The Condor 90:113–123

USE OF EXOTIC SALTCEDAR (*TAMARIX CHINENSIS*) BY BIRDS IN ARID RIPARIAN SYSTEMS[1]

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Abstract. Avian use of saltcedar (*Tamarix chinensis*) along the middle Pecos River was compared with similarly collected data along the lower Colorado River and Rio Grande. Use of saltcedar ranked high among all bird groups in all seasons on the middle Pecos River. In contrast, many species do not occur in saltcedar on the lower Colorado River, while few species winter in saltcedar on the lower Rio Grande. Occurrence of granivores and insectivores during winter in saltcedar on the Pecos River may be explained by seed-producing shrubs and annuals within or adjacent to these habitats. Most breeding birds on the Pecos River are summer visitors. These breeding species, though present, do not occur in saltcedar on the Colorado River despite abundant food resources and occur in intermediate abundances on the Rio Grande. Densities of several summer-visiting insectivores have declined markedly on the Colorado River since the proliferation of saltcedar, whereas they have remained relatively stable in other river valleys to the east. Biogeographical considerations, specifically elevational (climatic) gradients, are suggested reasons for this phenomenon.

Key words: Pecos River; Colorado River; Rio Grande; saltcedar; riparian; climatic gradients.

INTRODUCTION

Numerous avian studies over the last three decades have delineated patterns in species habitat use in native habitats. These studies are prevalent in the literature, whereas intensive studies on bird use of extensive stands of exotic vegetation have been few (Anderson and Ohmart 1984; for a review of other systems see Cody 1985:26–27). We describe a system in which much of the native vegetation has been replaced by an exotic plant species through a series of human-made manipulations. These manipulations have been consistent in time frame (1930s to present) over a large geographical area (the American Southwest). Describing patterns in transition from native to exotic vegetation by bird species may lead to field tests concerned with explaining the ability of certain bird species to occur successfully in exotic vegetation while other species fail to do so.

Rapid expansion of exotic saltcedar (*Tamarix chinensis*) in the arid Southwest has stimulated research on its life history and its effects on fauna and flora of native riparian habitats (Horton 1977). Serious concern has developed regarding potential loss of entire avian communities occurring in these riparian systems (Hunter et al., in press). Over 40% of all bird species found in Southwest river valleys depend partly or wholly on riparian vegetation (Carothers et al. 1974, Ohmart and Anderson 1982). Loss of native riparian vegetation and subsequent spread of saltcedar generally has been shown to have negative effects on the population sizes of many riparian species (Anderson et al. 1977b).

Studies of bird populations in riparian vegetation along the lower Colorado River indicate lower species richness and lower total density in saltcedar compared with most native riparian habitats (Anderson and Ohmart 1984). At least eight bird species once common on the lower Colorado River are now approaching extirpation (Grinnell 1914, Hunter 1984). On the Rio Grande near Presidio, Texas, some of these species occur in saltcedar habitats, but are found in lower densities than in the remaining native cottonwood (*Populus fremontii*) and willow (*Salix gooddingii*) habitats (Engel-Wilson and Ohmart 1978).

Along the middle Pecos River, before saltcedar became established, there were few existing tall, mature stands of vegetation that could be used by riparian birds (Hildebrandt and Ohmart 1982, Hunter et al. 1985). This contrasts with most other perennial desert riparian systems where extensive cottonwood-willow forests existed before human-made manipulations (Ohmart and Anderson 1982). Therefore, absence of riparian-dependent bird species in saltcedar in the Pecos

[1] Received 27 February 1987. Final acceptance 2 October 1987.

TABLE 1. Amount of riparian woodland vegetation in the lower Colorado, middle Rio Grande, and middle Pecos river valleys.

Community	Area (ha)		
	Colorado	Rio Grande	Pecos
Cottonwood-willow	3,354	60	834
Saltcedar	14,353	5,600	11,295
Honey mesquite	6,559	3,029	*
Screwbean mesquite–saltcedar mix	8,412	25	0

* The actual area for honey mesquite could not be adequately determined in the middle Pecos River Valley, as there was not a definitive break among floodplain, plains, and desert stands.

River Valley does not necessarily indicate population declines when compared to bird occurrence in the valley before the appearance of this exotic species. However, bird occurrence in saltcedar potentially indicates population expansions within or into the Pecos Valley.

