side of the dune system.

METHODS

Avian Densities

Avian species composition and breeding bird densities were determined for four habitats: desert microphyll woodland, desert psammophytic scrub, open Sonoran Creosote Bush scrub and dense Sonoran Creosote Bush scrub.

Birds were sampled using the spot-map method (Williams 1936), whereby one 20 ha grid pattern (11.4 ha in the microphyll forest due to habitat patchiness) was established in each of the four habitats, using plastic flagging and wooden stakes placed at 50 m intervals along 5 parallel lines, each 450 m in length and 112.5 m apart. Each flag or stake was labeled with a number corresponding to the transect line and a letter corresponding to the distance traveled from the beginning of the line. Each habitat was censused three to six times from 20 April to 6 May 1977. Censuses commenced one-half hour after sunrise and were completed by 0900. Density values are expressed in terms of number of breeding individuals per 40 ha (100 acres), a commonly used base for avian studies.

Vegetation Analysis

Vegetation in each plot was sampled using the line-intercept method described by Mueller-Dombois and Elenberg (1974). A 100 m transect was sampled in each habitat type, thus providing information on plant species dominance (an indication of cover), relative dominance, frequency and relative frequency.

The desert microphyll woodland habitat was located on the eastern edge of the dunes, approximately 4.8 km north of the intersection of Glamis and Highway 78 (T 13 S, R 17½ E, section unsurveyed). The psammophytic scrub plot was placed roughly 500 m south of Highway 78 and 200 m east of the Gecko Campground Road (T 13 S, R 17½ E, Sec. 36). The open Sonoran Creosote Bush scrub plot was established 4.5 km north of Glamis (T 13 S, R 17½ E, section unsurveyed), whereas the dense Creosote Bush plot was located approximately 50 m east of the Coachella Canal and 2.8 km south of Highway 78 (T 14 S, R 17 E, sections 1 and 12).

Diversity

Diversity values (to base e) were determined for the avian community in each habitat type using Shannon's (1948) formula. Plant species diversity indices were calculated from relative dominance values for each habitat.

RESULTS

Vegetation

Results of the vegetational analysis indicate that the desert microphyll woodland had the highest numerical dominance and frequency (Table 1). The latter value is an indication of plant density. The numerous Palo Verde trees were dense and tall, many reaching 8 m and above (Figure 1). Much of the understory within the plot was relatively thick and provided dense cover for species such as Gambel's Quail.

In contrast to the microphyll woodland habitat, the other plots contained much less cover. Vegetation in the psammophytic plot was unevenly distributed, low in stature, and relatively sparse (Figure 2).

Within the western corner of the open Creosote Bush plot were shallow, narrow washes containing Palo Verde which were utilized for nesting by several species such as Verdins and Black-tailed Gnatcatchers. The individual Creosote Bushes were fairly evenly spaced in the open Creosote Bush habitat (Figure 3), and were not inordinately large as they were in areas bordering the canal. Analysis of the dense Sonoran Creosote Bush scrub habitat yielded much larger dominance and frequency values than did the sparse creosote area. The dense Creosote Bush plot is shown in Figure 4.

Figure 1. Desert microphyll woodland, Algodones Dunes, California (for location see Methods), October 1977.

Figure 2. Desert psammophytic scrub, October 1977.

Figure 3. Open Sonoran Creosote Bush scrub, October 1977.

Figure 4. Dense Sonoran Creosote Bush scrub, October 1977.

A comparison of the plant species diversity (PSD) values for the various communities indicates that the microphyll woodland plot had the highest PSD (1.26), whereas the pure stand of dense creosote had a diversity value of zero. The psammophytic scrub and open Creosote Bush scrub had intermediate values (0.77 and 1.05 respectively) between these two extremes.

Table 1. Vegetation analysis of four Algodones Dunes habitats in Imperial County, California.

