Avian Population Responses to Salt Cedar Along the Lower Colorado River[1]

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Abstract.--Avian population responses to salt cedar were studied seasonally for three years along the lower Colorado River. Bird densities and diversities were examined in salt cedar and three additional types of riparian vegetation, all of similar horizontal and vertical configuration. Avian species were found to react to these plant community types seasonally in one of eight major ways. Three reaction types included species which showed a preference for or at least appeared not to avoid salt cedar, but the species involved represented a minority of the total species in the four vegetative types. Species which preferred or appeared not to avoid salt cedar were primarily ground feeders, granivores, or species which fed largely in other habitat types (e.g., agriculture). A disporportionate number of the species tolerating salt cedar belonged to Old World genera. Insectivores in general and frugivores in particular seemed to show greatest intolerance of salt cedar. Significantly fewer insectivores used salt cedar than would be predicted on the basis of insect biomass. Avoidance of salt cedar by insectivores may be related to the sticky exudate which may damage the plumage. Frugivores were absent from salt cedar because of the near total absence of available fruits and berries.

INTRODUCTION

The exotic salt cedar (*Tamarix chinensis*) was introduced into North America in the early 1800's for ornamental purposes (Horton 1977). By its successful competition with indigenous vegetation, salt cedar has been proven to be a very aggressive species. This is particularly true in areas which formerly flooded annually but which now remain dry as a result of dams along the Colorado River. The absence of flooding allows litter accumulation; subsequent fire kills or retards indigenous vegetation but not salt cedar (Ohmart, *et al*. 1977). Since the early 1900's salt cedar has become the dominant plant species and has replaced natural stands of cottonwood (*Populus fremontii*), willow (*Salix gooddingii*), screwbean mesquite (*Prosopis pubescens*), and honey mesquite (*Prosopis juliflora*) (Ohmart, *et al*. 1977).

We have been studying the avifauna of salt cedar and other riparian communities along the lower 443 km of the Colorado River since 1973. The study area encompasess some 4,400 ha of riparian vegetation and includes all of the major plant community types found along the lower river.

The value of salt cedar for birds has been discussed in a preliminary report (Anderson, *et al*. 1977a). They reported that in general salt cedar did not seem to attract as many species and in as great densities as vegetation indigenous to the Colorado River Valley. It was not their intent to answer questions relative to which species avoid salt cedar, which ones seemed to prefer it, nor to deal with seasonal responses of birds to salt cedar. They made only cursory comments about why various species may be avoiding salt cedar. This report is directed toward these particular points.

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METHODS

Six riparian community types were recognized in the valley using dominant vegetation as the criterion. Based on vertical profiles, these six dominant community types were subdivided into as many as six structural types (I-VI), each differing from the other by vertical structure, dominant vegetation, or both. For plant and animal sampling purposes we had at least four areas of 20 to 40 ha represented in each community-structural type. For details see Anderson et al (1977b).

Horizontal foliage diversity (HFD) is a measure of patchiness in a stand of vegetation. We calculated HFD for all major community types by establishing lines or transects 800 to 1,600 m long through the vegetation. Intervals of 150 m were marked along each line. Foliage volume measurements using the board technique (MacArthur and MacArthur 1961) were taken at heights of 0.2, 0.6, 1.5, 3.0, 4.5, 6.0, 7.5, 9.0, and every 1.5 m thereafter. Distance readings were converted to relative foliage volume and the mean of 2 or 3 points at each height was used to represent the vegetation profile in each 150 m section on each side of the line. A 1,500 m line would have a total of 20 sections (10 on each side). HFD for a given layer was the variance of the means for the 20 sections along the line (Anderson and Ohmart 1978).

Foliage height diversity (FHD), a measure of the vertical foliage diversity in a community, was calculated from $-\Sigma p_i \ln p_i$ where p_i represents the proportion of volume at the ith level using the same measurements as for HFD (Table 1).

The number of trees of each species in each area was determined by counting all trees within 15 m of the transect in each 150 m interval. The density of each tree species was expressed as the number per 0.2 ha.

The modified Emlen transect technique was used in censusing birds (Emlen 1971, 1977, Anderson, *et al*. 1977b). Each transect was censused 3 times per month. Bird densities in this report represent the average of 3 censuses per month for the 3-year period 1975-77 and were expressed as the number per 40 ha. Those species which had an average density less than 0.5 per 40 ha were excluded from the total.

Seasonal densities were derived by averaging the mean monthly densities for each season. Seasons included winter (December, January, February); spring (March, April); summer (May, June, July); late summer (August, September); and fall (October, November).

Insect biomass in each community was determined by weighing insects captured with 4,000 sweeps with an insect net on a transect in each community each month.

In order to facilitate discussion and to conserve on space, our discussion in this report draws on data collected from salt cedar, honey mesquite, willow, and mixed salt cedar-honey mesquite communities of vertical structural type IV only. Inclusion of other structural types would not alter any conclusions herein. It should also be emphasized that type IV is the most common vegetative configuration, constituting some 60 to 70 percent of the vegetation in the valley (Anderson and Ohmart 1976).