This study was conducted to determine bird use of saltcedar and other available riparian habitats found in the middle Pecos River Valley of New Mexico and Texas. Our results were compared with similarly collected data from the lower Colorado River and the lower Rio Grande and were used to determine what trends, if any, may exist in the Southwest on bird occurrence in saltcedar. An earlier paper concerned summer bird use comparisons of riparian habitats along these same river systems with respect to the lower Colorado River (Hunter et al. 1985). The present paper is concerned with year-round bird use patterns with respect to the Pecos River while expanding analysis on the summer bird data, including some species not treated in the previous paper and deleting other species.

STUDY AREA

The Pecos River study area extends from Santa Rosa, New Mexico, to Girvin, Texas, and includes approximately 12,000 ha of riparian woodlands. The middle Pecos River Basin lies along the southwestern border of the Great Plains where shortgrass prairie once was the primary ecotype (Bailey 1913). As the river nears the Texas-New Mexico border, Chihuahuan Desert becomes the dominant upland ecotype adjacent to riparian vegetation.

Groves of cottonwoods (*P. f. wislizenii*) remain where they were found historically at the north end of our study area near Roswell and Fort Sumner, New Mexico. The cottonwood stands have been reduced in size since the turn of the century, but because they were local to begin with the relative loss is minimal compared to other Southwestern systems. Honey mesquite (*Prosopis glandulosa* var. *glandulosa*) is a common plant species throughout the valley, but the short-growth form results from poor soil conditions and cold winters in the valley (Hildebrandt and Ohmart 1982).

Saltcedar invaded the Pecos River Basin in 1912. Approximately 31,200 ha of saltcedar were estimated to have occurred before 21,850 ha were cleared between 1967 and 1971. By 1980, there were 11,295 ha of saltcedar habitat, but only 834 ha of cottonwood-willow habitat along the middle Pecos River (Table 1; Hildebrandt and Ohmart 1982).

METHODS

Riparian vegetation was classified on the Pecos River into vegetation types on the basis of dominant tree species and the vertical distribution of foliage. Cottonwood, saltcedar, and honey mesquite plant communities were recognized. Different vertical configurations reflected the proportional distribution of vegetation among three vertical layers (0.0 to 0.6 m, 0.6 to 4.5 m, and >4.5 m). Six types were classified by vertical structure. Type I was the most structurally diverse, type II had only a well-developed upper canopy, type III had a well-developed midstory and poorly developed upper canopy and understory, and types IV, V, and VI had sequentially decreasing importance of the upper two layers (Fig. 1). Eighteen community-structure types (hereafter referred to as habitat types) are possible by combining species composition and vertical structure on the Pecos River. The habitat types differ from each other in vertical profile or in dominant vegetation, or both. This same classification system also was used in analysis of avian use of vegetation along the lower Colorado River (Anderson et al. 1983) and lower Rio Grande (Engel-Wilson and Ohmart 1978).

A modified Emlen (1971) variable-distance transect method was used three times per month on each transect to estimate bird densities (Anderson et al. 1977a). Twenty-eight transects were established in relatively homogeneous stands of riparian vegetation along the middle Pecos River and were classified into habitat types as described above. Number of transects in each habitat type

