1984. pp 694-705 in R.E. Warner and K.M. Hendrix (eds). California Riparian Systems - Ecology, Conservation, and Productive Management. Univ. of California Press, Berkeley.

COMPOSITION AND ABUNDANCE OF BIRD POPULATIONS IN RIPARIAN SYSTEMS OF THE CALIFORNIA DESERTS[1]

A. Sidney England, Larry D. Foreman, and William F. Laudenslayer, Jr.[2]

Abstract.--Avian population diversity, density, and species richness in desert riparian systems were analyzed using 73 breeding bird surveys, 62 winter bird-population studies, and biweekly surveys at 15 sites. Breeding bird surveys indicated that cottonwood/willow vegetation-types had the highest number of breeding and visiting species and the highest bird diversity among desert vegetation-types. Willow had the highest bird density. Winter bird-population studies showed that cottonwood/willow also had the highest species richness and diversity during winter, but palm and palo verde/ironwood had higher bird densities. All population variables were higher in desert riparian systems than in non-riparian desert vegetation-types during winter and breeding seasons. Results from desert riparian systems were compared with 27 breeding bird surveys and 18 winter population studies in cismontane California riparian systems. Avian density, diversity, and species richness generally were greater in cismontane riparian systems. A small number of resident ground granivorous bird species were found to comprise a large proportion of all individuals using desert riparian systems especially during summer. Biweekly surveys showed species richness varied considerably during the year; the 15 sites surveyed fell into four general patterns. Ecological factors such as size of riparian zone, presence of overstory and shrub vegetation, availability of water, visibility, and geographic location may affect total and breeding species numbers. Results are discussed with respect to ecological factors and land management implications.

INTRODUCTION

In 1976, the United States Congress charged the USDI Bureau of Land Management (BLM) with responsibility for preparing a comprehensive management plan for public lands in the deserts of California. As part of this effort, the California Desert Plan Program conducted extensive inventories and studies of many resources and uses found in the planning area. The wildlife staff began the inventory by compiling existing data including museum records, checklists, unpublished field notes and BLM sight records, and published articles. It was soon realized that little quantitative information existed on birds in the California deserts. Most publications prior to 1970 were primarily annotated species accounts confined to specific areas (e.g., Clark Mountain [Miller 1940]; Providence Mountains [Johnson et al. 1948]; Joshua Tree National Monument [Miller and Stebbins 1964]) and did not cover many of the widely distributed vegetation-types. Data collected by bird watchers were also restricted to a few sites (e.g., Morongo Valley, Furnace Creek Ranch) during selected seasons, and frequently only unusual species were recorded.

A twofold inventory design was used to collect basic descriptive data on the distribution, abundance, and seasonal variation of birds in California desert vegetation-types. First, per-

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[2]A. Sidney England is Wildlife Biologist, Larry D. Foreman is District Wildlife Biologist; both are with the Bureau of Land Management, California Desert District, Riverside, Calif. William F. Laudenslayer, Jr. is Regional Wildlife Ecologist, USDA Forest Service, Tahoe National Forest, Nevada City, Calif.

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manent study plots were established throughout the deserts and were censused during the breeding and winter seasons using standard spot-mapping techniques. The advantages of this method included compatibility with similar surveys conducted by others, relative repeatability, and accessibility to results by others through publication in "American Birds."

The second approach was a yearlong survey of selected desert riparian sites. This concentrated effort was warranted by the rarity of these sites in the California deserts, general knowledge of the importance of riparian systems to birds and other desert wildlife, and management concern arising from competing land uses. This year-round approach at specific sites allowed investigation of temporal changes in species richness and abundance not practical with spot-mapping techniques. It also permitted comparison of several vegetation-types of various sizes including very small oases which are typical of most desert riparian areas but are seldom addressed in riparian studies.

This paper presents inventory findings relevant to avian use of desert riparian systems. The following specific questions are discussed.

1. How do abundance and species richness vary by season and between desert riparian vegetation-types?

2. How important are desert riparian systems relative to non-riparian desert sites?

3. How do avian use patterns in desert riparian systems compare to those of cismontane California riparian systems?

4. What factors affect species richness in desert riparian systems?

Answers to questions such as these are needed for management of riparian systems in the California deserts.

METHODS

Study Area

For the purposes of this analysis, California deserts include all of the Mojave and Colorado deserts, within California and that portion of the Great Basin Desert within California east of the White and Inyo mountains. Riparian systems along the Colorado River and the perimeter of the Salton Sea are excluded.

Breeding and Winter Bird Surveys

Quantitative data on breeding and winter birds were collected using the spot-mapping techniques prescribed by the National Audubon Society for breeding bird censuses (Svensson 1970; Van Velzen 1972a) and winter bird-population studies (Kolb 1965). From 1976 through 1978, BLM employees and contractors conducted 62 winter bird-population studies and 73 breeding bird censuses in a wide variety of desert sites. Findings from these surveys were combined with other published studies using standardized National Audubon Society techniques in California desert and cismontane California riparian systems.

Avian diversity, population density, and species richness values were calculated for each survey. Diversity was computed using the Shannon-Wiener Index (Shannon and Weaver 1949):

$$H' = -\sum_{i=1}^{s} (p_i \ln p_i)$$

For comparisons among desert riparian vegetation-types, between riparian and non-riparian desert vegetation-types, and between desert and cismontane riparian vegetation-types, surveys were grouped into the following 11 vegetation-types based on the visually dominant plant(s) occurring on each study plot.

