las vegas wash coordination committee

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Las Vegas Wash Bird Census, 2000-2006

December 2010

SOUTHERN NEVADA WATER AUTHORITY

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Las Vegas Wash Project Coordination Team

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ABSTRACT

The Las Vegas Wash (Wash) is an ecologically important urban waterway draining flows from the Las Vegas Valley into Lake Mead at Las Vegas Bay. The Las Vegas Wash Coordination Committee is installing erosion control structures and conducting revegetation activities to stabilize the channel and improve its ecological function. The Las Vegas Wash Project Coordination Team conducted a bird census with the Red Rock Audubon Society from November 2000 through October 2006 to develop a baseline inventory of bird species using the Wash and compare the bird community present before (year one, Y1) and after weir construction and revegetation (years four through six, Y4-6). Censuses were conducted using a modified area search method at a 48-acre site encompassing the Bostick Weir, which was completed in 2003. Data are presented in two sections. The first analyzes Y4-6 using species richness and abundance and guild composition. In the second, data were adjusted to account for differences in census effort and compared to Y1. Habitat changes were also analyzed and compared.

In Y4-6, 80 species were detected. Species richness per census varied from 25 to 38, while abundance per census ranged from 126 to 777 individuals. Overall, 14 foraging guilds were detected. Changes in dominant habitat type occurred, shifting from salt cedar-dominated riparian and bare ground in Y1 to aquatic and bare ground in Y4-6. Comparing bird communities, mean species richness per census hour and median abundance per census hour increased significantly from Y1 to Y4-6 (Y1=9.3 [±0.51] species/census hour, Y4-6=11.9 [±0.58] species/census hour, $t=-2.63$, $p=0.01$; Y1=31.4 birds/census hour, Y4-6=120.6 birds/census hour, $U=41.0$, $p<0.001$). Of the 104 species identified between the two periods, 58 (55.8%) were shared, with 27 species unique to Y1 and 19 unique to Y4-6. Relative frequency of all aquatic foraging guilds present increased significantly and relative abundance of most aquatic foraging guilds also increased significantly from Y1 to Y4-6. The relative frequency of all other guilds experienced no significant change. Relative abundance of the three land-based guilds decreased significantly. However, when analyzing the median abundances of these guilds by census hour, neither foliage glean nor hawks declined significantly and ground glean increased significantly (Y1=21.10 birds/census hour, Y4-6=44.90 birds/census hour, $U=101.0$, $p=0.01$). Hawks was the only guild to experience a significant decline in mean species richness per census hour (Y1=0.71 [± 0.07] species/census hour, Y4-6=0.34 [± 0.09] species/census hour, $t=2.54$, $p=0.01$).

Results indicate that weir construction, impoundment creation and revegetation increase avian diversity on-site, largely by increasing aquatic and marsh bird richness and abundance and increasing their temporal use of the site. This is evidenced by the significant increase in mean species richness and median abundance per census hour in Y4-6. Likewise, the significant increase in the relative frequency of aquatic guilds, while the other guilds experienced no significant decline, indicates increased temporal use of the site by a greater diversity of guilds. Only hawks experienced a significant decline in mean species richness per census hour, and ground glean abundance actually increased significantly. This implies that the benefits to the aquatic guilds, which are dominated by waterbirds, were generally not detrimental to the other guilds, which are largely comprised of landbirds. While the main objective of the habitat modifications described in this report was not bird restoration, the data collected during the study show that stabilization and revegetation efforts can meet compliance obligations while also benefitting wildlife.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 Background

Located in the arid Mojave Desert, the Las Vegas Wash (Wash) is an ecologically important urban waterway carrying treated wastewater, urban runoff, shallow groundwater, and stormwater runoff from the approximately 1,600 square-mile Las Vegas Valley watershed to Lake Mead at Las Vegas Bay (Figure 1). The lake is the main source of drinking water for the approximately two million people living in the valley and also provides water for millions of downstream users. Up until the early 1900s, the Wash was an ephemeral stream, but as the human population in the valley increased, discharge of treated effluent turned the channel into a perennial stream and created extensive wetlands. However, as the population continued to increase, so did the flows entering the Wash. Headcuts formed, eroding and incising the channel, draining the wetlands, and depositing millions of cubic feet of sediment in Lake Mead (CAMP 2000).

