ECOLOGY OF THE MEXICAN DUCK

IN THE SULPHUR SPRINGS VALLEY OF ARIZONA

by

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ABSTRACT

From May 1973 to October 1974, I studied the composition and distribution of the waterfowl population in Arizona's Sulphur Springs Valley and emphasized the status and ecology of the Mexican Duck. The 6000-7000 wintering ducks consisted of 70 percent Pintails, 11 percent Mallards, and 19 percent other species. Approximately 150 Mexican Ducks are resident. The breeding population in 1974 was composed of 70 percent Mexican Ducks, 25 percent Mallards, and 5 percent obvious Mexican Duck/Mallard hybrids. From 1972 through 1974, an observed average of 37 Mexican Duck broods were produced annually. Brood size at fledging averaged 5.6 for the three years, yielding an annual production of 175-250 Mexican Ducks. Because many broods were not observed, this estimate is less than actual production in the valley.

Minimal disturbance was the most important habitat requisite for Mexican Ducks in summer, and shoreline cover seemed essential for broods. Human interference remained important on winter ponds but was less critical than during reproduction. Larger, shallow ponds seemed preferred in winter. Dense cover in summer or larger acreage in winter may compensate for disturbance at ponds.

The valley's Mexican Ducks are threatened by hybridization with Mallards and loss of habitat through continued depletion of the water table or replacement of pumpback methods by sprinklers.

INTRODUCTION

The Mexican Duck (Anas diazi) is endangered because of extensive marsh drainage and diversion of water in its historical habitat in New Mexico and western Texas (Aldrich and Baer 1970, Levy 1964). The species has extended its range into Arizona's Sulphur Springs Valley as a result of construction of irrigation ponds and ditches in the area, and the valley may now harbor more Mexican Ducks than exist within their original range in this country. Creation of suitable habitat in the region has simultaneously attracted many Mallards (Anas platyrhynchos). Sympatry and close evolutionary affinity between the two birds has resulted in a high incidence of hybridization which threatens the current taxonomic distinction of the Mexican Duck.

Habitat destruction and the consequences of hybridization indicate the immediate need for ecological study of the Mexican Duck. Scarcity of information in the literature influenced my decision to make the study a broad survey of the status and needs of this bird in the Sulphur Springs Valley. Objectives of the study were to determine the seasonal distribution and abundance of the valley's Mexican Duck population, to investigate the species' requirements and limiting factors, to observe and describe seasonal activities and overt behavior of the species, and to document existing land use in the valley for the purpose of appraising present and potential habitat for the Mexican Duck. Because the variety of species in the valley attest to the

area's potential as a waterfowl refuge, I also determined the seasonal distribution of other waterfowl species and suggest recommendations for waterfowl management in the valley.

THE STUDY AREA

I confined my investigations to a 55-mile long area which extended north and south of Willcox, Arizona. This region contained nearly all of the available waterfowl habitat in the Sulphur Springs Valley.

Location

The Sulphur Springs Valley is a large, intermontane trough extending from northeastern Sonora, Mexico, through Cochise County, Arizona, to the headwaters of Arivaipa Creek in Graham County (Figure 1). From its southern limit near the international boundary, the valley stretches north-northwestward for 90 miles, averaging 20 miles in width and covering 1800 square miles in surface area (Meinzer and Kelton 1913). Elevation of the valley floor ranges from 4150 to 4400 feet above sea level. The valley is bounded on the east by the Pinaleno, Dos Cabezas, Chiricahua, Pedregosa, and Perilla mountain ranges. The Galiuro, Winchester, Little Dragoon, Dragoon, and Mule Mountains border the western side.

Climate and Watershed

The arid to semi-arid climate is characterized by hot summers and cool, moderate winters. Low precipitation and humidity, high evaporation rates, and large daily fluctuations in temperature are typical. During the study period, temperatures at Willcox ranged from a low of 11°F in December of 1973 to a high of 107°F on three occasions in the

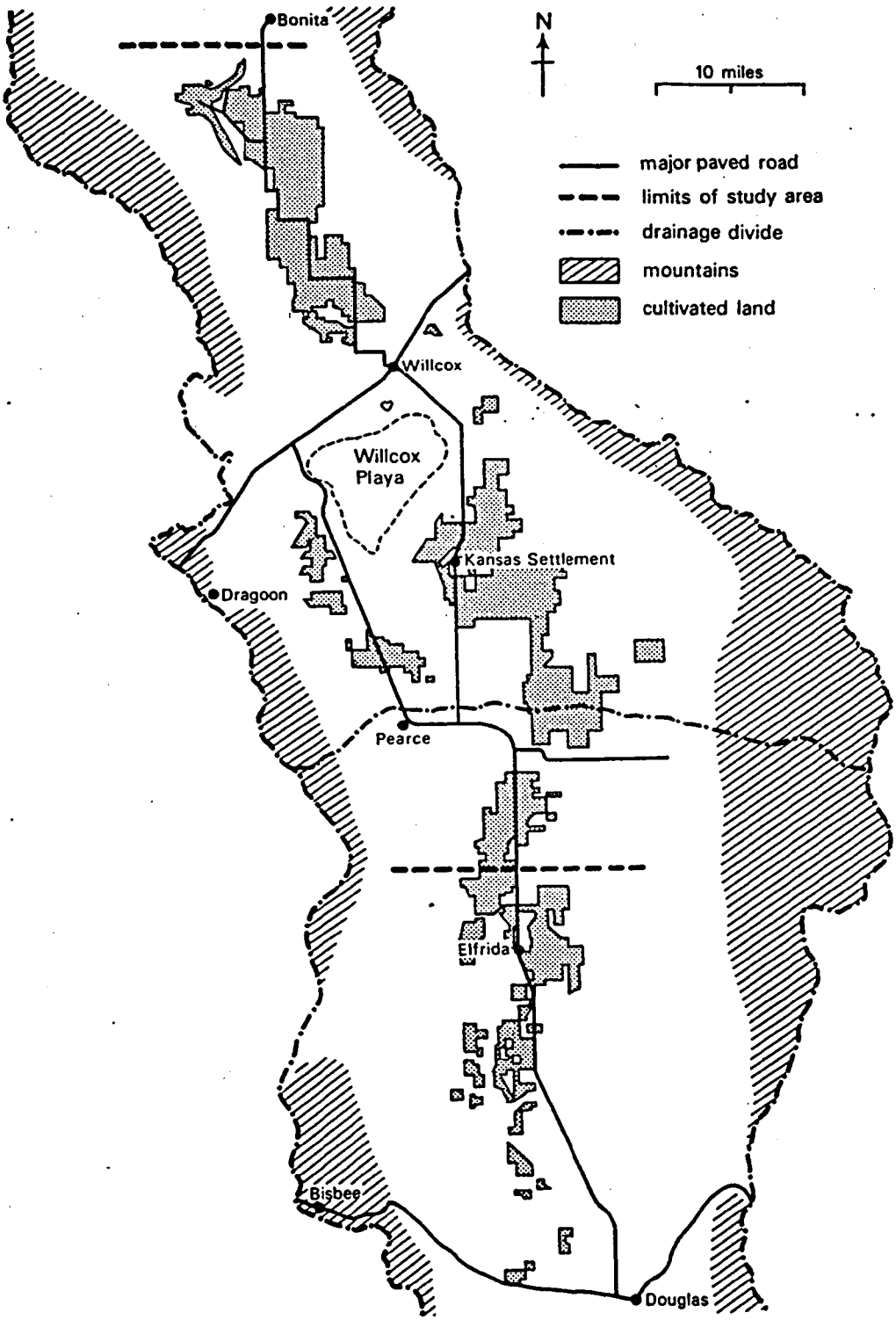

Figure 1. The Sulphur Springs Valley.

two summers (U. S. Department of Commerce 1973, 1974). Most rain falls from July to September during intense thunderstorms of short duration; light, general rains usually occur in winter. Total rainfall was extremely low in Arizona through all of 1973 and most of the nesting season the following year.

A series of ridges and buttes divides the valley into two drainages. The Willcox Basin includes the northern half of the valley and is a closed watershed system having all drainage to the Willcox Playa, where surface runoff and some underground water evaporate from the dry bed. The southern half of the valley comprises the Douglas Basin and all drainage is southward into Mexico by way of Whitewater Draw.

Soil and Vegetation

In the vicinity of the Willcox Playa, the water table lies only a few feet below the surface of the ground and may even reach the surface in times of high precipitation. A long geologic history of evaporation and subsequent concentration of minerals has produced extremely alkaline conditions in and around this dry bed (Meinzer and Kelton 1913). No vegetation is present on the lake bed itself. Several prime waterfowl areas are located on the outskirts of the playa, where only the most alkali-resistant plants survive. Prevailing plant forms in this outlying region are the saltbushes, burro-weed, alkali sacaton, and Mexican saltgrass.

Because the soil of the alkali and playa zones is unsuitable for farming, vegetation in these areas has remained essentially unchanged

since the advent of the white man. In some other parts of the valley, coverage by mesquite seems to be more extensive as a result of excessive grazing. Except in the alkali and playa region, most of the central axis of the valley has been developed for agriculture. Practically the only uncultivated plants in the farmland area are those surrounding the periphery of the irrigation ponds. These consist mainly of Johnson grass, wild millet, aster, curly-leaf dock, and various kinds of smartweed.

A more complete discussion of soil and native vegetation in the valley is available from Coates and Cushman (1955) and Meinzer and Kelton (1913).

Land Use

Until about 1910, cattle-raising comprised the valley's major industry, as most of the region was probably grass-covered before settlement (Meinzer and Kelton 1913). The first irrigation wells were drilled in 1910 (Coates and Cushman 1955). Agricultural development began at that point and has replaced cattle ranching as the valley's principal enterprise.

Total cultivated area in the Sulphur Springs Valley reached 147,500 acres by 1973 (calculated from Arizona Crop and Livestock Reporting Service 1974). Principal crops are sorghum, wheat, and cotton; others are alfalfa and other hay, barley, sugarbeets, lettuce, corn, peaches, and pecans. Figure 2 presents the 1973 distribution of acreages per crop in Cochise County, which comprises most of the cultivated portion of the Sulphur Springs Valley.

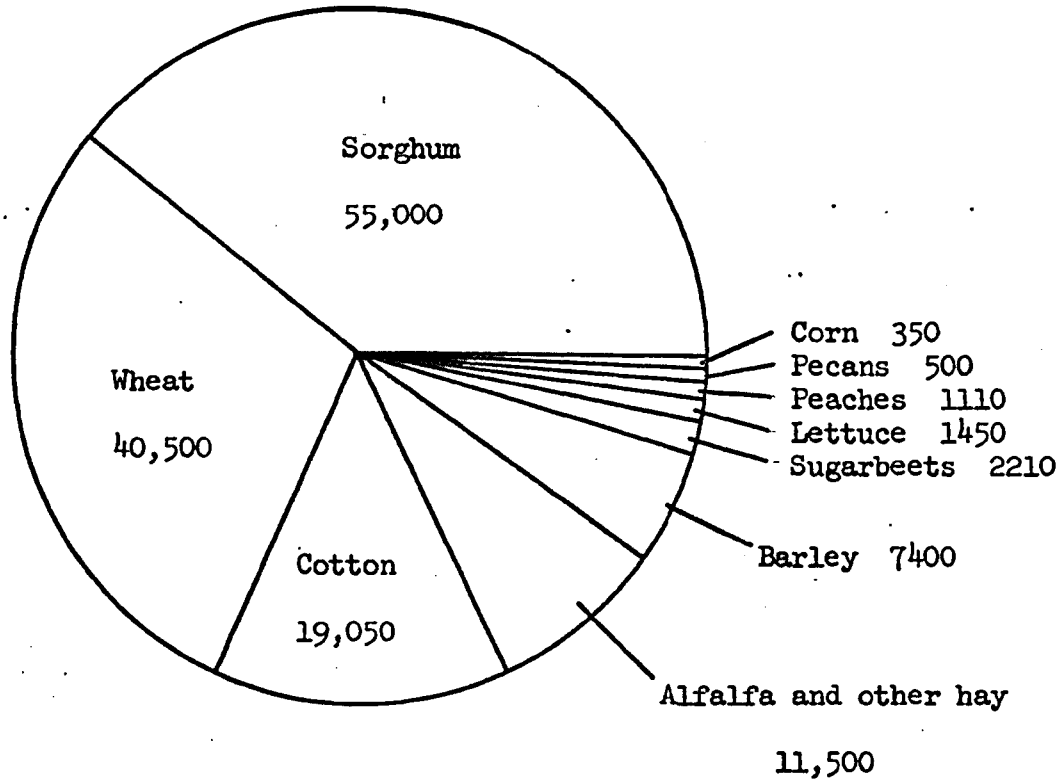

Figure 2. Acreages per crop in Cochise County in 1973.

Low rainfall and high evaporation in the valley dictate that all cropland be irrigated. Well water is pumped from the water table into small reservoirs, or pumpback ponds, and then channeled into individual rows or furrows of surrounding fields. In 1973-1974, approximately 150 "pumpbacks" were in use in the valley. More efficient use of water by movable overhead sprinklers has led to the retirement of some pumpback ponds since 1972.

These irrigation ponds and ditches provide most of the valley's waterfowl habitat. Waterfowl also use a country club lake, ephemeral ponds near the playa, and two ponds constructed by the Game and Fish Department. Locations of prime duck areas are listed in Appendix A.

Agricultural development in the valley has produced major changes in the area's ground-water system. Recharge to the water table originates from precipitation in the mountains and on the valley floor. Under natural conditions, discharge from the aquifer occurs by evaporation (mainly in the Willcox Basin), from transpiration by plants, and from flow out of the basin (Douglas drainage) by means of Whitewater Draw. Prior to extensive pumping from the aquifer, the underground water system was apparently in equilibrium, with natural discharge equaling recharge. By the 1960's the entire system had been altered.

During the pumping of a well, ground-water levels in nearby areas are lowered as water moves toward the pumped well. Eventually a cone-shaped gradient surrounding the well is formed which is sufficiently steep to supply the pump. As more water is withdrawn, this cone of depression expands and may merge with cones in adjoining areas.

Although ground-water has been used for irrigation in the valley since 1910, large-scale pumping was not initiated until the 1950's (Brown and Schumann 1969). A general increase in cultivated acreage also began at that time. The greatest amount of pumping has been concentrated around the Kansas Settlement area. Only slight depressions in the aquifer were present by 1952, when just a small amount of water had been pumped (White and Childers 1967). Greater changes have taken place since then. Ground-water no longer flows evenly toward the playa or toward Mexico but moves to centers of pumping. Depression in the water table along the valley's central axis has deepened. Slope of the aquifer is less uniform and the gradient at the mountain fronts is steeper. Whitewater Draw originally was sustained by base flow from ground-water seepage; its base flow has become greatly depleted. Springs number fewer than in former years. Less water is now available for phreatophytes.

Because of irrigation pumping, the amount of ground-water being annually withdrawn greatly exceeds the amount recharged to the underground reservoir. The subsequent decline of the water table carries implications for the future of both agriculture and waterfowl in the valley. Figures 3 and 4 demonstrate the increase in pumping and consequent depth to water in the Sulphur Springs Valley over recent decades (Arizona Water Commission 1973, 1974). Consistent lowering of the water table is evident in Figure 4, with the exception of one well (Sec. 23, T15S, R25E). The well's location at the playa's edge accounts for its relatively stable levels.

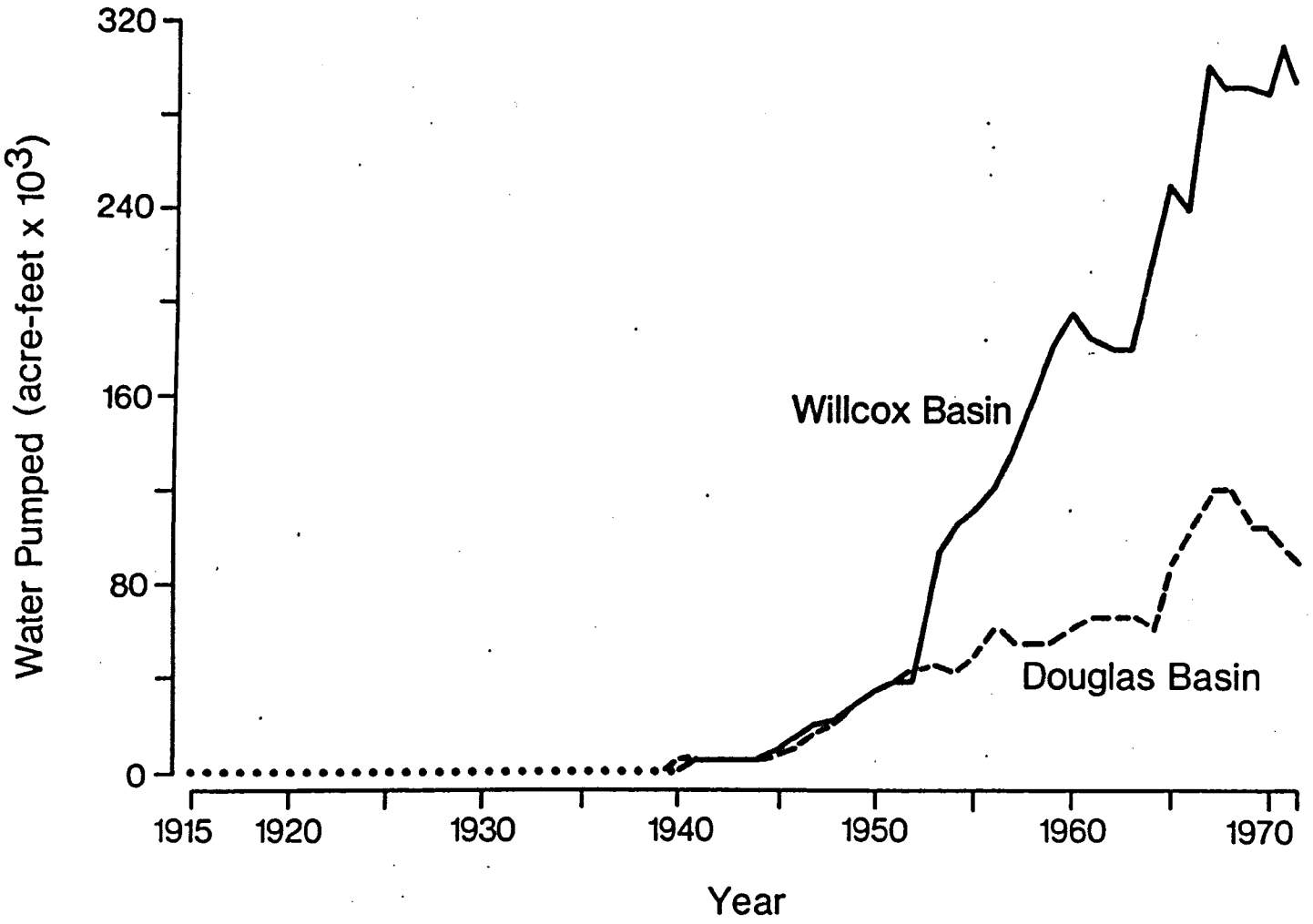

Figure 3. Increase of pumping in the Willcox and Douglas Basins, 1915-1972.