Vegetation-type	Visually dominant plants
Cottonwood/willow	Desert: Fremont cottonwood (*Populus fremontii*), willow (*Salix* spp.) Cismontane: Fremont cottonwood, willow, valley oak (*Quercus lobata*)
Willow	Willow
Palm	California fan palm (*Washingtonia filifera*)
Mesquite	Mesquite (*Prosopis glandulosa*), screwbean (*P. pubescens*)
Palo verde/ironwood	Palo verde (*Cercidium floridum*), desert ironwood (*Olneya tesota*), smoketree (*Dalea spinosa*)
Catclaw	Catclaw (*Acacia greggii*), black-banded rabbit brush (*Chrysothamnus paniculatus*)
Sycamore/live oak	Sycamore (*Platanus racemosa*), coast live oak (*Quercus agrifolia*)
Desert woodland	Single-leaved pinyon (*Pinus monophylla*), limber pine (*P. flexilis*), Utah juniper (*Juniperus osteosperma*), turbinella oak (*Q. turbinella*)
Desert scrub with overstory	Joshua tree (*Yucca brevifolia*), Mojave yucca (*Y. schidigera*), desert ironwood, ocotillo (*Fouquieria splendens*)
Desert scrub	Creosote bush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), shadscale (*Atriplex confertifolia*)

Average number of breeding and wintering species, average density, and average species diversity were computed for each vegetation-type. Breeding bird density and diversity values used only breeding males. Average number of species visiting census plots during the breeding season also was calculated; these data were not available for all censuses. Overall density, diversity, and species richness were also averaged for all desert vegetation-types, all "perennial" desert riparian systems, all "ephemeral" desert riparian systems, and cismontane riparian systems. For the purposes of this paper, the continuum of riparian system types present in the California deserts has been divided into two types: 1) "perennial"; and 2) "ephemeral". "Perennial" riparian systems typically have water at or near the surface throughout the year (e.g., springs, seeps, streams, etc.). "Ephemeral" riparian systems occur in washes where surface water typically is available for relatively short periods following storms.

Biweekly Surveys

Data on avian temporal and habitat use patterns were collected at 15 locations selected to represent the wide range of perennial riparian vegetation-types and sizes found in the California deserts (table 1). Study sites were established at each location; sites ranged in size from 0.2 ha. to 36.4 ha. One feature common to all sites was year-round presence of surface water. Censuses were conducted by systematically walking through each site recording all birds detected; individuals seen in riparian vegetation were recorded separately from individuals in adjacent non-riparian vegetation. Two plots were visited per day, one during the three-hour period following dawn and one during the three-hour period preceding sunset. Length of visit varied with the size of study site and the number of birds found. Each study site was visited approximately biweekly during the following periods: 6 November 1977 to 28 January 1978; 9 April 1978 to 17 June 1978; and 16 July 1978 to 3 January 1979.

Table 1.--Location and description of 15 "perennial" desert riparian study sites surveyed between November 1977 and January 1979. S--shrub; SO--shrub with tree overstory; SOP--shrub with tree overstory and pond(s). S.B.--San Bernardino County.

Study site	Location	County	Elev. (m.)	Size (ha.)	Vegetation Structure	Vegetation-type[1]	General Landform
Cottonwood Creek	White Mtns.	Mono	1,600	5.1	SO	Cottonwood/willow	montane
Sam Spring	Deep Spgs. Valley	Inyo	1,700	1.8	SO	Willow/locust	valley
Darwin Falls	Argus Mtns.	"	900	5.6	SO	Willow	montane
Chris Wicht Camp	Panamint Mtns.	"	900	2.9	SO	Cottonwood/willow	montane
Limekiln Spring	Panamint Mtns.	"	1,200	3.0	S	Willow	montane
Brewery Spring	Panamint Mtns.	"	1,400	4.6	S	Willow	montane
Kane Spring	Newberry Mtns.	S.B.	975	2.1	S	Mesquite/catclaw	valley
Old Woman Springs	Johnson Valley	"	975	36.4	SOP	Cottonwood/willow[2]	valley
Salt Creek	Salt Spring Hills	"	160	9.8	SO	Mesquite/salt cedar	valley
Horse Thief Springs	Kingston Range	"	1,400	1.0	SO	Cottonwood/willow	montane
Dove Spring	New York Mtns.	"	1,450	0.8	S	Dwarf ash/hackberry	montane
Cottonwood Spring	Granite Mtns.	"	1,300	0.2	SO	Cottonwood/willow	montane
Bonanza Spring	Clipper Mtns.	"	600	1.8	S	Arrowweed/salt cedar	valley
Mopah Spring	Turtle Mtns.	"	670	0.8	S	Palm/mesquite	valley
Iron Mtn. Pump. Stn.	Iron Mtns.	"	290	24.8	SOP	Suburban woodland[2]	valley

[1]Cottonwood (Populus fremontii), willow (Salix spp.), locust (Robinia pseudoacacia), catclaw (Acacia greggii), mesquite (Prosopis glandulosa), salt cedar (Tamarix sp.), dwarf ash (Fraxinus anomala), hackberry (Celtis douglasii), arrowweed (Pluchea sericea), palm (Washingtonia filifera).

[2]Consists primarily of man-created system with numerous ornamentals.