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
DESERT MICROPHYLL WOODLAND				
Brandegea *Brandegea bigelovii*	22.3	16.4	28	43.1
Palo Verde *Cercidium floridum*	74.8	54.9	12	18.4
Galleta Grass *Hilaria rigida*	1.5	1.1	2	3.1
Creosote Bush *Larrea tridentata*	22.5	16.5	6	9.2
Hairy-pod Peppergrass *Lepidium lasiocarpum*	0.7	0.5	1	1.5
Tumble-mustard *Sisymbrium altissimum*	0.7	0.5	1	1.5
Globemallow *Spaeralcea emoryi*	13.7	10.1	15	23.1
TOTAL	136.2	100.0	65	99.9
DESERT PSAMMOPHYTIC SCRUB				
Croton *Croton wigginsii*	9.9	77.3	11	68.8
Desert Dicoria *Dicoria canescens*	0.8	6.3	1	6.3
Mormon-tea *Ephedra trifurca*	1.5	11.7	3	18.8
Blazing star *Mentzelia longiloba*	0.6	4.7	1	6.3
TOTAL	12.8	100.0	16	100.2
OPEN SONORAN CREOSOTE BUSH SCRUB				
Palo Verde *Cercidium floridum*	1.1	9.6	1	10
Indigo Bush *Dalea emoryi*	0.5	4.4	1	10
Jimson Weed *Datura discolor*	0.2	1.8	1	10
Brittle-Bush *Encelia farinosa*	0.3	2.6	1	10

Table 1 (cont.)

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
Galleta Grass *Hilaria rigida*	0.8	7.0	1	10
Creosote Bush *Larrea tridentata*	8.2	71.9	4	40
Spanish Needles *Palafoxia arida* var. *arida*	0.3	2.6	1	10
TOTAL	11.4	99.9	10	100
DENSE SONORAN CREOSOTE BUSH SCRUB				
Creosote Bush *Larrea tridentata*	68.9	100	23	100

1 Dominance = Number of meters a given species was encountered along a 100 m line-intercept transect.

2 Relative dominance (percent) = (Dominance of a species/Total dominance of all species) x 100.

3 Frequency = The number of plants of a given species encountered on the line-intercept..

4 Relative frequency (percent) = (Frequency of a species/Total frequency) x 100.

Table 2. Avian species composition, densities, and distribution in the Algodones Dunes, Imperial County, California.

SPECIES	Desert Microphyll Woodland	Desert Psammophytic Scrub	Open Sonoran Creosote Bush Scrub	Dense Sonoran Creosote Bush Scrub
	BREEDING DENSITY (BIRDS/40 ha)			
Turkey Vulture *Cathartes aura*		V	V	
Red-tailed Hawk *Buteo jamaicensis*	V	V	V	
Marsh Hawk *Circus cyaneus*	V			4.0
Prairie Falcon *Falco mexicanus*		V		
American Kestrel *Falco sparverius*		V		
Gambel's Quail *Lophortyx gambelii*	20.6			
White-winged Dove *Zenaida asiatica*	8.3		V	
Mourning Dove *Zenaida macroura*	57.8	V	4.0	P
Ground Dove *Columbina passerina*			V	

Table 2 (cont.)

SPECIES	Desert Microphyll Woodland	Desert Psammophytic Scrub	Open Sonoran Creosote Bush Scrub	Dense Sonoran Creosote Bush Scrub
Roadrunner *Geococcyx californianus*	8.3			P
Long-eared Owl *Asio otus*	8.3			
Lesser Nighthawk *Chordeiles acutipennis*	*	4.0	V	4.0
Costa's Hummingbird *Calypte costae*	8.3			
Ladder-backed Woodpecker *Picoides scalaris*	8.3			
Ash-throated Flycatcher *Myiarchus cinerascens*	24.8			
Black Phoebe *Sayornis nigricans*	V			
Say's Phoebe *Sayornis saya*	V			
Cliff Swallow *Petrochelidon pyrrhonota*				V
Verdin *Auriparus flaviceps*	54.5		12.0	4.0
Cactus Wren *Campylorhynchus brunneicapillus*	24.8			
LeConte's Thrasher *Toxostoma lecontei*	16.6	V		4.0
Crissal Thrasher *Toxostoma dorsale*	8.3	V		4.0
Black-tailed Gnatcatcher *Polioptila melanura*	30.3		9.3	20.0
Loggerhead Shrike *Lanius ludovicianus*	4.2	V		
Starling *Sturnus vulgaris*	V			
House Finch *Carpodacus mexicanus*	24.8		V	
TOTAL DENSITY	308.2	4.0	25.3	40.0
Number of breeding species	15	1	3	6
Number of migrant species	28	3	8	11
Census dates	20, 21, 22, 23, 27 Apr.	21, 22, 27, 28 Apr. 4, 6 May	27, 28, 29 Apr.	20, 21, 22, 29 Apr.