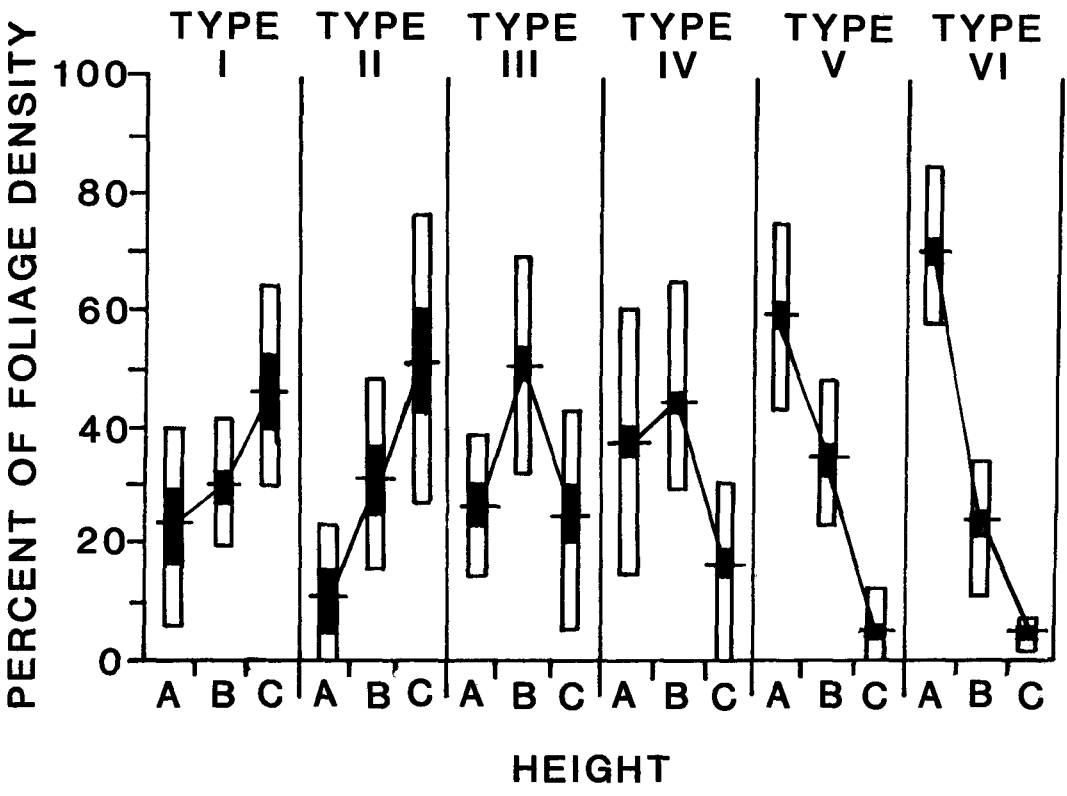

FIGURE 1. Proportional distribution of the vegetation in three vertical layers within various stands of vegetation, which overall were classified as belonging to vertical structural types (I to VI). Horizontal lines represent mean values; large rectangles represent ±1 SD; small rectangles represent ±2 SE. A = 0.0–0.6 m, B = 0.6–4.5 m, C = ≥4.5 m.

reflected the abundance of each habitat type within each valley (Appendix I). All stands sampled had a minimum width of 265 m.

Birds were censused from September 1979 to May 1981 on the Pecos River. Monthly densities for each habitat type were expressed as birds per 40 ha. Seasonal densities per habitat type were means of monthly averages. Seasons included fall (September, October, November), winter (December, January, February), spring (March, April, May), and summer (June, July, August). Seasons reflected actual changes in bird species composition. Only species that breed (summer visitors), winter (winter visitors), or that are permanent residents in riparian vegetation are considered in this study. Migrants are excluded because of their unpredictable occurrence in habitats. Species are grouped by food preferences and time of occurrence to facilitate data analysis in available habitats (Appendix II). On the Pecos River, these groups included granivores (12 species), winter-visiting insectivores (7 species), summer-visiting insectivores (18 species), and permanent-resident insectivores (14 species).

For each group, species richness and density were ranked during each season among habitat types. Summer-visiting insectivores did not occur during winter seasons (1979–1980 and 1980–1981) and winter-visiting insectivores did not occur during the summer season (1980), so these seasons were omitted from analysis for these groups, respectively. Ranks were summed across seasons for each habitat type. Friedman's two-way analysis of variance (ANOVA) of seasons was calculated to test whether ranks were randomly distributed among habitats across years for each bird group (Siegel 1956). Friedman's ANOVAs were calculated for each habitat type for species richness and number of individuals for each bird group and overall for total species richness and total number of individuals. The three top-ranked habitat types were identified by

the three lowest sums of ranks for species richness and density in each bird group across all seasons.

Habitat breadth was calculated by using information theory for all bird species for all seasons among the riparian habitat types recognized (Shannon and Weaver 1949). Species over 67% of maximum habitat breadth were considered to be generalists, whereas species under 33% of maximum habitat breadth were considered to be specialists. For each season, habitat breadth of all species present in at least one habitat was averaged to detect differences among seasons. Also, number of specialists and generalists was determined to add insight into general seasonal use of habitat types by birds on the Pecos River.

Comparing the occurrence of individual species in saltcedar better delineates differences between valleys. For the summer season, the proportion of each species' population occurring in each plant community was calculated by dividing the total number of individuals per 40 ha among all habitat types constituting each plant community (cottonwood-willow, saltcedar, screwbean mesquite [*P. pubescens,* on lower Colorado River only], and honey mesquite). Then the proportion of individuals per unit area for each plant community was determined for the three river systems. For each river valley, if the proportion of a given species was greater in any plant community than expected with an equal distribution of individuals among all plant communities, that species was considered to be using the plant community favorably. Preference is suggested (but not proven) by favorable use in that a larger number of individuals occurred in the plant community than would be expected by chance.

Number of species, both summer-visiting insectivores and permanent-resident insectivores, favorably using saltcedar habitats during summer was compared between each valley using binomial expansion (Sokal and Rohlf 1981). Of the total number of species using saltcedar favorably on the Pecos, we asked what was the probability that the number of species using saltcedar favorably on the Colorado or on the Rio Grande was statistically the same?