Biweekly survey results and literature review were used to assign each species at each site to one or more of eight seasonal status designations. Year-round, summer, and winter residents described species found throughout these time periods. Spring and fall migrants passed through the sites relatively quickly. Summer and winter transients included species that moved through the site, but unlike migrants, remained for extended periods on the way to or from breeding areas (e.g., Great Blue Heron), and species that occurred widely in the desert but were irregular in riparian systems (e.g., Red-tailed Hawk, Roadrunner). Vagrants differed from migrants because they were well outside their normal distributions (e.g., Brown Thrasher, Rose-breasted Grosbeak).

Breeding status at a study site was considered "confirmed" if nesting activity was observed or recently fledged young of species not found in the adjacent desert were seen. Breeding was considered "probable" if the species was known from literature or from other study sites to breed in desert riparian systems and was present at the site throughout the breeding season.

Total number of species observed at each site on all visits (species richness) and total number of breeding species (confirmed plus probable) at each site were plotted against study site size. Sites with shrubs only, shrubs with tree overstory, and shrubs with tree overstory and ponds were examined separately to determine the effects of vegetation structure on species richness and number of breeding species.

Temporal species richness patterns were analyzed by plotting number of species observed per visit at each site against time. If more than one visit occurred at a site in a single biweekly sampling period, the average number of species observed was used. Species richness:time curves for each site were inspected visually and combined into groups with similar patterns. Characteristic curves for each group were constructed by averaging the total number of species observed in each sampling period.

Total number of individuals counted on each visit to each site was plotted against time to show temporal abundance patterns. If multiple visits occurred at a site in one sampling period, the average number of individuals counted was used. Abundance curves were inspected visually to determine gross abundance patterns. Common bird names are those found in the "Checklist of North American Birds" (American Ornithologists' Union 1957), as amended by supplements (1973, 1976).

RESULTS

Breeding and Winter Bird Surveys

Distribution of surveys among vegetation-types and results of the analysis are presented in tables 2 (breeding birds) and 3 (winter birds). Ninety-nine breeding bird censuses and 80 winter bird-population studies were compiled for use in this analysis. Of these 179 surveys, 134 were in California desert (45 riparian and 89 nonriparian) and 45 were in cismontane California.

Among desert riparian vegetation-types, cottonwood/willow, willow, and palo verde/ironwood supported the highest numbers and greatest densities of breeding species. Diversity of breeding species also was highest in these vegetation-types. Cottonwood/willow supported approximately two to five times more breeding species than any other. The number of visiting species counted during breeding bird censuses was higher in perennial than in ephemeral desert riparian systems.

Results from winter bird-population studies indicated that cottonwood/willow, palm, and palo verde/ironwood supported more species than other desert riparian vegetation-types. Winter densities were highest in willow, palm, and palo verde/ironwood. With the exception of visiting species during the breeding bird censuses, all values for palo verde/ironwood, an ephemeral desert riparian vegetation-type, fell within the ranges of values for vegetation-types within perennial riparian systems. Comparisons between catclaw and other vegetation-types were complicated by the lack of replicate samples.

Comparing desert riparian and non-riparian systems data from tables 2 and 3 showed that density, diversity, and species richness of wintering birds were higher in desert riparian systems. Breeding bird densities were higher in all desert riparian systems than in non-riparian areas. The number of breeding species in desert woodland was comparable to that in willow and palo verde/ironwood and exceeded that in palm and mesquite. Desert scrub with overstory supported approximately the same number of breeding species as mesquite; palm supported a smaller number. Breeding species richness was higher in all desert riparian systems than in desert scrub. Only desert woodland was comparable to desert riparian vegetation-types in number of visiting species during the breeding season.

Cismontane riparian vegetation-types generally supported greater numbers of species as well as greater densities than desert riparian vegetation-types (table 2 and 3); diversity values were greater in cismontane vegetation-types during both seasons. Breeding bird surveys indicated only desert cottonwood/willow supported breeding species numbers comparable to cismontane riparian vegetation-types. Only in desert cottonwood/willow and willow were breeding densities similar to

Table 2.--Avian diversity, population density, and species richness for breeding bird censuses[1] in riparian and non-riparian desert sites and in cismontane riparian sites (mean ± 1 standard error). Sample size = number of surveys per site; sample size applies only to residents, values for visitors are smaller.

System/ Vegetation-type	Resident: Sample size	Resident: Number of species	Resident: Density (♂♂/40 ha.)	Resident: Diversity (H')	Visitor: Number of species
Desert riparian	24	16.1±2.1	295.2± 63.4	2.08±0.12	31.1± 6.1
Perennial	16	16.7±3.0	332.2± 89.0	2.04±0.17	34.7± 7.0
Cottonwood/willow	5	30.0±5.3	349.8±143.6	2.66±0.34	36.0±25.3
Willow	5	13.4±2.9	574.2±211.7	2.04±0.20	34.4± 7.4
Palm	2	5.5±0.5	133.0± 38.0	1.36±0.03	19.5± 0.5
Mesquite	4	9.8±1.7	107.5± 32.3	1.61±0.15	41.3± 8.6
Ephemeral	8	14.9±1.8	221.0± 67.0	2.16±0.14	13.3± 3.7
Palo Verde/ ironwood	7	15.3±2.0	237.3± 75.1	2.22±0.14	13.3± 3.7
Catclaw	1	12.0	107.0	1.74	-
Cismontane riparian	27	26.6±1.3	456.5± 61.4	2.78±0.07	12.9± 2.0
Cottonwood/willow	17	26.4±1.9	419.1± 94.5	2.73±0.11	15.4± 2.5
Sycamore/live oak	10	27.0±1.4	520.0± 41.7	2.86±0.05	8.2± 2.4
Other desert					
Woodland	5	13.4±0.8	72.2± 14.9	2.19±0.10	24.0± 3.8
Scrub with overstory	20	10.0±0.9	36.6± 5.3	1.64±0.11	7.8± 1.4
Scrub	23	3.4±0.4	20.5± 4.1	0.68±0.13	7.9± 1.4

