Responses of Riparian Species to Agricultural Habitat Conversions[1]

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Abstract.--Approximately 1100 ha of agricultural land and 540 ha of riparian habitats were censused over a 14-month period in the lower Colorado River Valley to examine relative use of these areas by riparian birds. We found that many species did not use agricultural lands at all; insectivorous species suffered severe losses through agricultural conversions, whereas fringillids, doves, some flycatchers, and the Brown-headed Cowbird used agricultural areas to a high degree. Riparian birds seemed to travel either very short distances into agricultural areas on rare occasions, or they frequently traveled great distances into those areas. Distance traveled from riparian vegetation was correlated with density and number of riparian species as were weedy margins, canals, and alfalfa (Medicago sativa). Also, agricultural-riparian edge was beneficial to certain species.

INTRODUCTION

Historically, riparian vegetation has been removed for many reasons (Ohmart, et al. 1977). More recently, riparian vegetation has often been cleared for agricultural purposes (approximately 1200 ha per year along the lower Colorado River). Natural ecosystems are challenged worldwide by the increasing demand for food and fiber by the ever burgeoning human population. Modern agricultural practices are less and less influenced by the constraints of natural systems and they present a real threat to wildlife existence (Davidson and Lloyd 1977).

A large portion of the lower Colorado River Valley is intensively farmed. Riparian communities are continuing to be extirpated, with a consequent loss of a certain segment of the riparian avifauna and replacement by other groups of birds. To date it is not known 1) which riparian species are lost when riparian vegetation is cleared; 2) if any riparian birds are benefited by adjacent agricultural land; 3) how far riparian birds will travel from riparian vegetation into agricultural areas; or 4) what factors (crops, weedy margins, farm buildings) in agricultural situations produce the most attractive situation for riparian birds. In this report we address only those questions concerned with the consequences of agricultural replacement of riparian vegetation to riparian bird species. In subsequent reports we will focus our attention on new bird species which are attracted to agricultural situations.

We census about 1700 ha of agricultural land every month along that portion of the Colorado River extending from Davis Dam, located on the Nevada and Arizona border, south to the International Boundary. Data for this report come from about 1100 ha of agricultural land located on the Colorado River Indian Reservation south of Parker, Yuma County, Arizona. Data were gathered each month between January 1977 and February 1978.

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METHODS

We censused nine transects totaling 43 km of agricultural land two or three times each month using a direct count technique. Density estimates (number of birds per 40 ha) for each month represent an average for censuses taken during a given month. Seven of the nine transects (each 4.8 km long) were located at different distances from riparian vegetation. The first was an agricultural-riparian vegetation edge; others were located at 0.4 km, 1.2 km, 1.6 km (2 transects), 2.0 km, and 2.4 km (2 transects) from riparian vegetation.

We censused a total of 5.8 km of transects in structural type IV cottonwood-willow (Populus fremontii-Salix spp.), 12.2 km of type IV honey mesquite (Prosopis velutina), and 3.1 km of type IV salt cedar (Tamarix chinensis) two or three times each month in the study area during the same period of time in order to obtain density and diversity of riparian birds. (For an explanation of how the vegetation was classified see Anderson, et al. 1977). Type IV vegetation was used for comparison with agricultural situations because it is the most common type in the lower Colorado River Valley (Anderson and Ohmart 1976). Density estimates (number of birds per 40 ha) represented averages of the monthly censuses. We used a modified Emlen census technique (Emlen 1971, 1977; Anderson, et al. 1977; Anderson and Ohmart 1977) for censusing riparian communities. For the sake of brevity, analysis of the other structural types is not dealt with herein. Censuses of agricultural-riparian edge situations were taken in January, March, June, July, October, November, December 1977 and January, February 1978.

In evaluating riparian species use of agricultural areas we first had to determine which species were "riparian." This determination was based on a list totaling 63 bird species present in cottonwood-willow, honey mesquite, and salt cedar communities over five seasons. Forty-one of these typical riparian species were present in agricultural areas at one or more seasons. The five seasons corresponded to major changes in avian community composition and population structure and included winter (December through February), spring (March, April), summer (May through July), late summer (August, September), and fall (October, November).

All swallows, swifts, hawks, falcons, shorebirds, wetland birds except marsh wrens, and species which only occurred as transients were omitted from the analysis. Monthly density estimates of each riparian species were determined for each of the five community types. The maximum distance (up to 2.4 km) to which each riparian species traveled into agricultural areas from riparian vegetation was recorded. We determined the average density of each species and the maximum distance traveled by summing the density of each species at its farthest distance and dividing by the number of months that the species traveled that far into agricultural areas. The average density throughout agricultural transects for a given species was incorporated for the corresponding months. An appearance at the greatest distance from riparian vegetation for a given species, even if it was only a single detection for one month, determined the maximum distance traveled.

Based on the number of months a species was present in agricultural areas relative to the number of months it was present in the valley, we devised a travel status for each riparian species observed in agricultural lands. We also did this in the riparian communities. Permanent residents included those species present in the river valley during all months, summer residents were those present for up to six months (April through September), and winter residents were those present for up to eight months (September through April). Where overlaps occurred, species were placed in the season representing their principal time of occurrence. Permanent residents observed in a particular community for only one to three months were considered rare in that community, those observed four to seven months were considered occasional, and those species present eight to 14 months were considered common. Summer residents observed in a particular habitat during only one month were considered rare, those observed two to three months were considered occasional, and those species observed four to six months were considered common in that community type. Winter residents present in a particular community type one to two months were considered rare; three to four months, occasional; and five to eight months, common. In the remainder of this report the term status will refer only to numbers of months present and will not be used to indicate numbers of individuals present during these months.

From the monthly composition of species and their status, we determined the time of year during which rare and occasional species traveled into agricultural areas. This was evaluated for annual residents only.