RESULTS

Eight of 18 possible habitat types were recognized from vegetation analysis in the middle Pecos River Valley: cottonwood-willow (CW) types II and V; saltcedar (SC) types III, IV, V, and VI; and honey mesquite (HM) types V and VI. Of habitat types found on the lower Colorado River (Fig. 1), all but type I were represented on the Pecos River. All habitats along the Pecos River occur along the Colorado River, although there are more (23) habitat types along the Colorado River (see Anderson et al. 1983). The lower Rio Grande had nine habitat types (Engel-Wilson and Ohmart 1978), and, as with the lower Colorado and middle Pecos rivers, the saltcedar community covered most available riparian areas (Table 1).

Ranks among Pecos River habitat types for each bird group were nonrandomly distributed except for summer-visiting insectivores in species richness and number of individuals (Friedman's ANOVA $\chi^2 \geq 19.7$, df = 7, $P < 0.025$; Table 2). SC IV, for every bird group, was among the top-ranked habitat types. HM V was an important habitat for the number of permanent-resident insectivore species and permanent-resident insectivore individuals. CW II and V were not consistently top- nor bottom-ranked for bird groups, but 54% of breeding bird species occurring in the cottonwood plant community showed a strong preference for this type as habitat specialists (Hildebrandt and Ohmart 1982). Therefore, CW II, V, and HM V were important for some bird species but were surpassed by saltcedar habitat types in overall species richness and bird density. HM VI was the poorest habitat type, being among bottom-ranked habitats for each bird group.

Average habitat breadths for birds occurring during summer 1980 (including permanent-resident insectivores) was higher than average habitat breadth for all other seasons (Table 3). Number of species considered generalists (49%) was higher during summer than any other season. Also, during summer, the lowest number of species considered specialists (18%) was present.

A significantly higher number of summer-visiting insectivores on the Pecos River used saltcedar favorably than on either the Rio Grande or the Colorado River (both, $P < 0.05$; Table 4). Valley comparisons for permanent-resident insectivores were not significantly different between both the Pecos and Colorado rivers, and the Pecos River and the Rio Grande (both $P > 0.05$; Table 5).

DISCUSSION

High occurrence of all bird groups in the saltcedar plant community on the Pecos River is in contrast to bird occurrence in saltcedar on both

TABLE 2. Friedman's two-way analysis of variance of bird ranks summed across seasons for each habitat type for each bird group on the Pecos River. For species and individuals in each bird group, the three top-ranked habitats are indicated by an X and the three bottom-ranked habitats by an O. CW = cottonwood-willow, SC = saltcedar, HM = honey mesquite (n = 8).

Bird group	Sum of ranks by habitat types								χ^2	$P <$
	CW II	CW V	SC III	SC IV	SC V	SC VI	HM V	HM VI		
Granivores										
Species	O	X		X	X		O	O	24.7	0.001
Individuals	X		X	X	O		O	O	22.5	0.001
Winter-visiting insectivores										
Species	O	X	O	X			X	O	19.4	0.01
Individuals	O		X	X	X		O	O	28.0	0.001
Summer-visiting insectivores										
Species	X		O	X	X		O	O	9.5	ns
Individuals	X	X	O	X			O	O	11.5	ns
Permanent-resident insectivores										
Species	O		O	X	X		X	O	33.0	0.001
Individuals		X	O	X	O		X	O	36.3	0.001
Total species	O		O	X	X		X	O	31.2	0.001
Total individuals	X	X		X	O		O	O	25.9	0.001

the lower Colorado River and the lower Rio Grande (Anderson et al. 1977b, Engel-Wilson and Ohmart 1978). Higher habitat breadth among species during summer and lower habitat breadth during winter were also found in bird species on the lower Colorado River (Rice et al. 1980). Saltcedar, though, was a relatively unimportant plant community to birds on the lower Colorado River, whereas on the Pecos River it was consistently among the most important habitats for birds.