[1]Sources: Loery (1967); Van Velzen (1972b, 1973, 1974, 1977, 1978, 1979, 1980, 1981); Gaines (1974, 1977); USDI Bureau of Land Management (1977, 1978, unpublished field data, Riverside, California); Tomoff (1977); Franzreb (1978).

cismontane riparian vegetation-types. However, the numbers of visiting species were greater in nearly all desert riparian vegetation-types than in cismontane riparian vegetation-types. Cismontane cottonwood/willow exceeded all desert riparian vegetation-types in species richness and density in winter; sycamore/live oak was comparable to several desert riparian vegetation-types.

Biweekly Surveys

A grand total of 190 bird species was observed at all sites on all visits combined. The total number seen at each site ranged from 41 at Brewery Spring to 122 at Old Woman Springs (table 4). Considerably more species were seen at the two large, man-created sites (Old Woman Springs and Iron Mountain Pumping Station) than at any other site. More species were recorded at sites supporting shrub vegetation with tree overstory than at sites with shrub vegetation only (fig. 1). The total number of species observed at sites having shrub vegetation with tree overstory increased with plot size (fig. 1); sites with ponds were included in this regression after excluding species dependent on open water. An analysis using average number of species per visit in place of total number of species produced similar results.

The number of confirmed breeding species ranged from zero at Dove and Cottonwood springs to nine at Old Woman Springs and Darwin Falls (table 4). Total number of breeding species (total breeding species), which included both confirmed and probable, ranged from two at Cottonwood Spring to 17 at Old Woman Springs. Sites having shrub vegetation with tree overstory generally supported more total breeding species than sites with shrub vegetation only (fig. 2). However, Cottonwood Spring, a site with shrub vegetation and tree overstory, had the lowest total breeding species. This may have been because it had the smallest area of all sites, and consisted of only three cottonwood trees with almost no shrub understory. Mopah Spring was classified as a site with shrub vegetation only, but fell within the range of breeding species for sites with tree overstory. The vegetation at this site was predominantly shrubs but included five palm trees and a number of large palo verde.

Table 3.--Avian diversity, population density, and species richness for winter bird-population studies[1] in riparian and non-riparian desert sites and in cismontane riparian sites (mean + 1 standard error). Sample size = number of surveys per site.

System/ Vegetation-type	Sample size	Resident: Number of species	Resident: Density (birds/40 ha.)	Resident: Diversity (H')
Desert riparian	21	25.3+ 2.4	537.9+164.0	2.05+0.11
Perennial	13	23.7+ 3.1	438.5+125.9	1.95+0.15
Cottonwood/willow	2	39.0+13.0	239.5+ 72.5	2.37+0.33
Willow	5	18.4+ 2.6	588.4+278.3	2.01+0.24
Palm	2	34.0+ 3.0	794.0+289.0	2.27+0.31
Mesquite	4	17.5+ 1.9	172.8+ 42.7	1.51+0.25
Ephemeral	8	27.9+ 3.9	699.5+389.1	2.22+0.15
Palo verde/ironwood	7	29.6+ 4.0	775.1+440.7	2.31+0.14
Catclaw	1	16.0	170.0	1.58
Cismontane riparian	18	40.4+ 3.1	779.2+117.4	2.76+0.08
Cottonwood/willow	8	51.4+ 4.2	978.5+229.5	3.01+0.12
Sycamore/live oak	10	31.6+ 1.9	619.7+ 87.8	2.57+0.07
Other desert				
Woodland	5	13.8+ 0.4	107.6+ 44.8	1.48+0.21
Scrub with overstory	15	13.4+ 1.5	69.1+ 10.3	1.35+0.19
Scrub	21	9.4+ 1.0	81.6+ 21.1	1.19+0.12

[1]Source: Ryder (1972, 1973, 1974); Ryder and Ryder (1975, 1976, 1978, 1979); Gaines (1977); Boyd and Cink (1980); Cink and Boyd (1981).

A seasonal status summary for avian species found at each site is shown in table 4. The largest group of species observed during the bi-weekly surveys was migrants. At 10 of 15 sites, more species were present during fall migration. The number of spring migrant species approximately equalled or exceeded fall migrants at the other five. Year-round resident species were uncommon at nearly all sites. Only Old Woman Springs and Iron Mountain Pumping Station, both large and diverse man-created systems, supported a significant proportion of year-round residents relative to the number of summer and winter residents. Summer residents were more common than winter residents at nine of 15 sites and approximately equal at the remaining six sites.

Species richness graphs for each site were classified into one of four general species richness patterns (table 4; fig. 3) based on shape (i.e., relative position and height of peaks). Five sites were classified as pattern A, summer and winter lows with nearly equivalent spring and late summer/fall peaks. Three sites were pattern B, high spring peak and relatively low late summer/fall peak. Cottonwood Creek and Dove Spring were the only examples of pattern C, with a spring high declining steadily to a winter low. The remaining five sites were pattern D, similar to pattern A except that the spring species richness peak was distinctly lower than the late summer/fall peak. Patterns A, B, and D, with late summer/fall peaks, reached highest values between mid-August and late October. These same patterns reached spring peaks from mid-April to early May; pattern C reached the spring peak in late May. All patterns reached winter lows from late December to early January and began to increase in mid-January.