Table 1.--Transect information and vegetation analyses for four community types found along the lower Colorado River. (Key: SC represents salt cedar; W, willow; SH, stands of mixed salt cedar and honey mesquite; HM, honey mesquite; FHD, foliage height diversity; HFD, horizontal foliage diversity.

	Number of Trees Per 0.2 Ha						Length of Transects (m)		Area (Ha)	
Community	SC	W	HM	Total	FHD	HFD	Total	Mean	Total	Mean Per Transect
SC	182	0	1	183	0.974	0.086	3,344	836	84	21
W	98	32	12	142	1.060	0.106	6,384	912	161	23
SH	34	0	16	50	0.892	0.074	3,800	950	96	24
HM	0	0	29	29	1.023	0.087	13,376	1,216	337	31

The average length (1.0 km) of the 26 transects in the type IV communities represented an area of about 25 ha (Table 1). Although the area represented by each community was quite different, it probably had little influence on the results. This conclusion is based on the findings (Anderson and Ohmart 1977) that avian density and diversity did not change much with additional transects after the total had reached 2500 to 3000 m in any particular vegetation type.

The vegetative characteristics were similar among the structural types studied, but willow somewhat exceeded the rest in HFD and FHD. This difference was mainly attributable to the presence of more vegetation above 7.5 m in willow stands. Areas classified as willow had a rather dense understory of salt cedar. In these areas, while salt cedar trees outnumbered willows, the latter were taller and occupied more area per tree on the average. Stands of mixed honey mesquite and salt cedar were recognized as distinct community types. Stands of honey mesquite with virtually no other kinds of trees were abundant and were one of the most distinct community types present. Stands termed salt cedar had virtually no other tree species present.

In structural type IV vegetation, 40 to 55 percent of the foliage volume was between 1.5 and 4.5 m. Between 10 and 20 percent was greater than 4.5 m, but almost none was greater than 8 m. Vegetation less than 1.5 m constituted between 30 and 40 percent of the total volume.

Birds were found to react to salt cedar in eight different ways. Species which reacted similarly were placed in a species group. Each of these groups, assigned a letter A-H, was represented diagrammatically in figure 1. Group A was represented by species with greatest densities where salt cedar was the only tree present; group B species were those in which salt cedar was supplemented by willow; group C species were in areas with salt cedar supplemented by willow and in areas where there was no salt cedar; group D species occupied areas with salt cedar supplemented by honey mesquite; group E species were in areas with no salt cedar; group F species were found in equal densities in all areas; group G species were in pure stands of salt cedar and pure stands of honey mesquite; group H species were in areas where salt cedar was supplemented by willow and in areas where salt cedar was supplemented by honey mesquite.

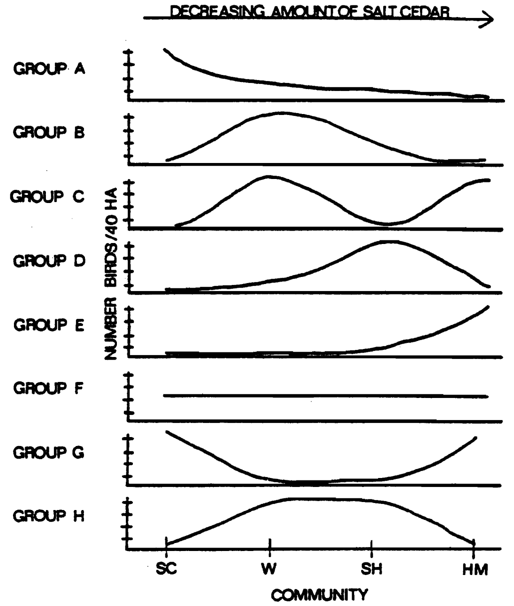

Figure 1.--Diagrammatic representation of the ways birds reacted to salt cedar.

RESULTS

Densities by Community

Bird densities were greatest in willow and honey mesquite, moderate in salt cedar-honey mesquite mixes, and smallest in salt cedar in summer (fig. 2). In willow and honey mesquite avian densities remained relatively high in winter, but were relatively low in pure stands of salt cedar and in stands of mixed salt cedar and honey mesquite. Bird densities during spring, late summer and fall tended to be similar for each vegetative type relative to the other vegetative types, with salt cedar having the smallest population.

Seasonal Variation in Group A

Those species with maximum densities in stands of pure salt cedar (group A) reached greatest total densities during summer (fig. 3). Differences in densities between summer and late summer were significant ($0.01>p>0.005$). No birds occurred in this group in winter, spring or fall. There were 5 and 3 species present in late summer and summer, respectively (Table 2, Appendix I).