On the lower Colorado River and lower Rio Grande, species richness and densities of birds in the saltcedar plant community were lowest during winter. Bird species tended to be more habitat specialized by occurring only in cottonwood-willow or honey mesquite plant communities in these river valleys (Engel-Wilson and Ohmart 1978, Rice et al. 1980). Differences in the amount of adjacent shrubs and presence of annuals within saltcedar habitat types could explain the high numbers of granivorous species and individuals found on the Pecos River (Hildebrandt and Ohmart 1982). The combination of food and shelter availability clearly affect the number of granivorous species found in those habitats during fall, winter, and spring (Appendix II). Winter-visiting insectivores also use saltcedar habitat types heavily on the Pecos River. On the lower Colorado River, winter-visiting insectivores were positively associated with num-

TABLE 3. Mean habitat breadth and proportion of avian species in the Pecos Valley considered specialists or generalists. Species 0–33% of maximum habitat breadth were considered specialists and species 67–100% of maximum habitat breadth were considered generalists.

Season	No. species	Mean habitat breadth	2 SE	Proportion of species in each percent of maximum habitat breadth group		
				0–33	34–66	67–100
Fall 1979	34	0.392	±0.103	41	27	32
Fall 1980	40	0.436	±0.096	37	25	37
Winter 1979	26	0.315	±0.105	58	27	15
Winter 1980	27	0.345	±0.106	52	30	18
Spring 1980	41	0.377	±0.090	44	34	22
Spring 1981	43	0.420	±0.080	40	30	30
Summer 1980	33	0.562	±0.076	18	33	49

TABLE 4. Summer-visiting insectivores occurring on the middle Pecos River that also occur on the lower Colorado River and/or lower Rio Grande. Percent of each species density by vegetation community is given to compare use of the saltcedar community among the valleys. Favorable use of saltcedar, indicated by +. Vegetation community abbreviations as in Table 2. SM = screwbean mesquite. Scientific names appear in Appendix II.

Species	Vegetation communities									
	Pecos			Colorado				Rio Grande		
	CW	SC	HM	CW	SC	HM	SM	CW	SC	HM
Yellow-billed Cuckoo	52.17	43.48+	2.17	68.29	2.43	19.51	9.76	55.38	9.09	36.90
Ash-throated Flycatcher	72.22	11.11	9.09	20.82	12.61	35.29	31.38	10.26	43.59+	46.15
Western Kingbird	67.24	17.24	15.12	59.62	26.92+	5.77	7.69	34.38	0.00	65.63
Northern Mockingbird	55.64	38.34+	6.02	51.61	12.90	22.58	12.90	19.93	16.01	64.06
Yellow-breasted Chat	42.11	57.89+	0.00	84.31	7.84	2.00	5.88	51.46	34.48+	14.07
Summer Tanager	87.18	12.82	0.00	97.57	2.43*	0.00	0.00	27.82	39.47+	32.71
Blue Grosbeak	40.54	55.41+	4.05	41.96	29.91+	3.57	24.55	43.35	23.08	33.57
Painted Bunting	0.00	81.82+	18.18	—	—	—	—	46.90	27.88	25.22
Brown-headed Cowbird	21.62	64.86+	13.51	32.83	25.81	13.85	27.51	54.87	28.52	16.61
Northern Oriole	71.11	25.93	2.96	46.60	12.59	21.77	19.05	40.00	20.00	40.00

* Summer Tanager densities in athel tamarisk (*T. aphylla*) habitat were high, but this habitat was very rare and nonexistent in other river valleys. Proportion of tanagers in saltcedar with athel tamarisk was 14.75%.

bers of shrubs that also provide cover for insects in winter (Anderson et al. 1978). Saltcedar habitat types on both the lower Colorado River and the lower Rio Grande characteristically lack shrubs and annuals, which were the main source of food for both granivores and winter-visiting insectivores during winter on the Pecos River (Cohan et al. 1978, Engel-Wilson and Ohmart 1978).

It is tempting to speculate that annuals and shrubs also harbor additional food for summer-visiting insectivores, thus influencing high use of saltcedar on the Pecos River by summer-visiting insectivores. However, Cohan et al. (1978) found that the ratio of insect biomass-to-insectivore biomass was higher in the saltcedar plant community during summer than in any other plant community during any other season on the lower Colorado River. Thus, a limited food base did not explain the lack of breeding insectivorous species in saltcedar. In addition, the most important food items for many medium-sized insectivores on the lower Colorado River are cicadas (*Diceroprocta apache*; Rosenberg et al. 1982), which are most abundant in stands of saltcedar (Glinski and Ohmart 1984; Anderson and Ohmart, unpubl. data). Insect species diversity on the Pecos River in saltcedar during summer does not differ markedly from that found on the lower Colorado River, except that cicadas are less abundant and orthopterans are more abundant on the former (Watts et al. 1977; Hunter, pers. observ.).

