Influence of Agriculture on Waterbird, Wader, and Shorebird Use Along the Lower Colorado River[1]

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Abstract.--Waterbird, wader, and shorebird use of the Colorado River was restricted to habitats in or immediately adjacent to the river prior to agricultural development. We studied agricultural habitats systematically for three years and identified those agricultural settings that were most important for individual species and groups of waterbirds, waders, and shorebirds.

INTRODUCTION

The importance of riparian habitats to wildlife and their rapid disappearance in the western states has received much attention over the past 10 years. Conversion of riparian habitats to agricultural land accounts for a major portion of the loss of riparian habitats. Yet, agricultural habitats have received little attention with regard to wildlife values, with the exception of studies on interfacing agriculture-riparian situations (Carothers et al. 1974, Conine et al. 1978) and a more comprehensive study of the influence of agriculture on wildlife in the lower Colorado River valley (Anderson and Ohmart 1982). From the latter study, we report here on the factors that influence waterbird, wader, and shorebird use of agricultural areas of the lower Colorado River valley.

Although many terrestrial riparian bird species have suffered from heavy habitat loss in the conversion of land to agricultural production in the lower Colorado River valley (approximately 120,000 ha since 1890), several groups of species using agricultural habitats have increased. Waterbirds, waders, and shorebirds are among the species that have benefitted from or at least make use of agricultural features. Most waterbirds and waders are associated with open water and marsh habitats which, like agricultural areas, have increased substantially since the beginning of the 20th century (Ohmart et al. 1977). Many of these species make use of both aquatic and agricultural areas for roosting and foraging, respectively. Geese, cranes, and several heron species are examples. In addition, shoreline and sandbars are very local in distribution; whereas, agricultural areas have proven to be among the most productive habitats for finding and studying many transient and resident shorebird species on the lower Colorado River (Anderson and Ohmart 1984).

We describe agricultural features most associated with occurrence of waterbirds, waders, and shorebirds. We report habitat use by presence/absence criteria because of the erratic occurrences of some agricultural features, the flocking tendencies of some species vs. the solitary nature of others, and the overall low densities of many species treated here. Finally, we examine the minimum range of agricultural features necessary to maximize use of an area by waterbirds, waders, and shorebirds in the lower Colorado River valley.

METHODS

The general study area includes agricultural land in southwestern Arizona and southeastern California. Five localities were studied; these included the Wellton-Mohawk and Imperial-Coachella valleys, the Mohave and Colorado River Indian Reservations, and Cibola National Wildlife Refuge (Anderson and Ohmart 1982). The latter three sites are directly adjacent to the lower Colorado River.

Birds were censused along 23 4.8-km transects three times per month. Agricultural land along each transect was subdivided into 0.2- or 0.4-km sections; each section usually represented a dis-

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tinct unit containing only one field type. Sampling included the area within 0.2 km lateral to each side of the transect, and the total number of hectares censused was calculated. In addition, we measured the extent of inhabited areas, margins, canals, and feedlots.

Major crop types included cotton, alfalfa, grass, wheat, and milo. In addition, fields growing lettuce, squash, tomatoes, onions, and melons were grouped under the category of truck crops because they are structurally similar, and cultivation and harvesting techniques are similar. When a field was being changed from one crop type to another, it often was cleared; such fields were referred to as plowed. Each field type was categorized as to whether or not it was irrigated and whether the crop was > or <25 cm tall.

Waterbirds and waders were censused monthly from March 1978 through October 1980. The number of times each crop/feature type was censused and the number of times each species was present in the field type was tabulated. A significant number of occurrences in a given situation was determined by finding the proportion of that feature among the total crop/feature occurrences. This proportion was the number of times a species would be expected to have been recorded in that situation if its occurrence was purely random. A significant association between the species and the crop/feature was defined as those cases where the number of occurrences within a particular situation was significantly larger than expected at $P \leq 0.05$. The number expected was the proportion of the crop/feature occurrences in the total pool of crops and features multipled by the total number of occurrences of the species. This approach identified important crops and features for each species, and general trends among species groups were defined to maximize agricultural use by birds.

Shorebird occurrences were tabulated for March-May (vernal migration) and July-October (autumnal migration) during 1978, 1979, and 1980. These months were periods of peak occurrence for most species. Shorebird associations with crop/feature types were identified for each species as determined for waterbirds and waders. Additional analysis was used to determine overall use of crop/features by shorebirds. We determined if the number of fields with shorebirds was significantly larger or smaller than would be expected by chance ($P \leq 0.05$) for each crop/feature type. Lastly, we determined if there was a greater use of either irrigated or nonirrigated fields across all crop types from a random distribution ($P \leq 0.05$) for each shorebird species.