Table 2.--Number of bird species, percent of total number of species, number of granivorous and insectivorous species and species of uncertain food habits occurring in various groups (see text for description of groups) during the five seasons. Values for each season represent the average for the season for three years (1975-77).

Groups Present and Season	Number of Species	Percent of Total Species	Number of Insectivorous Species	Number of Granivorous Species	Uncertain
Winter					
B	22	53.7	16	4	0
D	3	7.3	2	1	2
E	14	34.2	3	11	0
F	1	2.5	1	0	0
H	1	2.5	1	0	0
Total Species	41		23	16	2
Percent of Total		100.2[1]	56.1	39.0	4.9
Spring					
B	18	40.0	11	7	0
C	8	17.8	8	0	0
D	5	11.1	2	3	0
E	12	26.6	2	10	0
F	2	4.4	1	1	0
Total Species	45		24	21	0
Percent of Total		99.9[1]	51.0	44.6	0
Summer					
A	3	7.3	0	3	0
B	19	46.3	14	4	1
C	6	14.6	5	1	0
E	6	14.6	5	1	0
F	4	9.7	4	0	0
G	3	7.3	1	2	0
Total Species	41		28	11	1
Percent of Total		99.8[1]	68.3	26.8	2.4
Late Summer					
A	5	13.2	2	3	0
B	18	47.4	13	5	0
E	7	18.4	5	2	0
F	5	13.2	4	1	0
H	3	7.9	1	2	0
Total Species	38		25	13	0
Percent of Total		100.1[1]	65.8	34.2	0
Fall					
B	8	25.0	6	2	0
C	6	18.8	5	1	0
D	6	18.8	4	2	0
E	8	25.0	0	8	0
F	4	12.5	3	1	0
Total Species	32		18	14	0
Percent of Total		100.1[1]	65.2	43.8	0

[1]Totals not equaling 100 percent are due to rounding off.

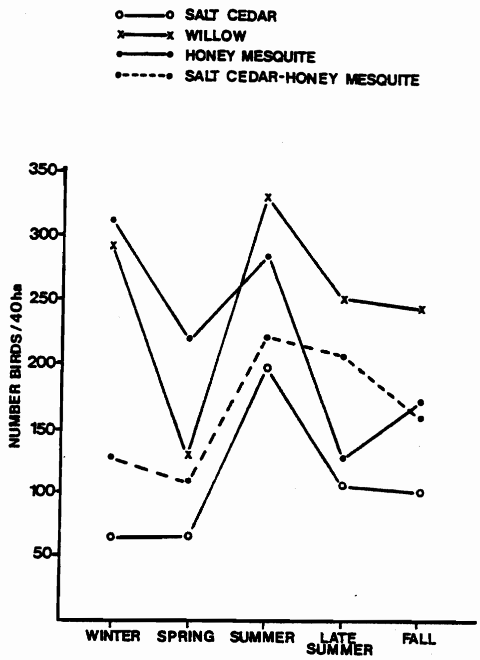

Figure 2.--Average avian densities for various seasons (1975-77) in communities along the lower Colorado River.

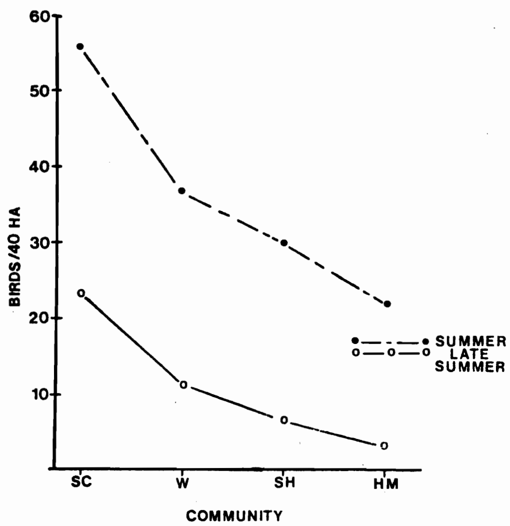

Figure 3.--Birds with greatest densities in salt cedar communities (group A). Abbreviations as in Table 1.

Seasonal Variation in Group B

Total densities of birds tolerating salt cedar when it was supplemented by willow (fig. 4) reached peak numbers during winter, were smallest during spring, and were intermediate at other seasons. Total densities did not differ ($p>0.05$) in spring and late summer. There were 22 species present in this group in winter, 18 in spring and late summer, 19 in summer, and 8 in fall (Table 2, Appendix I). This group included over 40 percent of the total species present in all but one season (fall).

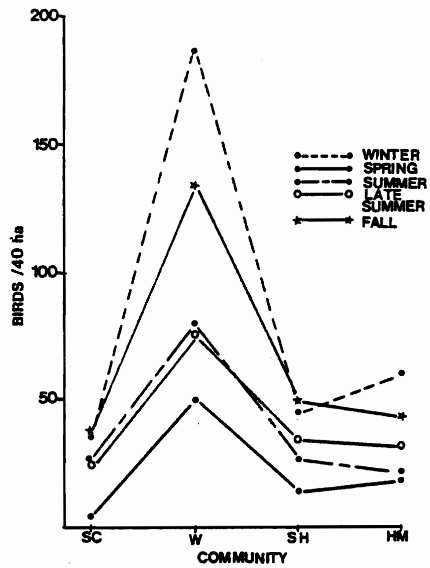

Figure 4.--Birds with greatest densities in willow communities (group B). Abbreviations as in Table 1.