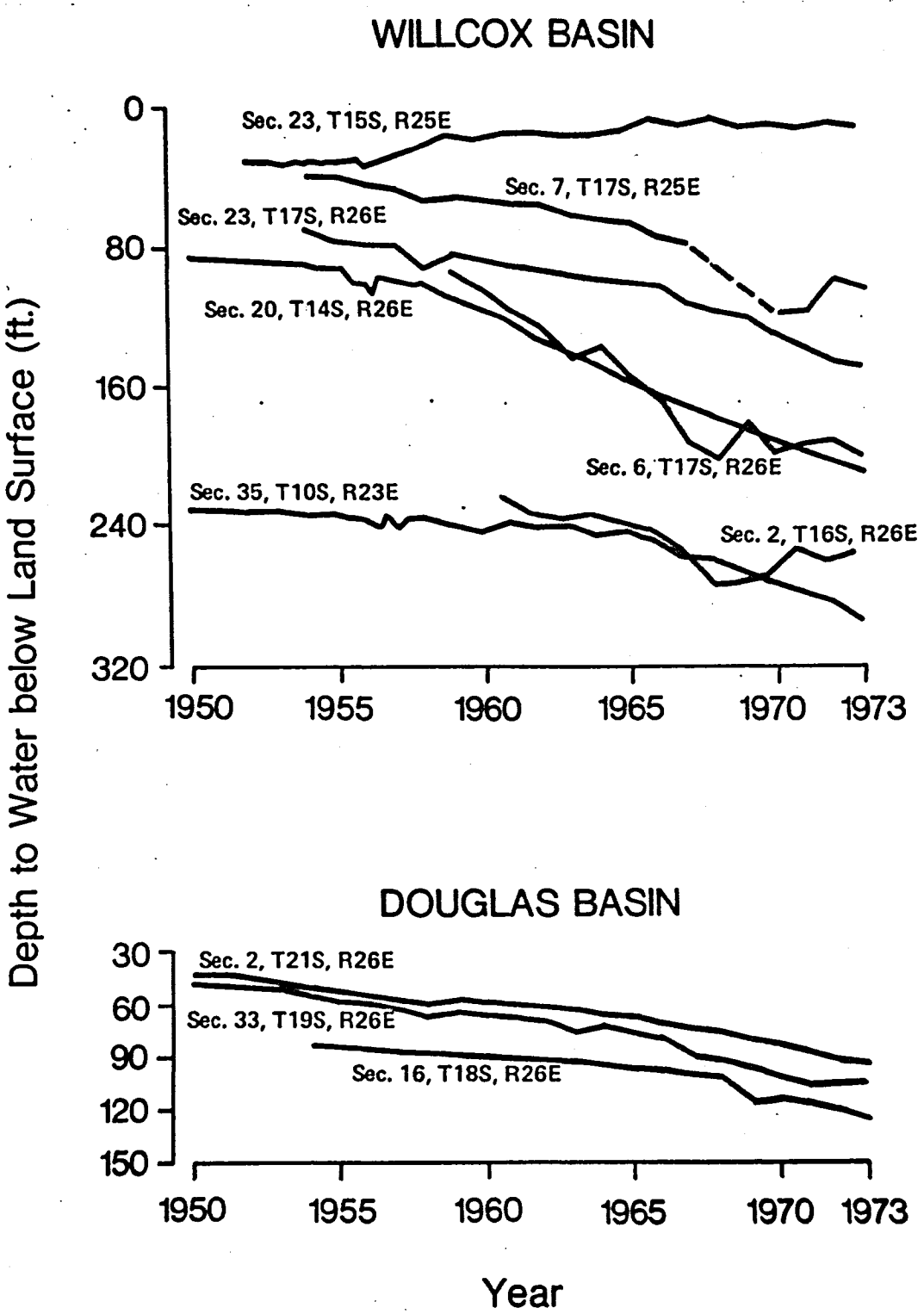

Figure 4. Depth to water in selected wells in the study area, 1950-1973.

METHODS

Organization of the project began in May of 1973. Intensive field work was confined mainly to the period from August 1973 to early October 1974. I attempted to concentrate on activities and behavior which would most efficiently produce a general survey of the Mexican Duck's status and ecology in the valley.

Survey and Observation Techniques

Initially I searched the study area for waterfowl habitat. By using infrared aerial photographs at the Arid Lands Studies Office of the University of Arizona, I located water sites within a 55-mile long region extending north and south of Willcox (Figure 1). These locations were then plotted on topographic maps for use in the field. Aerial reconnaissance in October 1973 revealed several water areas which were either not evident in the photographs or had been formed since the date of the photography.

Certain sites were utilized more heavily than others by waterfowl, and I censused all duck species at these prime areas during daylight hours at least once a week. A thorough survey of the approximately 30 main locations required nearly two days. I accompanied a local farmer and G. Patrick O'Brien, the regional wildlife manager, in a nighttime brood-count census in August of 1974.

At each pond I recorded the numbers of each duck species, their sex ratios when possible, pertinent behavior, and the numbers

and kinds of other water birds present. When necessary, I tramped through peripheral vegetation to flush hiding birds. Possible repeated sightings of the same bird were excluded from the final census results at each area. During the nesting season I also recorded the numbers of broods seen per water area, number of ducklings in each brood, approximate age of the young, and species of the attending hen. Age of ducklings was estimated on the basis of body size and plumage characters (Gollop and Marshall 1966, Southwick 1953). Scientific and common names of observed water birds are presented in Appendix B.

Study of Aquatic and Surrounding Habitat

At 40 ponds I recorded vegetation density, surface acreage, maximum distance to escape cover, water depth, and degree of human disturbance. Chi-square and student's *t*-tests related the habitat factors to brood production. To analyze environmental variables, their interrelationships, and dependent duck counts, I used correlation coefficients, multiple regression, and one-way and factorial analysis of variance. The last four techniques were applied separately to data from winter and summer, and Mexican Duck numbers comprised the dependent variable. Census figures entered the investigation in two ways: as the average number of ducks per pond and, in separate analysis, as duck counts adjusted for a one-acre pond.

In both winter and summer I visually estimated density of the vegetation immediately peripheral to the 40 water areas. Vegetation was considered dense or not dense depending on its estimated ability to conceal a duck hidden within it. To determine the acreage of each

pond, I paced off the necessary dimensions and used geometric formulas to calculate the surface area. I consulted aerial photographs when water sites were irregularly shaped. Knowledge of the shape of each pond allowed me to figure the maximum distance a duck could be from cover on a particular pond.

Depths of long, rectangular pumpback ponds were determined by a method suggested in part by G. Patrick O'Brien. Two persons stretched a rope across the width of each pond; a shorter, weighted rope hung from the center of this main strand. Measurements could then be taken systematically from one end of the pond to the other. For some rectangular sites and all large, irregularly shaped areas, I worked from an air mattress and determined depth with a six-foot pole marked in feet.

Each water area was placed in one of three categories. Low disturbance ponds were located on isolated or little-used property; surrounding areas were either pasture or idle farmland; vehicular traffic was nonexistent or limited to farm machinery. Medium disturbance ponds were adjacent to or near cropland; a moderately-used dirt or gravel road might be nearby. High disturbance ponds were located near a site of regular human activity, such as farm buildings, business establishment, or paved road.

At each of 27 water sites, I collected data on vegetation once in the period from mid-June to mid-August. Appendix C lists the scientific and common names of plants at these ponds. Each pond was divided into central, marginal, and shoreline zones. The central zone comprised the main open water area. The marginal zone designated the water within a few feet from shore, where emergent plants may or may not have been

present. The shoreline zones referred to terrestrial vegetation immediately surrounding the pond. At 30-yard intervals along the shore of each pond, I recorded the species present in a circular plot of one yard diameter in each of the three zones. The frequency of occurrence of each species was calculated for every pond, and the average of each species' percentages for the 27 ponds represents the entire study area. Using the percent occurrence figures, I calculated the relative frequency of each kind of plant. These procedures, modified from a technique used by Madsen (1974), are demonstrated in the following example:

Species	Percent Occurrence			Relative Frequency
A			70.0	$\frac{70.0}{120.0}$ = 58.3 percent
B	average percent occurrences by species for all ponds	=	35.0	$\frac{35.0}{120.0}$ = 29.2 percent
C			15.0	$\frac{15.0}{120.0}$ = 12.5 percent
				100.0 percent

Species A was present in 70 percent of the circular plots surveyed at an average pond. In terms of these plots, 58.3 percent of the plants tallied on the study area were species A.

In August of 1974, a water sample was collected from each of six ponds in the study area. Four of the sites are known to have produced broods that year. The Department of Agricultural Chemistry and Soils at The University of Arizona analyzed these samples for ion and soluble salt content, electrical conductivity, and pH.

To investigate the presence and build-up of DDT residues in the food chain of the Mexican Duck, I collected several types of samples to be tested by the Toxicology Laboratory of the Department of Entomology, University of Arizona. Water samples were taken from five of the six ponds utilized for the general water analysis. Algae, pondweed (Potamogeton), Johnson grass, and snails from several water areas were also tested. I obtained one sample of fat tissue from a Mexican Duck killed by a hunter (courtesy of G. Patrick O'Brien, wildlife manager).

Laboratory personnel performed hexane partitioning to extract pesticide residues from the water samples. A 2:1 hexane/ethanol combination removed residues from the pulverized vegetation and snails. For fat tissue, extraction was from florisil using hexane and 6 percent ethyl ether. Residues in all samples were quantitatively identified by electron-capture gas chromatography.

RESULTS

The Sulphur Springs Valley may be considered a valuable haven not only for the endangered Mexican Duck but for other waterfowl as well. The following data demonstrate the variety of species present in the valley and also provide a general overview of the annual cycle and ecological relationships of the Mexican Duck.

Seasonal Distribution and Abundance of the Valley's Waterfowl

Numbers and proportions of the various species of waterfowl in the valley fluctuate throughout the year (Table 1). In general, Mexican Ducks and some Mallards comprise the resident breeding population; the rest of the Mallards and other waterfowl are present only during the wintering period.

Autumn Migration

Increase in numbers of waterfowl began in August in both years of the study. The Sierra Bonita Ranch Cienega harbored more wintering ducks than any other body of water but was not located until November 1973. Figures for the autumn of that year are therefore not a reliable index to the rate of increase in fall migrants. In Table 1, discovery of the Ranch Cienega accounts for the early November rise in numbers of Mallards, Pintails, Lesser Scaup, and Ruddy Ducks.

Table 1. Numbers of waterfowl seen on the study area. -- Figures indicate the maximum number of each species sighted in any one day during consecutive two-week periods.

	Mexican Duck	Mallard	Gadwall	Pintail	Teal (any species)[a]	Blue-winged or Cinnamon Teal[a]
Peak Number:	133	700	16	4600	--	--
Date			Biweekly Maximum Count			
8/1-15, 1973	7	1	0	0	--	19
8/16-31	31	13	0	50	--	78
9/1-15	43	0	0	124	--	59
9/16-30	16	2	0	100	--	40
10/1-15	24	35	0	80	95	--
10/16-31	9	0	0	54	22	--
11/1-15	110	38	0	625	--	--
11/16-30	16	62	13	450	3	--
12/1-15	20	34	0	192	70	--
12/16-31	12	47	0	285	--	--
1/1-15, 1974	25	140	0	1235	--	--
1/16-31	15	25	0	1110	--	--
2/1-15	30	40	0	2330	--	--
2/16-28	75	700	0	4600	--	--
3/1-15	40	425	0	1260	--	--
3/16-31	133	268	0	68	--	--
4/1-15	52	173	16	30	--	--
4/16-30	86	21	0	21	--	--
5/1-15	23	6	1	3	--	--
5/16-31	35	18	1	11	--	--
6/1-15	42	21	0	2	--	--
6/16-30	34	3	0	2	--	--
7/1-15	2	4	0	0	--	--
7/16-31	42	1	0	2	--	--
8/1-15	66	1	0	2	--	38
8/16-31	45	0	0	14	--	90
9/1-15	27	0	1	195	430	--
9/16-30	42	1	0	175	310	--
10/1-15	27	0	0	82	133	--

Table 1. (Continued) Numbers of waterfowl seen on the study area.

	Green-winged Teal	Blue-winged Teal	Cinnamon Teal	American Wigeon	Northern Shoveler	Redhead
Peak Number:	435	7	100	115	196	29
Date			Biweekly Maximum Count			
8/1-15, 1973	2	--	--	0	1	1
8/16-31	14	--	--	0	29	0
9/1-15	35	--	--	5	90	0
9/16-30	20	--	--	4	171	0
10/1-15	--	--	--	76	100	5
10/16-31	--	--	--	5	190	6
11/1-15	35	0	0	12	100	2
11/16-30	44	--	--	27	122	21
12/1-15	--	--	--	2	91	1
12/16-31	5	0	0	28	88	0
1/1-15, 1974	11	0	14	1	40	7
1/16-31	205	0	20	8	34	7
2/1-15	435	7	45	51	119	29
2/16-28	325	0	41	42	128	16
3/1-15	330	3	35	115	120	25
3/16-31	355	4	60	51	190	19
4/1-15	128	0	42	9	196	2
4/16-30	42	4	100	40	77	0
5/1-15	4	5	27	6	12	1
5/16-31	5	3	7	2	0	2
6/1-15	2	2	6	0	2	1
6/16-30	2	1	2	0	6	1
7/1-15	0	0	4	0	0	0
7/16-31	0	0	0	0	0	0
8/1-15	7	--	--	0	0	0
8/16-31	250	--	--	0	5	0
9/1-15	--	--	--	0	10	0
9/16-30	--	--	--	1	0	0
10/1-15	--	--	--	6	3	0

Table 1. (Continued) Numbers of waterfowl seen on the study area.

	Ring-necked Duck	Canvas-back	Lesser Scaup	Buffle-head	Ruddy Duck	Common Merganser	Black-Bellied Tree Duck
Peak Number:	16	104	40	5	125	3	6
Date			Biweekly Maximum Count				
8/1-15, 1973	0	0	0	1	0	0	0
8/16-31	0	0	0	1	1	0	0
9/1-15	0	0	0	0	1	0	0
9/16-30	0	0	0	1	2	0	0
10/1-15	2	0	0	1	29	0	0
10/16-31	0	0	0	0	7	0	0
11/1-15	1	6	40	0	125	3	0
11/16-30	0	47	34	5	70	0	0
12/1-15	0	83	0	0	18	0	0
12/16-31	0	104	7	0	36	0	0
1/1-15, 1974	2	43	2	0	12	0	0
1/16-31	2	85	2	2	8	0	0
2/1-15	2	17	0	2	7	0	0
2/16-28	2	18	0	2	13	0	0
3/1-15	16	8	1	1	17	0	0
3/16-31	5	4	4	0	23	0	0
4/1-15	6	0	0	0	13	0	0
4/16-30	3	0	19	0	10	0	0
5/1-15	3	0	1	0	6	0	0
5/16-31	0	0	1	0	3	0	0
6/1-15	2	0	1	0	1	0	6
6/16-30	0	0	1	0	4	0	0
7/1-15	0	0	0	0	0	0	0
7/16-31	0	0	1	0	2	0	0
8/1-15	0	0	1	0	3	0	1
8/16-31	0	0	1	0	0	0	0
9/1-15	0	0	0	0	0	0	0
9/16-30	0	0	1	0	0	0	0
10/1-15	0	0	0	0	2	0	0

[a]Species were indistinguishable because of eclipse plumage or poor visibility.

Wintering Period

Pintails comprised 70 percent of the winter population of ducks in the valley. Mallards made up more than 10 percent of the winter aggregation, outnumbering Mexican Ducks five to one. Green-winged Teal and Northern Shovelers also exceeded the total number of Mexican Ducks. Other migrants found in relatively substantial numbers (100 or more) included Ruddy Ducks, American Wigeons, Canvas-backs, and Cinnamon Teal. Several additional species in Table 1 were seen sporadically and usually in small numbers.

The valley harbors numerous wintering water birds other than ducks. Nearly 1200 Sandhill Cranes were seen during one day's census. These wary birds find refuge in the isolated grassy expanses surrounding the playa and have an ample food supply in the waste grain of nearby harvested sorghum fields. The only geese sighted were a transient White-fronted Goose and Snow Goose.

With some exceptions, wintering ducks favored larger water areas isolated from human activity or disturbance. The country club lake at Willcox was utilized heavily by all species, though not by large numbers of Mexican Ducks. Groups of ducks and other birds used the lake's central sand bars for resting and preening. Aggregations of Northern Shovelers and diving ducks were usually present on one of the two sewage purification ponds at the edge of Willcox. Occasional human intrusion plus lack of vegetation or shallow water probably accounted for the near-absence of Mexican Ducks at this site. Except for Shovelers, dabbling ducks were rarely seen there.