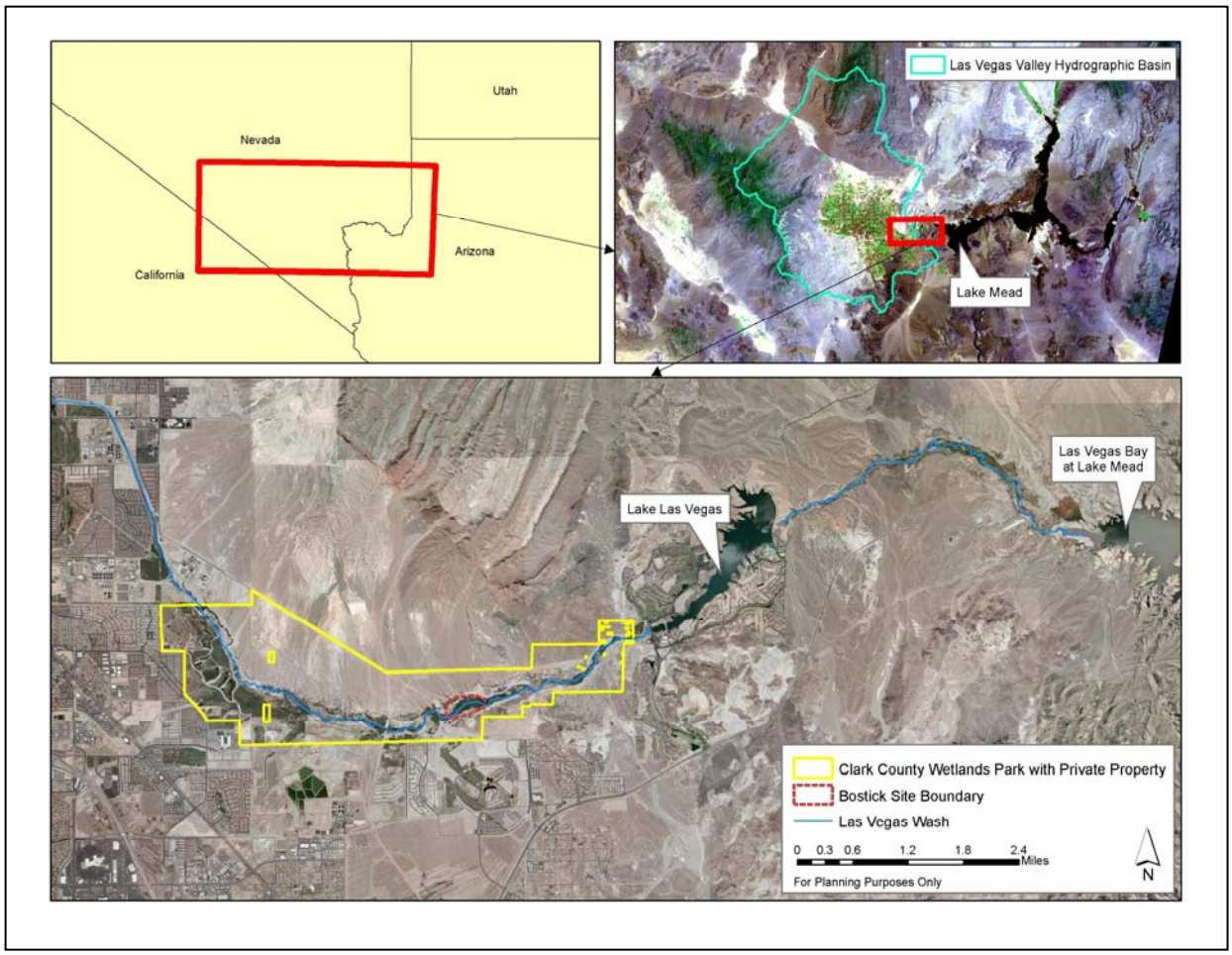

Figure 1. Las Vegas Wash location and general study area map.