Seasonal Variation in Group C

Species in group C tolerated salt cedar when it was supplemented by willow but reached peaks about as great in honey mesquite, where salt cedar was absent. Densities in this group were greatest in summer, were much smaller in spring and fall, and the group was not represented in late summer or winter (fig. 5). A total of 8 species occurred in this group in spring and 6 in summer and fall (Table 2, Appendix I).

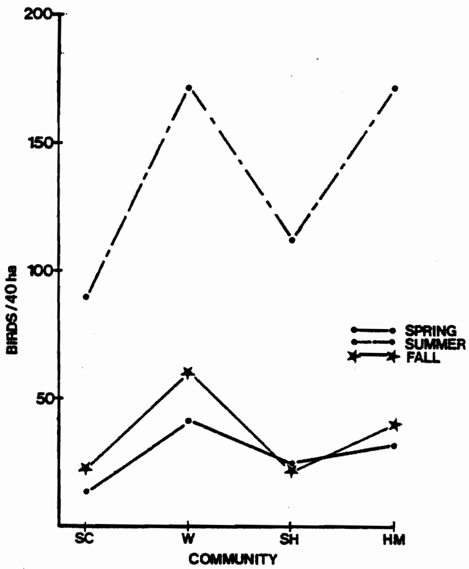

Figure 5.--Birds with greatest densities in willow and honey mesquite communities (group C). Abbreviations as in Table 1.

Seasonal Variation in Group D

Those species tolerant of salt cedar when it was supplemented with honey mesquite reached maximum densities in fall (fig. 6). Densities during spring and winter were smaller than during fall and the group was not represented in summer or late summer. Six species comprised this group in fall, 3 in winter and 5 in spring (Table 2, Appendix I).

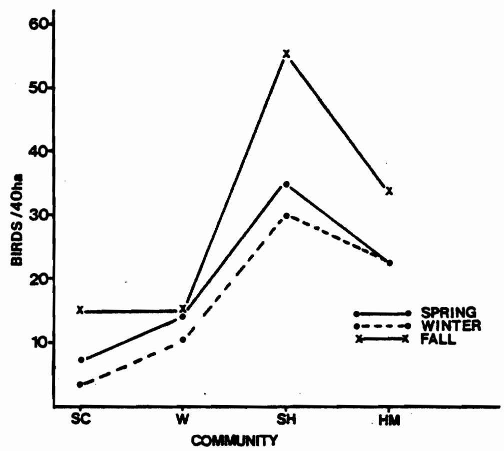

Figure 6.--Birds with greatest densities in salt cedar-honey mesquite communities (group D). Abbreviations as in Table 1.

Seasonal Variation in Group E

This species group reached maximum densities in honey mesquite (where salt cedar was entirely absent) during winter and was most poorly represented in summer (fig. 7). The group was represented in winter by 14 species, in spring by 12, in summer by 6, in late summer by 7, and in fall by 8 species (Table 2, Appendix I).

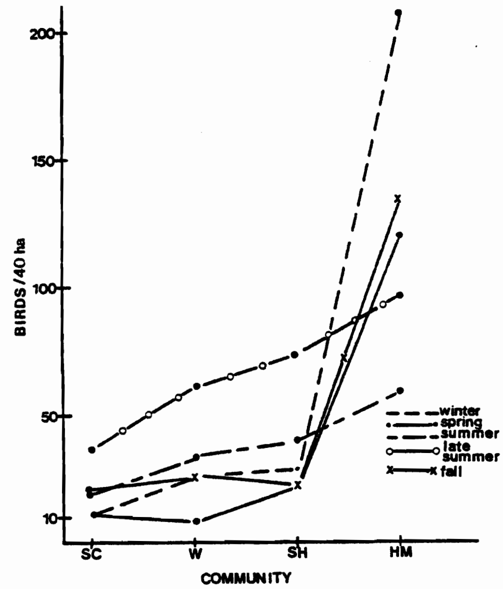

Figure 7.--Birds with greatest densities in honey mesquite communities (group E). Abbreviations as in Table 1.

Seasonal variation in Group F

Birds which did not deviate ($p>0.05$) from an even distribution among the 4 vegetative types investigated reached maximum densities in spring, late summer and fall and were nearly absent in winter (fig. 8). The birds in this group reached somewhat greater densities in spring, and a somewhat greater density in salt cedar in fall, but numbers were too small to detect a significant trend. The group was characterized by having few species. The peak number of species (5) was reached in late summer; there were 4 species in summer and fall, 2 species in spring, and one in winter (Table 2, Appendix I).