RESULTS

Crop/Feature Types

The most often encountered crop/feature types include, in order of highest-to-lowest frequency of occurrence, margins, nonirrigated plowed, nonirrigated alfalfa >25 cm, nonirrigated alfalfa <25 cm, and nonirrigated cotton >25 cm (table 1).

Table 1.--Number of times each field type occurred (4 ha or more) on agricultural censuses for waterbirds and waders (full three years) and shorebirds (migration periods only). N = times crop/feature censused; Prop. = proportion.

Crop/feature	Irrigated	Waders and Waterbirds N	Waders and Waterbirds Prop. of total	Shorebirds N	Shorebirds Prop. of total
Plowed	Yes	73	0.017	54	0.032
	No	468	0.109	308	0.185
Alfalfa					
>25 cm	Yes	55	0.013	34	0.020
>25 cm	No	432	0.101	162	0.097
<25 cm	Yes	49	0.011	21	0.013
<25 cm	No	393	0.092	95	0.057
Cotton					
>25 cm	Yes	75	0.018	57	0.034
>25 cm	No	388	0.091	220	0.132
<25 cm	Yes	23	0.005	12	0.007
<25 cm	No	177	0.041	99	0.059
Milo					
>25 cm	Yes	11	0.003	--	--
>25 cm	No	48	0.011	--	--
<25 cm	Yes	0	0.000	--	--
<25 cm	No	16	0.004	--	--
Wheat					
>25 cm	Yes	22	0.005	25	0.015
>25 cm	No	163	0.038	121	0.072
<25 cm	Yes	15	0.004	18	0.010
<25 cm	No	148	0.035	51	0.031
Truck crop					
>25 cm	Yes	6	0.001	3	0.002
>25 cm	No	51	0.012	29	0.017
<25 cm	Yes	9	0.002	2	0.001
<25 cm	No	82	0.019	23	0.015
Grass					
>25 cm	Yes	10	0.002	7	0.004
>25 cm	No	107	0.025	70	0.042
<25 cm	Yes	14	0.003	14	0.008
<25 cm	No	132	0.031	62	0.037
Canal	---	165	0.039	182	0.109
Margins	---	496	0.116	--	--
Inhabited	---	88	0.021	--	--

Percentage of irrigated field types for the entire census period was 8.4%, and during the period of shorebird censusing the percentage was 14.6%. Milo, margins, and inhabited areas were not used by any shorebirds so were not included in analysis for this species group.

Wading Birds

The Great Egret (Casmerodius albus), Great Blue Heron (Ardea herodias), Green-backed Heron (Butorides striatus), and Snowy Egret (Egretta thula) were associated with canals far more than with any other agricultural feature (table 2). Of these species, the Green-backed Heron was the only heron to be largely restricted to canals with this

Table 2.--Fields in which use by wading birds was significantly ($P<0.05$) greater than expected with a random distribution. IR = irrigated; NI = not irrigated; > = height greater than 25 cm; < = height less than 25 cm; + indicates presence in crop/feature but not significantly associated with it. Not all field types are represented, only those are shown that had at least one species significantly associated with it.

		Percent of total occurrences												
			Alfalfa				Plowed		Milo		Grass			Total %
Species	Total occurrences	Canals	<IR	<NI	>IR	>NI	IR	NI	>NI	<IR	>IR	<IR	<NI	sign. assoc.
Great Egret	109	55	+	15	+	+	-	-	-	-	-	-	-	70
Great Blue Heron	64	56	+	17	+	+	-	-	-	-	-	-	-	73
Green-backed Heron	37	81	-	-	-	-	-	-	-	-	-	-	-	81
Snowy Egret	26	19	8	+	4	+	-	-	-	-	+	4	-	35
Cattle Egret (Bubulcus ibis)	109	+	+	4	6	+	6	+	-	-	4	6	15	41
White-faced Ibis (Plegadis chihi)	15	+	33	-	7	-	20	-	-	-	+	7	-	67
Sandhill Crane (Grus canadensis)	74	-	+	20	+	24	+	19	8	4	+	-	-	75

eature accounting for 81% of its total occurrence n agricultural areas. Snowy and Cattle egret istributions were closest to a random distribu- ion across available agricultural features among ading species.

The Cattle Egret, White-faced Ibis, and Sand- ill Crane were not significantly associated with anals (table 2). The Cattle Egret was signifi- antly associated with plowed, alfalfa, and grass ields, but it did not matter whether the fields ere irrigated or not. In contrast, the wintering andhill Crane occurred almost exclusively in non- rrigated alfalfa, plowed, and milo fields; where- as, at the other extreme, the migratory White- aced Ibis occurred only in irrigated alfalfa, lowed, and grass fields.