Spring Migration

Wintering Ducks began departing at the end of February and were generally gone by mid-April. Numbers of Sandhill Cranes decreased from a maximum figure on 31 January 1973 (1160-1170) to zero by the middle of March. All Mexican Ducks, some Mallards, and at least one pair of Pintails remained in the valley for the breeding season.

Nesting and Brood Rearing

Although some northern visitors were present until mid-April, dispersal of mated resident birds began in early March. Pair activity was evidently at its height around the first of April, and isolated pairs of ducks were noted on many of the scattered pumpbacks. By early 1974 no water remained in the 40-acre Sierra Bonita Ranch Cienega or the 20-acre Willcox Country Club Lake, two of the three large water areas which were used by several thousand ducks during the winter. Nearly all other impoundments were smaller, ranging between 0.25 and 1.5 surface acres. Because of this insufficient range of pond sizes, I do not know whether spring dispersal in this valley is a movement from larger bodies of water to smaller ones supposedly more suited to nesting and brood rearing.

In the three summer seasons of 1972-1974, Mexican Ducks, Mallards, Pintails, Cinnamon Teal, and possibly Green-winged Teal produced young in the valley. Teal and Pintail records were unusual, and nesting Mexican Ducks far outnumbered Mallards. Table 2 shows the distribution of the various nesters observed through the three-year period. Figures are considered minimal because some broods certainly

went undetected. However, as the majority of water sites were located in that area, production data in this paper provide an approximate, though conservative, picture of the duck population. The 1972 and 1973 figures indicate a smaller proportion of Mallards, hybrids, and unknowns than were probably present, according to G. Patrick O'Brien, who gathered most of the data for the two years. To provide a more accurate estimate of the Mallard/Mexican Duck population, I adjusted my 1974 brood numbers according to the frequency of drakes censused that year during the early spring period of pair activity.

Table 2. Numbers of broods observed on the study area, 1972-1974.

Species	1972 Obs[a]	1973 Obs[a]	1974 Obs[a]	1974 Adj[b]
Mexican Duck	37	43	30	31
Mallard	2	5	9	11
Hybrid	0	0	0	2
Unknown (Mex-Mall)	0	0	5	--
Pintail	0	0	1	1
Cinnamon Teal	0	1	0	0
Unidentified Teal	0	1	0	0
TOTAL	39	50	45	

[a]Number of broods observed.

[b]Numbers of broods adjusted according to the observable composition of the breeding Mallard/Mexican Duck population in 1974 (69.8 percent Mexican Ducks, 24.9 percent Mallards, 5.2 percent obvious hybrids).

No nests were found during the study, though I searched intensively at sites where paired ducks were active. I therefore relied on analysis of brood data to create a rough estimate of waterfowl production in the valley. Table 3 presents the numbers of ducks produced on the study area during the three-year period. Sizes of broods at flight age each year (Table 4) were used to calculate the numbers of Mexican Ducks and Mallards. Pintail and Cinnamon Teal production was also based on observed brood sizes, but the figure for the unidentified teal brood was estimated according to teal data provided by Bent (1951). Production in 1974 was determined from brood numbers which had been adjusted according to the observable male composition of the breeding Mexican Duck/Mallard population. Locations of broods are given in Appendix D. Geographic placement of the pertinent ponds can be found by referral to Appendix A.

Table 3. Estimated numbers of ducks produced on the study area, 1972-1974.

	Estimated Numbers of Ducks Produced		
Species	1972	1973	1974
Mexican Duck	207	254	173
Mallard	11	30	57
Hybrid	0	0	10
Pintail	0	0	10
Cinnamon Teal	0	7	0
Unidentified Teal	0	6	0
TOTAL	218	297	250

Table 4. Numbers of Mallard and Mexican ducklings seen per brood, 1972-1974. -- Sample size is in parentheses. 1972 and 1973 observations were provided by G. Patrick O'Brien.

AVERAGE OBSERVED BROOD SIZES

	1972	1973	1974	
Size Class	Mexican Duck and Mallard	Mexican Duck and Mallard	Mexican Duck	Mex, Mall, and unidentified Mex-Mall
Downy	5.5 (24)	6.1 --	4.7 (22)	4.1 (36)
One-quarter grown	4.8 (25)	5.4 (24)	4.4 (12)	4.1 (15)
One-half grown	6.2 (7)	4.3 (10)	5.4 (4)	4.8 (6)
Three-quarters grown or fledged	5.6 (16)	5.9 (20)	5.6 (14)	5.3 (16)

RANGE OF MEXICAN DUCK AND MALLARD BROOD SIZES

Size Class	1972	1973	1974
Downy	1-11	2-13	2-10
Three-quarters grown or fledged	2-10	2-11	1-10

Because no nests were found, brood data were used to estimate the nesting season. The egg laying period of the closely related Mallard averages around eight days (Keith 1961, Smith 1971, Stoudt 1971). About 26 days are required for incubation (Bent 1951). Back-dating each brood by its age plus 34 days for laying and incubation produced a rough picture of the 1974 reproductive period for Mexican Ducks and Mallards (Figure 5). The nesting season (first egg laying to last hatch) extended from late March to mid-June, while brood rearing spanned the period between late April and mid-September. The latter halves of April and May seemed to comprise the respective peaks for laying and hatching. Mexican Duck data make up most of the laying and hatching curves. The graph indicates little if any difference in the nesting chronologies of the two species.

Only limited field work was undertaken in September and October of 1974. If any birds remained in broods at that time, they were not observed. In the previous year, I noted one nearly-grown brood of flightless Mexican Ducks as late as the end of September. These juveniles were again seen in association with the hen on the 11th and 16th of October (personal communication on 18 October 1973 from Walter Anderson, graduate student). This brood may have protracted the 1973 reproductive season longer than what is normal and was probably the result of renesting.

Sites used in the nesting season were generally pumpback ponds. The valley contained very few water areas of other sorts. Alternate types used by waterfowl included the Willcox Country Club Lake (dry in 1974), two Arizona Game and Fish Department ponds near the playa, an

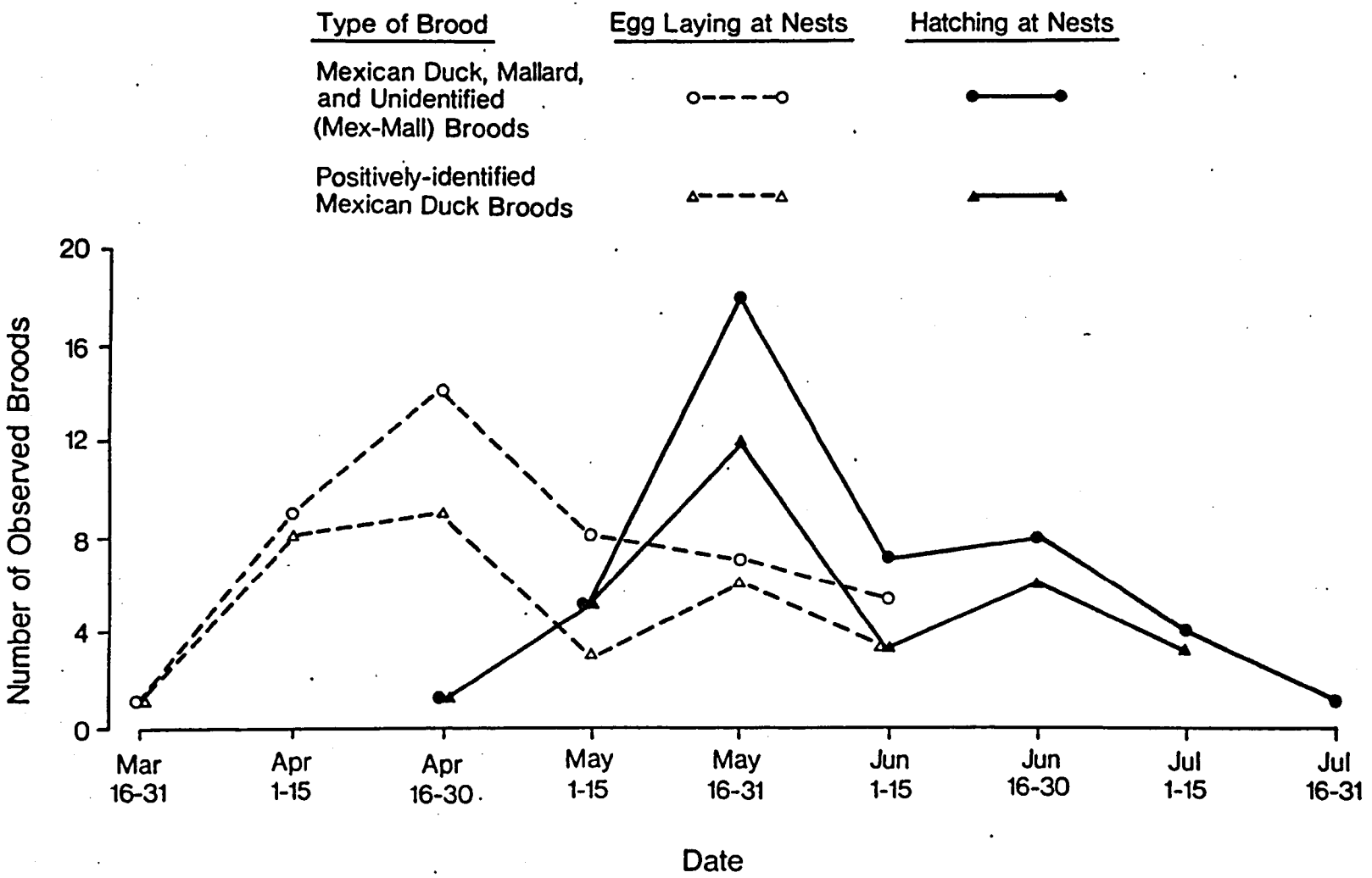

Figure 5. 1974 nesting season chronology.

abandoned gravel pit supplied year-round by water table seepage, and one cattle tank. Human activity was probably responsible for the lack of broods at the Willcox golf course pond, though ducks nested in areas which were close by but apparently less disturbed. Excessive disturbance and lack of cover probably made the Willcox sewage purification ponds unattractive to ducks; however, a brood was observed there in 1973 (personal communication from G. Patrick O'Brien on 16 May 1973).

Small groups of two or three post-breeding drakes were first evident in early May, group size increasing somewhat before the onset of the eclipse period. Some of these birds were probably nonbreeders. I never encountered any flightless ducks, and in June and July I saw mostly females and young.

Various kinds of shorebirds also nest in the Sulphur Springs Valley. My findings include an incubating Killdeer, one downy brood of Snowy Plovers, and a juvenile American Avocet dead from unknown cause. Other water birds such as American Coots probably produced young which were not observed.

Mexican Duck Activities and Behavior

Feeding, resting, courting, and mating activities were observed during winter. Except for Sandhill Cranes, I never saw waterfowl feeding in harvested grain fields. Ducks at the ponds fed or displayed most vigorously in the morning and evening hours, then rested, preened, and dozed during midday. This dichotomy of activity became more pronounced as the weather became hotter.

I observed Pintails, Mallards, and Green-winged and Cinnamon Teal courting from late November to late March, with most activity occurring in January and February. On 21 March 1973, I watched a group of drake Mexican Ducks courting on a small, isolated pumpback. Their activity corresponded with Hochbaum's (1944) description of pre-nuptial courtship as characterized by several males competing before a female. Although the individuals I observed were at too great a distance to discern detail, basic patterns appeared to match those commonly described for the Mallard (Delacour 1956, Johnsgard 1955). Head pumping, which may be seen in both sexes, was most frequent and consisted of rapid up-and-down movements of the head. Also observed was the head dipping or "grunt-whistle" motion wherein drakes dipped the bill into the water, then suddenly yanked head and bill skyward, scattering water over the breast and back. Drakes occasionally assumed an upright position in the water, accompanied by vigorous wing flapping.

In general the Sulphur Springs population of Mexican Ducks and Mallards appeared paired by the end of February. I witnessed copulation by a Mallard pair on 22 November 1973 and 31 January 1974.

The unsuccessful nest search plus the seclusion and wariness of mated birds prohibited observation of nesting activities.

Most brood sightings occurred in the evening or early morning. I presume ducklings to be more active at night because twilight and darkness provide concealment and also bring out abundant insects. I participated in one nighttime census and found several broods by that method.

The territorialism which was so important in the nesting phase did not appear during the brood rearing period. On at least one occasion, I saw two family groups of hens and young swimming together. As many as three females with broods were observed on one pond simultaneously, yet I noted no friction between hens. In this latter instance, the mate of one hen accompanied her and the young but showed no antagosiam toward other groups. It seems, however, that females may act to maintain some degree of brood segregation. I once watched a Mexican duckling leave its broodmates and linger quite close to a Mallard female and her one youngster until a sudden peck from the hen sent it back to its family.

Unity of activity among broodmates was evident, especially in the younger birds. I noticed a strong tendency for members of broods to remain bunched together, even when the hen was absent.

There was ample opportunity to observe defense and escape reactions by hens and broods, though I disturbed the birds as little as possible. A relatively unobtrusive approach caused the hen to quietly lead her brood away. She usually hid herself and young in peripheral vegetation but sometimes emerged alone later, approaching remarkably close to the intruder in a few cases. In one instance the nearest aquatic cover consisted of scattered tumbleweeds which offered little protection. Within these the hen gathered her young closely to her and all relied on total immobility for concealment. On occasions when my appearance was sudden, the startled quacking of the hen sent all ducklings scurrying and flapping for the nearest cover. Describing similar activity in Blue-winged Teal and Pintails, Hochbaum (1944) and Sowls

(1955) point out that different types of calls by the hen appear to release certain defensive reactions in the young.

Feigning behavior by the hen was her most common reaction to human intrusion. After the young dashed for cover, the maternal bird often flapped conspicuously across the water, uttering loud cries. On one occasion similar behavior occurred on land.

Ducklings which were hard-pressed or suddenly disturbed sometimes resorted to diving, emerging later in the protection of overhanging vegetation. One time several brood members surfaced with only crown, eyes, and nostrils above water; they remained so until I left the area. Diving reactions were only seen in ducklings less than half grown.

Hybridization

Close relationship among members of the genus Anas is demonstrated by the many cases of crossbreeding and the high incidence of fertility among hybrids (Johnsgard 1960b). Similarity of courtship between Mallards and Mexican Ducks plus their association during the winter period of pair formation can presumably lead to much crossmating. In recent decades these factors plus creation of new waterfowl habitat have resulted in sympatric breeding by these two species in the Sulphur Springs Valley.

Because hybrid characteristics could not always be detected in the field, I was unable to determine the incidence of crossbreeding in the study area. On one occasion a drake Mallard was seen paired to a Mexican Duck hen. That crosspairing occurs to a considerable degree

is indicated by the relative numbers of hybrid drakes. I tallied Mexican Duck, Mallard, and obvious hybrid drakes during the period of spring pair activity after the migrant Mallards had departed and before drakes went into eclipse plumage. This produced a ratio of 13.1 Mexican Ducks: 4.7 Mallards: 1 hybrid. I consider this a rough index of the composition of the breeding population. The proportion of hybrids assuredly is low, however, for hybrid characteristics were frequently obscure.

In pure strains of Mallards and Mexican Ducks, such wide variation in female body coloration exists that the extremes of each species may overlap (Lindsey 1946). Positive identification of some hens may be impossible, especially in the field. In a sympatric zone where cross-breeding occurs, such a task becomes insurmountable. I therefore recorded only male crosses when assessing the numbers of hybrids.

Plumage patterns of hybrid males exhibited various degrees of blending of parental characteristics. Commonly present was a metallic green coloration on the head involving the crown, nape, or postocular area. Hybrid drakes often possessed the Mallard's black-and-white rear and curled upper tail coverts. Mallard traits were often evident in the body plumage but were generally subdued or obscured by the plain dusky color of Mexican Duck influence. The upper breast sometimes tended toward chestnut, but less demarcation existed between chest and belly coloration, the undersides being darker than in pure Mallards. Scapulars often showed Mallardlike vermiculations. One hybrid featured the dark eyeline of the Mexican Duck. Bill color may approximate that of either species.

Though not as dark as in the female, tail feathers of drake Mexican Ducks are noticeably dusky (Delacour 1956). Male Mallards possess pure white tails. Bill color in female Mexican Ducks varies from a flat gray, often with lateral tinges of orange, to dusky along the center and brilliant orange on the sides (Delacour 1956, Zahm 1973). On occasion I viewed male Mexican Ducks having obviously light rectrices, including a couple of drakes whose tail feathers appeared pure white. Bill color of all hens matched the description for Mexican Duck females. Never did I see the mandibular orange-and-black splotching generally ascribed to hen Mallards, yet plumage coloration indicated that some of the nesting females were of this species. Resident female Mallards surely were present because several mated drakes were observed during the early nesting season. Confusing the picture further were drakes possessing a variety of conflicting characteristics. Perhaps these anomalies indicate that the valley's population is to a large extent hybrid.

Requirements and Limiting Factors of the Mexican Duck

Summer Habitat Analysis

Because waterfowl tend to be gregarious in winter, the presence of other species at a pond during that season presumably did not influence the area's use by Mexican Ducks. On the other hand, territorialism in the reproductive period conceivably could limit ducks on a particular pond. In that case some birds could be forced onto suboptimal sites, confounding my efforts to determine preferred habitat. To partially test this possibility, I performed three Chi-square tests using the

following respective data: (1) only positively identified Mallard and Mexican Duck broods, (2) #1 plus consideration of unknown broods as Mexican Ducks, (3) #1 plus consideration of unknown broods as Mallards. In all instances the presence of both Mallard and Mexican Duck broods on a given pond was shown to be independent of each other's influence (χ^2 = .618, .078, .805; d.f. = 1, $p < .05$). I therefore consider my censuses of Mexican Ducks at each pond to be indicative of the ducks' preferred winter and brood rearing habitats. Territoriality of nesting pairs may have introduced error into my analysis of summer habitat other than brood ponds.