Since the Pecos River was largely devoid of mature riparian vegetation before the appearance of saltcedar, the number of breeding bird species currently using saltcedar would suggest that bird species expanded into and within the valley with the spread of saltcedar. For Yellow-billed Cuckoos (*Coccyzus americanus*), Yellow-breasted Chats (*Icteria virens*), and Summer Tanagers (*Piranga rubra*), differential selection of saltcedar among the three river valleys is suggested (Table 4), as these three bird species have suffered serious population declines on the lower Colorado River concomitant with native habitat loss (Hunter 1984). There is historical evidence that Crissal Thrashers (*Toxostoma crissale*), Summer Tanagers, Blue Grosbeaks (*Guiraca caerulea*), and Painted Buntings (*Passerina ciris*) expanded their distribution concurrently with expansion of saltcedar in the Pecos River Valley (Bailey 1928, Ligon 1961, Hubbard 1978). All of the above species are summer-visiting insectivores, except for the Crissal Thrasher.

The number of summer-visiting insectivore species declining on the lower Colorado River but occurring in saltcedar on the middle Pecos River and lower Rio Grande suggests the following sequence of events. As cottonwood-willow was removed and replaced by saltcedar on the lower Rio Grande, many summer-visiting insectivore species persisted by breeding in saltcedar. Although some species densities were lower than those found in cottonwood-willow, breeding populations have persisted because of their use

TABLE 5. Permanent-resident insectivores occurring on the middle Pecos River that also occur on the lower Colorado River and/or the middle Rio Grande. Percent of each species density by vegetation community is given to compare use of the saltcedar community among the valleys. Favorable use of saltcedar habitats, indicated by +. Scientific names appear in Appendix II. Abbreviations as in Tables 2 and 4.

	Vegetation communities									
	Pecos			Colorado				Rio Grande		
Species	CW	SC	HM	CW	SC	HM	SM	CW	SC	HM
Greater Roadrunner	8.33	75.00+	16.67	16.67	26.19+	29.76	27.38	16.00	12.00	72.00
Ladder-backed Woodpecker	80.00	13.33	6.67	47.68	6.75	19.83	25.74	46.15	30.77	23.08
Cactus Wren	0.00	0.00	100.00	25.49	6.34	58.17	9.80	0.00	0.00	100.00
Crissal Thrasher	7.14	64.29+	28.57	19.62	17.72	43.67	18.99	0.00	12.50	87.50
Loggerhead Shrike	13.33	20.00	66.76	20.62	19.59	37.11	22.68	15.09	28.30	56.60
Pyrrhuloxia	0.00	17.65	82.35	—	—	—	—	0.00	0.00	100.00

of saltcedar (Table 4). As saltcedar from the Pecos River joined with saltcedar on the Rio Grande, many of these species were able to spread north from Texas into eastern New Mexico. Other species, such as Yellow-billed Cuckoo and Summer Tanager, could have spread into saltcedar from the south as well as from the cottonwood bosques to the north of the study area.

If these events are correct, why haven't summer-visiting insectivore species made the transition to saltcedar on the lower Colorado River where an abundant food supply exists during summer? Also, why do summer-visiting insectivore species on the Pecos River show differences in selection of saltcedar among valleys whereas the permanent-resident insectivore species do not? Differences in the vegetation structure of saltcedar itself is not apparent, but local weather conditions may play an important role.

Elevational gradients from east to west in the arid Southwest may influence use of exotic habitats. Elevation lowers from east to west and mean summer temperatures are hotter; the lower Colorado River represents the most extreme summer environment. Species that are migratory and midsummer breeders may be unable to use saltcedar or other riparian vegetation (i.e., honey mesquite and open stands of cottonwood-willow) that do not provide multilayered foliage which favorably modifies local climatic conditions during summer. Thus, discrimination of structure types within plant communities, such as cottonwood-willow, become most important to these species where climatic conditions are harsh during summer. Structure types IV through VI, of which almost all saltcedar and mesquite stands consist, cannot ameliorate extreme temperatures as well as structure types I through III (Fig. 1). On the lower Colorado River the bird species that occur in saltcedar, as well as almost all other available riparian plant communities during midsummer, nest early (March through June) and/or have insulated nests (Hunter et al., in press). The only exception is the Blue Grosbeak which arrives in May, like the species that have declined.