Waterbirds

Grebes, cormorants, coots, and diving ducks (pochards and mergansers) were overwhelmingly ssociated with canals (table 3). Geese were ssociated exclusively with plowed, alfalfa, milo, heat, and grass fields, with all but the Snow oose occurring largely in nonirrigated fields. uddle ducks were associated both with canals and rrigated crops with two species (American Wigeon nd Northern Pintail) occuring only in irrigated ields.

Nineteen of the 25 species treated under this ategory have 100% of their occurrences associated ignificantly with one or more agricultural crop/ eature types. However, three species (Snow oose, Mallard, and Northern Pintail) have less han 60% of their occurrences associated signifi- antly with some agricultural crop/feature and hus have a more random distribution in agricul- ural habitats. Agricultural situations were most important to puddle ducks and geese, given the number of occurrences compared with other species within this group.

Shorebirds

Fifteen of 17 species of shorebirds were significantly associated with irrigated plowed fields (table 4). In addition, four species each were significantly associated with nonirrigated plowed, irrigated and nonirrigated grass <25 cm; three species with irrigated wheat >25 cm; two species each with nonirrigated alfalfa <25 cm, irrigated and nonirrigated grass >25 cm, and canals. Significant associations with field types were restricted to plowed fields for nine species with all but two of these only with irrigated plowed fields (the exceptions were Black-bellied Plover and Mountain Plover). Common Snipe and Spotted Sandpiper were associated most significantly with canals over all other crop/features.

Eight species occurred significantly more often in irrigated than in nonirrigated fields (table 4). Four species occurred significantly more often in nonirrigated than in irrigated fields. Overall, there were 26 significant associations between shorebirds and irrigated fields and 12 with nonirrigated fields, with eight species significantly associated with at least one each irrigated and nonirrigated crop/feature type.

All shorebird occurrences together indicated that they were found more often than expected by chance alone in irrigated and nonirrigated plowed, irrigated grass >25 cm and <25 cm, irrigated wheat >25 cm, and canals (table 5). Shorebirds occurred less often than expected by chance alone in non- irrigated alfalfa >25 cm, irrigated and nonirri- gated cotton >25 cm, and nonirrigated cotton

Table 3.--Agricultural crops and features with which grebes, cormorants, coots, ducks, and geese were associated with a frequency greater than expected with a random distribution. Abbreviations, symbols, and notes as in table 2.

Species	Total occurrences	Canals	Percent of total occurrences: Plowed IR	Plowed NI	Alfalfa >IR	Alfalfa >NI	Alfalfa <IR	Alfalfa <NI	Milo >IR	Milo >NI	Wheat <IR	Wheat <NI	Grass >IR	Grass <IR	Total % sign. assoc.
Pied-billed Grebe (Podilymbus podiceps)	3	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Eared Grebe (Podiceps nigricollis)	1	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Double-crested Cormorant (Phalacrocorax auritus)	1	100	-	-	-	-	-	-	-	-	-	-	-	-	100
American Coot (Fulica americana)	9	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Common Merganser (Mergus merganser)	12	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Red-breasted Merganser (M. serrator)	3	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Bufflehead (Bucephala albeola)	2	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Common Goldeneye (B. clangula)	15	80	-	-	-	-	-	-	-	-	-	-	-	-	80
Total Mergini	32	91	-	-	-	-	-	-	-	-	-	-	-	-	91
Greater Scaup (Aythya marila)	1	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Lesser Scaup (A. affinis)	4	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Redhead (A. americana)	4	25	50	-	-	-	-	-	-	-	-	-	25	-	100
Ring-necked Duck (A. collaris)	3	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Total pochards	12	75	17	-	-	-	-	-	-	-	-	-	8	-	100
Wood Duck (Aix sponsa)	1	100	-	-	-	-	-	-	-	-	-	-	-	-	100
Cinnamon Teal (Anas cyanoptera)	63	56	16	-	5	-	6	-	3	-	-	-	-	-	86
Blue-winged Teal (A. discors)	5	60	-	-	20	-	-	-	-	-	-	-	-	-	80
Green-winged Teal (A. crecca)	15	47	40	-	-	-	-	-	7	-	7	-	-	-	100
Northern Shoveler (A. clypeata)	3	33	67	-	-	-	-	-	-	-	-	-	-	-	100
Mallard (A. platyrhynchos)	12	25	33	-	-	+	-	+	-	-	-	+	-	-	58
American Wigeon (A. americana)	6	-	83	-	-	-	-	-	-	-	-	17	-	-	100
Northern Pintail (A. acuta)	27	-	48	-	-	+	-	+	7	-	-	+	-	4	59
Total puddle ducks	131	38	31	-	-	-	5	-	4	-	-	-	-	-	78
Canada Goose (Branta canadensis)	30	-	-	30	-	23	-	27	3	7	-	-	-	-	90
Brant (B. bernicla)	1	-	-	-	-	-	-	100	-	-	-	-	-	-	100
Greater White-fronted Goose (Anser albifrons)	1	-	-	-	-	-	-	100	-	-	-	-	-	-	100
Ross Goose (Chen rossii)	2	-	-	-	-	-	-	100	-	-	-	-	-	-	100
Snow Goose (C. caerulescens)	9	-	11	+	-	+	11	+	-	+	-	+	-	-	22
Total geese	43	-	-	24	-	22	-	36	2	4	-	-	-	-	88