During the warm months of the year, the environment must fulfill the multiple needs of ducks involved in nesting, brood rearing, and molting. Because no nests or flightless birds were seen, descriptions of nesting and molting habitat must be speculative to some degree. The presence of broods at a pond may be indicative of nearby nesting cover, except in cases where hens and young have traveled between ponds.

The limited number of Mexican Duck nests discovered by investigators in recent years were generally located in relatively dense cover in areas free from intrusion by livestock or humans (Davis and Bevill 1970, Williams 1973, 1974, Zahm 1973). The related Black Duck (Anas rubripes) tends to select sites at which the most adequate cover is present at the time of nesting (Coulter and Mendall 1968). Nesting activity began in March on the study area, when little or no protection was afforded by idle farm fields and the sparse, sometimes burned-over weed growth from the previous year. In the absence of other cover, I

suspect that Mexican Duck hens use the dense stands of wintergrown barley or wheat which frequently adjoined the pumpback ponds. Of 21 ponds known to have produced broods in 1974, 13 were adjacent to these crops (Table 5). In addition to wheat or barley, dense growth of alkali sacaton or limited cover in nearby mesquite pastures provided protection in a few areas. Table 5 suggests that the presence of apparently adequate cover at a pond does not guarantee nesting. Other ecological necessities may be lacking, there may exist a surplus of suitable breeding areas, or some of the so-called nonproductive sites may actually have supported unobserved broods. The data do show that nesting depends on the presence of cover plants. Winter crops are of particular importance in exclusively agricultural sections where native vegetation or pastureland is scarce.

Table 5. 1974 nesting cover at 21 productive ponds and at a similar number of randomly selected nonproductive ponds.

Type of Cover	Productive Ponds	Nonproductive Ponds
Wheat or Barley	8	7
Mesquite Pasture	3	2
Dense Peripheral or Surrounding Grass	5	2
Wheat or Barley plus Mesquite Pasture	1	1
Wheat or Barley plus Dense Peripheral or Surrounding Grass	4	0
No Cover	0	12
TOTAL	21	24

All ducklings which I saw used only those ponds having sufficient peripheral cover for concealment. Generally broods were protected by dense shoreline grasses which in many cases overhung the ditch or pond. Very few ponds in the valley had extensive stands of cattails or rushes.

Statistical tests performed on the composite of habitat data did not always produce consistent or explicable results. Tables 6 and 7 summarize the major outcomes of summer analysis.

Vegetation. Plants at the water sites were studied both in reference to species composition and overall density. In studying the relation between plants and use of ponds by Mexican Ducks, I applied statistical analysis only to the vegetation density data. Presumably the use of vegetation as cover is of greater value to ducks than the presence of any one plant species at a pond. Furthermore, I observed no tendency for particular kinds of plants to occur at prime duck areas but not other ponds.

Common and scientific names of all encountered plants may be found in Appendix C. Appendix E presents in detail the percent occurrence and relative abundance of these species in the three pond zones (central, marginal, and shoreline). Table 8 summarizes the distribution of major plants at the ponds and denotes those which are often consumed by waterfowl.

The five most common plants along the water areas were Johnson grass, aster, wild millet, curly-leaf dock, and smartweed. The last three are important duck foods (Martin and Uhler 1951). In addition Martin and Uhler report that domestic sorghum (Sorghum vulgare) is

Table 6. One-factor effects of summer habitat variables on the presence of Mexican Duck broods or adults. -- Level of significance is in parentheses. NA = not analyzed, ↑= increased, ↓= decreased.

Method of Analysis	Dependent Variable	Shoreline Vegetation Density	Water Depth	Pond Acreage	Disturbance	Maximum Distance to Cover
Chi-square	Presence of Brood	↑ density, ↑ broods (.05)	NA	NA	↓disturbance, ↑broods (.005)	NA
t-test	Presence of Brood	NA	Not sig.	Not sig.	NA	Not sig.
Correlation Coefficients	Duck counts	NA	Not sig.	↑acreage, ↑ave. counts (.05)	NA	↑distance, ↑ave. counts (.01)
Multiple Regression	Duck counts	NA	Not sig.	Not sig.	NA	↑distance, ↑ave. counts (.01)
One-way Analysis of Variance	Duck counts	- - - - - No significant differences shown between groups - - - - - -				
Factorial Analysis of Variance	Duck counts	Not sig.	Not sig.	Not sig.	↓disturbance, ↑ave. counts	NA

Table 7. Interactions between habitat variables. -- Level of significance is in parentheses.

TWO-FACTOR INTERACTIONS BETWEEN HABITAT VARIABLES

Statistical Procedure	Variables Tested	Season	Significant Results
Factorial Analysis of Variance (applied to all binary combinations of independent variables)	Vegetation density Depth Acreage Disturbance Maximum distance to cover	Summer	Disturbance vs. maximum distance to cover: negative interaction (.05)
Correlation Coefficients	Acreage vs. depth Acreage vs. max. dist. to cover Depth vs. max. dist. to cover	Summer	Acreage vs. maximum dist. to cover: positive correlation of .921 (.01)
	Acreage vs. depth Acreage vs. max. dist. to cover Depth vs. max. dist. to cover.	Winter	Acreage vs. max. dist. to cover: positive correlation of .881 (.01)

EFFECT OF TWO-FACTOR INTERACTION ON A RESPONSE VARIABLE

Statistical Procedure	Interaction of Habitat Variables	Response Variable	Season	Significant Results
Factorial Analysis of Variance (applied to all binary combinations of habitat variables vs. their combined effect on any response variable)	Veg. x depth Veg. x acreage Veg. x disturb. Depth x acreage Depth x disturb. Acre. x disturb.	Depth Acreage Maximum distance to cover Ave. duck counts Adjusted duck counts	Summer	(Acreage x disturbance) vs. (average duck counts): high disturbance decreases ave. no. of ducks, except in larger ponds (.05)

Table 8. Relative abundance of major[a] plants at water sites. -- All names are from Kearney and Peebles (1960).

Relative Abundance	Scientific Name	Common Name
Abundant in most areas under observation	Aster riparius	Aster
	Echinochloa crusgalli[b]	Wild millet
	Polygonum[b]	Smartweed
	Rumex crispus[b]	Curly-leaf dock
	Salsola Kali	Russian thistle
	Sorghum halepense	Johnson grass
Found scattered in most areas	--	Algae
	Amaranthus Palmeri[b]	Careless weed
	Eleocharis[b]	Spikerush
	Erigeron canadensis	Horseweed
	Euphorbia albomarginata	Rattlesnake weed
	Helianthus annuus	Common sunflower
	Solanum elaegnifolium	Silverleaf nightshade
	Sonchus	Sow-thistle
Occasional plants or communities	Andropogon barbinodis	Cane Beardgrass
	Hoffmanseggia densiflora	Hogpotato
	Lactuca serriola	Prickly lettuce
	Leptochloa fascicularis	Gray sprangletop
	Potamogeton[b]	Pondweed
	Prosopis juliflora	Velvet mesquite
	Scirpus	Bulrush
	Sporobolus airoides	Alkali sacaton
	Typha domingensis	Cattail
Scarce (widely scattered) or in localized areas only	Aristida hamulosa	Three-awn
	Asclepias subverticillata	Poison milkweed
	Bassia hyssopifolia	Smother-weed
	Descurainia Sophia	Tansy-mustard
	Distichlis stricta	Inland saltgrass
	Eragrostis obtusiflora	Alkali lovegrass
	Paspalum distichum	Knot grass
	Polypogon monspeliensis	Rabbitfoot grass
	Salix Gooddingii	Goodding willow
	Tamarix pentandra	French tamarisk

[a] comprising more than 10 percent of species frequency in sample area.

[b] a common food of western ducks (Martin and Uhler 1939).

commonly consumed by western ducks. Dense growth of related Johnson grass (S. halepense) along the periphery of most ponds therefore probably supplied a plentiful food source while also providing excellent cover for broods and adults. I frequently observed ducks feeding on seed heads of Johnson grass. Of the two Mexican Duck alimentary tracts which I studied, one contained mostly Johnson grass seeds plus some seeds from curly-leaf dock.

Factorial analysis of variance indicated no significant influence of vegetation density on numbers of adult ducks per water area. However, the presence of broods at any given pond was shown to be related to vegetation density by a Chi-square test ($\chi^2 = 4.11$; d.f. = 1; $p < .05$).

Water Depth. According to statistical analysis, depth of ponds did not influence the presence of Mexican Ducks in the summer season.

Pond Acreage. Multiple regression and factorial analysis of variance revealed no strong association between pond size and use by Mexican Ducks. Correlation analysis did show a relationship between acreage and average duck counts per pond ($r = .327$; $p < .05$), but no significant correlation existed between acreage and numbers of waterfowl adjusted for a one-acre pond. With my sample size, there is no statistical evidence that impoundment size exerted significant summertime influence on distribution of Mexican Ducks.

Disturbance. Broods tended to be present where impoundments were relatively free from human activity ($\chi^2 = 16.471$; d.f. = 2; $p < .005$). Factorial analysis of variance disclosed significant interaction between disturbance at a pond and the consequent mean number of

adult ducks ($F_{2,26} = 5.336$; $p < .05$). This relationship is represented by the following equation:

$$MD = 1.620 + 1.871D_I - 0.677D_{II} - 1.194D_{III}$$

MD = predicted number of Mexican Ducks per pond
D_I = low disturbance
D_{II} = medium disturbance
D_{III} = high disturbance

In general a low disturbance level did not inhibit the use of ponds by Mexican Ducks, while higher levels acted with increasing strength to discourage the presence of these waterfowl.

Vegetation around a pond's periphery may compensate for a high degree of human intrusion. The only brood pond located in a high disturbance area also had dense stands of tall grass about its circumference.

Disturbance and pond size may also act together to determine the suitability of the habitat. Figure 6 presents the situation pictorially. Here it is evident that increasing disturbance will reduce the average number of Mexican Ducks in ponds of small to medium size. This trend does not occur where ponds are larger than one acre. The suggestion is that the inimical effect of disturbance is mitigated by large acreage, which offers protection by distance. The fact that duck numbers in Figure 6 are average, not adjusted, counts should not affect conclusions in reference to disturbance because in each vertical plane acreage remains constant.

Maximum Distance to Cover. No logical relationship was evident between this variable and use of ponds by Mexican Ducks. A Student's t-test failed to reach the .05 significance level. Significant positive

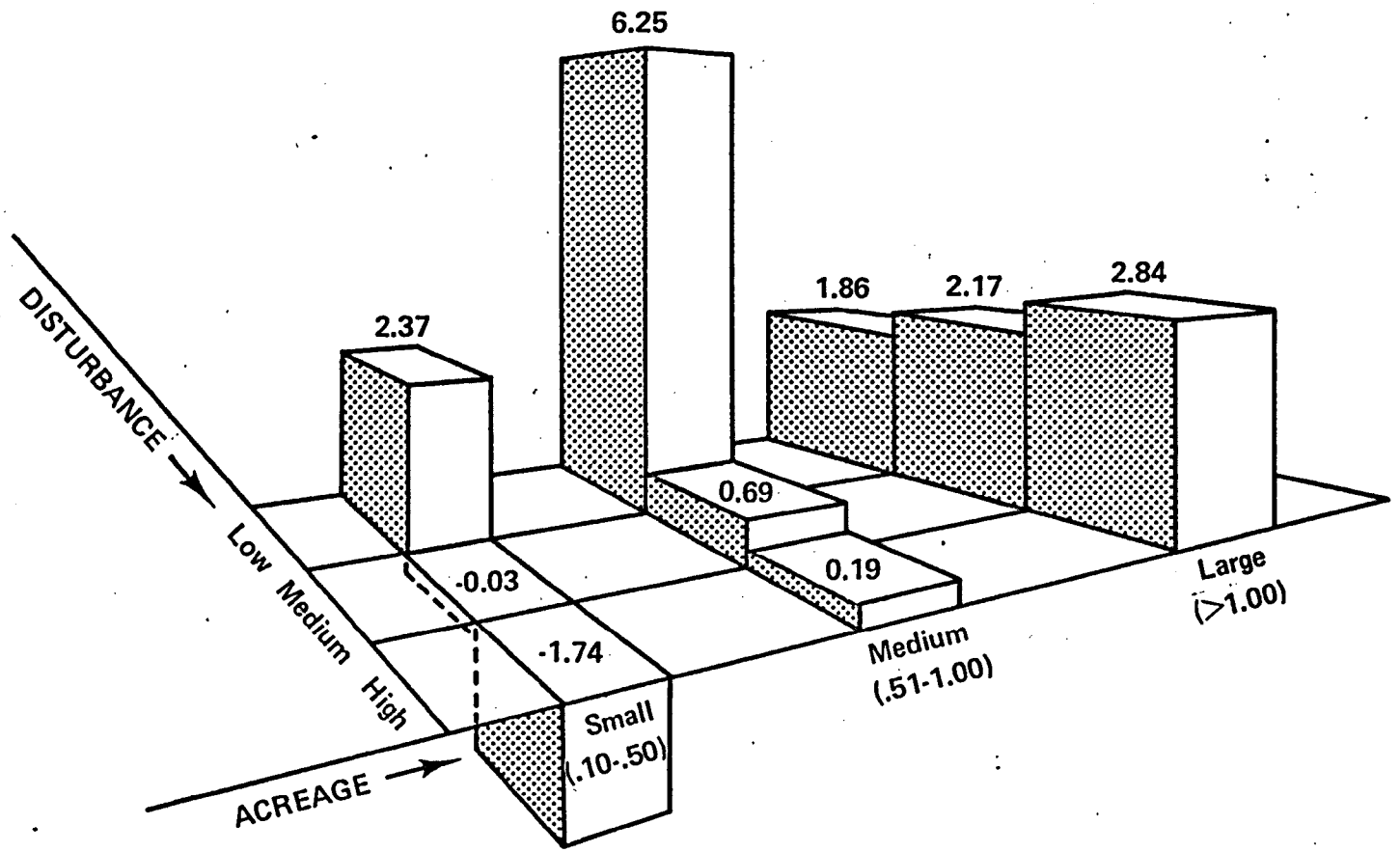

Figure 6. Effect of acreage-disturbance interaction on summer Mexican Duck counts. -- The horizontal plane represents the mean number of ducks for all censused ponds. Vertical blocks indicate the deviation from that mean in each acreage-disturbance category.

correlation was noted between distance to cover and average numbers of ducks per pond ($r = .327$; $p < .05$). Regression analysis revealed the following relationship:

$$MD = .953 + 6.555DC$$

MD = predicted number of Mexican Ducks per pond
DC = maximum distance to cover
$R = .400$
$R^2 = .157$
$p(DC) = .006$

Though distance to cover appeared significant in the equation beyond the .01 level in affecting the presence of ducks, the low value of R^2 points out that this relationship accounts for only 16 percent of the variation in duck numbers at ponds. Conclusions therefore cannot be drawn with reliability.

Winter Habitat Analysis

The influx of northern ducks during fall migration greatly increases the valley's wintering waterfowl population. Up to 6000 ducks were noted on the larger bodies of water in winter, contrasting to the summer situation in which breeding pairs generally utilized smaller, scattered areas. Greater pond acreage accommodates the congregations of gregarious wintering birds and also provides extensive surface area for courting.

I am unable to adequately characterize the habitat factors conducive to pair formation of Mexican Ducks because courtship in this species was observed on only one occasion. Essential features in the San Simon Valley include open areas with good visibility and gently sloping shorelines free of tall vegetation (Davis and Bevill 1970).

Size of the area seems unimportant. Although the courting Mexican Ducks I observed were on a small pumpback, most displays and matings of other waterfowl were noted on the larger areas.

Table 9 summarizes the main results of winter habitat analysis. Significant interactions between winter pond factors are given in Table 7.

Shoreline Vegetation Density. This variable acting alone was not shown to significantly affect winter pond use by Mexican Ducks.

Water Depth. Increasing depth was found to be negatively correlated with average numbers of ducks ($r = .547$; $p < .01$). Regression demonstrated a similar association (see below).

Pond Acreage. Multiple regression analysis showed the following relationship among pond depth, acreage, and average numbers of ducks:

$$MD = 4.616 - .707PD + .102PA$$

MD = predicted number of Mexican Ducks per pond
PD = pond depth
PA = pond acreage

$R = .655$
$R^2 = .489$
$p(PD) = .001$
$p(PA) = .020$

The linear relation suggests that Mexican Ducks tend to occur on winter ponds of shallower depth and larger size. Depth and acreage were not significantly correlated. Depth appears to be the more important of the two habitat variables (standard partial regression coefficients 0.534 and 0.360, respectively). In addition significant correlation was shown between increasing acreage and duck counts ($r = .379$; $p < .05$). No test, however, showed the association of acreage and adjusted counts to be significant, although examination of data from the analysis of variance suggested an inverse relation between the two variables.

Table 9. One-factor effects of winter habitat variables on the presence of Mexican Ducks. -- Level of significance is in parentheses. NA = not analyzed, ↑= increased, ↓= decreased.

Method of Analysis	Dependent Variable	Shoreline Vegetation Density	Water Depth	Pond Acreage	Disturbance	Maximum Distance to Cover
Correlation Coefficients	Duck Counts	NA	↓depth, ↑ave. counts (.01)	↑acreage, ↑ave. counts (.05)	NA	Not sig.
Multiple Regression	Duck Counts	NA	↓depth, ↑ave. counts (.01)	↑acreage, ↑ave. counts (.05)	NA	Not sig.
One-way Analysis of Variance	Duck Counts	Some between-group differences were shown at the .01 significance level. Generalizations are:				
		No trend	↑depth, ↑adjusted counts	↓acreage, ↑adjusted counts	↓disturbance, ↑adjusted counts	NA
Factorial Analysis of Variance	Duck Counts	- - - - - - - -Insufficient data for valid analysis- - - - - - - - -				

Disturbance. Data from the one-way analysis of variance indicated that a high level of pond disturbance discourages waterfowl use. All pond groups which were significantly different from others and never contained ducks also invariably were subjected to heavy human activity.