Consequently, in 1998, the Las Vegas Wash Coordination Committee (LVWCC) was formed and charged with stabilizing and enhancing the ecological function of the degraded waterway. This community stakeholder group, comprised of members from local, state, and federal agencies, as well as local citizens, developed the Las Vegas Wash Comprehensive Adaptive

Management Plan (2000) as a roadmap to meet its goals. The plan specified 44 action items, including constructing approximately 22 erosion control structures or weirs, conducting revegetation activities, and developing a long-term fish and wildlife management plan. As no inventories of Wash wildlife had been conducted since the 1970s (Lawson undated, Bradley and Niles 1973, Miller 1974), baseline studies were needed to establish the biota present at the onset of management actions to enable any changes resulting from those actions to be quantified and to assist with the development of the wildlife management plan. The first of these studies was a cooperative bird census conducted by the Las Vegas Wash Project Coordination Team (Wash Team; the implementation arm of the LVWCC), with the Red Rock Audubon Society, from November 14, 2000, through October 25, 2006.

Weir construction and subsequent revegetation with native plants, while conducted primarily for compliance reasons, should benefit the avian community on the Wash by increasing the diversity and extent of native habitats. The dominant vegetation in place prior to weir construction is generally monotypic stands of salt cedar (*Tamarix ramosissima*). These stands are cleared during construction. Once the weirs (typically gently-sloping rock riprap structures) are constructed, impoundments form upstream, increasing aquatic habitat for waterbirds. Volunteer emergent vegetation fills in the spaces in the rocks, increasing emergent wetland habitat for marsh dependent species, and active revegetation creates native riparian habitat on the banks and further enhances emergent wetlands in the channel. Upland and desert riparian vegetation is also planted where appropriate. Riparian and wetland habitats are critically important to birds (Knopf and Samson 1994, Gibbs 1993), but have declined significantly from their historical extents (Skagen et al. 2005, Dahl 1990), making the habitat being created on the Wash all the more valuable.

1.2 Census Goals

The goals of the Wash bird census were to: (1) perform a thorough inventory of bird species in the Wash, including seasonal migrants, (2) record use of the Wash by birds during pre-construction, construction, and post-construction activities associated with weirs, and (3) compare bird species present in revegetated habitat versus those present at the site before revegetation.

Van Dooremolen (2005) summarized results from the first three years of the study, completing goal 2 and partially fulfilling goal 1. This report provides a summary of data collected during years four through six (Y4-6), compares the bird community present post-habitat modification (Y4-6) with the community present prior to modification (year one; Y1), and completes the species inventory, thus completing the goals of the study.

2.0 METHODS

2.1 Study Area

The Wash is located in Clark County, Nevada, in the southeastern portion of the Las Vegas Valley (Figure 1). Although two sites, Sunrise Mountain Outfall (Sunrise) and Bostick, were monitored on the Wash in the first year, censuses continued only at the Bostick site for the entire length of the study. With the exception of the final bird list, data from the Sunrise site are not included here (see Van Dooremolen 2005), so the description is limited to the Bostick site.

The Bostick site comprised a 48-acre area located on the Wash approximately 5.5 miles upstream of Lake Mead (at lake elevation 1,220 feet). At the onset of the census in November 2000, the Wash ran through the site in a narrow channel (Figure 2). A low, wide floodplain encompassed most of the south bank and a narrower floodplain existed on the north, bisected with small channels. Patches of dense salt cedar occurred across the floodplain, as well as areas with sparse cover from salt cedar, forbs (e.g., cocklebur [*Xanthium strumarium*]), quailbush (*Atriplex lentiformis*), and common reed (*Phragmites australis*). Other habitat types included bare upland with little or no ground cover, and upland salt cedar with patches of quailbush. Other minor, but important vegetation components included a linear patch of salt cedar that was interspersed with native riparian species, such as willow species (*Salix* spp.), arrowweed (*Pluchea sericea*), and cottonwood (*Populus fremontii*) within the floodplain on the north side. Small sandbars and mudflats stretched along the edges and in the center of the channel.