Permanent-resident insectivore species found on the Pecos River represent a small subset of those species found on the lower Colorado River. Of the species found on the Pecos, there was little difference in their use of saltcedar among valleys. There are, however, several additional permanent–resident insectivore and early breeding summer-visiting insectivore species that are very rare or absent on the lower Rio Grande and middle Pecos but are common on the lower Colorado. These include the Verdin (*Auriparus flaviceps*), Black-tailed Gnatcatcher (*Polioptila melanura*), and Lucy's Warbler (*Vermivora luciae*). These species occur in saltcedar and other plant communities on the lower Colorado River but become rare and restricted to honey mesquite on the lower Rio Grande and middle Pecos River (Engel-Wilson and Ohmart 1978, Hunter et al. 1985). These are primarily Sonoran and Chihuahuan desert species. With the exception of the migratory Lucy's Warbler, colder winters in western Texas and eastern New Mexico may disallow successful invasion into other riparian plant communities such as saltcedar. Habitat use by these species in these areas may be regulated by high winter mortality in the same areas where they breed (Fretwell 1972). Overall, it appears

that permanent-resident species, as well as winter visitors, are under the most intensive selective pressure during the winter months. This is contrary to most work which centers on the breeding season as the period of highest selective pressure (however, see Rice et al. 1980, Fischer 1981). Factors influencing habitat selection among permanent-resident and winter-visiting species (such as physiological stresses, food limitation, and competitive interaction) may be best studied during the winter season (Rice et al. 1980).

There are environmental extremes, such as seasonal temperature, that may be important in species' use of all available habitats. Species with similar breeding phenology, residency status, and habitat preferences appear to be responding in a similar manner in the use of saltcedar (Hunter et al. 1985). Migratory, midsummer-breeding bird species largely associated with cottonwood-willow types I through III on the lower Colorado River occur in saltcedar as well as other plant communities within a variety of structure types on the lower Rio Grande and middle Pecos River. Conversely, permanent-resident, spring-breeding, honey mesquite-associated species show the opposite trend by remaining habitat restricted and rare on the lower Rio Grande and middle Pecos River while they use saltcedar to some extent on the lower Colorado River. Similar patterns based on residency status were reported for species studied in adjoining riparian and desert habitats by Szaro and Jakle (1985). Data from other river valleys in the arid Southwest are presently under study to further investigate and test ideas on direct associations between climate and habitat flexibility among species.

ACKNOWLEDGMENTS

We thank T. D. Hildebrandt who supervised the Pecos River fieldwork. The following field biologists helped collect data on the Pecos River: W. Howe, M. Axelrod, P. Thoumsin, T. Weaver, G. Rogowitz, R. Martin, D. Lausch, and J. Wielgus. A. K. Webb, L. C. Richardson, and K. V. Rosenberg assisted with data analysis. We thank S. M. Cook, J. R. Durham, and C. D. Zisner for editing the paper and adding, often insightful, suggestions. Typing and figures were completed by C. D. Zisner. The manuscript was improved by critical reading by K. A. Conine, R. W. and C. Engel-Wilson, V. Hink, M. Jakle, A. Laurenzi, and two anonymous reviewers. This work was supported by Bureau of Reclamation Contract No. 9-07-57-V0567.

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APPENDIX I. Number of transects and area covered in each habitat type on the Pecos River by month (three censuses on each transect each month).

Habitat type	Number of transects	Combined length of transects (m)	Total area covered per three censuses (ha)
CW II	1	1,524	114
CW V	4	2,896	222
SC III	2	1,524	93
SC IV	9	9,753	597
SC V	4	4,724	348
SC VI	2	1,524	114
HM V	2	2,591	303
HM VI	4	5,944	438

APPENDIX II. Bird species in the Pecos River Valley and their group affiliation. Birds/40 ha in CW II, CW V, SC IV, and HM V during summer and winter seasons are given. These habitats were the most important in overall species richness and/or total density. Species for which zero densities are shown for the listed habitats occurred in other habitats and/or other seasons not treated in this appendix. Summer densities are from June, July, August 1980. Winter densities are from December, January, February 1979–1980 and 1980–1981.