Seasonal Variation in Group G

Birds were present in group G only in summer (fig. 8) when there were 3 species present (Table 2, Appendix I).

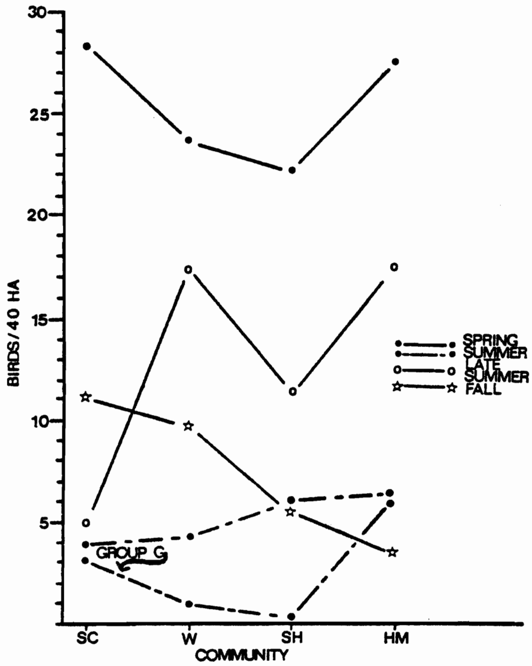

Figure 8.--Birds with densities occurring equally in all communities (group F) or with greatest densities in salt cedar and honey mesquite communities (group G). Abbreviations as in Table 1.

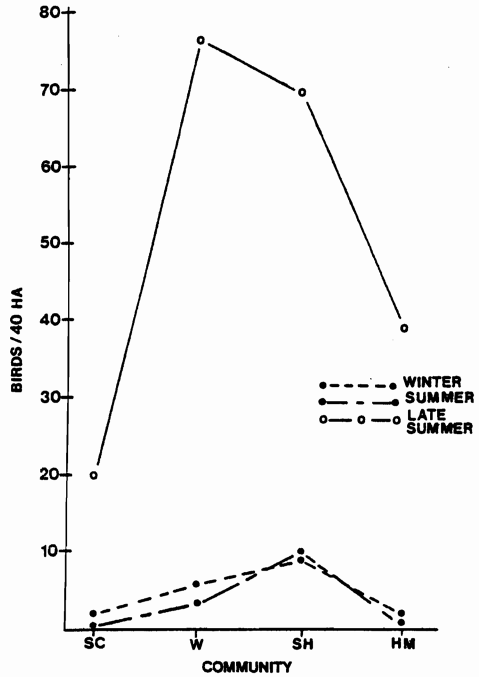

Figure 9.--Birds with greatest densities in willow and salt cedar-honey mesquite communities (group H). Abbreviations as in Table 1.

Seasonal Variation in Group H

Densities of birds showing preference for willow and mixed salt cedar-honey mesquite communities were most abundant in late summer and were nearly absent at other seasons (fig. 9). Three species comprised the group in late summer and one in winter (Table 2, Appendix I).

Overall Species Response to Salt Cedar

In winter and spring only a single species out of 41 and 45 species, respectively, showed tolerance to salt cedar (Table 2). This was an insectivorous species (Gila Woodpecker, _Melanerpes uropygialis_) in winter and a ground feeding granivorous species (Mourning Dove, _Zenaida macroura_) in spring. In summer, 10 of 41 species showed tolerance to salt cedar. All of them were primary consumers and included the Mockingbird (_Mimus polyglottos_), House Sparrow (_Passer domesticus_), White-crowned Sparrow (_Zonotrichia leucophrys_), White-winged Dove (_Zenaida asiatica_), and Ground Dove (_Columbina passerina_). The last 4 of these are ground feeders which feed extensively in agricultural areas or are largely absent in summer (White-crowned Sparrow). Among the 5 insectivores, the Cliff Swallow (_Petrochelidon pyrrhonota_) feeds aerially over salt cedar, and the Roadrunner (_Geococcyx californianus_) is a ground feeder. Only the Bell Vireo (_Vireo bellii_), Blue Grosbeak (_Guiraca caerulea_), and Black-tailed Gnatcatcher (_Polioptila melanura_) feed in the vegetation.

In late summer 10 of 38 species showed extensive tolerance of salt cedar. Among them, 4 (White-crowned Sparrow, Brown-headed Cowbird, _Molothrus ater_, Lincoln Sparrow, _Melospiza lincolnii_, and Ground Dove) feed extensively in agricultural areas or marshes (Lincoln Sparrow). Among the 5 insectivores were 4 permanent residents, the Gila Woodpecker, Ladder-backed Woodpecker (_Picoides scalaris_), Crissal Thrasher (_Toxostoma dorsale_), and Loggerhead Shrike (_Lanius ludovicianus_), and one winter visitor, the Ruby-crowned Kinglet (_Regulus calendula_).