V = visitor (seen throughout the spring and summer in the area but not nesting on the plot).

P = Present, breeding density undetermined.

* = Breeding within 0.5 km in nearby creosote scrub.

Avian Species Composition and Densities

The desert microphyll woodland contained the highest density of breeding birds as well as the greatest number of breeding species (Table 2). More species including migrants and visitors, were observed there than in any other habitat. Verdins, Black-tailed Gnatcatchers and House Finches were particularly abundant in the woodland. The dense Creosote Bush scrub supported the next highest density and contained five breeding species. Of 17 species noted in the open creosote habitat, only 3 were nesting, with the Verdin achieving the highest density.

Desert psammophytic scrub was the least utilized habitat. Only the Lesser Nighthawk was observed nesting there.

The avifauna of the microphyll woodland habitat represented the highest bird species diversity (BSD) value (2.44) in contrast to a diversity of zero in the psammophytic scrub plot. Dense Creosote Bush scrub possessed a higher BSD than did open Creosote Bush scrub (1.64 versus 1.01 respectively).

DISCUSSION

Species occurrence is determined by how closely a given habitat meets the species' niche requirements. Such requisites include, but are not limited to, food (quality, accessibility, quantity), nest sites, song posts, cover, water availability (critical for some species), presence of predators, foliage volume, and climate. The quality of the habitat influences the total density of the avifauna. Cover and the amount of foliage available are particularly important since they provide, at least for many species, nest sites, song posts, food, habitat for insects upon which insectivorous birds prey, foraging surface, and protection against both inclement weather conditions and predators.

The results of this study provide an estimate of breeding bird density and are not absolute values. Because of the rather broad nesting period for these desert birds the plots could not be censused at the peak of the breeding season for every species. For example, when the study was initiated one pair of Long-eared Owls was feeding nestlings. In contrast, Lesser Nighthawks were in the process of establishing territories and young did not hatch until June. Even though the censuses were somewhat late for some species and early for at least one other, the results represent an estimation of breeding bird density at a particular stage in the breeding season. For most species, this represents a reasonably accurate estimate.

Several species undoubtedly foraged in a habitat type different from that in which they nested. Such was the case for the Long-eared Owl which nested in microphyll woodland but foraged over the nearby open creosote scrub and psammophytic scrub habitats. Because of this, their density was probably overestimated since their territory encompassed

a larger area than just the woodland. Most of the species, however, both foraged and nested within the same territory.

In this study the microphyll woodland provided far more cover, as reflected in the dominance figures, than did any of the other habitats. The robust Palo Verde trees and dense understory were particularly attractive to certain species. For example, thicket-dwelling species such as the Crissal Thrasher, Gambel's Quail and Ladder-backed Woodpecker appeared to be restricted to this habitat. Some species such as the Long-eared Owl, Ladder-backed Woodpecker, Ash-throated Flycatcher and House Finch require tall plants for nesting (Raitt and Maze 1968). The vegetation in the microphyll woodland provided considerable foraging substrate in addition to nest sites and song posts. It also served as a refuge against the hot summer temperatures. During the migratory season many migrants took advantage of the attributes of this habitat.

The total avifauna density in the microphyll woodland approximates the estimation of the breeding bird density for Milpitas Wash (328-342 birds/40 ha, Tomoff, unpubl.), a microphyll woodland about 32 km east of the microphyll woodland plot in this study. In contrast to the microphyll woodland, the psammophytic scrub habitat provided very little cover and a relatively low plant species diversity. Consequently this habitat type supported a very meager avifauna.