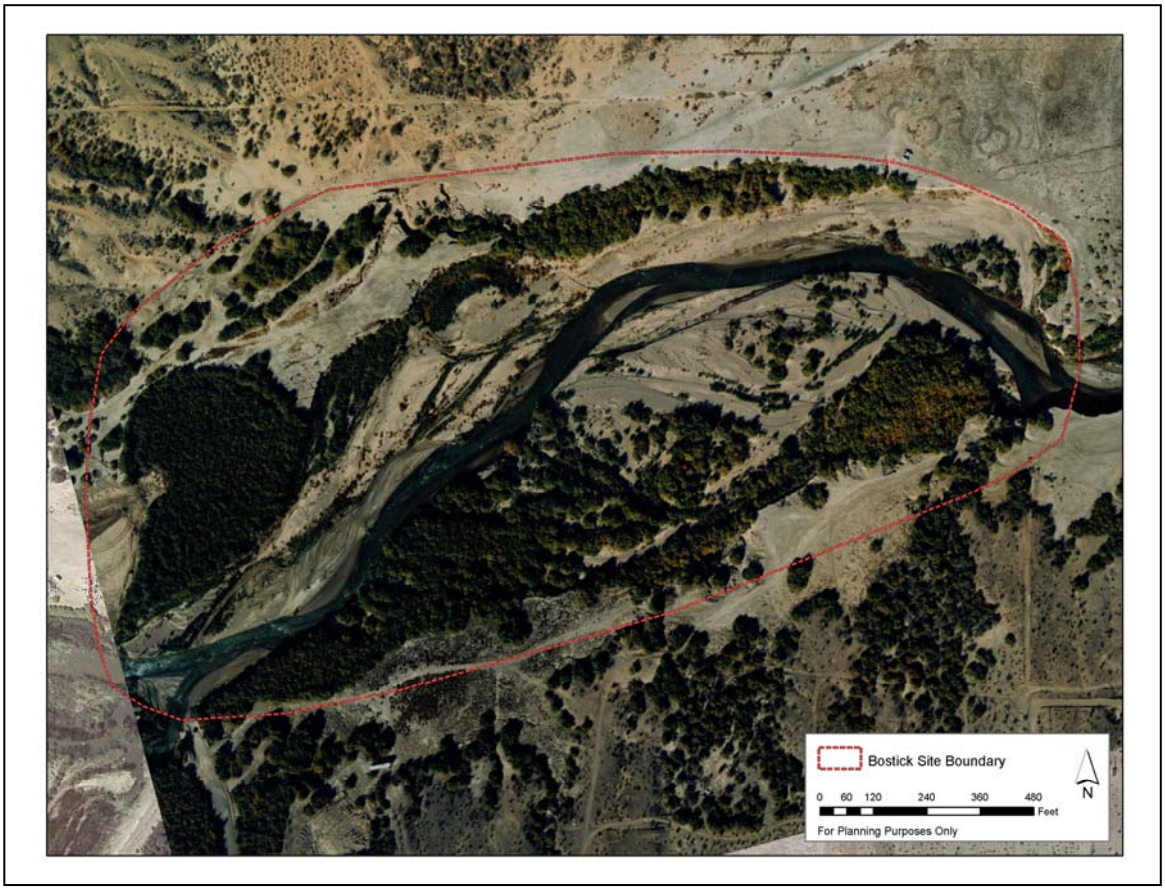

Figure 2. The Bostick site, November 2000.

Construction of the Bostick Weir began in September 2002 and was completed in August 2003. A large impoundment, or pond, formed upstream of the structure. The weir itself was the largest constructed on the Wash to date, a large-diameter rock riprap structure forming a low-sloping waterfall. The spaces between the boulders rapidly filled in with passive recruits (cattails [*Typha domingensis*], common reed, and Goodding willow [*S. gooddingii*]) and actively planted bulrush (*Schoenoplectus* spp.). The Wash Team revegetated the banks from 2003 through 2005. Floodplain areas were planted with native riparian species (e.g., willows, screwbean mesquite [*Prosopis pubescens*]), bulrush was planted on the water's edge, and upland plant species such as

honey mesquite (*P. glandulosa*) and creosote (*Larrea tridentata*) were planted in the drier areas. Bulrush was planted in the impoundment in spring 2006 (Figure 3).

Figure 3. The Bostick site, September 2006.