Table 4.--Agricultural crops and features with which shorebirds were associated with a frequency greater than expected with a random distribution on transects. Abbreviations, symbols, and notes as in table 2.

Species	Total occurrences	Percent of total occurrences: Plowed IR	Plowed NI	Alfalfa <NI	Grass >IR	Grass >NI	Grass <IR	Grass <NI	Wheat >IR	Canals	Percent accounted for by crop/features	All crop/features IR	All crop/features NI
Black-bellied Plover (Pluvialis squatarola)	19	42	37	-	+	+	-	-	-	-	79	+	+
Killdeer (Charadrius vociferus)	287	11	+	10	+	+	+	+	4	+	25	+	68
Mountain Plover (C. montanus)	16	75	63	-	-	-	-	-	-	-	88	+	69
Black-necked Stilt (Himantopus mexicanus)	28	25	+	+	11	-	7	11	-	-	54	+	+
American Avocet (Recurvirostra americana)	9	67	+	-	-	-	+	-	-	-	67	78	+
Greater Yellowlegs (Tringa melanoleuca)	36	30	-	-	10	5	8	-	-	-	53	+	+
Lesser Yellowlegs (T. flavipes)	6	50	+	+	-	-	-	-	-	-	50	+	+
Willet (Catoptrophorus semipalmatus)	18	19	+	-	-	-	+	+	+	+	39	+	+
Spotted Sandpiper (Actitis macularia)	29	+	-	-	-	-	-	-	-	-	83	100	-
Whimbrel (Numenius phaeopus)	45	36	+	+	4	9	4	22	-	-	75	75	+
Long-billed Curlew (N. americanus)	52	17	27	13	+	+	8	19	+	-	78	+	68
Western Sandpiper (Calidris mauri)	10	40	+	-	-	-	-	-	-	+	40	70	+
Least Sandpiper (C. minutilla)	61	30	+	+	+	-	+	+	18	+	68	94	+
Long-billed Dowitcher (Limnodromus scolopaceus)	27	41	+	+	+	+	-	-	+	-	41	63	+
Common Snipe (Gallinago gallinago)	17	+	-	-	-	+	-	-	12	59	71	82	+
Wilson Phalarope (Phalaropus tricolor)	8	38	-	-	+	-	+	-	-	+	38	88	+
Ring-billed Gull (Larus delawarensis)	37	30	46	+	+	+	+	+	-	-	76	+	65

Table 5.--Overall shorebird use of agriculture by numbers of species and all shorebirds combined. Irr. = irrigated; Pres. = present; Sign. assoc. = significantly associated; Obs. = observed; Exp. = expected; NS = not significant.

Crop/ feature	Irr.	Number of species: Pres.	Number of species: Sign. assoc.	Fields with shorebirds: Obs.	Fields with shorebirds: Exp.	Binomial P
Plowed						
—	Yes	17	15	32	12.5	+<0.001
—	No	13	4	130	72.3	+<0.001
Alfalfa						
>25 cm	Yes	5	0	8	7.8	NS
>25 cm	No	7	0	18	37.9	-<0.001
<25 cm	Yes	8	0	9	5.1	NS
<25 cm	No	8	2	23	22.3	NS
Cotton						
>25 cm	Yes	5	0	7	13.3	-<0.05
>25 cm	No	4	0	9	51.6	-<0.001
<25 cm	Yes	4	0	3	2.7	NS
<25 cm	No	2	0	6	23.1	-<0.001
Grass						
>25 cm	Yes	9	2	3	1.2	NS
>25 cm	No	9	2	12	16.8	NS
<25 cm	Yes	11	4	10	2.4	+<0.001
<25 cm	No	8	4	21	16.8	+<0.025
Truck						
>25 cm	Yes	1	0	2	0	NS
>25 cm	No	1	0	6	7.4	NS
<25 cm	Yes	1	0	1	0	NS
<25 cm	No	3	0	4	5.9	NS
Wheat						
>25 cm	Yes	6	3	12	5.9	+<0.01
>25 cm	No	7	0	12	28.2	-<0.001
<25 cm	Yes	4	0	2	3.9	NS
<25 cm	No	2	0	7	12.1	NS
Canals						
—	—	7	2	59	42.6	+<0.01