Figure 4 shows the results from three study sites selected to represent the range of avian abundance patterns. Abundance was considerably more erratic than species richness because abundance was affected by time of survey, weather conditions, and encounters with large flocks. Highest abundances were reached in summer and fall at 13 of 15 sites (e.g., Cottonwood Creek and Horse Thief Springs). Nine were highest from mid-July to late August (e.g., Cottonwood Greek); six of these had peak abundances two to six times greater than any other time of year. The curves for the remaining four sites with highest abundances in summer/fall also had peaks from mid-July to late August, but these were exceeded by peaks from early September to mid-October (e.g., Horse Thief Springs). Kane Springs and Darwin Falls had lows in summer and peak abundances in early December.

Table 4.--Breeding and seasonal status summary for avian species found at 15 perennial desert riparian sites surveyed between November 1977 and January 1979.

	Number of Species									No. Breeding Species[2]			Species Richness Pattern[3]
		Resident			Transient		Migrant						
Study Site	Overall	Su	W	Yr[1]	Su	W	Sp	F	Vagrant	Total	C	P	
Cottonwood Creek	75	19	6	(1)	10	17	32	30	1	15	8	7	C
Sam Spring	74	15	5	(2)	9	12	21	44	0	11	4	7	A
Darwin Falls	75	13	14	(3)	6	10	31	40	4	10	9	1	A
Chris Wicht Camp	59	9	4	(0)	5	9	23	29	3	6	5	1	A
Limekiln Spring	42	7	4	(0)	5	4	6	22	2	4	2	2	D
Brewery Spring	41	6	6	(0)	7	3	11	19	0	4	2	2	D
Kane Spring	43	8	5	(2)	9	11	22	16	0	3	2	1	B
Old Woman Springs	122	19	22	(10)	11	20	48	75	4	17	9	8	A
Salt Creek	80	10	8	(1)	9	18	31	46	4	7	3	4	A
Horse Thief Springs	82	15	8	(2)	11	9	33	45	2	12	5	7	D
Dove Spring	44	8	4	(1)	9	5	17	15	1	5	0	5	C
Cottonwood Spring	64	7	3	(0)	22	10	21	28	3	2	0	2	D
Bonanza Spring	46	7	5	(3)	6	8	29	20	0	3	2	1	B
Mopah Spring	50	10	3	(2)	7	12	20	18	0	7	4	3	B
Iron Mtn. Pump. Stn.	121	14	14	(7)	14	24	33	80	8	13	4	9	D

[1]Yr = Year-round resident species. These numbers are included in both summer (Su) and winter (W) resident totals.

[2]C = Confirmed; P = Probable.

[3]See figure 3 for graphs describing four (A-D) species richness patterns.

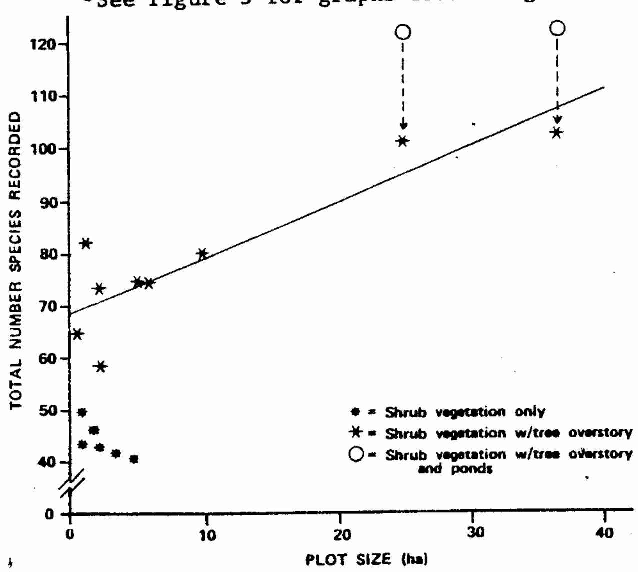

Figure 1.--Total number of species observed (species richness) as a function of plot size and vegetation structure at 15 perennial desert riparian study sites surveyed between November 1977 and January 1979. Data points for sites with ponds adjusted to exclude species dependent on open water before computing the regression equation for plots with overstory trees (y= 1.05x + 69).

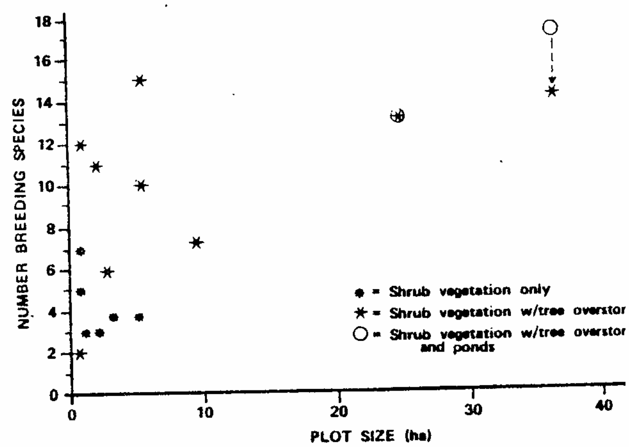

Figure 2.--Total number of breeding species (confirmed and probable) as a function of plot size and vegetation structure at 15 perennial desert riparian study sites surveyed between November 1977 and January 1979 (results from study sites with ponds are shown with and without species dependent on open water).