2.2 Bird Censuses

Censuses were conducted using a modified area search method. Wash Team staff established a standard path with which the field crew traversed the site, but the path was adapted periodically to accommodate landscape changes. Volunteers from the Red Rock Audubon Society assisted with the censuses identifying all birds seen and heard. The number of volunteers conducting each survey varied from one to four. A minimum of one Wash Team staff member was present to record data, and once trained, assist with finding and identifying birds. Censuses began within two hours after sunrise and concluded before five hours after sunrise and were timed. Data recorded for each bird detection included: species, number of individuals, location within the site, age and sex when known, and activity. Flyovers were also recorded. In Y1, little additional information was collected on flyovers. In Y4-6, if a bird was flying, the field crew noted whether it was interacting with the habitat (e.g., a flock of northern rough-winged swallows catching insects over the water) or just a pure flyover, not using the resources of the site. There were also differences in the way individuals were counted in Y1 and in Y4-6. In Y1, if a bird or birds moved into a different part of the site and used a different habitat type or engaged in a new activity, the bird was often given a new record, meaning that birds were occasionally double-counted. In Y4-6, additional care was taken not to double count individuals.

Census frequency and length also varied between the two periods. During the first year (November 14, 2000 through October 30, 2001), censuses were conducted weekly to biweekly (n=37) and lasted an average of approximately 1.5 hours. In the fourth and fifth study years, censuses were conducted infrequently (March 31, 2004-October 10, 2005; n=5) to allow the vegetation to mature, and during the sixth and final year (December 6, 2005-October 25, 2006), censuses were conducted approximately bimonthly (n=6). Censuses conducted in Y4-6 lasted an average of approximately 2.5 hours.

2.3 Data Analyses

Analyses focused on describing the bird community present at the Bostick site during Y4-6 (the time period following construction of Bostick Weir and subsequent revegetation activities), and determining whether that community differed from the community present during Y1. Although two years of data were collected prior to the commencement of weir construction, only the first year was considered appropriate for comparison because the majority of the vegetation was cleared from the site early in the second year. While some clearing occurred during Y1, it was limited to approximately 20% of the site.

2.3.1 Y4-6

The bird community present in the final years of the study was described in terms of species richness and abundance for the three-year time period and for the breeding and non-breeding seasons. The breeding season was defined as the period from March 16 through September 15 (n=6) and the non-breeding season was defined as the period from September 16 through March 15 (n=5). These date ranges were determined by examining the data to discover when common summer and winter residents arrived and departed, but some overlap exists, meaning that some winter residents remain into April or even later and some summer residents may remain into October. Migrant species move through the area during the breeding season as defined, so not all species recorded during that period may actually breed in the Wash. Total species richness for each time period was calculated as the sum of the number of unique species detected during each pre-defined period and includes flying birds that were aerially foraging or fishing on the site. Species richness per census was calculated by totaling the number of unique species detected per event. Abundance per census was calculated as the sum of the number of individual birds detected per event. Estimates of the abundance of each species were generated using the maximum number of individuals detected during a census for the three-year period and for the breeding and non-breeding seasons.

As in the first report summarizing results from this study (Van Dooremolen 2005), all of the species detected were grouped into foraging guilds using their primary foraging technique as described in Erhlich et al. (1988). Guilds are groups of species that exploit environmental resources in similar ways, but are not necessarily closely related taxonomically (Ehrlich et al. 1988). Total guild richness represents the total number of unique guilds detected during the three-year period. Guild richness per census was calculated by summing the number of foraging guilds detected during each event. Guild species richness per census was calculated as the sum of the number of species detected within each guild. Guild abundance per census was calculated by summing the number of individuals detected of each species within the guild.

2.3.2 Comparing Communities: Y1 and Y4-6

2.3.2.1 Habitat

High resolution (6-inch to 1-foot per pixel) aerial imagery of the site was analyzed with ESRI's ArcGIS 9 geographic information system (GIS) software, and supplemented with notes taken on plant communities in the field. Imagery from November 2000 was used to delineate habitat types present in Y1 and calculate their approximate percent cover to the nearest whole number. Habitats were categorized into one of six types: bare, upland, riparian, marsh, aquatic, and revegetetation site (reveg site; Table 1). Nominal habitat types that never exceeded 2% cover were not included. Aerial imagery from September 2004, 2005 and 2006 was used to track maturation of habitat and changes in percent cover following weir construction and revegetation in Y4-6. Cover values were calculated for each habitat type for each year. Means were then generated for each type and used to graphically represent the overall change from Y1 and to better note whether any differences were significant.