RESULTS

Seasonal Density and Diversity of Riparian Species Among Community Types

Seasonal densities of riparian species were consistently higher in the agricultural-riparian edge than in the other habitat types (fig. 1). Cottonwood-willow and honey mesquite densities were consistently higher than those in salt cedar and agricultural areas. Densities in salt cedar and agricultural areas were similar except in summer, when densities were greater in salt cedar. This is attributable almost entirely to the influx of large numbers of White-winged Doves (Zenaida asiatica) and Mourning Doves (Zenaida macroura) into salt cedar.

The density of White-crowned Sparrows (Zonotrichia leucophrys) and Gambel Quail

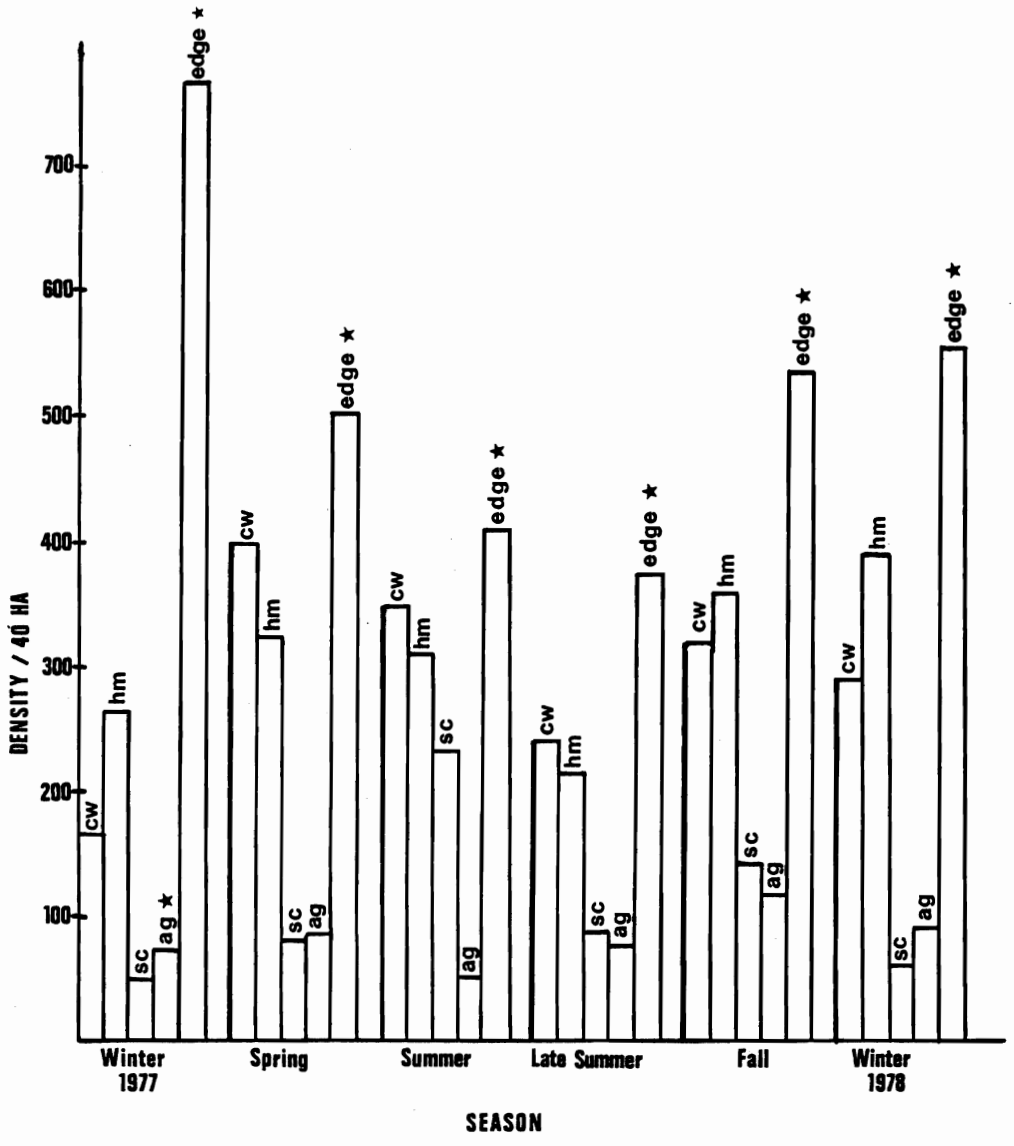

Figure 1.--The average seasonal density (n per 40 ha) of all riparian bird species in the riparian community types, agricultural areas, and the agricultural-riparian edge. Cw represents cottonwood-willow; hm, honey mesquite; sc, salt cedar; ag, agricultural areas. The * indicates that the average was for fewer months than all those included in the season.

(Lophortyx gambelii) were consistently largest in the agricultural riparian edge and accounted for a large proportion of the population in the edge community (Table 1). Other species with greatest densities in the agricultural-riparian edge during a majority of the months in which they were present in the valley included the Loggerhead Shrike (Lanius ludovicianus), Yellow-rumped Warbler (Dendroica coronata), Verdin (Auriparus flaviceps), and Brewer Sparrow (Spizella breweri). All of these species except the Verdin were considered common in agricultural areas and therefore seemed to benefit from the agricultural-riparian edge (Table 2). Verdins may benefit from the nearness of agricultural areas, but they rarely venture from the riparian vegetation into agricultural lands. The rest of the 35 riparian species showed a greater density in the riparian communities a majority of the months. Only seven riparian species (Ground Dove, Columbina passerina, Brewer Sparrow, House Finch, Carpodacus mexicanus, Western Kingbird, Tyrannus verticalis, Chipping Sparrow, Spizella passerina, Say Phoebe, Sayornis saya, and Brown-headed Cowbird, Molothrus ater) had a greater density in agricultural areas than in riparian communities for a majority of the months during which they were present.

Table 1.--The average seasonal density (n per 40 ha) of the Gambel Quail and White-crowned Sparrow in agricultural-riparian edge compared to average total density of riparian species there.