In fall 4 species showed as much or more tolerance to salt cedar as other riparian vegetation. These were the Chipping Sparrow (_Spizella passerina_), Blue-gray Gnatcatcher (_Polioptila caerulea_), Starling (_Sturnus vulgaris_), and Orange-crowned Warbler (_Vermivora celata_). The Chipping Sparrow and Starling feed primarily in agricultural areas; the gnatcatcher and warbler are insectivorous.

In summary, among the 19 species (of 65 total species) which showed as much tolerance to salt cedar as other riparian vegetation (groups A, F and G), only 2 species displayed this tolerance during more than one season (White-crowned Sparrow and Ground Dove). Among the 19 species, 8 fed largely outside of riparian vegetation. Eleven species were largely riparian and among them only one, the Gila Woodpecker, tolerated salt cedar as much as the other vegetation types during more than one of the five seasons.

Numerically Dominant Birds in Salt Cedar

In winter the 5 most abundant species in salt cedar (2 primary consumers and 3 insectivores) accounted for 44 percent of the total winter population in salt cedar (Table 3), but these species had an average of only 9 percent of their total population in salt cedar. None of them was represented by more than 14 percent of the total population found in the 4 community types combined.

In spring the 5 most abundant species (2 primary consumers and 3 insectivores) accounted for 66 percent of the total population in salt cedar (Table 3). These species had an average of 13 percent of their total population in salt cedar. Over 28 percent of the Mourning Dove population occurred in salt cedar.

In summer the 5 most abundant species (4 primary consumers and one insectivore) accounted for 75 percent of the population (Table 3). These species averaged 15 percent of their population in salt cedar. Nearly 41 percent of the total White-winged Dove population occurred in salt cedar.

In late summer the 5 most abundant species (3 primary consumers and 2 insectivores) accounted for 61 percent of the population (Table 3). They had an average of 12 percent of their total population in salt cedar. About 59 percent of the Brown-headed Cowbird population occurred in salt cedar.

In fall the 5 most abundant species (2 primary consumers and 3 insectivores) accounted for 70 percent of the total population in salt cedar. About 35 percent of the Orange-crowned Warbler population occurred in salt cedar.

A total of 11 species accounted for the most numerous species in salt cedar on a seasonal basis (Table 3); the Abert Towhee (Pipilo aberti) was the numerically dominant species during four seasons and the Mourning Dove and Gambel Quail (Lophortyx gambelii) during three seasons. It should be emphasized that the peak population of these species occurred in vegetation other than salt cedar during one or more seasons.

Summary of Densities and Species Using and Avoiding Salt Cedar

Those species in groups A, F and G were considered to prefer salt cedar or not to be affected by it and constituted about 2 percent of the total species present in winter and spring, about 13 percent in fall, and about 25 percent in summer and late summer (Table 4). Two other groups (D and H) appeared to reach maximum densities in areas where salt cedar was mixed with indigenous vegetation. Species in these groups accounted for between 0 and 19 percent of the total species present in all 4 communities. Species in groups B, C and E appear to avoid salt cedar and account for 66 percent to 88 percent of the total species present.

Table 3.--The percent of birds in each group which occurred in salt cedar. These percentages were obtained by dividing the number within each group which occurred in salt cedar by the total number in all four communities. This was done for each season. The column labeled A-H is the percentage of the total population which occurred in salt cedar.

	Percent of Total Birds Within Each Group Which Occurred in Salt Cedar								
Season	A	B	C	D	E	F	G	H	A-H
Winter	-	11.0	-	5.0	4.4	-	-	5.2	8.0
Spring	28.7	12.3	11.2	8.8	0.6	27.6	-	-	13.0
Summer	38.7	15.1	16.5	16.3	13.1	30.0	34.4	-	19.3
Late Summer	51.9	16.1	9.8	-	17.1	-	-	9.8	16.3
Fall	38.0	14.6	15.6	13.3	10.0	-	-	-	13.0

Species tolerating or preferring salt cedar (groups A and G) accounted for 1 to 17 percent of the total density. Those that seemed to profit by mixes accounted for 0 to 29 percent, and those which seemed to avoid salt cedar accounted for 58 to 87 percent of the total densities (Table 5).

Biomass of Insects and Insectivores

At all seasons there was a significantly ($p<0.01$) smaller biomass of insectivores in salt cedar than the average biomass for all communities (fig. 10). There was also a significantly smaller biomass of insects at all seasons in salt cedar than in the other community types. From winter to summer the biomass of insects increased almost 15-fold per 8,000 sweeps in all communities collectively. In salt cedar the insect biomass increased 43-fold from winter to summer but insectivore biomass increased less than 3-fold. In late summer overall insect biomass decreased by 75 percent and in salt cedar by 83 percent. Insectivore biomass decreased overall by 19 percent and decreased in salt cedar by 18 percent. Thus in summer even though there was significantly greater biomass of insects in other communities, if the ratio of insectivore biomass to insect biomass had been the same in salt cedar as in all communities, we would have expected about 1900 grams of insectivores. There was about 1700 grams; significantly ($p<0.01$) less than expected. In late summer the biomass of insects was again less in salt cedar, but the weight of insectivores was very close to expected. In fall and spring there were significantly ($p<0.01$) fewer insects

Table 4.--Number of species for each of five seasons which reacted to salt cedar in various ways along the lower Colorado River. The percent of total species present for each season is given in parentheses.