Type	Description
Aquatic	Open water, shallow water and mudflats
Bare	Unsaturated areas with <10% cover both within and above the floodplain
Marsh	Saturated to inundated areas dominated by emergent plant species
Reveg Site	Actively planted areas too new to create target habitat structure; typically structurally similar to bare or upland
Riparian	Areas within the floodplain >75% cover dominated by woody plants
Upland	Dry areas with variable % cover adjacent to and above the floodplain; can include desert scrub and/or desert riparian species

Table 1. Description of habitat types.

2.3.2.2 Bird Communities

To compare the bird communities present in Y1 and Y4-6, total species richness and total detections were calculated for each period overall and for the breeding and non-breeding seasons (as previously defined), discarding all flyovers. Only those birds that were noted as making some form of physical contact with the site were included in the comparative analyses (e.g., an osprey diving into the water for a fish), so aerially foraging species such as raptors and swallows may be under-represented in the results. Total species richness was calculated as described in Section 2.3.1. Total detections were calculated as the sum of the number of individuals detected each census during the different time periods. Mean species richness and abundance were also calculated for each time period overall (Y1, n = 37; Y4-6, n=11) and for the breeding and non-breeding seasons as previously defined (breeding season: Y1, n=20; Y4-6, n=6; non-breeding season: Y1, n=17; Y4-6, n=5). It should be noted here that the issue of double-counting in Y1 led Van Dooremolen (2005) to not include measures of abundance in the analyses of the first three years of data. The decision was made to include abundance here, making note that Y1 abundance may be overestimated for species with large territories. The data were vetted to remove records that explicitly stated that the individual had previously been recorded.

Linear regressions were performed to determine whether differences in mean richness and abundance were related to changes in observer effort including census duration (the number of hours spent conducting the census) and total skilled observer hours (observer hours; the number of skilled observers multiplied by census duration). The regression of census duration and

species richness yielded the highest correlation (r^2=0.611), with observer hours less correlated (r^2= 0.449). The regression of observer hours and abundance yielded the highest correlation (r^2=0.449), with census duration less correlated (r^2=0.336). Data were tested to determine whether adjusting by either measure of effort impacted the statistical significance of the results. Dividing abundance by census duration gave the same result as dividing the data by observer hours. Dividing species richness by census duration gave a different result than dividing by observer hours. Given the stronger relationship between species richness and census duration and the lack of difference in outcome between effort adjustments to abundance, both richness and abundance data were adjusted by dividing by census duration, yielding richness per census hour and abundance per census hour. Values that met parametric assumptions were tested for significant differences using paired t-tests; reported values are means. Values that violated parametric assumptions were tested for significance using Mann-Whitney rank sum tests; reported values are medians. SigmaStat 3.5 was used to perform all statistical analyses, and the significance level was set at $p < 0.05$.

The bird communities present in Y1 and Y4-6 were also compared from a foraging guild perspective. The method a species uses to forage for food often determines in what type of habitat it will be found, making guild analysis a useful approach for determining habitat-related changes in a bird community over time. To aid in this analysis, guilds were further classified into three broad categories: aquatic, land or aerial. Aquatic guilds are comprised almost exclusively of waterbirds (i.e., waterfowl, herons, egrets, bitterns, rails, shorebirds, and gulls), while the land and aerial guilds are dominated by landbirds (raptors, passerines, etc.; ground glean is considered a land guild and is dominated by landbirds but does include some waterbirds). Several guilds and species were rarely detected in Y1 and Y4-6 or rarely detected in Y1 but then detected on the majority of the censuses in Y4-6. This resulted in zero-inflated data for most guilds, making meaningful statistical analyses of differences in mean guild species richness and abundance per census hour difficult for all but a few guilds. So to reflect any changes in the guilds, the relative frequency and abundance of each guild was calculated for each period overall and for the breeding and non-breeding seasons. Relative frequency was defined as the number of censuses the guild was detected out of the total number of censuses conducted in each time period, and relative abundance was defined as the total number of individuals detected of a guild divided by the total number of all individuals detected during the given time period. To determine whether changes were statistically significant, z-tests were performed comparing Y1 and Y4-6 relative frequencies and abundances for each guild. Relative abundance and frequency for all species were also calculated for Y1 and Y4-6.