	Season					
Density	Winter 1977	Spring 1977	Summer 1977	Late Summer 1977	Fall 1977	Winter 1978
$\bar{X}$ Total Density Riparian Species	765	505	410	377	581	556
$\bar{X}$ Density White-crowned Sparrow	326 (42.6%)	192 (38.0%)	-	-	283 (48.7%)	247 (44.4%)
$\bar{X}$ Density Gambel Quail	59 (7.7%)	96 (19.0%)	76 (18.5%)	187 (49.6%)	61 (10.5%)	37 (6.7%)

Table 2.--The status of 41 riparian species in agricultural areas, the agricultural-riparian edge, and three riparian community types. (Code: R = rare; O = occasional; C = common.)

Species	Agricultural Areas	Edge	Cottonwood-Willow	Honey Mesquite	Salt Cedar
Permanent Residents					
Gambel Quail, Lophortyx gambelii	C	C	C	C	C
Mourning Dove, Zenaida macroura	C	C	C	C	C
Ground Dove, Columbina passerina	O	R	R	O	O
Inca Dove, Scardafella inca	R	-	R	R	R
Roadrunner, Geococcyx californianus	C	C	O	C	O
Common Flicker, Colaptes auratus	O	O	C	C	C
Gila Woodpecker, Melanerpes uropygialis	R	R	C	C	R
Ladder-backed Woodpecker, Picoides scalaris	R	C	C	C	C
Black Phoebe, Sayornis nigricans	O	O	C	R	R
Verdin, Auriparus flaviceps	R	C	C	C	C
Cactus Wren, Campylorhynchus brunneicapillus	R	O	O	C	O
Long-billed Marsh Wren, Cistothorus palustris	O	R	C	R	R
Mockingbird, Mimus polyglottos	O	O	R	C	R
Crissal Thrasher, Toxostoma dorsale	R	C	C	C	C

Table 2. Continued.

Species	Agricultural Areas	Edge	Cottonwood-Willow	Honey Mesquite	Salt Cedar
Permanent Residents (Continued)					
Black-tailed Gnatcatcher, Polioptila melanura	R	C	C	C	C
Loggerhead Shrike, Lanius ludovicianus	C	C	C	C	O
Brown-headed Cowbird, Molothrus ater	C	O	O	O	O
House Finch, Carpodacus mexicanus	C	O	O	O	O
Abert Towhee, Pipilo aberti	C	C	C	C	C
Summer Residents (April - September)					
White-winged Dove, Zenaida asiatica	C	C	C	C	C
Lesser Nighthawk, Chordeiles acutipennis	O	-	O	C	C
Ash-throated Flycatcher, Myiarchus cinerascens	R	C	C	C	C
Wied Crested Flycatcher, Myiarchus tyrannulus	R	-	C	-	-
Western Kingbird, Tyrannus verticalis	C	C	C	O	R
Northern Oriole, Icterus galbula	C	C	C	C	O
Summer Tanager, Piranga rubra	R	-	C	R	R
Blue Grosbeak, Guiraca caerulea	O	C	C	O	C
Winter Residents (September/October - April)					
Say Phoebe, Sayornis saya	C	C	C	R	O
House Wren, Troglodytes aedon	R	C	C	C	C
Bewick Wren, Thryomanes bewickii	R	C	C	C	C
American Robin, Turdus migratorius	R	-	C	C	O
Mountain Bluebird, Sialia currucoides	R	R	R	R	R
Ruby-crowned Kinglet, Regulus calendula	R	C	C	C	C
Orange-crowned Warbler, Vermivora celata	C	C	C	C	C
Yellow-rumped Warbler, Dendroica coronata	C	C	C	C	C
Sage Sparrow, Amphispiza belli	O	R	R	O	R
Dark-eyed Junco, Junco hyemalis	C	O	C	C	O
Chipping Sparrow, Spizella passerina	O	R	O	R	R
Brewer Sparrow, Spizella breweri	C	O	R	O	R
White-crowned Sparrow, Zonotrichia leucophrys	C	C	C	C	C
Lincoln Sparrow, Melospiza lincolnii	C	C	C	R	R

Species numbers showed a pattern similar to that exhibited by densities, with the exception of the agricultural-riparian edge (fig. 2); cottonwood-willow and honey mesquite communities had more riparian species than were found in agricultural areas and salt cedar. In four of the six seasons encompassed by the study presented in figure 2 (spring, summer and fall 1977 and winter 1977-78), agricultural areas and salt cedar had a number of species more similar to each other than to the other community types.

Agricultural situations and salt cedar had lower densities and number of species than other riparian community types. It may be more than coincidental that both of these communities are exotic in the valley.