In the same test, two groups of prime ponds were found to be significantly different from other less-used ponds ($F_{17,29} = 5.164$; $p = .003$). Inspection of the groups' characteristics suggests a vegetation-disturbance interaction whereby poor vegetation density at a pond can be compensated for by low disturbance, and higher disturbance may be offset by dense shoreline growth.

Distance to Cover. Two analyses failed to show that this variable influenced the presence of Mexican Ducks at water areas in the winter season.

Water Analysis

To obtain a more complete assessment of the Mexican Duck's environment, water samples from six ponds on the study area were tested for general chemical content. Results of this analysis are presented in Table 10. The first four ponds listed were productive in 1974; the remaining two apparently produced no broods the past three years. Ions of calcium, sodium, bicarbonate, and sulfate comprised the chief dissolved solids. These representative ponds were slightly alkaline.

Pesticide Analysis

Table 11 shows the DDT residues recovered in one Mexican Duck and in various aspects of the species' habitat. Because the duck's food pyramid has at its base the watery environment which supports minute

Table 10. Chemical analysis of water from selected pumpback ponds in 1974.

Pond Name and Location	Ionic Content (ppm)									Soluble Salts (ppm)	Elec. Cond.	pH
	HCO_3^-	Ca^{++}	Na^{++}	$SO_4^=$	Mg^{++}	Cl^-	Fl^-	NO_3^-	CO_3^-			
Robbs Pond ($SW\frac{1}{4}$, $NE\frac{1}{4}$, sec. 13, T15S, R25E)	205	98	89	78	22	160	1.33	26.6	0	655	1.08	7.6
Robison East ($SW\frac{1}{4}$, sec. 15, T16S, R26E)	122	58	52	141	6.6	22	1.00	2.6	0	403	0.56	7.7
Spreckle's Long ($NW\frac{1}{4}$ + $SW\frac{1}{4}$, sec. 9, T16S, R26E)	161	63	53	98	1.8	16	1.78	18.8	0	395	0.59	7.1
Robison-sec. 17 ($NE\frac{1}{4}$, sec. 17, T16S, R26E)	127	37	62	107	4.8	71	1.82	3.3	0	412	0.50	7.5
Pond No. 66 ($NW\frac{1}{4}$, sec. 3, T16S, R26E)	176	22	41	30	9.6	10	1.66	4.2	0	295	0.35	7.2
Pond No. 78 ($NW\frac{1}{4}$, sec. 31, T17S, R27E)	234	28	62	17	4.3	24	5.05	0.15	0	375	0.42	7.1

Table 11. Residues of chlorinated hydrocarbons found in the Mexican Duck's food chain.

Level of Sample	Location of Sample	Amount of Residue (ppm)			
		pp'-DDE	pp'-DDT	op'-DDT	Unknown
Water	Robbs Pond	0.0005	--	--	--
	Pond #16	0.0005	--	--	--
	Robison East	0.0005	--	--	--
	Spreckle's Long	0.0005	--	--	--
	Pond #78	--	--	--	7.5
Vegetation					
Johnson grass:	One-Mile	0.009	0.014	0.008	--
	Spreckle's Long	0.013	0.009	0.004	--
Pondweed and algae:	Gravel Pit	--	--	--	--
	One-Mile	0.076	--	--	--
	Spreckle's Long	0.28	--	--	--
	J. Hill Pond	0.35	--	--	--
Snails	Gravel Pit	--	--	--	--
	One-Mile	0.16	--	--	--
	Spreckle's Long	0.72	--	--	--
	J. Hill Pond	1.7	--	--	--
Mexican Duck (fat tissue; one bird, four samples)	Kansas Settlement agricultural area	$\bar{X}$=28.9	--	--	--

food organisms, several water samples were tested. The pondweed and Johnson grass, snails, and duck fat roughly represent major ascending trophic levels.

Detected residues primarily involved p,p'-DDE, the major metabolite of DDT. Also found were traces of unmetabolized p,p'-DDT and o,p'-DDT. Natural breakdown of DDT since the 1969 ban explains the presence of only minute amounts of the intact pesticide. Many studies show residue concentration to progressively increase along the food chain (Hunt 1966). With some overlap, biological magnification was evident in this project's analysis, the lowest and highest concentrations appearing respectively in water and in duck fat.

DISCUSSION

This project was an attempt to appraise the life cycle and ecology of a species which has been studied relatively little in the past. To increase the base of knowledge necessary for efficient management of this bird, I gathered a broad spectrum of data. Results of the investigation are not intended to be conclusive, and my inferences must to some degree remain speculative pending further field study by future workers.

Requirements and Limiting Factors of the Mexican Duck

Reproduction

Nesting of any duck species in the valley probably begins earlier than with most waterfowl elsewhere, not being influenced by the rainy season as are Mexican Ducks in Mexico (Williams 1974) or by wintry conditions as may happen in the North. Sowls (1955) suggests the presence of a temperature threshold just above freezing which inhibits early spring activity. On the research area freezing temperatures rarely occurred after early March. Correspondingly, laying began in the latter half of that month. Early nesting by Mexican Ducks preceded the departure of the last winter visitors, their leaving being contingent upon the warm weather period in northern breeding ranges. Availability of irrigation water is another factor allowing reproductive activities to commence sooner in the Sulphur Springs Valley than seems apparent for Mexican Ducks in central Mexico (Williams 1974) or New Mexico (Aldrich and Baer 1970), areas where presence of sufficient water may be a

limiting influence. Because of pumping, the 1973-1974 drought and the record-breaking heat in early summer of 1974 probably had little effect on nesting and brood rearing.

Climatic and hydrologic factors in the valley thus allow a prolonged reproductive season, benefiting duck production. Back-dating of brood ages indicated that the nesting period commenced in late March, and brood rearing continued to mid-September (Figure 5). However, these conclusions must be tentative, for reliance on brood data for determination of the nesting season can easily produce erroneous results. Not all broods were detected, and mistakes in aging surely occurred. No nests were located, so only successful nesting attempts are reflected in the graph. Losses to predators may have been heavy in early spring when cover was sparse. Had it been possible to record failures due to predation or to desertion for other reasons, I suspect that a higher and earlier nesting peak would be indicated.

In addition to climate and irrigation, the following factors also influence the valley's production of young: (1) population size, (2) age and sex composition of the breeding population, (3) habitat, particularly the quality and number of breeding ponds, (4) nest and brood losses, (5) renesting effort. Age structure and sex composition could not be accurately assessed in this investigation due to problems in the field. Each of the other contributory elements will be discussed.

Field conditions introduced some degree of error into my census and brood data. Cover was usually insufficient to hide the observer, and heat waves made visibility poor. Positive identification of adults and broods was sometimes impossible because of hybridization or the

similarity and occasional overlap in characteristics of female Mallards and Mexican Ducks. Movements of ducklings between ponds may have caused minor mistakes in brood censusing.

My data lead me to estimate that approximately 150 Mexican Ducks are present in the valley during the breeding season. The reproductive capacity of these ducks seems substantial enough to ensure survival of the species in the area, provided that habitat, mortality, and other factors do not become abnormally limiting.

Kalmbach (1939) considers 60-70 percent nesting success to be a reasonable standard by which waterfowl populations may be maintained or increased. Accordingly the Sulphur Springs population of Mexican Ducks requires the production of 45-52 broods each year. In the past three nesting seasons, an annual average of 37 broods were observed in the Kansas Settlement area alone. The valley's total production probably exceeds this figure because many broods surely were not observed and no breeding censuses were taken north of Willcox. Inasmuch as numbers of Mexican Ducks have not declined here in recent years, I believe that annual increment reaches the necessary figure for population maintenance.

In the three nesting seasons from 1972 through 1974, brood sizes of ducklings at or near flight age averaged 5.7 on the research area. This is identical to the two-year mean for Mexican Ducks in the neighboring San Simon Valley in 1968 and 1969 (Davis and Bevill 1970). The figure also compares favorably with a 19-year average in Canada for the Mallard, one of the most successful ducks in the Northern Hemisphere (Pospahala, Anderson, and Henny 1974).

The number of Mexican Ducks in the valley and their successful reproduction suggest the presence of adequate habitat. Hochbaum (1944) hypothesizes that availability of water areas and the intolerance between drakes largely determine the carrying capacity of a region. The Sulphur Springs Valley may permit an operative coaction of these two factors. Territories have been found to be larger in unbroken water areas (Hochbaum 1944). Thus territorial ducks in an area containing fewer but larger ponds might force some pairs out of the region or onto suboptimal habitat. In this valley, however, I suspect that the abundance of small pumpback ponds allows spacing of pairs so that conflict is reduced but a large breeding population can still be accommodated. In discussing spacing, resource division, and breeding density in Mallards, Dzubin and Gollop (1972, cited by Pospahala et al. 1974:45) speculate, "Where a preponderance of ponds are less than 1.5 acres (0.6 ha.) in size..., spacing behavior disperses pairs among ponds and may play an important role in determining breeding densities or dispersing some later arriving pairs to other habitats." More than 90 percent of the water areas in the Sulphur Springs Valley contain less than 1.5 acres. The numerous small ponds may effectively distribute the breeding population, according to Dzubin and Gollop's hypothesis.

Extent of the study area, density of cover, and the unproductive nest search precluded detection of nest and brood losses. Potential causes of nest destruction or desertion involve overgrazing, farm machinery, and predation. Grazing, especially when heavy, has been shown to adversely affect nesting cover and densities of breeding ducks (Sowls 1955, Kirsch 1969). Cattle were present during the nesting season on

Arizona Game and Fish Department property and at J. Hill Pond. By trampling peripheral vegetation and eating emergent plants, the livestock at these ponds affected attractiveness of the habitat for ducks and may have influenced reproductive performance at the sites. In general, however, destruction from grazing does not seem to be a major problem in the valley.

Plowing, cultivating, and harvesting activities threaten waterfowl nests located in farm fields. If a large percentage of nesting Mexican Ducks do utilize the dense stands of winter wheat, farm machinery is probably not a major cause of nest loss. Plowing and cultivation of the valley's wheat fields is completed before spring, and harvesting occurs after most broods are hatched. An intensive nest study in the area could shed more light on the danger imposed by such agricultural practices. Were this factor a problem, techniques exist which can alleviate nest destruction without hindering farm operations (Milonski 1958).

Any reduction in predators which might be due to human presence is probably more than counterbalanced by destruction from domestic dogs and cats. My observations do not reflect mortality due to predation or other causes, even though brood sizes surely were reduced with time. Multiple sightings of the same brood were too infrequent to allow detection of decreased numbers of young. Other factors might account for the apparent slight increase in brood size with age shown in Table 4. Broods which are initially small may be more vulnerable to losses than larger ones. Because only surviving ducklings are seen, the average brood size at fledging age might thus be greater, even though larger

broods have also lost young. Group mergers would also increase apparent brood size at fledging.

Adverse weather is not a factor of concern in affecting nest success or brood survival in the area. Irrigation pumping prevents pond evaporation that could take place due to high temperatures and low humidity. However, complete drawdown of water occasionally happens in pumpback ponds. Danger to flightless broods is intensified if the drawdown is prolonged or other water areas are not accessible to the young.

Many investigators have noted overland movements of hens and young between ponds (Evans and Black 1956, Berg 1956, Keith 1961). According to Hochbaum (1944), broods generally follow the path of least resistance in these travels and are often found on roads and man-made paths. The network of roads and farm machinery trails throughout the study area may have resulted in limited brood mortality.

Renesting can be important in maintaining waterfowl numbers, especially where nest or brood losses are high. I found no direct evidence of renests but circumstances suggest its occurrence. The lengthy warm season and the nonmigratory habits of Mexican Ducks should facilitate renesting. The nearly-grown brood observed in late September and October, 1973, may have been the result of a second attempt. In Florida the closely related Mottled Duck (Anas fulvigula fulvigula) breeds in latitudes similar to those of the Mexican Duck and generally completes nesting by June 15 (Stieglitz and Wilson 1968). This would leave ample time for second efforts. The plenitude of midsummer water areas in the Sulphur Springs Valley probably encourages late or second attempts. In extensive studies of Mallards throughout southern Canada, significant

positive correlation was found between late nesting and the number of July ponds (Pospahala et al. 1974). A considerable amount of renesting probably takes place in high disturbance regions such as the study area, where ducks may desert nests because of interference from humans, dogs, and machinery.

Some young birds produced from late nesting attempts may succumb to hunters before flight age is attained. Hens could be subject to the same danger because they enter wing molt after the young are raised.

Habitat

Although a considerable part of the environmental investigation was inconclusive, some suggestions did emerge. Mexican Duck habitat may be visualized as a set of complex and little understood relationships among pond depth and size, water quality, amount of human disturbance, and the various aspects of vegetation: species composition, density, and interspersion. Such interaction may have prevented discernment of the pure effect of individual environmental factors and contributed to vague results in statistical analysis. There was an indication that insufficiency of one factor at a pond may be compensated for by the superior quality of another. Environmental requirements may also vary according to differential use of habitat for courting, nesting, brood rearing or molting.

The degree of interference by man or his machines appeared the most influential habitat factor in summer, affecting both brood distribution and numbers of adults at water sites. How much disturbance Mexican Ducks can tolerate remains to be determined. Upon detection of my

presence, Mallards and especially Mexican Ducks flushed before other species. However, Stieglitz and Wilson (1968) believed that Mottled Ducks in Florida withstand considerable disturbance, as only three of 117 observed nests were deserted.

Vegetation density emerged as the only other environmental factor of substantial statistical importance in summer. Dense peripheral plant growth appeared to be correlated with the presence of broods at ponds but showed no definite relation to numbers of adult ducks. Vegetation density is probably of greater value to ducklings, as it affords necessary insect food and also escape cover for the flightless young. The importance of thick growth for broods and also for molting ducks has been pointed out by Johnsgard (1956). At the Bosque del Apache refuge in New Mexico, all Mexican Duck brood ponds possessed dense escape cover adjacent to the water area (Zahm 1973). Though peripheral cover may be less essential for grown birds, evidence from Uhlig (1963) indicates its influence in promoting adult waterfowl use of farm ponds and pits. I presume that this factor attains more overall importance in agricultural areas, where outlying grazing or farming land may include insufficient vegetation for waterfowl during much of the year.

Studies by Martz (1967) and Jarvis and Harris (1971) have demonstrated correlation between the amount of residual cover and breeding phenomena such as nest site selection, pair density, and nesting success. Availability of the previous year's vegetation is especially important where warm temperatures stimulate breeding before new plant growth commences. Autumn burning of weeds adjacent to ponds and roadsides reduces the amount of cover for spring nesters. However, if a

large portion of early breeders in the study area use winter wheat, they would not be critically subject to lack of nesting cover.

Aquatic vegetation also influences the distribution of breeding ducks. Most pumpback ponds were virtually free of aquatic plants, owing to their depth and perhaps in some cases to fluctuating water levels. A few areas did have ample stands of cattail or bulrush, regarded as good cover plants for broods (Knight 1965). Leopold (1959) felt that wetlands containing some cattail or tule marsh are preferred by Mexican Ducks in Mexico. Martin and Uhler (1951) found pondweed to comprise the largest volumetric percentage of plant material consumed by western ducks. In my study the several ponds containing pondweed were generally prime waterfowl areas.

I found that larger ponds had more Mexican Ducks in summer but not in direct proportion to the pond's acreage. Smith (1971) noted that Mallard broods and breeding pairs preferred areas under one acre in size in Alberta parklands. Fifty-eight percent of Mallard broods studied in Saskatchewan were found on ponds containing less than two surface acres (Stoudt 1971). On the other hand, many studies have shown broods or adults to make use of relatively larger ponds (Berg 1956, Evans and Black 1956, Smith 1953). Evans and Black speculate that intolerance between pairs largely influences the spacing of breeding adults, whereas distribution of broods seems governed by habitat requirements. The investigators found that ducklings demonstrated preference for water areas of two to five acres. Ponds smaller than two acres in size were intensively used by ducks only when population pressure forced breeding birds onto this supposedly suboptimal habitat.

Because nearly all ponds in the valley are less than two surface acres, no adequate spectrum exists by which preference could be tested. These small ponds may be less desirable but perhaps are used because of population pressure. Alternatively, limited acreage may not be unattractive to ducks, and the many small ponds could be a positive factor partially responsible for the Mexican Duck's breeding success in the region. The latter suggestion finds support in Leopold's (1933) law of interspersion or edge effect: A maximum amount of shoreline promotes a maximum number of breeding duck territories, if adequate cover and other requirements are met. The numerous irrigation ponds in the Sulphur Springs Valley provide a high amount of edge effect, allowing more territorial shoreline than would fewer but larger water areas.

Both correlation and regression studies showed average duck numbers to increase when distance to cover increased. These results are incongruous in a season when nearby cover seems essential for broods or perhaps molting adults. The fact that distance to cover is a corollary of acreage ($r = .921$; $p < .01$ in Table 6) may be confounding the situation, for larger acreage should increase the number of ducks. Pond size and distance to cover may simply be correlates with other factors more important to habitat use. Broods may also have been sighted more readily when cover was farther away. Furthermore, because cover can conceal predators, a large maximum distance from cover may in fact be safer for broods than close cover. This effect could account for the confusing statistical results I obtained.

I detected no relation between depth of ponds and their summer use by Mexican Ducks. Seventy percent of the ponds analyzed averaged

more than two feet in depth, and very few possessed the shallow shorelines favored by dabbling ducks. Dispersal of pairs during the breeding season demands the use of some less desirable areas, and perhaps an insufficient number of shallow (< two feet) water sites existed to allow spacing of the birds in any discernible pattern. The dispersion factor was less operative once territorialism ceased, but I still noted no tendency for ducks to congregate on shallower (or deeper) ponds.

In the study of winter habitat, one-way analysis of variance demonstrated the presence of significant differences among the various groups of ponds but did not reveal the nature of these differences. My interpretations of this test originate from visual inspection of the data, and conclusions should therefore be considered as mere suggestion.