3.0 RESULTS

3.1 Y4-6

Excluding pure flyovers, 80 species were detected in the three-year period, six of which were new to the study, including: American wigeon, redhead, ruddy duck, least bittern, sora, and plumbeus vireo (a seventh new species, lesser nighthawk, was noted as a flyover). Sixty-eight species were detected in the breeding season and 55 were detected in the non-breeding season. Species richness per census varied from 25 to 38 (Figure 4), while abundance per census ranged from 126 to 777 individuals (Figure 5). The highest abundances, more than 700 birds per census, were detected during the early February 2005 and late January 2006 censuses. The

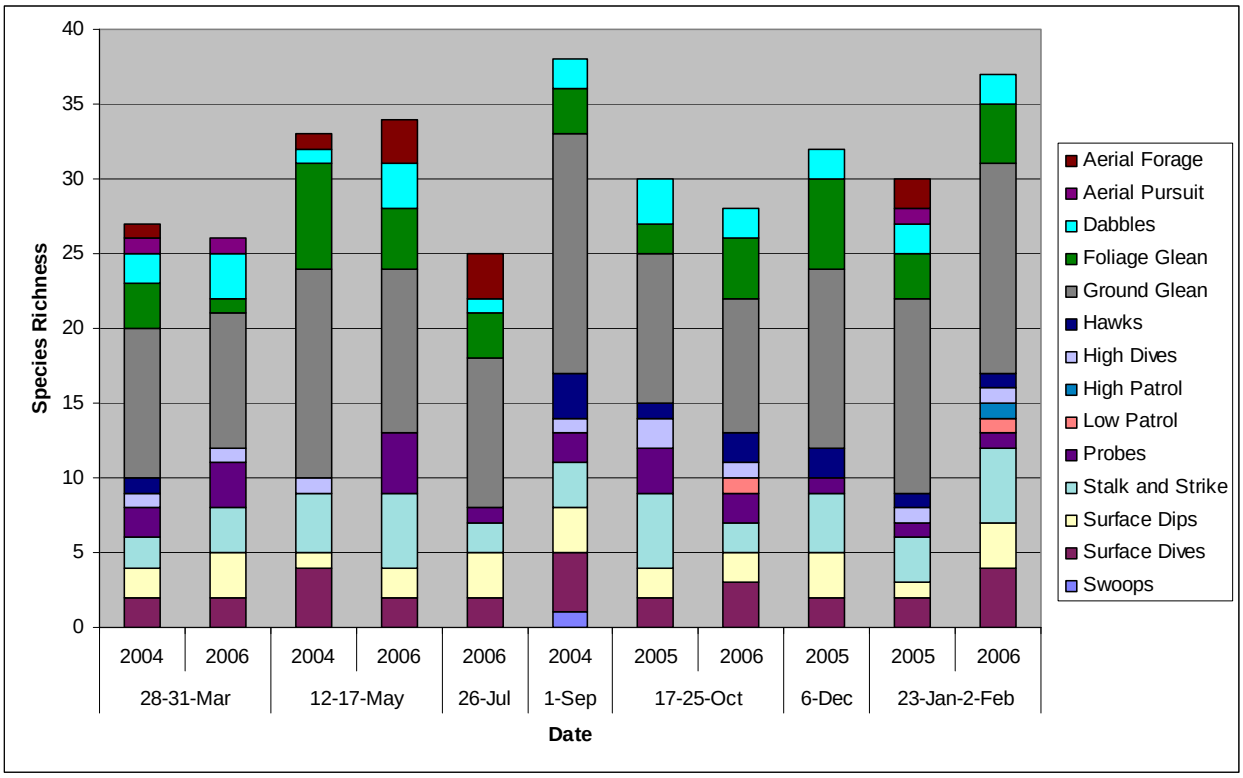

Figure 4. Y4-6 species richness by guild and date.