Group/species	Summer				Winter			
	CW II	CW V	SC IV	HM V	CW II	CW V	SC IV	HM V
Granivores								
Ring-necked Pheasant (*Phasianus colchicus*)	0	2	8	0	0–0	0	1–1	0–0
Northern Bobwhite (*Colinus virginianus*)	2	0	1	0	0–0	0–0	0–0	0–0
Scaled Quail (*Callipepla squamata*)	0	0	1	1	0–0	0–0	0–0	6–9
Mourning Dove (*Zenaida macroura*)	140	51	103	0	220–61	0–0	0–0	0–3
Sage Sparrow (*Amphispiza belli*)					0–0	0–0	0–0	3–2
Song Sparrow (*Melospiza melodia*)					0–0	0–0	3–1	1–0
Lincoln's Sparrow (*Melospiza lincolnii*)					0–0	0–0	0–0	0–0
Swamp Sparrow (*Melospiza georgiana*)					0–0	0–0	0–0	0–0
White-crowned Sparrow (*Zonotrichia leucophrys*)					0–0	0–0	82–46	45–2
Dark-eyed Junco (*Junco hyemalis*)					0–19	243–72	30–81	0–0
House Finch (*Carpodacus mexicanus*)	0	10	6	2	0–0	0–2	1–0	0–0
Lesser Goldfinch (*Carduelis psaltria*)	0	0	0	0	0–0	0–0	0–0	0–0
Winter-visiting insectivores								
Say's Phoebe (*Sayornis saya*)					0–0	1–0	1–0	0–2
Brown Creeper (*Certhia americana*)					0–3	0–1	0–0	0–0
Bewick's Wren (*Thryomanes bewickii*)					0–0	5–8	17–15	8–2
Ruby-crowned Kinglet (*Regulus calendula*)					0–0	3–3	2–4	1–1
Hermit Thrush (*Catharus guttatus*)					0–0	0–0	1–1	0–0
American Robin (*Turdus migratorius*)					1–0	0–8	0–1	0–2
Green-tailed Towhee (*Pipilo chlorurus*)					0–0	0–0	0–1	1–0
Summer-visiting insectivores								
Yellow-billed Cuckoo (*Coccyzus americanus*)	7	5	8	1				
Lesser Nighthawk (*Chordeiles acutipennis*)	1	1	0	1				
Common Nighthawk (*Chordeiles minor*)	0	4	1	4				
Black-chinned Hummingbird (*Archilochus alexandri*)	14	0	0	0				
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	26	3	0	0				
Ash-throated Flycatcher (*Myiarchus cinerascens*)	1	12	1	3				
Western Kingbird (*Tyrannus verticalis*)	9	30	4	1				
Northern Mockingbird (*Mimus polyglottos*)	53	21	49	9				
Yellow-breasted Chat (*Icteria virens*)	0	4	6	0				
Summer Tanager (*Piranga rubra*)	13	4	1	0				
Blue Grosbeak (*Guiraca caerulea*)	7	23	31	2				

APPENDIX II. Continued.

Group/species	Summer				Winter			
	CW II	CW V	SC IV	HM V	CW II	CW V	SC IV	HM V
Indigo Bunting (*Passerina cyanea*)	0	1	1	1				
Painted Bunting (*Passerina ciris*)	0	0	8	1				
Cassin's Sparrow (*Aimophila cassinii*)	0	0	1	3				
Lark Sparrow (*Chondestes grammacus*)	10	40	5	2				
Common Grackle (*Quiscalus quiscula*)	124	0	0	0				
Brown-headed Cowbird (*Molothrus ater*)	2	6	25	4				
Northern Oriole (*Icterus galbula*)	18	30	8	1				
Permanent-resident insectivores								
Greater Roadrunner (*Geococcyx californianus*)	0	1	9	2	0–0	0–1	3–1	0–0
Ladder-backed Woodpecker (*Picoides scalaris*)	5	7	0	1	2–6	1–4	0–0	2–2
Northern Flicker (*Colaptes auratus*)	11	21	0	0	12–9	13–16	4–7	0–0
Blue Jay (*Cyanocitta cristata*)	0	0	0	0	3–0	0–0	0–0	0–0
Verdin (*Auriparus flaviceps*)	0	0	0	0	0–0	0–0	0–0	1–1
Cactus Wren (*Campylorhynchus brunneicapillus*)	0	0	0	2	0–0	0–0	0–0	1–1
Eastern Bluebird (*Sialia sialis*)	0	0	0	0	0–4	0–0	0–0	0–0
Crissal Thrasher (*Toxostoma crissale*)	0	1	5	4	0–0	0–0	3–3	2–2
Loggerhead Shrike (*Lanius ludovicianus*)	1	0	1	2	0–0	3–1	0–0	1–1
European Starling (*Sturnus vulgaris*)	1	1	0	0	4–12	1–1	0–0	0–0
Pyrrhuloxia (*Cardinalis sinuatus*)	0	0	2	7	0–0	0–0	0–0	2–0
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	0	0	10	0	0–0	0–0	6–8	1–1
Black-throated Sparrow (*Amphispiza bilineata*)	0	0	1	21	0–0	0–0	0–0	10–7
Total species	19	22	25	22	6–7	8–11	13–14	15–15
Total individuals/40 ha	445	287	298	75	242–116	271–117	154–170	84–38