Winter habitat analysis showed some change in relative importance of habitat factors when compared to summer data. Depth of ponds was found to be significant in all winter analyses but never in summer. In general, shallower depths seemed favored by winter ducks. Necessity for dispersion disappears after the reproductive season and should allow more selection of optimum areas such as the shallower ponds usually considered attractive to dabblers.

In comparison with smaller ponds, larger areas yielded greater average duck counts in both seasons. Determination of the wintertime influence of acreage is complicated by the apparent correlation between smaller ponds and higher per-acre ("adjusted") duck numbers. My information is insufficient to clarify whether larger acreage increases the unit value of Mexican Duck habitat or whether more acres merely accommodate more birds. Larger ponds did seem to receive greater use in

winter, as increased acreage was generally significant in attracting waterfowl in that season but not always in summer. The birds probably select more expansive water sites in winter due to lack of territorialism, the gregariousness of ducks at that time, and the use of large areas for courtship.

As in summer, the level of human disturbance at winter ponds continued to be influential, with low interference areas harboring more ducks. The nature of the statistical test precludes comparison of the winter and summer impact of disturbance. I presume that this variable plays a more major role in summer, when isolated, undisturbed areas are required by molting adults or flightless young. Furthermore, wintering ducks may find protection in the large, gregarious flocks of that season, thus compensating somewhat for the adverse effect of human activity. Similarly vegetation density may be less important in winter, when no flightless adults or young are present and the large flocks can provide security when cover is sparse. Vegetation density was not specifically analyzed in winter; however, inspection of pond characteristics in the analysis of variance showed no relation between amount of cover and numbers of Mexican Ducks.

General water quality in the valley seems comparable to that in previous decades. I compared my pond samples with tests of well water taken in the same areas between 1942 and 1957 (Brown et al. 1963). Both now and at that time, ions of calcium, sodium, and bicarbonate were the primary dissolved solids in pumped water from the Willcox and Douglas Basins. In addition sulfate ions were present in considerable quantity in my samples. Water quality data from Brown et al. (1963) indicate a

highly elevated total dissolved solids content in water in or near the playa, owing to evaporation and consequent mineral concentration in that region. Such is probably the case in the Arizona Game and Fish Department ponds and the Country Club Lake vicinity. These sites were not tested. Soluble salt content was somewhat elevated in water from Robb's Pond, located about four miles from the playa.

As a result of many years of agriculture in the valley, DDT residues are present throughout the Mexican Duck's food chain. The highest concentrations in this analysis were seen in Mexican Duck fat. Concentration in the bird as a whole was probably less than indicated because lipid material has been noted to retain residues to a greater degree than other tissues (Dustman and Stickel 1969, Heath 1969). Retention tends to be especially high in the uropygial gland, which comprised part of the analyzed fat. Never did the amount of residue approach the toxic level (1600 ppm) found in the fat of grebes known to have died of DDT poisoning (Hunt and Bischoff 1960). However, aberrations in reproduction and other functions can occur as a result of sublethal concentrations.

The limited extent and scope of this analysis restrict its usefulness in assessing the amount and effect of DDT in the Mexican Duck's environment. These data may find utility in future studies in southeast Arizona or when added to the wealth of information already gathered on this pesticide.

In addition to pesticide contamination, a large number of pumpback ponds contain other features undesirable for Mexican Ducks. High disturbance typifies the valley in general. Many ponds also have tall,

steep banks formed by the dumping of excavated earth around the circumference. This produces a lack of loafing sites plus hampered visibility and subsequent vulnerability to human or predator intrusion. Davis and Bevill (1970) noted that areas with steep banks were not attractive to Mexican Duck broods. However, because most of the valley's pumpbacks have field and roadside locations, high banks are probably helpful to some degree in isolating waterfowl from nearby traffic and farming operations.

In spite of the above negative factors, the pumpback method does provide favorable habitat features for waterfowl. The many small and scattered ponds allow necessary dispersion during the nesting period. Pumping assures a permanent water supply, lengthening the nesting season and reducing duckling mortality. Crops of winter wheat create nest cover early in the year when residual natural growth is sparse. I assume the birds select areas which have the right combinations of necessary elements, as is suggested by factorial interrelation and compensation found in the statistical analysis.

Threats to the Valley's Mexican Ducks

Duck hunting, hybridization, and certain agricultural practices are potential sources of danger to the Mexican Duck in the Sulphur Springs Valley. Hunting is probably the least menacing factor but nonetheless should not be disregarded. Although on the protected list, Mexican Ducks are mistakenly shot by hunters because of the duck's similarity to female Mallards. Hunting loss is probably not of major

importance in the area, for local production of the species seems to remain good.

Ironically the Mexican Duck's success in the Sulphur Springs Valley may be threatened by the same industry responsible for their presence. Because of high rates of pumping, decline of the water table has been dramatic. No estimates are available concerning the projected feasibility of agriculture in the region, but the future of irrigation farming presumably would be limited in an area where lowering of the aquifer proceeds so rapidly. Ephemeral ponds near the playa are dependent on seasonal precipitation and the level of the water table, which reaches to the surface in that area during parts of the year. All permanent water sites are artificial. Continued depletion of the underground reservoir and disappearance of agriculture would therefore eliminate virtually all waterfowl habitat.

The advent of sprinkling systems poses a threat more immediate than the demise of agriculture in the valley. Recent years have seen an upsurge in numbers of movable overhead sprinklers, which are more efficient on some soils in use of water and are often preferred over pumpback methods. Over 100 circular sprinklers were probably in use by the end of 1974, as compared to a single machine two years earlier (personal communication on 13 December 1974 from Carmy Page, director of the Cochise County Agricultural Extension Service, Willcox, Arizona). Continuation of this trend could signal the end of extensive pumpback irrigation and the waterfowl habitat these ponds and ditches provide.

Some encouragement may be found in the long-range prognosis expressed by Carmy Page. According to his views, a complete transition

to sprinklers will probably be forestalled by their adaptation to some soils and not others. Mr. Page estimates that at least one-third of the present number of pumpbacks will remain in service long-term. Extrapolation from this conjecture suggests a future total of about 50 pumpback ponds which will be available for use by ducks. With proper management and improvement of these ponds plus creation of areas expressly for waterfowl, the valley could continue to be a haven for the Mexican Duck.

Coincident with the spread of Mexican Ducks into the valley, an influx of Mallards has also occurred, both forms moving in to occupy new habitat which has been created only in recent decades. This sympatry has resulted in extensive hybridization which may threaten the Mexican Duck's status as a distinct entity.

Consideration of this bird's hybridization involves some debated issues, particularly in regard to the taxonomic status of the Mexican Duck. I have attempted to conform my inferences to evidence substantiated in the literature, but the unresolved nature of related topics demands that many of my ideas remain speculative.

In the isolation and subsequent differentiation of two related populations, the development of intrinsic isolating mechanisms may or may not reach completion before secondary contact occurs. Hybridization can result when the evolved mechanisms are less than perfect. The morphological similarity of Mexican Ducks and Mallards, their uninhibited association in the study area, and the apparently very high incidence of hybridization suggest that recent association of the two forms came about before speciation was complete. Johnsgard (1961) speculates that as few as two gene pairs may constitute the genetic basis of sexual

dimorphism in the mallard group (Anas platyrhynchos, A. diazi, A. fulvigula fulvigula, A. fulvigula maculosa, A. rubripes). His extensive investigation of these waterfowl indicates Mexican Ducks to be the most closely related to the common Mallard. Both he and Hubbard (1974) have advanced hypotheses to account for the evolutionary differentiation of these closely related birds. Johnsgard (1961) has proposed reclassifying the Mallard and Mexican Duck as subspecies: Anas platyrhynchos platyrhynchos and A. p. diazi, repectively.

Similar and contrary views have been presented by numerous workers. Aldrich and Baer (1970) favor considering the Mexican Duck a distinct species, based on the degree of reproductive isolation which they assert is apparent in sympatric regions. However, I found no evidence in my study area that any obvious physical, behavioral, or ecological barriers act to separate the two forms reproductively. Both types freely associated in mixed groups and formed cross-pairs. Considering Johnsgard's (1961) data suggesting few allelic differences between the two forms, I too find insufficient justification for classifying each as a full species.

According to Johnsgard's (1961) hypothesis, Mexican Ducks and Mallards have only lately established secondary contact after a long period of isolation. Extensive pumping of underground water began about 1950 in the Sulphur Springs Valley (Brown and Schumann 1969), leading to the very recent range extension of the two forms across an arid barrier. Sympatry of Mallards and Mexican Ducks in the valley has produced a zone which, according to my observations, may be largely hybrid. If the Sulphur Springs Valley now contains the majority of this country's

Mexican Ducks, extensive crossbreeding here could genetically swamp the U. S. population of the species.

The degree to which introgression of Mallard genes will affect the Mexican Duck is dependent on the presence and strength of isolating mechanisms between the two populations. Possible separating forces involve ecological, seasonal, behavioral, and postmating factors. Study of the mallard group shows that these mechanisms are far from perfect, though apparently some gene exchange is precluded by their action.

Former segregation of Mallard and Mexican Duck breeding ranges is suggestive of respective adaptation to more northerly or southerly climates. Before the advent of large-scale southwestern agriculture, separation of Mallard and Mexican Duck ranges seemed to be produced partly by the seasonal precipitation differences which govern nesting.

The confusing array of observations in the literature indicates that while some behavioral and postmating isolating mechanisms do exist, members of the mallard group are too similar for these separating agents to produce complete reproductive isolation. Delacour (1956) and Aldrich and Baer (1970) refer to a lack of association between Mexican Ducks and wintering Mallards, yet I detected no segregation in my study area at any point before spring dispersal. The marked similarity of courtship in the mallard group apparently has facilitated interbreeding among some members (Johnsgard 1961). Sterility is ineffective as a postmating isolating mechanism because fertility is common among crosses of Anas (Johnsgard 1968). The fecundity of Mallard/Mexican Duck hybrids on the study area is indicated by the substantial percentage of individuals possessing intermediate or patchy characteristics.

Whether hybrids are at a disadvantage during pair formation is debatable. I noted a few cross-pairings involving hybrids, but small sample size and difficulties in identification prohibit any estimation of frequency. The intermediate signal characters of hybrids may limit successful courtship and pairing (Sibley 1957, Mayr 1970). Johnsgard (1960a) found some indication of selection against domestic Mallard hybrids competing for mates.

Evidence suggests that the bright plumage colors and patterns exhibited by most drakes may act as "supernormal releasers" to the females of monomorphic species, stimulating a female response stronger than that elicited by the courtship of drakes of their own kind (Sibley 1957). Johnsgard (1968) reports a lower species discrimination by displaying drakes as contrasted to hens. Mallard hybrids are usually the product of a drake Mallard mating with a female of another species, rather than vice-versa (Dilger and Johnsgard 1959). A combination of decreased species discrimination and stronger plumage patterns in Mallards could undermine the integrity of the Mexican Duck's gene pool, especially if a surplus of Mallards exists. This hypothesis remains to be tested.

Comparison of field observations with the afore-mentioned factors contributory to hybridization suggests that the valley's incidence of crossbreeding is quite high. Winter censuses of drakes revealed a ratio of three Mallards for every Mexican Duck. As this season is the period of pair formation, mixed company on wintering grounds may be an estimate of sympatry (Johnsgard 1967) and may contribute to interbreeding in spring. The resident interspecific ratio in spring of 1974

became one Mallard for every five Mexican Ducks, and the nesting population consisted of 5 percent obvious hybrids. The actual percentage of crossbreeds certainly is greater than this figure, for subtle differences are hard to detect in the field. In Mallards and Black Ducks, the small genetic controls (perhaps two allelic pairs) which govern male plumage differences allow only about 15 percent of the sympatric population to be phenotypically pure (Johnsgard 1967). Genetic mechanisms probably operate similarly in my study area to produce a percentage of hybrids much greater than what is outwardly discernible.

The extent to which this hybrid zone will affect the species structure of the Mexican Duck cannot be estimated at present. According to Selander (1971:116), the amount of introgression in such a situation may vary widely and, "not infrequently, there is no demonstrable introgression into populations of the parental forms despite the continued existence of a hybrid 'swarm' in the contact zone, presumably because of selection against potentially introgressant genes." Evidence is inadequate at this point to judge whether Mallard/Mexican Duck hybrids are sufficiently successful and intermediate in ecological tolerance to cause geographic expansion of the present hybrid zone.

Several factors appear to place the Mexican Duck at a selective disadvantage genetically in this country. (1) Mallard/Mexican Duck hybrids seem quite successful, as suggested by their high frequency in the valley. (2) The comparatively small size of the Mexican Duck's gene pool makes it vulnerable to possible swamping. (3) The Mallard is a notedly adaptable and opportunistic bird (Delacour 1956), perhaps more tolerant of disturbance than the Mexican Duck. Mallards will

probably continue to invade the Southwest as breeding ducks as long as agriculture continues to provide habitat. Irrigation ponds and ditches may in fact be better suited to Mallards than to Mexican Ducks (U. S. Fish and Wildlife Service 1973). Virtually nothing is known of differences in habitat selection between the two species. Further study of this topic is essential for management of the Mexican Duck.

Seasonal Activities and Behavior of the Mexican Duck

Field-feeding

I found no direct evidence of the feeding in grain fields which is typical of ducks in agricultural areas (Sowls 1955, Winner 1959). No ducks were seen in winter fields of any kind, and the crepuscular flights I did see appeared to lack the regularity and cohesiveness in size and timing that is characteristic of movements to and from feeding grounds. Waterfowl in this area may not utilize waste grain or perhaps do so irregularly and in small numbers. One local farmer did report the presence of foraging aggregations of up to 300 ducks on one of his standing winter wheat fields. However, waterfowl in Manitoba rarely used unharvested grain, doing so only when croplands were flooded (Bossenmaier and Marshall 1958). The wheat field reportedly used in my study probably attracted ducks because of the water which frequently spilled over from the adjacent pumpback.

Reproduction

Findings of Girard (1941) and Johnsgard (1955) suggest that November through January constitutes the major display period of

Mallards and Black Ducks (Anas rubripes), two close relatives of the Mexican Duck. Commencement of sexual display begins in December among Mexican Ducks in the neighboring San Simon Valley of New Mexico (Davis and Bevill 1970). I observed courtship among Mexican Ducks on only one occasion. Such activity probably occurred throughout the winter but was not detected in that season, partly because these dull-plumaged ducks were relatively inconspicuous in the large congregations of migrants on the wintering areas.

Pair bonds generally are well-formed in Mallards by December or January (Sibley 1957). In the San Simon Valley, pair formation of Mexican Ducks seems to begin in December, reaching completion about February if sex ratios are fairly even (Davis and Bevill 1970). On my study area, pairing of Mallards and Mexican Ducks seemed complete by the end of February.

Although dabbler drakes normally desert their mates around the second week of incubation, this generalization may not always apply to Mexican Ducks. In June of 1974, I watched an unattended brood of half-grown Mexican ducklings for perhaps a quarter hour, at which point they were joined by a drake and hen. Both adults remained with the young for 15 minutes, until the approach of farmers flushed the male. Lindsey (1946) observed one Mexican drake with a female whose eggs were nearly ready to hatch. At New Mexico's Bosque del Apache refuge, Zahm (1973) noted two drakes associating with mates whose broods were present or nearby. Such observations made by myself and other workers may be exceptional. On the other hand, they may exemplify a pair attachment among Mallard-like forms which is more substantial than that of most

anatids. Male Mottled Ducks (Anas fulvigula maculosa) have been observed to remain with the female until the eggs hatch (Engeling 1950, cited by Stieglitz and Wilson 1968). Evidence has led Stieglitz and Wilson to speculate that Florida's Mottled Ducks (A. f. fulvigula) may form more or less permanent pair bonds, broken temporarily while the female is engaged in brood rearing.

Hochbaum (1944) advances another explanation: Most reports of drakes accompanying a hen with young originate in regions featuring scattered sloughs and potholes, such as the study area, rather than a large degree of continuous water surface. Relatively isolated males in these regions may show prolonged attachment to territories and mates because no extensive water areas exist to draw postbreeding drakes together.

Molting

I found no conclusive evidence that postbreeding Mexican Ducks remain in the valley to molt. With the exception of females with broods, there appeared to be a scarcity of Mexican Ducks and a complete lack of Mallards from mid-June to mid-August in both years of the study. I never encountered a flightless adult of any species. Disappearance could be explained by the secretiveness of molting birds and the abundance of cover in many areas. Mallards may have been present but unrecognized in the eclipse plumage and bill coloration which make them inseparable from Mexican Ducks. On the other hand, postbreeding individuals may pass the molting period in more suitable localities elsewhere. Many thousands of Pintail drakes whose mates are nesting in

Canada come to Oregon's Malheur National Wildlife Refuge to molt (letter dated 29 August 1974 from Walter Anderson). Studies by Hochbaum (1944) and Oring (1964) show evidence of extensive movements of dabblers from breeding marshes to distant molting areas. Hochbaum surmises that many midsummer migrants in his Manitoba study area originate from the province's smaller breeding marshes and innumerable sloughs, ditches, and potholes. Similarly the small ponds and ditches of my study area may lack prerequisites which molting birds can find elsewhere, perhaps in the adjoining San Simon Valley.

Among other factors, size and isolation of wetlands seem to largely influence the quality of molting habitat (Hochbaum 1944, Oring 1964). Extensive surface area can facilitate open-water feeding by flightless birds otherwise vulnerable to terrestrial predators. The valley contains no large water areas with suitable cover, and the isolation required by flightless ducks is not found in the agricultural area. Protective, concealing cover may be at a seasonal low, as many croplands surrounding pumpbacks will have been harvested and weed growth is often burned. These suboptimal qualities may cause movement of post-breeding ducks from the valley. Resolution of the question awaits further observation and could be aided by banding studies.