<25 cm. The most abundant field types were usually not the places where shorebirds occurred most frequently. Although cotton fields were avoided largely by shorebirds, these fields indirectly enhanced shorebird habitat because they were periodically plowed and attracted significant numbers of shorebirds. Overall, shorebird occurrence in agricultural areas was related to routine agricultural practices (plowing, irrigation) and with the presence of canals. However, 12 of the 17 species preferred either irrigated or nonirrigated fields and did not randomly occur in both situations. In order to maximize diversity of shorebirds, a mosaic of irrigated and nonirrigated fields are desirable.

DISCUSSION

As Orians (1975) has stated, there is a need to study organisms that have been exposed to perturbation resulting from the unprecedented modification of the environment by humans. Clearing of land for agricultural purposes creates new habitat for species that previously may not have occurred in the area while, at the same time, destroying habitat that may cause the original fauna to disappear unless these latter species are able to take advantage of the new situation. All of the species treated here have increased in their occurrence in the valley since the 1800's due largely to the activities of man, including agricultural practices, storage of water in large reservoirs (primarily for irrigation), and creation of stable marshlands.

Grinnell (1914) described the lower Colorado River's aquatic and semiaquatic avifauna as depauperate; he recorded few species and low numbers of herons, waterfowl, and shorebirds north of the Gila-Colorado river confluence. Presently, all of these species occur in rather stable numbers responding to the food resources provided by agricultural areas, roosting and foraging sites of open water areas, and/or a combination of these. The vast majority of species treated here are transient and winter visitors and do not depend on agricultural areas for nesting. Exceptions are Killdeer and a few Cinnamon Teal.

Cranes and geese are almost totally dependent on agricultural areas for foraging. On the three lower Colorado River national wildlife refuges, recent increases in abundance for both cranes and geese are attributed to managing aquatic or semiaquatic roosting sites with adjacent agricultural foraging sites (mostly alfalfa and milo fields). Shorebird, waterbird, and wading species associated with irrigated fields must track this resource as flooded fields are infrequent and ephemeral. Flooding of fields attracts not only species treated here, but also swallows, water pipits, and blackbirds, which flock to feed on invertebrates displaced by irrigation water. Waterbird and some wading species (especially Green-backed Herons) find more stable foraging sites in the extensive canal systems, especially along larger dirt-banked canals that usually have a constant flow of water. Spotted Sandpipers and some waterbirds use the more sterile cement-lined canals to a greater extent.

Several species treated here have undoubtedly undergone range extensions directly associated with the expansion of agricultural practices. Most dramatic has been the expansion of the Cattle Egret, originally introduced from the Old World into the New World Tropics. This species became established in the southeastern United States in the 1950's and has spread north and west into areas of extensive agricultural and horticultural production. Cattle Egrets were first found on the lower Colorado River in 1970 and are on the verge of establishing several breeding colonies. Mountain Plovers and Whimbrels were considered casual in Arizona before the 1940's (Monson and Phillips 1981), but both species are now regular, and hundreds of individuals occasionally occur in agricultural situations.

Most, if not all, shorebirds have benefitted from various agricultural features on the lower Colorado River, although this region is not a major migration route for this group. However, shorebird

use of agriculture in regions where shorelines and estuaries have been extensively developed, such as in Florida and California, is in need of immediate attention, given the desperate situation outlined by Myers (1983) for this group. Our paper outlines important agricultural features for shorebird use that may be compared with data collected in other regions.

Of all the habitat changes experienced in the lower Colorado River valley, as well as many other major southwestern riparian systems, the conversion of vast areas to agricultural production is certainly the most dramatic. The abundant foods provided by agricultural habitats benefit a wide variety of birds that can opportunistically use them. Since nesting sites are not a concern for many of these species on the lower Colorado River, they may attain relatively high densities. If survival has been high in these overwintering or migratory individuals, then the population biology of these species may be changing, with effects perhaps evident on their northerly breeding grounds. Although a number of species are benefitting from the development of agriculture, the future of many riparian species in agricultural areas is not optimistic unless a mosaic of native riparian habitats and developed lands is managed for conserving both the original and new avifaunas.

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