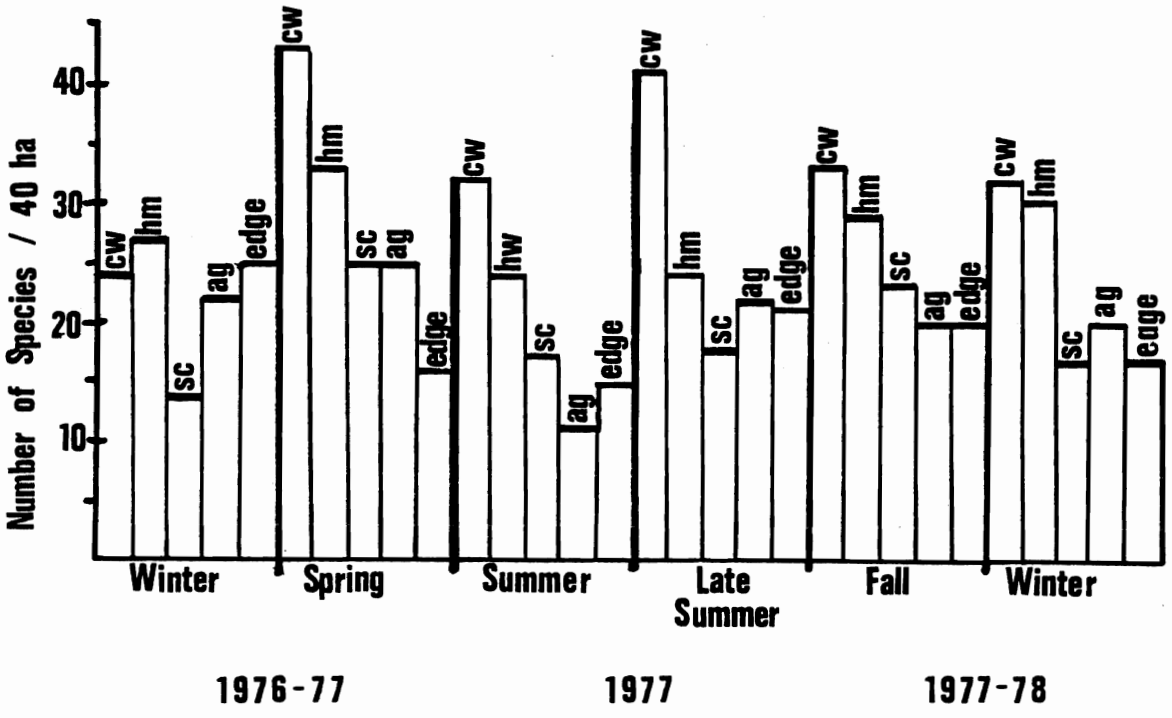

Figure 2.--The average number of riparian species (n per 40 ha) by season in the riparian community types, agricultural areas, and the agricultural-riparian edge. Cw represents cottonwood-willow; hm, honey mesquite; sc, salt cedar; ag, agricultural areas.

Status

The status of riparian species is presented in Table 2. Cottonwood-willow, honey mesquite, salt cedar, and the agricultural-riparian edge all shared 10 species, the status of which was lower in agricultural areas than in riparian vegetation (one tyrannid, two picids, seven insectivores), and all communities had only one species (a fringillid) whose status increased from riparian to agricultural areas. The proportions and composition of riparian species whose status either stayed the same or changed in the riparian communities relative to agricultural areas differed in each community (Appendix I).

The greatest proportion (37 percent) of species with an increased status in agricultural areas occurred in salt cedar (Table 3). Cottonwood-willow had the least (15 percent) species in this category. Cottonwood-willow and honey mesquite had the greatest number of species with an increased status in riparian habitat (42 percent and 34 percent, respectively). Thirty-two to 44 percent of the species had a similar status relative to agricultural lands in the riparian habitats.

Distance Traveled From Riparian Vegetation

For annual, summer, and permanent residents we attempted to determine the maximum travel distance from riparian vegetation for each species (fig. 3). These fall into two major groups: those which traveled up to 0.4 km (16 species), and those which traveled to nearly the maximum distance (2.4 km) from riparian vegetation (17 species). Additionally, 8 species traveled intermediate distances.

Of those species which traveled 0.4 km or less, 11 occurred rarely, 2 occurred occasionally, and 3 occurred commonly in agricultural areas. Of those species which traveled 2.0 to 2.4 km from riparian vegetation, 13 were common, 4 were occasional, and none were rare. Plainly, species which rarely use agricultural lands tend not to travel far into them (11 of 15 species) and species common in agricultural lands

Table 3.--Status summary of 41 riparian species in agricultural areas. Status is number of months present, not density. Species in each community type are compared relative to agricultural areas. Species numbers refer to increases or decreases from riparian to agricultural areas.

Community	Number of Riparian Species			
	Lower in Agricultural Areas	Equal in Agricultural Areas	Higher in Agricultural Areas	Total
Salt Cedar	13 (31.7%)	13 (31.7%)	15 (36.6%)	41
Honey Mesquite	14 (34.2%)	17 (41.4%)	10 (24.4%)	41
Cottonwood-Willow	17 (41.5%)	18 (43.9%)	6 (14.6%)	41
Agricultural-Riparian Edge	10 (24.4%)	18 (43.9%)	13 (31.7%)	41

generally travel throughout those areas (17 of 21 species). Species which occurred occasionally in agricultural areas showed no consistent pattern relative to distance traveled into those areas (fig. 3). All of the species which traveled less than 0.4 km had a rare status in agricultural areas.

Those species commonly occurring in agricultural lands but which did not travel far into those areas included the Roadrunner (Geococcyx californianus), Abert Towhee (Pipilo aberti), Gambel Quail, and Dark-eyed Junco (Junco hyemalis), all ground feeding species. Gambel Quail showed a concentrated density at the agricultural-riparian edge. Commonly occurring species which traveled throughout agricultural areas included 6 fringillids, 2 warblers, 2 doves, 2 flycatchers, the Brown-headed Cowbird, Northern Oriole (Icterus galbula), Loggerhead Shrike, Mockingbird (Mimus polyglottos), and Long-billed Marsh Wren (Cistothorus palustris).

Species traveling short distances into agricultural lands which had a rare status were 2 woodpeckers, 4 small insectivores, 2 flycatchers, the Mockingbird, Bewick Wren (Thryomanes bewickii), and Ground Dove. Rare species traveling farther into agricultural areas included the American Robin (Turdus migratorius), Summer Tanager (Piranga rubra), and Cactus Wren (Campylorhynchus brunneicapillus).

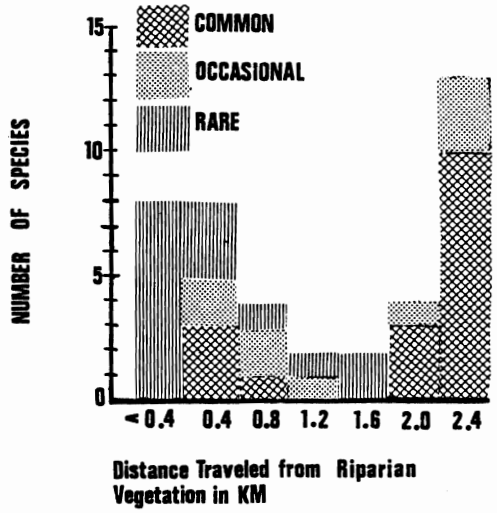

Figure 3.--The number of riparian species of each status (status throughout agricultural areas) and the maximum distance they traveled from riparian vegetation into agricultural areas.