Migration

Whether Mexican Ducks in this country constitute a sedentary or partially migratory population has not been determined. Johnsgard (1961) cites evidence for considering the U. S. segment of the species as seasonally mobile. On the other hand, Leopold (1959) sees no

indication of long movements by this duck. My data indicate that Mexican Duck numbers were rising in the valley between approximately February 1 and March 15. The apparent increase may reflect a true springtime influx of birds from Mexico or may only be an artifact of the census situation, especially when one considers that my visits to ponds could not always be regular or systematic. Any apparent trend in duck numbers could partially result from clustering of birds in one pond or another.

On 19 February 1974 I visited the Playa Pond, which was previously dry and thus rarely censused. I found the site well watered and containing approximately 6000 ducks, Mexican Ducks comprising a small portion of the total. As this pond was the valley's prime waterfowl area, counts at the site from that point on may explain the tabular increase of Mexican Ducks in early spring (Table 1). However, counts of this species at the Ranch Cienega, the second most frequented area, generally increased during the same period. Also, peak numbers of Mexican Ducks in the valley and at the Playa Pond and Ranch Cienega coincided on the same day. My observations may indicate springtime migration of a wintering group from Mexico, but the data are too circumstantial to provide a solid basis for judgment on this issue. The problem will probably not be resolved until clarified by banding evidence.

Importance of the Valley for Waterfowl

In the past the distribution of the Mexican Duck involved the San Simon Valley on the Arizona-New Mexico border, the Rio Grande Valley of New Mexico, and a few areas in western Texas. The majority of the population still dwells in Mexico, extending to the volcanic belt south

of Mexico City (Aldrich and Baer 1970). Although still present in small numbers over virtually all of its former range, the bird no longer is found in much of this extensive area. Dwindling numbers of Mexican Ducks prompted Levy (1964:558) to describe the species as the rarest of our native waterfowl.

The alarming rate of wetland destruction in this country along with the simultaneous decline in numbers of Mexican Ducks indicates that this species is becoming limited by availability of habitat. Levy (1964) expressed the fear that the U. S. population of Mexican Ducks in the mid-sixties filled all suitable nesting areas. Shallow, sluggish waterways provided excellent waterfowl habitat in the Southwest prior to erosion caused by overgrazing (Levy 1964). With the resultant lowering of the water table, these natural marshy areas disappeared. Drainage, farming, and diversion of water for other human needs have continued the trend. Irrigation farming is doubly deleterious by its eradication of marshes and also by the subsequent pumping which lowers the water table.

In the Sulphur Springs Valley, irrigation appears to have temporarily benefited the species. No extensive waterfowl habitat existed in the area prior to development, and records show no evidence of Mexican Ducks before 1968 (personal communication on 19 December 1974 from Gale Monson, co-author of The Birds of Arizona). Pumping of water into artificial impoundments has vastly increased here in the past three decades (Arizona Water Commission 1973), allowing the ducks to spread into this valley concurrent with marsh destruction in their historical habitat. I estimate the valley to contain at least 150 of the birds; this is one of the largest concentrations of the species in the U. S. at present.

Use of the valley by Sandhill Cranes also shows the value of the region for water birds. Although formerly common in the state, sightings of these birds had become exceedingly rare by 1964 (Phillips, Marshall, and Monson 1964). At the time of this writing, my observations on the research area provided the earliest arrival date and maximum count in Arizona (personal communication on 19 December 1974 from Gale Monson).

Field work produced other records of note which further attest to the potential of the area. My sightings are presented in the following paragraphs; the accompanying state records were obtained from Gale Monson.

Black-bellied Tree Ducks were almost nonexistent in Arizona until the past few years. They were first seen in the Sulphur Springs Valley in 1973, and a major percentage of subsequent state records originate from this region. I noted several groups of the ducks during the study period.

Pintails have rarely bred in Arizona. I observed a brood of ten Pintail ducklings at the Grassland Pond; these constituted the first nesting record of that species in the southern portion of the state. Unfortunately, evidence indicates that the young later perished when the pond evaporated, pumping having been stopped due to legal problems.

Although not a threatened species, Canvasbacks have declined in numbers over recent years. Many of these ducks wintered on the valley's deeper water areas during the study.

I spotted a transient White-fronted Goose at an isolated pond in mid-March of 1974. Uncommon in Arizona the year round, this species is especially rare in spring.

A Semi-palmated Plover was noted at the Country Club Lake in August and September of 1973 (personal communication on 30 September 1973 from Walter Anderson). This shorebird is considered rare in Arizona, although such classification may only be due to lack of identification or search.

Snowy Plovers were never known to breed in the state until they began doing so near Willcox in 1972. This locality remains one of only two recorded nesting areas in Arizona. In June of 1974 I observed two adults with three or four recently hatched young near the Country Club Lake at Willcox.

American Avocets are commonly seen in the saltgrass region surrounding the Willcox Playa and have nested there since 1969. In the summer of 1973 I found a dead juvenile at the Grassland Pond. The birds are still uncommon nesters in the state, and not too many are found where they do nest.

Several types of gulls and terns utilized the Country Club Lake during migration or winter, including the uncommon Sabine's Gull I noted on 10 October 1973.

A complete list of the valley's observed water birds is given in Appendix B. Apparently the Sulphur Springs Valley is attracting many species previously unusual or unknown in the area. In a state where aquatic habitat is lacking, the region supplies a welcome stopoff place for migrants. Large numbers of ducks remain through the winter. Creation of water areas in the valley, though it be for agricultural purposes, is exceptional to the general trend of wetland eradication in the Southwest. This fact plus the use of this disturbed area by supposedly

intolerant Mexican Ducks and Sandhill Cranes attests to the importance of the region for aquatic birds, a value which could be enhanced by additional wetland creation.

The area's worth for these birds probably fluctuates in accordance with natural and man-made causes. Unusually high precipitation in the fall and winter of 1972-1973 produced attractive wintering areas which became dry before or during the 1974 drought. The Ranch Cienega contains little water in most years. In the winter period of 1973-1974, however, it supplied 40-50 acres of shallow dabbler habitat and harbored as many as several thousand ducks at once. At Willcox the rains had filled the numerous ephemeral hardpan ponds surrounding the Country Club Lake. By summer of 1974 the largest bodies of water in the study area were gone: Evaporation had eliminated the Ranch Cienega and the transitory ponds near the Country Club Lake; legal and other complications stopped pumping at the lake and the Game and Fish ponds. I believe this to be the primary reason for lower duck counts in autumn of 1974, especially because larger water areas should be the type most attractive to wintering waterfowl.

Considerations for Management

The needs and interrelated factors which assure the optimum productivity of the Mexican Duck are presently unknown. The purpose of this project has been to survey the Mexican Duck's current status in the Sulphur Springs Valley and to provide an initial base of ecological study from which further investigations of this species can proceed. Using the information which I have gleaned from the literature and have

gathered in this project, I consider the following recommendations to be helpful in management of the Mexican Duck.

Seasonal Requirements

The different activities included in the annual cycle of waterfowl demand some seasonal variation in habitat requirements. These changing needs should be reflected in the various types of habitat provided by an efficient management program.

Spring and summer activities include all the aspects of nesting, brood rearing, and molting. The reproductive carrying capacity of a waterfowl area is promoted by consideration of the needs of territorial birds. Creation of irregular shorelines would provide more edge effect (Hochbaum 1944) and thereby benefit breeding capacity. Adequate cover is necessary throughout reproduction and molting but is especially important in the first part of the breeding season for the earlier nesting which is typical of the valley's Mexican Ducks. The vulnerability of nests, young, and flightless adults requires a minimum of local man-related activity.

The gregariousness of wintering waterfowl replaces the dispersion which was evident during the breeding season. Large ponds typify winter habitat and provide for the large concentrations and courting activities of these ducks. Creation of a few sizeable ponds in choice locations would probably attract more wintering birds because larger ponds are few in number and may be avoided due to their usual placement in high disturbance areas.

General Requirements

The permanent summer ponds resulting from irrigation practices help to increase duck production in the valley. Zahm (1973) feels that Mexican Ducks are attracted by clear or semi-clear water which aids the production of aquatic insects and submergent food plants. Most pumpbacks contain murky water. Perhaps turbidity at some areas could be avoided by lessened inflow and outflow, if compatible with agricultural operations. Stable water levels facilitate growth of emergents (Low 1945, Berg 1956) and also benefit submergent vegetation (Morse 1950). Shearer (1960) found greater numbers of breeding ducks on stock dugouts having stable levels. Complete drawdowns can produce brood mortality and should be avoided. Most pumpbacks lack even marginal shallow areas which are attractive to ducks. Future alteration or creation of duck ponds can hopefully rectify this situation.

Cover. In terms of waterfowl needs, the absence of natural vegetation during much of the year is one of the most detrimental factors caused by farming activities in the valley. Dense stands of winter wheat are one of the few benefits, permitting earlier nesting than may be possible elsewhere in the Mexican Duck's range. In general, however, other cultivated crops do not constitute suitable cover, and fields are bare during most months anyway. Dense weed growth in narrow strips of land alongside pumpbacks and roadsides provides some protection, but these areas are often burned in late summer.

Future management considerations should involve establishment of ponds expressly for waterfowl so that adequate cover can be provided without conflicting with agricultural priorities. When possible,

natural growth could be promoted on idle areas in the farming region either by postponing mowing until the land is needed or through the planting of cover for waterfowl if feasible and necessary. Prevention of overgrazing, especially at prime water areas and during nesting, can benefit waterfowl and also ranchers by increasing the amount of cover and helping to prevent soil erosion. Leopold (1933) points out that most waterfowl commence nesting before suitable new vegetation is present. Cessation of weed burning should increase duck production by leaving more residual cover from the previous year.

The presence of emergent vegetation should improve the quality of waterfowl areas, provided that emergent growth is not extreme. Knight (1965) and Keith (1961) warn of the negative impact on nesting habitat when the tules become overly dense or completely border potholes. Beard (1964) discusses the importance of interspersion of emergents and open water areas in providing respective escape and feeding units for broods. Interspersion of the two should also facilitate access by adults to emergent and submergent food plants. According to evidence presented by Low (1945), deeper spots in the center of ponds may thin or eliminate emergent vegetation. Creation of pumpbacks or duck ponds with alternate deep and shallow areas could serve to intersperse the cover.

Food. The artificial nature of the valley's water areas is not as conducive to optimum growth of waterfowl foods as a natural marsh would be. As is the case with many important cover plants, maintenance of shallow, constant water levels should also increase the amount of food plants. Ponds having plentiful emergent cover and submerged

aquatics would in turn harbor an abundance of snails, crustaceans, and other animal life utilized as food by waterfowl.

It remains for future workers to undertake a detailed analysis of food plant availability and use in this region. Artificial propagation may or may not be necessary. Ducks may consume waste grain to a large extent, compensating for any lack in natural foods.

Loafing Sites. Preference by adults for water areas containing artificial loafing spots has been documented by Uhlig (1963). Adequate resting areas also increase the number of resident broods and favorably influence the carrying capacity of the habitat (Beard 1964). Ducks of all species made extensive use of the central sand bar at the Country Club Lake. Few other loafing spots were present on the study area. Being designed for agricultural purposes, pumpback ponds generally lack bare shoreline and interior or peninsular mud bars which could be used by resting birds. New ponds could incorporate mud or sand spits, and existing pumpbacks could be improved by installation of anchored rafts or logs.

Isolation. Analysis of Mexican Duck habitat showed human interference to be the most detrimental environmental influence. Reproductive capacity of the population could probably be enhanced by limited public access to prime waterfowl areas not located on farmland.

In spite of future efforts to aid the Mexican Duck through habitat improvement, the species may still be threatened with taxonomic extinction by hybridization with Mallards. If the current but largely unenforceable protection of Mexican Ducks were extended to include the valley's female Mallards, the resultant shooting of only drake Mallards

might accomplish a two-fold purpose. This would eliminate hunting loss of Mexican Ducks which occurs through mistaken identity, and cross-pairings between female Mexican Ducks and male Mallards would be reduced. Such a drastic measure would have limited success in hindering hybridization, however. Sacrifice of Mallards would not prevent continued incorporation of this adaptable species into the resident population. Furthermore, even if all drake Mallards were destroyed, only about half of the Mallard/Mexican Duck cross-pairings would be disrupted. This proportion might be higher if female Mexican Ducks are indeed attracted to male Mallards according to Sibley's (1957) "supernormal releaser" hypothesis.

Prospective Areas for Development

At present the valley's numerous small and scattered ponds may aid Mexican Duck production by providing an effective compromise between density-dependent (territorial intolerance) and density-independent (environmental) factors. In the next few years, however, increased use of sprinklers may reduce the number of pumpback ponds to one-third of the current total. In anticipation of that possibility, I suggest the following areas as prospective for development as waterfowl habitat.

Careful selection and improvement of existing pumpback ponds could provide a substantial amount of habitat with less expense than construction of totally new areas. Irrigation ponds or ditches which have consistently attracted the most Mexican Ducks the past three years include the Aravada area, Whitewater Ditch, Robison-Section 17, and J. Hill and Mile Long Pond. It might be worthwhile to preserve these

and other areas for waterfowl even if their use for agriculture was discontinued. Most pumpbacks would benefit by implementation of suggestions for improvement mentioned earlier.

By far the largest congregations of wintering waterfowl were seen on the Ranch Cienega and the 35-acre Playa Pond. Both sites are the most isolated and also the largest of the valley's water areas. At least one of these areas should be maintained year-round. Other ponds, most of which measure under two acres, do not as adequately fill the needs of wintering ducks for large acreage. Most water in the shallow Ranch Cienega originated from heavy rains in the fall and winter of 1972-1973. The adjoining pumpback perhaps could supply any water not provided by precipitation. Government ownership of the Playa Pond might make that area's maintenance more feasible than that of the other. I have no precise information by which to judge the relative ease or expense of either alternative.

The best prospective land for waterfowl may lie in the grassy, alkaline region surrounding most of the playa. This area is presently suited only for livestock. Limited grazing could be permitted without harming waterfowl production, provided that enough water sites were constructed to avoid concentration of cattle around one or two ponds. Dense growth of Mexican saltgrass and alkali sacaton probably supplies adequate cover. Disturbance would tend to be low. During parts of the year, ephemeral ponds near Willcox are filled by the high water table, and the aquifer usually lies only a few feet below the surface in other areas adjacent to the playa. In terms of waterfowl needs, maintenance of duck ponds in this region would not be overly expensive.

SUMMARY

To obtain ecological information on the endangered Mexican Duck, I studied the waterfowl of Arizona's Sulphur Springs Valley in Cochise and southern Graham Counties from May 1973 to October 1974. I gathered supplementary data on other species present in the area to aid in documenting the valley's importance for waterfowl.

Seventeen species of ducks are present in the valley at various times of the year. During winter the area also attracts hundreds of rare Sandhill Cranes and numerous other water birds. About 150 Mexican Ducks are resident in the valley, perhaps making this region the species' major stronghold in this country. In 1974 the study area's observed breeding population consisted of 70 percent Mexican Ducks, 25 percent Mallards, and 5 percent obvious hybrids. One pair of Pintails also nested. An annual average of 37 Mexican Duck broods were known to have been produced from 1972 through 1974.

Ponds having low disturbance and dense cover were preferred by hens with broods. Summer analysis of Mexican Duck habitat showed disturbance to be the major factor influencing pond use by adults. There were some indications that larger acreage attracted more waterfowl, while pond depth exerted no discernible influence. Characteristics of winter ponds reflected a seasonal change in waterfowl requirements. Disturbance remained important in affecting the presence of Mexican Ducks; vegetation density was relatively inconsequential. Pond depth

and acreage attained more influence, with shallower water and larger areas harboring more birds.

Construction of irrigation ponds in the valley has produced local sympatry of Mallards and Mexican Ducks. Resultant hybridization between the closely related forms may endanger the Mexican Duck's status as a taxonomically distinct entity.

Though temporarily benefiting the species, the valley's agriculture threatens the Mexican Duck through depletion of the water table and replacement of pumpback methods by sprinkler systems. These trends show the need for an efficient management program in the Sulphur Springs Valley. The successful breeding of Mexican Ducks on disturbed and artificial areas indicates that creation of permanent, suitable waterfowl habitat could help to preserve this important population.