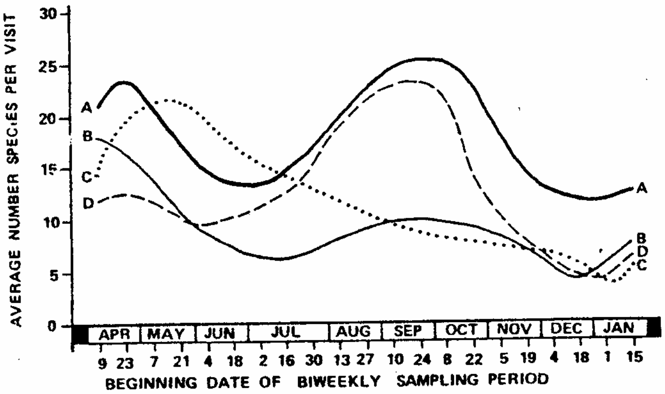

Figure 3.--Avian species richness patterns at 15 perennial desert riparian study sites surveyed between November 1977 and January 1979. Pattern A--nearly equivalent peaks in spring and late summer/fall. Pattern B-- high spring peak and relatively low late summer/fall peak. Pattern C--peak in spring declining steadily to winter low. Pattern D--low spring peak and relatively high late summer/fall peak.

Most major abundance peaks were due to large numbers of summer, winter, or year-round resident ground granivores (i.e., California Quail, Gambel's Quail, Mountain Quail, Chukar, Mourning Dove, Horned Lark [at Old Woman Springs only], House Sparrow, House Finch, Black-throated Sparrow, Dark-eyed Junco, Brewer's Sparrow [at Cottonwood Creek only], White-crowned Sparrow, and Golden-crowned Sparrow). These species accounted for 50-90% of the height of summer/fall abundance peaks (fig. 4A and 4B). Most sites showed a small increase in bird numbers during spring migration. Generally this peak was not dominated by resident ground granivores and was more evident when these species were removed (fig. 4). Late fall/early winter populations varied in the proportion of resident ground granivores. The White-crowned Sparrow, a ground granivore, was a common winter resident (fig. 4C). However, two foliage insectivores, the Ruby-crowned Kinglet and the Yellow-rumped Warbler, frequently were more abundant than resident ground granivores (fig. 4A and 4B).

DISCUSSION

Importance of Desert Riparian Systems

The presence of trees or arborescent shrubs in riparian and non-riparian desert systems is an important variable influencing the breeding avifauna. Although quantitative data on vegetation-type structure are not provided, increasing breeding bird diversity, density, and species richness