Effect of Distances on Riparian Species Densities

We compared the average density of riparian species at their maximum distance from riparian vegetation and their average density throughout all of the agricultural areas censused. (Riparian species occurring rarely in agricultural areas were omitted from this analysis, as were those which traveled less than 0.4 km from riparian vegetation; the effect of distance on these species is obvious.) These two averages revealed that 54 percent (14 of 26) of the occasional and common status riparian species showed a lower density at maximum distance traveled into agricultural areas (fig. 4, Appendix II). Only 4 of the 9 fringillid species had smaller densities at maximum distances from riparian vegetation.

Seasonal Use of Agricultural Areas By Permanent Resident Riparian Species

Nineteen permanent resident riparian species occurred in agricultural situations;

seven of these occurred commonly, five occurred occasionally, and seven occurred rarely. A majority of the common users were in agricultural areas the year around; only the Loggerhead Shrike was present on a seasonal basis, from August through February. Of the occasional users, the Long-billed Marsh Wren was present in agricultural areas from October through February; the Black Phoebe (Sayornis nigricans) occurred only from December through March; the Common Flicker (Colaptes auratus) appeared in agricultural areas from October through March; the Mockingbird occurred only between March and September.

Species considered rare in riparian vegetation occurred in agricultural areas in winter and early spring months and/or September and/or October. Five rare species were in agricultural areas in the winter-early spring, five were in agricultural areas during late summer, and three rare status species were present once during both seasons.

Agricultural Factors Associated With Greatest Densities and Diversities of Riparian Species

Multiple regression analysis indicated that there were two primary factors correlated with densities and diversities of riparian birds in agricultural areas for each month. Distance from riparian vegetation was a factor most often correlated with both density and number of riparian species in agricultural situations (Tables 4 and 5). The presence of canals and weedy margins was among the most important

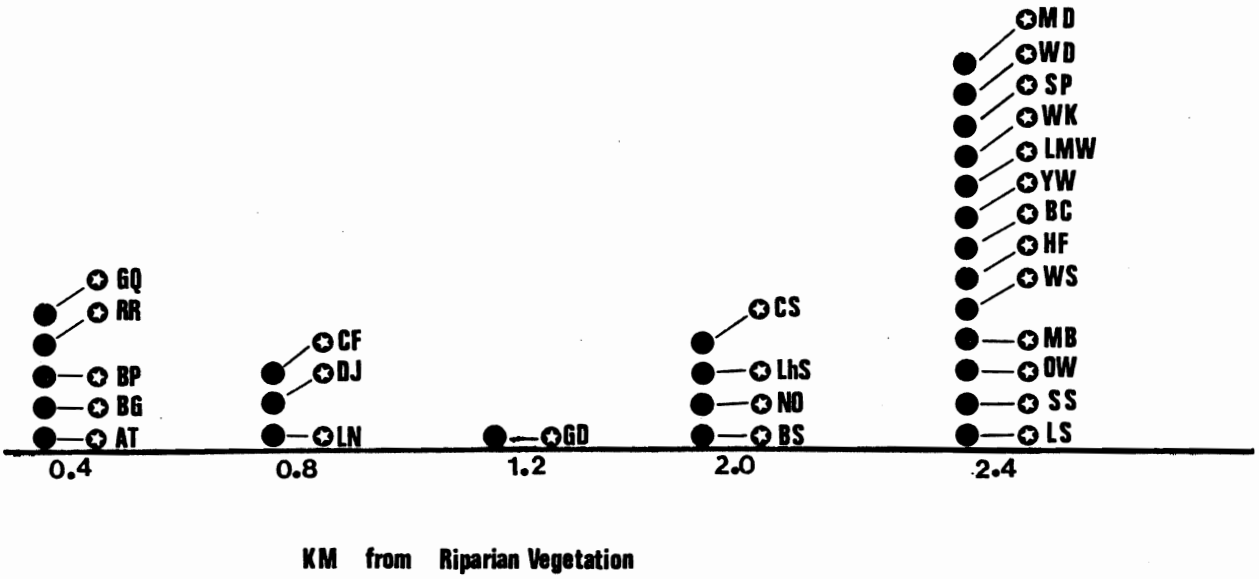

Figure 4.--Density changes of riparian species at their maximum distance traveled into agricultural areas from their density throughout agriculture. The horizontal lines mean that the density was the same or greater at the maximum distance. The angled lines mean a drop in density at the maximum distance. The species are placed at the maximum distance which they traveled into agricultural areas. Rare status species were omitted.

GQ=Gambel Quail
RR=Roadrunner
BP=Black Phoebe
BG=Blue Grosbeak
AT=Abert Towhee
CF=Common Flicker
DJ=Dark-eyed Junco
LN=Lesser Nighthawk
GD=Ground Dove
CS=Chipping Sparrow
LhS=Loggerhead Shrike
NO=Northern Oriole
BS=Brewer Sparrow
MD=Mourning Dove
WD=White-winged Dove
SP=Say Phoebe
WK=Western Kingbird
LMW=Long-billed Marsh Wren
YW=Yellow-rumped Warbler
BC=Brown-headed Cowbird
HF=House Finch
WS=White-crowned Sparrow
MB=Mockingbird
OW=Orange-crowned Warbler
SS=Sage Sparrow
LS=Lincoln Sparrow

Table 4.--Months when different field types and distance from riparian vegetation were the most important factors correlating with riparian species' densities in agricultural areas. The months for which R values are listed are the months when the test was significant ($p<0.05$ level).