Season	Number of Species			
	Preferring or Not Objecting to Salt Cedar (Groups A, F, G)	Occurring in Greater Densities in Salt Cedar-Honey Mesquite Mixes Than In Pure Stands of Either (Groups D and H)	Avoiding Salt Cedar (Groups B, C, E)	Total
Winter	1 (2.4)	4 (9.7)	36 (87.8)	41
Spring	1 (2.2)	6 (13.1)	38 (84.5)	45
Summer	10 (24.4)	0 (0.0)	31 (75.6)	41
Late Summer	10 (23.7)	3 (8.9)	26 (68.4)	38
Fall	4 (12.5)	6 (18.8)	22 (68.8)	32

Table 5.--Number of birds for each of five seasons which reacted to salt cedar in various ways along the lower Colorado River. The percent of the total density present for each season is given in parentheses.

Season	Number of Individuals			
	Preferring or Not Objecting to Salt Cedar (Groups A, F, G)	Occurring in Greater Densities in Salt Cedar-Honey Mesquite Mixes Than In Pure Stands of Either (Groups D and H)	Avoiding Salt Cedar (Groups B, C, E)	Total
Winter	4 (0.6)	86 (12.2)	616 (87.3)	706
Spring	27 (5.7)	80 (16.8)	368 (77.5)	475
Summer	179 (17.4)	0 (0.0)	852 (82.6)	1,031
Late Summer	95 (13.3)	208 (29.1)	412 (57.6)	715
Fall	31 (4.0)	123 (15,9)	621 (80.1)	775

in salt cedar, but given that biomass of insects, there were significantly ($p<0.01$) more birds than expected.

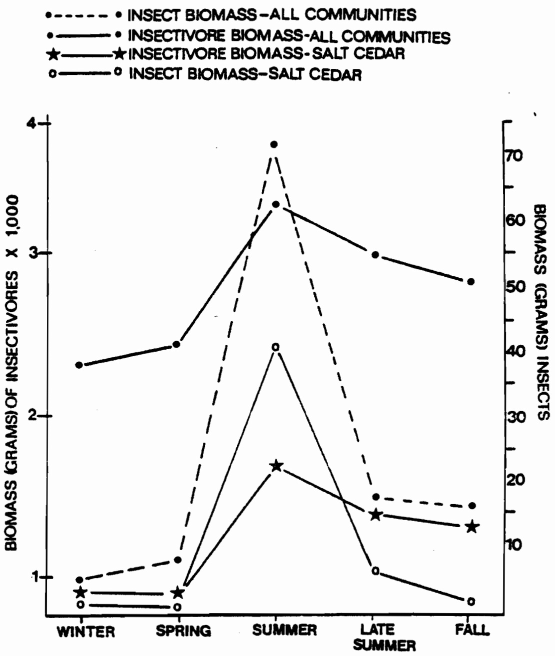

Figure 10.--The biomass of insects in all communities and in salt cedar, and the biomass for the insectivorous birds in all communities and in salt cedar for the seasons of 1976 and 1977.

DISCUSSION

From the above information it is clear that salt cedar has a low value to a majority of species present along the lower Colorado River. Those species which used it as much as other vegetation tended to be granivores, mainly found outside of riparian vegetation, including doves which used riparian vegetation for nesting but which fed mainly in agricultural areas.

It may also be noteworthy that of 11 species belonging to Old World genera, 6 (55 percent) either preferred or at least did not avoid salt cedar at one or more seasons. Among the 54 species belonging to New World genera, only 15 (28 percent) preferred or did not avoid salt cedar at one or more seasons. Since salt cedar is indigenous to the Old World, it may be that a greater proportion of the species belonging to Old World genera are somewhat adapted to it.

It is difficult for local populations of birds unadapted to salt cedar to become adapted to it because there is insufficient genetic isolation between adapted and maladapted groups of individuals. Adaptive gene complexes are constantly broken down because of interbreeding. If, however, salt cedar were to predominate to the near total exclusion of other kinds of vegetation, some avian adaptation to salt cedar might occur, particularly in local sedentary populations.

We have observed that salt cedar leaves exude a sticky material which causes one's hair to become stiff and sticky. This sticky exudate may also cause avian plumages to become stiff and sticky. It would be difficult for insectivores to avoid this exudate if they foraged among the vegetation; thus they avoid it altogether. Another group of birds, frugivores, avoid salt cedar nearly completely because the major source of fruit, i.e. from mistletoe (Phoradendron californicum), does not occur in salt cedar.