APPENDIX A

LOCATIONS OF MAIN WATERFOWL AREAS OR BROOD PONDS

Pond Name	Location
Aravada	SW¼, Sec. 23, T17S, R26E
Ausberger	NW¼, SW¼, Sec. 1, T16S, R25E
Baptist Church	NE¼, Sec. 1, T16S, R25E
Big T	NW¼, SW¼, Sec. 11, T17S, R26E
Cal Jones	SW¼, NW¼, Sec. 18, T17S, R27E
Community Center	NW¼ + SW¼, Sec. 14, T16S, R25E
Country Club Flooded	SW¼, Sec. 7, T14S, R25E
Country Club Lake	SE¼, Sec. 7, and NE¼, Sec. 18, T14S, R25E
Ditton	NW¼, Sec. 4, T17S, R26E
Forbes	SE¼, NW¼, Sec. 6, T15S, R26E
Frog Pond	NW¼ + SW¼, Sec. 28, T16S, R26E
Grassland Pond (Az. Game & Fish Dept.)	NE¼, SW¼, Sec. 11, T16S, R25E
Gravel Pit	NW¼, SW¼, Sec. 12, T15S, R25E
Hart's Slough	NW¼ + SW¼, Sec. 10, T16S, R26E
J. Hill Pond	SW¼, SW¼, Sec. 22, and NW¼, NW¼, Sec. 27, T15S, R25E
J. Hill Tank	SE¼, NE¼, Sec. 28, T15S, R25E
J. Moss Slough	NW¼, NE¼, Sec. 1, T17S, R25E
Lewis Hybrid	SW¼, Sec. 20, and NW¼, Sec. 29, T16S, R26E
Lewis New	NW¼, SE¼, Sec. 30, T16S, R26E

Lewis Slough	Nonexistent by 1974
Meer's New	Nonexistent by 1974
Meer's Tule	SW¼, SW¼, Sec. 22, T16S, R26E
Minnow Pond	NW¼, NE¼, Sec. 29, T16S, R26E
One Mile Pond	SW¼, NW¼, Sec. 18, T16S, R26E
Playa Pond (Az. Game & Fish Dept.)	SE¼, SE¼, Sec. 3, T15S, R25E
Ranch Cienega	SW¼, SW¼, Sec. 30, T10S, R23E
Rigg's Lettuce	SW¼, SE¼, Sec. 22, T17S, R26E
Rigg's Slough	Nonexistent by 1974
Robbs Pond	SW¼, NE¼, Sec. 13, T15S, R25E
Robbs-Forbes	NE¼, Sec. 12, T15S, R25E
Robbs Ditch	Temporary
Robbs Steep	NE¼ + SE¼, NE¼, Sec. 13, T15S, R25E
Robison Deast	NW¼ + SW¼, SW¼, Sec. 15, T16S, R26E
Robison Home	SW¼, NW¼, Sec. 16, T16S, R26E
Robison-Section 17	NW¼ + SW¼, NE¼, Sec. 17, T16S, R26E
Round Pond	SW¼, Sec. 26, T16S, R26E
Settlement Bar	NW¼, NW¼, Sec. 36, T15S, R25E
Sewage Ponds	NW¼, SW¼, Sec. 5, T14S, R25E
Small T	NW¼ + SW¼, NW¼, Sec. 2, T17S, R26E
Small Whitewater	NE¼, Sec. 20, T19S, R26E
Spreckle's Long	NW¼ + SW¼, Sec. 9, T16S, R26E
Spreckle's Small	SE¼, NW¼, Sec. 8, T16S, R26E
Three Sisters	NE¼, SW¼, Sec. 5, T17S, R25E
Whitewater Ditch	SE¼, Sec. 17, and NE¼, Sec. 20, T19S, R26E

APPENDIX B

SCIENTIFIC AND COMMON NAMES OF WATER BIRDS
OBSERVED ON THE STUDY AREA

C = Common
U = Uncommon

S = Summer resident
W = Winter resident or migrant

Scientific Name	Common Name	Classification
Podiceps nigricollis	Eared Grebe	C-SW
Aechmophorus occidentalis	Western Grebe	W
Podilymbus podiceps	Pied-billed Grebe	C-SW
Ardea herodias	Great Blue Heron	C-SW
Egretta thula	Snowy Egret	SW
Nycticorax nycticorax	Black-crowned Night Heron	SW
Ixobrychus exilis	Least Bittern	U-SW
Plegadis chihi	White-faced Ibis	CW
Anser albifrons	White-fronted Goose	UW
Chen caerulescens	Snow Goose	UW
Dendrocygna autumnalis	Black-bellied Tree Duck	US
Anas platyrhynchos	Mallard	C-SW
A. diazi	Mexican Duck	C-SW
A. strepera	Gadwall	W
A. acuta	Pintail	CW
A. crecca	Green-winged Teal	CW
A. discors	Blue-winged Teal	W
A. cyanoptera	Cinnamon Teal	CW
A. americana	American Wigeon	CW
A. clypeata	Northern Shoveler	CW
Aythya americana	Redhead	W
A. collaris	Ring-necked Duck	W
A. valisineria	Canvasback	CW
A. affinis	Lesser Scaup	W
Bucephala albeola	Bufflehead	W
Oxyura jamaicensis	Ruddy Duck	CW
Mergus merganser	Common Merganser	W
Grus canadensis	Sandhill Crane	CW
Porzana carolina	Sora	W
Gallinula chloropus	Common Gallinule	SW
Fulica americana	American Coot	C-SW
Charadrius semipalmatus	Semi-palmated Plover	UW
C. alexandrinus	Snowy Plover	C-SW
C. vociferus	Killdeer	C-SW

Scientific Name	Common Name	Classification
Squatarola squatarola	Black-bellied Plover	CW
Capella gallinago	Common Snipe	SW
Numenius americanus	Long-billed Curlew	W
Actitis macularia	Spotted Sandpiper	SW
Catoptrophorus semipalmatus	Willet	UW
Tringa solitaria	Solitary Sandpiper	UW
T. melanoleucus	Greater Yellowlegs	CW
T. flavipes	Lesser Yellowlegs	CW
Calidris melanotos	Pectoral Sandpiper	UW
C. bairdii	Baird's Sandpiper	CW
C. minutilla	Least Sandpiper	CW
C. mauri	Western Sandpiper	CW
Limnodromus scolopaceus	Long-billed Dowitcher	CW
Micropalama himantopus	Stilt Sandpiper	UW
Limosa fedoa	Marbled Godwit	UW
Recurvirostra americana	American Avocet	CS
Himantopus mexicanus	Black-necked Stilt	W
Steganopus tricolor	Western Phalarope	CW
Lobipes lobatus	Northern Phalarope	W
Larus delawarensis	Ring-billed Gull	W
Xema sabini	Sabine's Gull	UW
Sterna forsteri	Forster's Tern	UW
Chlidonias niger	Black Tern	W

APPENDIX C

SCIENTIFIC AND COMMON NAMES OF PLANTS FOUND IN VICINITY OF PONDS

Names are from Kearney and Peebles (1960). (A) = Species seen only in outlying areas more than ten yards from water.

Scientific Name	Common Name
Typha domingensis	Tule; cattail
Potamogeton pectinatus	Sago pondweed
P. foliosus	Leafy pondweed
Festuca octaflora	Sixweeks fescuegrass
Eragrostis cilianensis	Stinkgrass
E. Barrelieri	Mediterranean lovegrass
E. diffusa	Spreading lovegrass
E. arida	Desert lovegrass
E. obtusiflora	Mexican saltgrass
E. curvula	Weeping lovegrass
E. Lehmanniana	Lehmann lovegrass
Distichlis stricta	Inland saltgrass
Scleropogon brevifolius	Burro-grass
Agropyron sp.	Wheatgrass
Triticum aestivum	Cultivated wheat
Polypogon monspeliensis	Rabbitfoot grass
Sporobolus airoides	Alkali sacaton
Aristida hamulosa	Three-awn
Hilaria mutica (A)	Tobosa
Leptochloa filiformis	Red sprangletop
L. fascicularis	Gray sprangletop
Cynodon dactylon	Bermuda grass
Chloris virgata	Feather fingergrass
Bouteleoua Rothrockii	Rothrock grama
Eriochloa gracilis (A)	Southwestern cupgrass
Paspalum distichum	Knot grass
Panicum capillare	Old-witch grass
P. obtusum	Vine mesquite
Echinochloa crusgalli	Wild millet
Andropogon barbinodis	Cane beardgrass
Sorghum halepense	Johnson grass
S. vulgare	Sorghum; milo
Cyperus odoratus	Flatsedge
C. esculentus	Chufa

Scientific Name	Common Name
Scirpus paludosus	Alkali bulrush
S. Olneyi	Olney's bulrush
S. validus	Softstem bulrush
Eleocharis macrostachya	Creeping spikerush
Eleocharis Parishii	Spikerush
Yucca elata (A)	Soaptree yucca
Populus Fremontii	Fremont cottonwood
Salix Gooddingii	Goodding willow
Morus microphylla	Texas mulberry
Rumex crispus	Curly-leaf dock
Polygonum argyrocoleon	Persian wiregrass
P. lapathifolium	Nodding smartweed
P. pennsylvanicum	Largeseed smartweed
Chenopodium murale	Nettleleaf goose-foot
C. Fremontii	Goose-foot
C. sp.	Goose-foot
Atriplex patula	Saltbush
Atriplex sp.	Saltbush
Kochia scoparia	Summer cypress
Bassia hyssopifolia	Smother-weed
Sueda Torreyana	Burro weed
Salsola Kali	Russian thistle
Amaranthus Palmeri	Carelessweed
Portulaca retusa (A)	Purslane
Talinum aurantiacum (A)	--
Argemone platyceras	Prickle-poppy
Lepidium oblongum	Pepper-grass
L. medium	Pepper-grass
Descurainia Sophia	Tansy-mustard
Wislizenia refracta	Jackass clover
Acacia Greggii	Catclaw
Prosopis juliflora	Velvet mesquite
Hoffmanseggia densiflora	Hogpotato
Crotalaria pumila	Rattle-box
Medicago sativa (A)	Alfalfa
Melilotis officinalis	Yellow sweetclover
M. albus	White sweetclover
Kallstroemia grandiflora	Arizona poppy
Euphorbia albomarginata	Rattlesnake weed
Tamarix pentandra	French tamarisk
Sphaeralcea angustifolia	Globe-mallow
S. subhastata	Globe-mallow
Sida lepidota	--
Hybanthus verticillatus	--
Asclepias subverticillata	Poison milkweed
Convolvulus incanus	Bindweed

Scientific Name	Common Name
Ipomoea hirsutula (A)	Morning glory
Cryptantha crassisepala	Cryptantha
Tetraclea Coulteri	--
Chaemesaracha coronopus	--
Physalis Fendleri	Ground-cherry
Solanum elaegnifolium	Silverleaf nightshade
S. americanum	Nightshade
Datura meteloides	Sacred datura
Veronica peregrina	Purslane speedwell
Plantago Purshii	Wooly Indian-wheat
Kuhnia rosmarinifolia	--
Heterotheca subaxillaris	Camphor-weed
Chrysothamnos nauseosus	Rabbit-brush
Aplopappus tenuisectus	Burro-weed
Aster riparius	Aster
Erigeron divergens	Fleabane
E. canadensis	Horseweed
Conyza Coulteri	--
Gnaphalium chilense	Cotton-batting
G. sp.	Cud-weed
Franseria acanthicarpa	Bur-weed
Zinnia grandiflora	Zinnia
Helianthus annuus	Common sunflower
Verbesina encelioides	Crown-beard
Hymenothrix Wislizeni	--
Bahia absenthifolia	--
Gaillardia pulchella	Firewheel
Pectis papposa	Chinchweed
Senecio longilobus	Threadleaf groundsel
Sonchus asper	Prickly sow-thistle
S. oleraceus	Sow-thistle
Lactuca serriola	Prickly lettuce

APPENDIX D

LOCATIONS OF BROODS, 1972-1974

1972 and most of 1973 observations were provided by G. Patrick O"Brien.

MX = Mexican Duck; ML = Mallard; MX-ML = unidentified Mexican Duck, Mallard, or hybrid; T = unidentified teal; CT = Cinnamon Teal; P = Pintail; -- = pond nonexistent

Pond Name	Broods Produced		
	1972	1973	1974
Aravada	5 MX	4 MX	2 MX
Arizona Game & Fish Dept. (Grassland & Playa Ponds)	3 MX, 1 ML	3 MX, 3 ML, 1 CT	1 P
Ausberger	0	1 MX	0
Baptist Church	1 MX	1 MX	0
Big T	0	1 MX	1 MX, 1 ML
Cal Jones	(reported)	2 MX	0
Community Center	0	5 MX, 1 ML	1 MX
Country Club Flooded	--	--	1 MX
Country Club Lake	0	3 MX	--
Ditton	--	1 MX	1 MX-ML
Forbes	(reported)	1 MX	1 ML
Frog Pond	2 MX	1 MX	0
Gravel Pit	0	0	1 MX, 1 ML
Hart's Slough	0	0	1 MX, 1 MX-ML
J. Hill Pond	4 MX	1 MX, 1 ML	2 MX, 1 MX-ML

Pond Name	1972	1973	1974
J. Hill Tank	1 MX	0	0
J. Moss Slough	0	1 MX	1 ML
Lewis Hybrid	1 MX	0	1 MX, 1 MX-ML
Lewis New	--	1 MX	0
Lewis Slough	1 MX	1 MX	--
Meer's New	--	1 MX	--
Meer's Tule	1 MX	2 MX	3 MX, 1 ML
Minnow Pond	1 MX	1 MX	0
One Mile Pond	3 MX	3 MX	5 MX
Rigg's Lettuce	0	1 T	0
Rigg's Slough	4 MX	1 MX	--
Robbs Pond	0	0	1 MX
Robbs-Forbes	--	--	1 MX
Robbs Ditch	--	--	1 MX
Robbs Steep	0	0	1 ML
Robison East	0	0	1 MX-ML
Robison Home	2 MX	0	1 MX, 1 ML
Robison-Section 17	4 MX	3 MX	2 MX, 1 ML
Round Pond	0	1 MX	0
Settlement Bar	1 MX	0	0
Small T	0	1 MX	1 MX
Small Whitewater	1 MX	(reported)	--
Spreckle's Long	0	1 MX	4 MX, 1 ML
Spreckle's Small	1 MX	0	0

Pond Name	1972	1973	1974
Three Sisters	0	1 MX	0
Whitewater Ditch	1 MX	1 MX	1 MX

APPENDIX E

PERCENT OCCURRENCE AND RELATIVE FREQUENCY OF PLANTS IN VICINITY OF PONDS

Genera containing multiple species are listed only by the generic name (i.e., Potamogeton).

Species or Genus	Percent Occurrence	Relative Frequency (percent)
CENTRAL ZONE		
Open Water	69.51	60.13
Potamogeton	13.97	12.08
Algae	10.74	9.29
Echinochloa crusgalli	5.16	4.46
Dead Tumbleweeds (Salsola Kali)	5.01	4.34
Polygonum	4.05	3.50
Typha domingensis	1.44	1.25
Paspalum distichum	1.15	1.00
Rumex crispus	1.06	0.92
Scirpus	0.94	0.82
Sonchus asper	0.74	0.64
Eleocharis	0.72	0.62
Aster riparius	0.46	0.40
Sorghum halepense	0.42	0.36
Gnaphalium	0.10	0.09
Leptochloa fascicularis	0.10	0.09

Species or Genus	Percent Occurrence	Relative Frequency (percent)
	MARGINAL ZONE	
Open Water	51.78	43.36
Potamogeton	11.29	9.45
Echinochloa crusgalli	11.26	9.43
Algae	10.80	9.05
Dead Tumbleweeds (Salsola Kali)	10.19	8.53
Typha domingensis	5.14	4.31
Polygonum	4.85	4.06
Sporobolus airoides	3.20	2.68
Rumex crispus	2.11	1.77
Eleocharis	1.98	1.65
Leptochloa fascicularis	1.70	1.43
Aster riparius	1.68	1.40
Erigeron canadensis	1.27	1.06
Sonchus asper	0.74	0.62
Scirpus	0.56	0.47
Sorghum halepense	0.49	0.41
Eragrostis obtusiflora	0.16	0.13
Paspalum distichum	0.15	0.13
Gnaphalium	0.10	0.09
	SHORELINE ZONE	
Sorghum halepense	48.88	14.94
Echinochloa crusgalli	37.14	11.36

Species or Genus	Percent Occurrence	Relative Frequency (percent)
Aster riparius	22.53	6.89
Rumex crispus	22.44	6.87
Polygonum	20.81	6.37
Salsola Kali	13.32	4.08
Solanum	11.86	3.63
Sonchus	11.73	3.59
Amaranthus Palmeri	10.95	3.35
Leptochloa	9.54	2.92
Andropogon barbinodis	9.20	2.81
Hoffmanseggia densiflora	8.24	2.52
Erigeron	8.10	2.48
Sporobolus airoides	7.24	2.22
Euphorbia albomarginata	6.19	1.89
Eragrostis	5.90	1.81
Asclepias subverticillata	5.47	1.67
Helianthus annuus	5.40	1.65
Lactuca serriola	5.26	1.61
Dead Tumbleweeds (Salsola Kali)	4.78	1.46
Descurainia Sophia	4.41	1.35
Dead Grass or Weeds	3.63	1.11
Bassia hyssopifolia	2.64	0.81
Scirpus	2.63	0.81
Melilotis	2.51	0.77

Species or Genus	Percent Occurrence	Relative Frequency (percent)
Sphaeralcea	2.51	0.77
Bare Ground (covering sample)	2.50	0.77
Paspalum distichum	2.36	0.72
Tamarix pentandra	2.33	0.71
Salix Gooddingii	2.05	0.63
Eleocharis	2.02	0.62
Polypogon monspeliensis	1.76	0.54
Aristida hamulosa	1.38	0.42
Verbesina encelioides	1.31	0.40
Distichlis stricta	1.18	0.36
Cyperus	1.13	0.35
Chenopodium	1.05	0.32
Panicum	0.92	0.28
Aplopappus tenuisectus	0.90	0.28
Plantago Purshii	0.85	0.26
Veronica peregrina	0.84	0.26
Prosopis juliflora	0.83	0.26
Chaemesaracha coronopus	0.83	0.25
Sida lepidota	0.79	0.24
Typha domingensis	0.75	0.23
Heterotheca subaxillaris	0.68	0.21
Sorghum vulgare	0.68	0.21
Lepidium	0.63	0.19

Species or Genus	Percent Occurrence	Relative Frequency (percent)
Triticum aestivum	0.52	0.16
Festuca octaflora	0.51	0.16
Atriplex	0.45	0.14
Wislizenia refracta	0.40	0.12
Gaillardia pulchella	0.38	0.12
Populus Fremonti	0.36	0.11
Cryptantha crassisepala	0.34	0.10
Cynodon dactylon	0.29	0.09
Hymenothrix Wislizeni	0.28	0.09
Gnaphalium	0.23	0.07
Conyza Coulteri	0.23	0.07
Chloris virgata	0.21	0.07
Senecio longilobus	0.19	0.06
Zinnia grandiflora	0.19	0.06
Physalis Fendleri	0.18	0.05
Crotalaria pumila	0.16	0.05
Kochia scoparia	0.12	0.04
Bahia absenthifolia	0.11	0.03
Kallstroemia grandiflora	0.10	0.03
Sueda Torreyana	0.09	0.03
Datura meteloides	0.08	0.02
Scleropogon brevifolius	0.08	0.02
Argemone platyceras	0.07	0.02

Species or Genus	Percent Occurrence	Relative Frequency (percent)
Tetraclea Coulteri	0.06	0.02
Morus microphylla	0.06	0.02
Bouteleoua Rothrockii	0.04	0.01
Hybanthus verticillatus	0.04	0.01
Convolvulus incamus	0.03	0.01
Chrysothamnos nauseosus	0.02	0.01
Agropyron sp.	0.01	0.002

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