	Year and Month													
	1977											1977	1978	
Factors	01	02	03	04	05	06	07	08	09	10	11	12	01	02
Distance	X	X	X	X		X	X	X*		X		X	X	
Canals	X	X					X	X		X	X		X	
Weedy Margins			X	X		X			X			X		X
Alfalfa					X			X	X					X
Pasture											X			
Wheat					X									
R^2 Value	0.869	0.824	0.737	-	-	0.483	0.451	-	-	-	-	0.667	0.505	-
R Value	0.928	0.908	0.858	-	-	0.695	0.671	-	-	-	-	0.817	0.711	-

*Those months with 3 field types had a field type as a most important factor with each of two other field types. The R values were exactly the same in the 2 sets of pairs. The starred field type was the one most important in both combinations.

Table 5.--Months when different field types and distance from riparian vegetation were the most important factors correlating with number of riparian species in agricultural areas. The months for which R values are listed are the months when the test was significant ($p<.0.05$ level).

	Year and Month													
	1977											1977	1978	
Factors	01	02	03	04	05	06	07	08	09	10	11	12	01	02
Distance	X	X	X	X	X	X*	X	X	X	X	X	X	X	X
Canals												X	X	
Weedy Margins	X					X	X							
Alfalfa		X	X	X				X	X		X		X	X
Pasture										X				
Inhabited Areas					X	X								
R^2 Value	0.640	-	-	-	0.827	0.727	0.716	0.735	0.755	0.785	0.579	0.842	0.814	-
R Value	0.800	-	-	-	0.910	0.852	0.846	0.857	0.869	0.886	0.761	0.918	0.902	-

*See note on Table 4.

factors correlated with density in 13 of 14 months (Table 4) and with number of species in 5 of 14 months (Table 5). The presence of alfalfa was an important factor correlated with density in four months; and with the number of species in 8 of 14 months. The density of riparian species was most often correlated with the presence of canals and weedy margins in conjunction with distance from riparian vegetation, whereas the number of riparian species was most often correlated with the presence of alfalfa in conjunction with canals and weedy margins and with the distance from riparian vegetation. Three other situations (presence

of pasture, wheat, or inhabited areas) were sporadically correlated with density and number of riparian species.

In 11 of 14 months, densities were dominated by one or two species (accounting for 46 percent or more of the total). In fall, winter, and spring, those species were the White-crowned Sparrow and/or Yellow-rumped Warbler, or Brown-headed Cowbird. In summer, densities were dominated by Mourning and White-winged doves. These species were strong influences on density correlations with field types.

In winter, early spring (March), and summer the correlations of agricultural situations with densities of riparian species were significant ($p \leq 0.05$), with the combined agricultural factors accounting for 45 to 87 percent of the variation in densities (Table 4) during these months. Significant correlations included only canals, weedy margins, and distance as most important factors. Densities of the above mentioned species were apparently enhanced by the presence of noncultivated situations (weedy margins and canals), especially when the areas were close to riparian vegetation.

From May through January the correlations with the number of riparian species were significant ($p \leq 0.05$), and the most significant pair of agricultural factors accounted for 58 to 84 percent of the variance, suggesting that distance from riparian vegetation in combination with one of the five field types was an important factor when considering number of riparian species present in agricultural areas (Table 3).

There was a greater number of significant correlations between agricultural variables and number of riparian species present than with density, and the correlations tended to be higher. This suggests that the complexity of factors involved in explaining the presence of riparian species may be less than the complexity of factors involved in explaining density of riparian species in agricultural areas.

DISCUSSION

In evaluating riparian bird use of agricultural areas, it is important 1) to consider the status and population level of the species in a riparian situation relative to that in agricultural areas, 2) to know when a species appears in agricultural areas, and 3) to realize whether its presence is directly related to the goals of agriculture or whether it is incidental or even antithetical to agricultural goals.

The value of agricultural situations to riparian species is limited if a species occurs in a high density in riparian habitat but occurs rarely in agricultural situations, or if a species occurs more commonly in agricultural areas compared to riparian habitat but in a lower density relative to other riparian communities. Additionally, if a species common in agricultural areas is there because of nearness to riparian vegetation (often a largely fortuitous matter) or because of the presence of weedy margins (a situation often opposed to agricultural goals), any apparent value of agricultural areas should be evaluated with caution.

Densities and Status

Our data showed that with respect to densities of riparian birds, agricultural situations did not support populations as large as most species in native riparian communities. There were 25 species whose status was similar or increased in agricultural areas relative to any one or more of the riparian community types, but 17 of these had lower densities in agricultural areas. Thus the value of agricultural areas to these birds is limited. If one defines a valuable habitat as one in which a species' density and status remains the same or increases relative to other habitats, there were only 8 (19.5 percent) of 41 riparian species observed in agricultural areas in this category. There were an additional 21 riparian species which did not use agricultural areas (Appendix III). The loss to agricultural areas of any community type of riparian vegetation analyzed herein would result in dramatic changes in the status and density of strictly insectivorous species.

Impact Caused by Loss of Salt Cedar

The loss of salt cedar to agricultural situations would be less detrimental to riparian species than loss of any other riparian community type. In fact, some species other than insectivores might be enhanced by such losses; there would be changes in species composition. This is not the case with loss of cottonwood-willow and honey mesquite communities. There were more species which preferred (as determined by frequency of appearance, not density) agricultural areas to salt cedar than there were species which preferred agricultural areas to cottonwood-willow or honey mesquite. Less than 20 percent of the species preferred agricultural areas to cottonwood-willow and approximately 25 percent preferred it to honey mesquite, whereas over 33 percent of the species

preferred agricultural areas to salt cedar. Although the greatest number of species were seen to hold a status in agricultural lands equivalent to honey mesquite, cottonwood-willow, and the riparian edge, it should be remembered that only a few of them had a density equivalent to or higher in agricultural areas as compared to the riparian communities.