Birds which are more abundant in salt cedar when it is supplemented by honey mesquite may benefit because more insects are produced in salt cedar than mesquite alone (Anderson and Ohmart, unpubl. data). Since mesquite is comparatively easy for birds to forage in (no exudate, rather sparse leaf cover), certain species may benefit from the enhanced insect fauna in mesquite when salt cedar is present.

A stand of pure salt cedar can be enhanced for wildlife by removal of some of it (perhaps as little as 20 percent) and replacing it with honey mesquite and/or willow. We know from other data (Anderson, et al., this symposium) that addition of quail bush (Atriplex lentiformis) and ink weed (Suaeda torreyana) will increase certain bird populations. In addition, a stand of salt cedar can be further improved by clearing and replanting in ways which will increase vertical and horizontal foliage diversity. Through a combination of adding more plant species favorable to wildlife and manipulating the vegetative structure, it may prove to be relatively easy and economically feasible to manipulate salt cedar to enhance the vegetative community for wildlife.

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Appendix I.--Bird species occurring in various communities along the lower Colorado River for various seasons of 1975-76. Each species, depicted by a capital letter, occurs in its greatest density in one or two communities and corresponds to the graphs in figures 3-7.

Species	Winter	Spring	Summer	Late Summer	Fall
Gambel Quail, *Lophortyx gambelii*	E	E	E	H	D
Mourning Dove, *Zenaida macroura*	D	F	C	E	B
White-winged Dove, *Zenaida asiatica*	-	D	A	H	-
Ground Dove, *Columbina passerina*	B	B	A	A	-
Yellow-billed Cuckoo, *Coccyzus americanus*	-	-	B	B	-
Roadrunner, *Geococcyx californianus*	D	C	F	B	-
Lesser Nighthawk, *Chordeiles acutipennis*	-	-	E	H	-
Black-chinned Hummingbird, *Archilochus alexandri*	-	-	B	-	-
Common Flicker, *Colaptes auratus*	B	B	B	B	B
Ladder-backed Woodpecker, *Picoides scalaris*	B	B	C	F	C
Yellow-bellied Sapsucker, *Sphyrapicus varius*	B	-	-	-	-
Gila Woodpecker, *Melanerpes uropygialis*	F	C	B	F	C
Western Kingbird, *Tyrannus verticalis*	-	B	B	B	-
Wied Crested Flycatcher, *Myiarchus tyrannulus*	-	-	B	B	-
Ash-throated Flycatcher, *Myiarchus cinerascens*	D	C	C	B	D
Black Phoebe, *Sayornis nigricans*	B	B	-	-	-
Say Phoebe, *Sayornis saya*	B	-	B	-	-

Appendix I. Continued.

Species	Winter	Spring	Summer	Late Summer	Fall
Rough-winged Swallow, Stelgidopteryx ruficollis	-	-	B	-	-
Cliff Swallow, Petrochelidon pyrrhonota	-	-	F	-	-
Scrub Jay, Aphelocoma coerulescens	B	-	-	-	-
Verdin, Auriparus flaviceps	E	C	C	E	C
White-breasted Nuthatch, Sitta carolinensis	B	-	-	-	-
Brown Creeper, Certhia familiaris	B	-	-	-	-
House Wren, Troglodytes aedon	B	B	-	-	B
Bewick Wren, Thryomanes bewickii	B	C	B	B	B
Cactus Wren, Campylorhynchus brunneicapillus	E	E	E	E	C
Long-billed Marsh Wren, Cistothorus palustris	B	B	-	-	-
Mockingbird, Mimus polyglottos	E	E	G	E	E
Crissal Thrasher, Toxostoma dorsale	E	C	E	F	D
American Robin, Turdus migratorius	B	E	-	-	C
Hermit Thrush, Catharus guttatus	H	-	-	-	B
Western Bluebird, Sialia mexicana	E	E	-	-	E
Blue-gray Gnatcatcher, Polioptila caerulea	E	-	-	-	F
Black-tailed Gnatcatcher, Polioptila melanura	E	E	F	E	D
Ruby-crowned Kinglet, Regulus calendula	B	C	-	A	B
Cedar Waxwing, Bombycilla cedrorum	E	B	-	-	-
Phainopepla, Phainopepla nitens	E	E	E	F	E
Loggerhead Shrike, Lanius ludovicianus	B	D	C	A	D
Starling, Sturnus vulgaris	B	B	-	-	F
Bell Vireo, Vireo bellii	-	B	F	E	-
Orange-crowned Warbler, Vermivora celata	B	F	B	B	F
Lucy Warbler, Vermivora luciae	-	D	E	-	-
Yellow-rumped Warbler, Dendroica coronata	B	B	-	B	C
Yellowthroat, Geothlypis trichas	-	B	B	-	-
Yellow-breasted Chat, Icteria virens	-	-	B	B	-