It is not just the foliage volume or density but, perhaps more importantly in many cases, the kind or quality of vegetation available in a habitat that influences species density. Although extensive stands of pure creosote are prevalent throughout the deserts of the Southwest, few birds select them as breeding habitats. Hensley (1954) found no nesting birds in a pure Sonoran Creosote Bush flat in Organ Pipe Cactus National Monument, Arizona. However, if creosote is part of a fairly diverse plant community and is intermingled with cacti, mesquite *(Prosopis* sp.) or Catclaw *(Acacia greggii)*, a fairly substantial number of birds will use it (Anderson and Anderson 1946). A habitat of Creosote Bush, Burro-Weed *(Ambrosia dumosa)*, Brittle-Bush, Buckhorn Cholla *(Opuntia acanthocarpa)*, and Catclaw, supported 127 birds/40 ha and 14 species (Hutchinson 1942). In another study in Arizona, a Sonoran Creosote Bush scrub plot supported a density of 70 birds/40 ha and 16 species (Hensley 1954).

Though few studies have examined its use, some foraging may occur within Creosote Bushes. Anderson and Anderson (1946) found Verdins and gnatcatchers (*Polioptila* sp.) apparently searching for insects on creosote. They observed Cactus Wrens walking along the ground, peering at the twigs, and jumping upward to catch foliage-inhabiting insects. They also noted House Finches and House Sparrows *(Passer domesticus)* nibbling on the creosote buds, pulling off the fruits, crushing them, and eating the seeds.

Presumably Creosote Bushes are of limited value in providing suitable nest sites because of their relatively thin twigs and non-supportive branches. However, the large Creosote Bushes present in the dense Creosote Bush habitat provided more elaborate branches and stronger support. Black-tailed Gnatcatchers and Verdins evidently had little difficulty in using these Creosote Bushes for nest sites.

It has generally been thought that the more floristically diverse habitats have a more diverse and complex fauna. Both the number of plant species and amount of vegetative cover may influence avian densities. In the dense Creosote Bush plot, the plant species diversity was zero, yet this habitat contained more birds than did the more botanically diverse sparse Creosote Bush plot. Presumably this was because the dense Creosote Bush habitat provided a greater structural diversity than the open Creosote Bush. In a study of various habitats in the Sonoran Desert of southern Arizona, Tomoff (1974) found a positive relationship between BSD and physiognomic coverage diversity along a habitat gradient. In desert scrub habitats, plant species composition was extremely significant in determining makeup of breeding bird communities and in providing suitable nest sites (Tomoff 1974). Apparently it is not just the amount of and distribution of cover among the various life-forms but also the floral composition which is important.

Other workers have noted a positive correlation between BSD and the foliage height diversity (FHD) (MacArthur and MacArthur 1961, MacArthur et al. 1962, 1966, Karr and Roth 1971, and others). Yet this relationship does not hold for all habitats (Balda 1969, Carothers et al. 1974, and others). Tomoff (1974) found the MacArthur model to be inconsistent in predicting BSD from FHD values in desert scrub communities. Since FHD values following the above cited method were not derived for the plots in this study, a comparison with the aforementioned results cannot be made.

Presumably, along with FHD and PSD, the actual plant species present should be considered. Certain plant species evidently are of more value to birds than are others. Hence, it is not just the diversity of plants (either with respect to FHD or PSD) which may influence BSD but also factors such as the composition of the flora, the amount of foliage available, and the structural complexity of the habitat.

SUMMARY

Avian species composition, breeding bird densities and habitat preferences were determined for four habitats in the Algodones Sand Dunes in southeastern California. Desert microphyll woodland supported the highest breeding bird density (308.2 birds/40 ha), the most breeding species (15), the greatest overall number of species (49, including migrants and visitors) and the highest bird species diversity (2.44). This

is in contrast to sparsely vegetated psammophytic scrub habitat which contained a density of 4.0 birds/40 ha and only one breeding species. Dense, luxuriant, pure Creosote Bush scrub habitat and an open Creosote Bush scrub habitat supported densities of 40.0 and 25.3 birds/40 ha, respectively.

A vegetational analysis indicated that the microphyll woodland had the highest dominance value (136.2), which is an indication of cover, and both the highest frequency and plant species diversity values (65 and 1.26 respectively). The open Creosote Bush scrub contained the least amount of cover, whereas the dense Creosote Bush scrub achieved a value of zero for plant species diversity.

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