Total Number of Birds in Agricultural Areas

The replacement of riparian vegetation by agricultural areas does not necessarily result in a decline in the total number of birds per unit area, because a different assemblage of species is attracted to agricultural areas. No matter how negative agricultural areas may be for riparian birds, it would be an error to assume that it has an overall negative value to birds in general. Data presentation and discussion are beyond the scope of this paper, but we have data (unpublished) which indicate that total bird densities in agricultural land often remain as high or higher than in riparian vegetation.

Effect of Agricultural-Riparian Edge

Agriculture is not entirely detrimental to all riparian species, since densities of some species increased in agricultural-riparian edge areas. Although these densities were dominated by a few species, all were found to be species having a common status in agricultural areas.

Agricultural-riparian situations could be used as a mitigating measure to offset losses due to agricultural encroachment. We have shown that the distance from riparian vegetation is important to density and number of riparian species in agricultural areas. The regression correlations coincide with observations that the average density decreased at maximum distance traveled in 54 percent of the riparian species. We know that if rarely visiting riparian species do go into agricultural areas they are not leaving riparian vegetation far behind. These findings, as well as knowledge that agricultural-riparian edges support a high density of riparian birds, suggest that an increase of agricultural-riparian ecotone acreage would be beneficial to riparian birds. If strips of riparian vegetation could be left at 1 km (half-mile) distances, relatively large densities of riparian species could be maintained, and birds which rarely use agricultural areas, as well as occasional and common ones, could venture into agricultural land when riparian land is cleared.

Importance of Alfalfa, Canals, and Weedy Margins

Regression analyses also revealed the potential importance of alfalfa, canals, and weedy margins to the number of riparian species present in agricultural areas. The value of alfalfa in attracting riparian species may be biased in that it is a field type often associated with weedy margins. So, whether the effect of alfalfa is contingent upon the presence of weedy margins or is solely because birds are attracted to alfalfa remains to be determined. Regression tests also suggest that the presence of canals and weedy margins enhances density and diversity of riparian species in agricultural situations. Weedy-margined agricultural areas, as opposed to cleared, barren areas, appear to be valuable in enhancing agricultural situations for riparian species.

Although these field types were correlated with density and number of riparian species in agricultural areas, the enhancement offered by them was beneficial to only a portion of birds in riparian habitat. These were the riparian species commonly seen in agricultural situations in high densities and which often showed no distance effects on their densities.

Seasonal Use of Agricultural Areas

For some species agricultural lands may not be considered a valuable habitat, but they nonetheless use it to a degree. Some annual residents use agricultural areas only on a seasonal basis. Insect biomass declined from late summer to lowest levels in winter and spring in all riparian communities (Anderson and Ohmart 1978). Berry-producing riparian vegetation is in fruit in winter. The Loggerhead Shrike, Long-billed Marsh Wren, Common Flicker, and Black Phoebe used agricultural areas only in periods of declining and low insect biomass. The Mockingbird used agricultural areas only during non-fruiting seasons for riparian vegetation. Similarly, when rare insectivorous species were in agricultural areas it was in winter and late summer. They, too, were using agricultural lands in periods of low food resource and in months during the post-breeding season. Perhaps food resource and dispersal pressures accounted for the presence of these species in agricultural situations.

In conclusion, our findings suggest that replacement of riparian vegetation has an overall negative impact on riparian avian species. Insectivorous species will be most drastically affected. Some of the loss is offset by the creation of agricultural-riparian edge in conjunction with main artery delivery canals, by the existence of weedy margins, and possibly by crops such as alfalfa. Agricultural land may serve as a food supplement to birds during winter when food resources are often depauperate for insectivores.

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Appendix I.--Status change (common, occasional, rare) in various community types relative to agricultural areas (Ag). The designations CW, HM, and SC refer to Cottonwood-willow, Honey Mesquite, and Salt Cedar communities, respectively.

Species whose status stayed the same in:

Ag-CW	Ag-HM	Ag-SC	Ag-Riparian Edge
Gambel Quail (*Lophortyx gambelii*)	Gambel Quail	Gambel Quail	Gambel Quail
Mourning Dove (*Zenaida macroura*)	Mourning Dove	Mourning Dove	Mourning Dove
White-winged Dove (*Zenaida asiatica*)	White-winged Dove	White-winged Dove	White-winged Dove
Inca Dove (*Scardafella inca*)	Inca Dove	Inca Dove	Roadrunner
Lesser Nighthawk (*Chordeiles acutipennis*)	Roadrunner	Ground Dove	Gila Woodpecker
Say Phoebe (*Sayornis saya*)	Wied Crested Flycatcher	Gila Woodpecker	Common Flicker
Western Kingbird (*Tyrannus verticalis*)	Mountain Bluebird	Wied Crested Flycatcher	Say Phoebe
Mountain Bluebird (*Sialia currucoides*)	Loggerhead Shrike	Mountain Bluebird	Black Phoebe
	Orange-crowned Warbler	Orange-crowned Warbler	Western Kingbird
	Yellow-rumped Warbler	Yellow-rumped Warbler	Mockingbird
	Northern Oriole	Summer Tanager	Mountain Bluebird
	Summer Tanager	Abert Towhee	Loggerhead Shrike
	Blue Grosbeak	White-crowned Sparrow	Orange-crowned Warbler
	Abert Towhee		Yellow-rumped Warbler
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Appendix I. Continued.