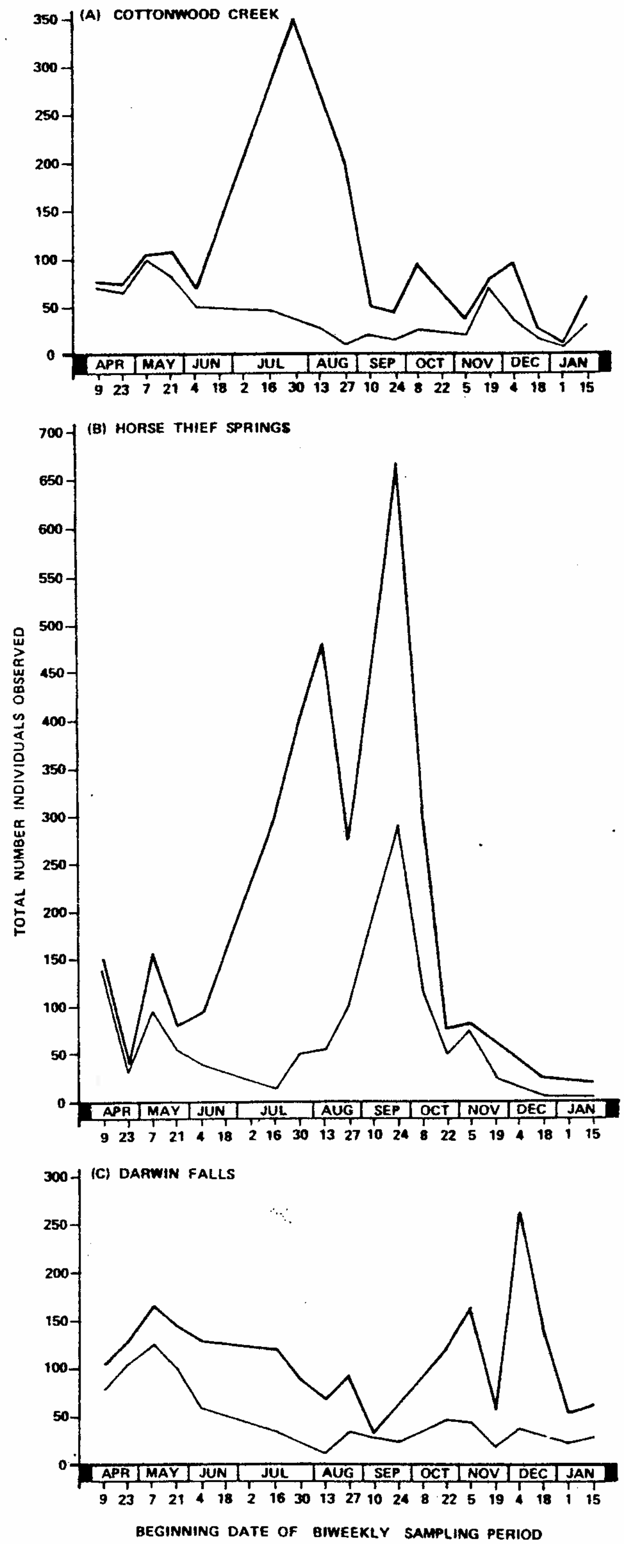

Figure 4.--Avian abundance patterns at three perennial desert riparian study sites surveyed between November 1977 and January 1979. Upper line on each graph includes all species; lower line excludes selected ground granivores (e.g., California Quail, Gambel's Quail, Mountain Quail, Chukar, Mourning Dove, House Sparrow, House Finch, Black-throated Sparrow, Dark-eyed Junco, White-crowned Sparrow, Golden-crowned Sparrow).

are related with increasing amounts of trees and arborescent shrubs. Among desert riparian vegetation-types, cottonwood/willow, willow, and palo verde/ironwood typically have the greatest overstory canopy and thus have a wider availability of perches, nest sites, and foraging substrates. These vegetation-types support more breeding species at higher densities and have higher breeding species diversities than vegetation-types with less overstory (table 2). California fan palms supply a vertical habitat component but do not have the dense canopy provided by trees and arborescent shrubs. To a lesser degree, desert scrub with overstory, dominated by Joshua tree or ocotillo, also has a vertical component, but lacks much of the structural complexity that provides foraging and nesting substrate.

Overstory canopy is also important in non-riparian desert vegetation-types during the breeding season. Overstory vegetation decreases in amount from desert woodland to desert scrub with overstory to desert scrub. The number of breeding species and their density and diversity decline in a similar manner (table 2).

During the winter, birds are less dependent on trees and arborescent shrubs for perching and nesting. At that time, density, diversity, and species richness in riparian and non-riparian systems are not as well correlated with presence or absence of overstory canopy. Among riparian vegetation-types, palm had the highest bird densities in winter; species richness values there were comparable to cottonwood/willow and exceeded all other desert vegetation-types. This observation may be explained by the fact that California fan palms are restricted to the Colorado Desert, which is warmer in the winter than the Mojave and Great Basin deserts. Among non-riparian vegetation-types, desert woodland and desert scrub with overstory supported nearly equal numbers of species; bird densities in desert scrub exceeded desert scrub with overstory.

In addition to the frequent presence of trees or arborescent shrubs, riparian conditions generally result in a total vegetation that is denser than that found in non-riparian desert areas. This denser vegetation contributes to the higher bird densities found in desert riparian systems during breeding and winter seasons by augmenting the food and cover provided by trees and arborescent shrubs.

Surface water is also an important habitat component influencing bird use, especially during the summer months. Smyth and Coulombe (1971) have shown that granivorous birds, including Gambel's Quail, Mourning Dove, White-winged Dove, House Finch, and Black-throated Sparrow, drank regularly at Upper Carrizo Spring in the Santa Rosa Mountains of southern California. Insectivorous and frugivorous birds were seen drinking less regularly or not at all. Our study found that 13 species of summer, winter, or year-round resident ground granivores accounted for a large majority of birds seen at 15 perennial riparian areas (fig. 4). Nine of these species were present during the summer, but only two (House Sparrow and House Finch) nested almost exclusively in riparian vegetation. The rest of these birds presumably were drawn to the spring largely for water during the hot, dry summer months.

The importance of desert riparian systems to birds is not limited to large sites. Relatively small sites are used by many species over the course of a year (fig. 1); this is especially true for sites with tree overstory. Small sites with tree overstory generally support more breeding species than sites with shrub vegetation only (fig. 2). However, the number of breeding species does not show the correlation with plot size found for total number of species (fig. 1). Cottonwood Spring, the smallest site with overstory vegetation, almost completely lacked shrub cover under its three cottonwoods and supported fewer breeding species than any other site. However, Horse Thief Springs, the next larger site with overstory, had numerous large cottonwoods and patches of tall dense shrubs. It supported among the highest numbers of breeding birds.

Small sites also can support large numbers of individuals. The Cottonwood Creek site is approximately five times larger than Horse Thief Springs (table 1). However, Horse Thief Springs supported numbers of birds comparable to Cottonwood Creek during spring and winter and considerably more in summer and fall (fig. 4). Local factors including surrounding habitat, geographic location, topography, and availability of water in adjacent areas may explain why some sites support more birds than would be expected considering size alone.

The species composition of bird populations in desert riparian systems is extremely dynamic. This is reflected in the species richness patterns illustrated in figure 3. The typical pattern has peaks in spring and fall with lows in summer and winter. Relatively few species are resident in desert riparian systems; most are either transients, migrants, or vagrants (table 4). Breeding species typically are present only during the spring when food and water are most available and temperatures are relatively mild. However, the peak in number of individuals frequently is composed of relatively few species (fig. 4). At nine of 15 sites, sampled biweekly peak abundance preceded peak species by approximately one month.