Species whose status stayed the same in (cont'd):

Ag-CW	Ag-HM	Ag-SC	Ag-Riparian Edge
Loggerhead Shrike (*Lanius ludovicianus*)	Sage Sparrow		Northern Oriole
Orange-crowned Warbler (*Vermivora celata*)	Dark-eyed Junco		Abert Towhee
Yellow-rumped Warbler (*Dendroica coronata*)	White-crowned Sparrow		White-crowned Sparrow
Northern Oriole (*Icterus galbula*)			Lincoln Sparrow
House Finch (*Carpodacus mexicanus*)			
Abert Towhee (*Pipilo aberti*)			
Dark-eyed Junco (*Junco hyemalis*)			
Chipping Sparrow (*Spizella passerina*)			
White-crowned Sparrow (*Zonotrichia leucophrys*)			
Lincoln Sparrow (*Melospiza lincolnii*)			

Species whose status was greater in the riparian:

Ag-CW	Ag-HM	Ag-SC	Ag-Riparian Edge
Gila Woodpecker (*Melanerpes uropygialis*)	Lesser Nighthawk	Lesser Nighthawk	Ladder-backed Woodpecker
Ladder-backed Woodpecker (*Picoides scalaris*)	Gila Woodpecker	Ladder-backed Woodpecker	Common Flicker
Common Flicker (*Colaptes auratus*)	Ladder-backed Woodpecker	Common Flicker	Ash-throated Flycatcher
Ash-throated Flycatcher (*Myiarchus cinerascens*)	Common Flicker	Ash-throated Flycatcher	Verdin
Wied Crested Flycatcher (*Myiarchus tyrannulus*)	Ash-throated Flycatcher	Verdin	House Wren
Black Phoebe (*Sayornis nigricans*)	Verdin	House Wren	Bewick Wren
Verdin (*Auriparus flaviceps*)	House Wren	Bewick Wren	Cactus Wren
House Wren (*Troglodytes aedon*)	Bewick Wren	Cactus Wren	Crissal Thrasher
Bewick Wren (*Thryomanes bewickii*)	Cactus Wren	Crissal Thrasher	Black-tailed Gnatcatcher
Cactus Wren (*Campylorhynchus brunneicapillus*)	Mockingbird	American Robin	Ruby-crowned Kinglet
	Crissal Thrasher	Black-tailed Gnatcatcher	Blue Grosbeak
	American Robin	Ruby-crowned Kinglet	
	Black-tailed Gnatcatcher	Blue Grosbeak	
	Ruby-crowned Kinglet		

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Appendix I. Continued

Species whose status was greater in the riparian (cont'd):

Ag-CW	Ag-HM	Ag-SC	Ag-Riparian Edge
Long-billed Marsh Wren (Cistothorus palustris			
Crissal Thrasher (Toxostoma dorsale)			
American Robin (Turdus migratorius)			
Black-tailed Gnatcatcher (Polioptila melanura)			
Ruby-crowned Kinglet (Regulus calendula)			
Summer Tanager (Piranga rubra)			
Blue Grosbeak (Guiraca caerulea)			

Species whose status was greater in agricultural areas:

Ag-CW	Ag-HM	Ag-SC	Ag-Riparian Edge
Ground Dove (Columbina passerina)	Ground Dove	Roadrunner	Ground Dove
Roadrunner (Geococcyx californianus)	Say Phoebe	Say Phoebe	Inca Dove
Mockingbird (Mimus polyglottos)	Black Phoebe	Black Phoebe	Lesser Nighthawk
Brown-headed Cowbird (Molothrus ater)	Western Kingbird	Western Kingbird	Wied Crested Flycatcher
Sage Sparrow (Amphispiza belli)	Long-billed Marsh Wren	Long-billed Marsh Wren	Long-billed Marsh Wren
Brewer Sparrow (Spizella breweri)	Brown-headed Cowbird	Mockingbird	American Robin
	House Finch	Loggerhead Shrike	Brown-headed Cowbird
	Chipping Sparrow	Northern Oriole	Summer Tanager
	Brewer Sparrow	Brown-headed Cowbird	House Finch
	Lincoln Sparrow	House Finch	Sage Sparrow
		Sage Sparrow	Dark-eyed Junco
		Dark-eyed Junco	Chipping Sparrow
		Chipping Sparrow	Brewer Sparrow
		Brewer Sparrow	
		Lincoln Sparrow	

Appendix II.--Average density (n/40 ha) of riparian species at maximum distances traveled from riparian vegetation into agricultural land and their average densities throughout agricultural land.

Species	$\bar{X}$ density at maximum distance from riparian vegetation	$\bar{X}$ density throughout agricultural areas
Gambel Quail	2	4
Mourning Dove	12	15
White-winged Dove	14	16
Ground Dove	2	2
Roadrunner	1	2
Lesser Nighthawk	1	1
Common Flicker	1	3
Black Phoebe	1	1
Say Phoebe	1	1
Western Kingbird	2	3
Long-billed Marsh Wren	1	3
Mockingbird	1	1
Loggerhead Shrike	1	1
Orange-crowned Warbler	1	1
Yellow-rumped Warbler	5	8
Northern Oriole	1	1
Brown-headed Cowbird	13	21
Blue Grosbeak	1	1
House Finch	5	7
Abert Towhee	1	1
Sage Sparrow	6	2
Dark-eyed Junco	1	3
Chipping Sparrow	5	6
Brewer Sparrow	5	5
White-crowned Sparrow	18	34
Lincoln Sparrow	4	2
Totals	106	145

Appendix III.--Riparian species lost with agricultural encroachment.

Yellow-billed Cuckoo (Coccyzus americanus)
Black-chinned Hummingbird (Archilochus alexandri)
Anna Hummingbird (Calypte anna)
Yellow-bellied Sapsucker (Sphyrapicus varius)
Brown Creeper (Certhia familiaris)
Hermit Thrush (Catharus guttata)
Western Bluebird (Sialia mexicana)
Blue-gray Gnatcatcher (Polioptila caerulea)
Cedar Waxwing (Bombycilla cedrorum)
Phainopepla (Phainopepla nitens)
Bell Vireo (Vireo bellii)
Lucy Warbler (Vermivora luciae)
Yellow-breasted Chat (Icteria virens)
Indigo Bunting (Passerina cyanea)
Evening Grosbeak (Hesperiphona vespertina)
Pine Siskin (Carduelis pinus)
Lesser Goldfinch (Carduelis psaltria)
Lawrence Goldfinch (Carduelis lawrencei)
Green-tailed Towheee (Pipilo chlorurus)
Rufous-sided Towhee (Pipilo erythrophthalmus)
Black-throated Sparrow (Amphispiza bilineata)