Explanations for variations in species richness patterns (fig. 3, table 4) must be tentative since they are based on the data for one year collected at biweekly intervals. Four of five sites with lower species richness in the spring than in the late summer/fall were at high-elevation montane locations. These sites remain colder and less productive later in the spring and may be cooler and more moist, and support food longer than lower elevation and valley sites in the late summer/fall. These reasons could explain the observed pattern. However, two high-elevation montane sites, Cottonwood Creek and Dove Spring, had the highest species richness in the spring and declined throughout the year to winter lows. The reasons for this pattern are less obvious, especially since the number of migrant species recorded at each site was nearly the same in spring and fall (table 4). Iron Mountain Pumping Station, a low-elevation valley site, also showed a low spring peak relative to the fall. However, this site had an extremely high fall peak which may have been due to migrants being attracted to this large, highly visible site for food and water.

Medium to large sites in valleys and low-elevation montane sites had nearly equal species richness peaks in late summer/fall and spring. Small, low-elevation sites situated in valleys had high spring peaks and relatively low fall species richness peaks. Low species richness in the late summer/fall may have been due to lack of resources at very small, hot sites and lower probability that migrating birds could find these oases. Elevation, size, and visibility appear to be variables affecting the number of bird species using desert riparian systems during migration.

In the breeding season, more visiting species are found in desert riparian systems than in cismontane riparian systems (table 2). This pattern probably is due to the isolated nature of desert riparian sites and the relative unsuitability of adjacent desert areas for many birds. Water, cover, and food usually are more available in areas surrounding cismontane sites than those surrounding desert riparian sites. In the desert, many species found in adjacent areas must visit riparian sites. In addition, most studies of birds at desert riparian sites census the entire vegetation at the site. In cismontane locations, the riparian vegetation frequently is more widely distributed; study plots usually include only part of the available vegetation. Therefore, a greater percentage of the species utilizing riparian vegetation may be censused at desert sites than at cismontane sites at any given time.

Management Implications

Riparian systems associated with permanent water are very limited in the desert. However, washes, which are included in the preceding analysis, are more numerous. As we and others have shown, riparian habitats play a vital role in the desert ecosystem by providing water, food, and cover for resident and transient riparian birds, migrating birds, and non-riparian birds, such as quail and doves.

There are, in addition to the intensive use made of these high-value, low-quantity desert riparian systems by wildlife, numerous common high-intensity non-wildlife uses. For example, livestock and feral burros often congregate or linger in riparian habitats to take advantage of shade, forage, and drinking water. Recreationists are attracted to riparian systems in the desert by the shade and high visual quality. Washes are used as vehicular thoroughfares because they lack major obstacles. Mining operations frequently use the water associated with riparian systems in mining or mineral processing. They are also focal points of cultural resources, such as historic and native American sites.

Many of these uses are potentially in conflict with wildlife or maintenance of the riparian community. Riparian systems are generally recognized as vital to desert resident and migrant birds. Understanding the importance of riparian systems is vital to land managers as they attempt to resolve use conflicts. Resolution of these conflicts should take into consideration the breadth of resources which are critical to birds. Among these are the availability of surface water and the presence of a tree overstory and dense groundcover. Proper management should be aimed at maintaining or enhancing all of the individual components making up the riparian zone.

The geographic distribution of riparian systems should also be taken into account when assessing conflicts. Species such as Brown Towhee and Lazuli Bunting breed only in riparian vegetation in the Mojave and Great Basin deserts. Others, including Verdin, Abert's Towhee, and Black-tailed Gnatcatcher, generally are restricted to riparian systems in the Colorado Desert. An adequate distribution of well-managed riparian systems is essential, especially to the maintenance of species with limited distributions in the California deserts.

Results from biweekly surveys indicate that late December and early January is the time of lowest species richness (fig. 3) and bird abundance (fig. 4) at desert riparian sites. Winter bird-population studies conducted primarily in January and February show that midwinter to late winter species richness and abundance is higher. Thus, if it is necessary to create a disturbance such as building a fence or installing a management facility, construction during late December and early January is likely to have less of an impact than at other times. Of course, activities which damage habitat will be harmful to birds regardless of the season.

Human development and artificial habitats can be beneficial to the avifauna. Results of biweekly surveys (table 4) show that the two sites with the highest overall species occurrence (Old Woman Springs and Iron Mountain Pumping Station) are to a large degree man-made systems. Old Woman Springs (122 species recorded) includes a reservoir, residences, gardens, and ornamental trees mixed with native vegetation. Iron Mountain Pumping Station (121 species recorded) is an entirely artificial site with residential areas, parks, and a reservoir. These two sites were also especially high in number of year-round resident, fall migrant, and vagrant species. In addition to their structural diversity, with tall trees, buildings, dense shrubbery, and open water, these sites were exceptionally large (36.4 ha. and 24.8 ha. respectively). Their low elevation (975 m. and 290 m. respectively) made both sites conducive to winter residents and winter transients. Thus, if properly mixed with native vegetation, artificial components can create structural diversity and provide nest and perch sites otherwise not available.

There are a few sites in the desert which are unusually rich in bird species. These frequently become focal points for birdwatchers (e.g., Morongo Valley, Furnace Creek Ranch). Such sites are normally large and diverse and support a substantial tree overstory. However, as knowledge of these sites increases, the importance of smaller, less well-known riparian sites can become obscured. Large sites have special management significance not only for the rarity of some of the birds found in them but also for the high level of public interest in their integrity. However, these sites and their contributions should not overshadow the importance of numerous other riparian sites and the contribution they make to supporting the desert avifauna.

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