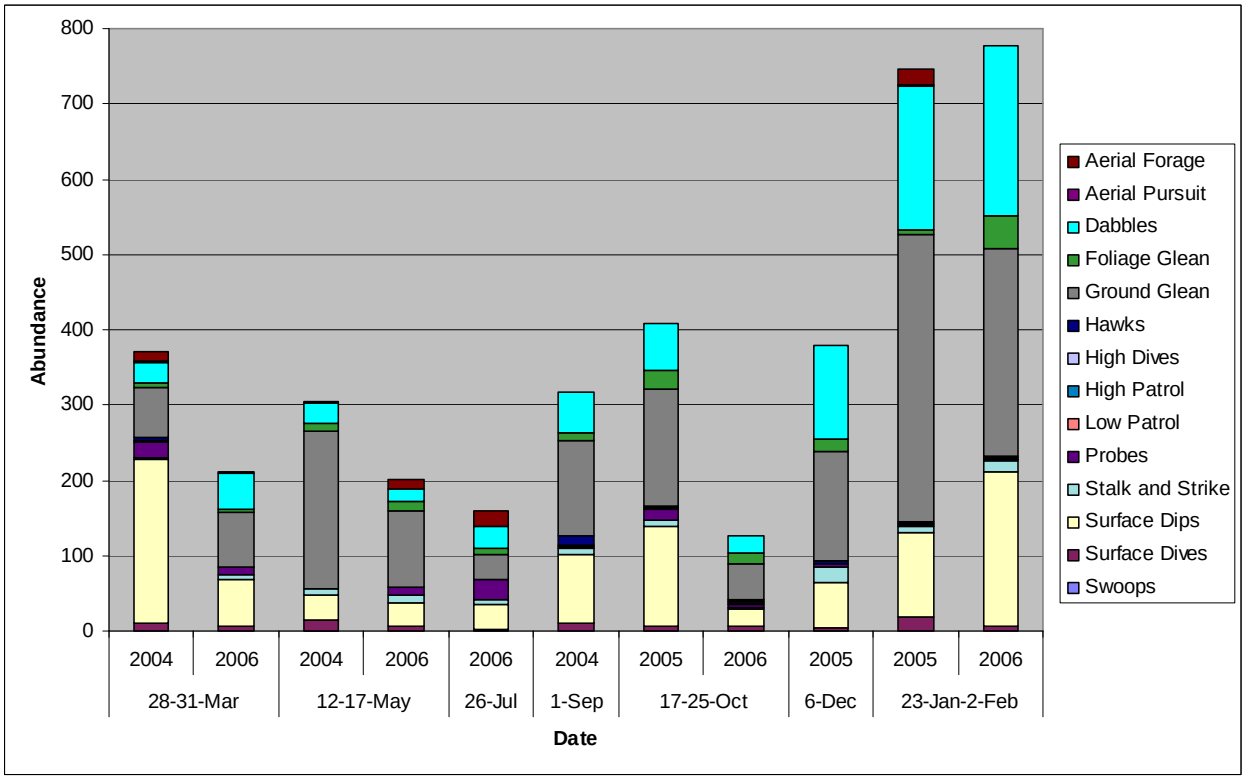

Figure 5. Y4-6 abundance by guild and date.

lowest abundance was recorded on the final census, October 25, 2006. Overall, mean species richness was 30.9 and mean abundance was 363.8. Mean species richness varied only nominally across the breeding and non-breeding seasons. However, mean abundance varied substantially with an increase of more than 225 birds per census from the breeding to the non-breeding season. The ten most abundant species detected overall and the ten most abundant species detected in the breeding season accounted for approximately 75% of the total abundance for each time period. In the non-breeding season, the ten most abundant species accounted for more than 85% of the total abundance detected (Appendix A).

Overall 14 foraging guilds were detected. Guild richness ranged from 8 to 11 per census, with a mean of 9.4 guilds. Across censuses, the ground glean guild was consistently the richest and typically the most abundant, while the majority of the aerial guilds (aerial pursuit, high patrol, low patrol, and swoops) were the least rich and abundant (Figures 4 and 5). Four of the six aquatic guilds were represented on all 11 censuses, as were foliage glean and ground glean.

3.2 Comparing Communities: Y1 and Y4-6

3.2.1 Habitat

In Y1, the dominant habitat types were bare at 38% cover and riparian (predominantly salt cedar) at 36% (Figures 2 and 6). Upland (largely salt cedar mixed with quailbush) provided 13% of total site cover, while aquatic habitat covered 12%. A nominal (less than 2%) amount of emergent marsh was present.

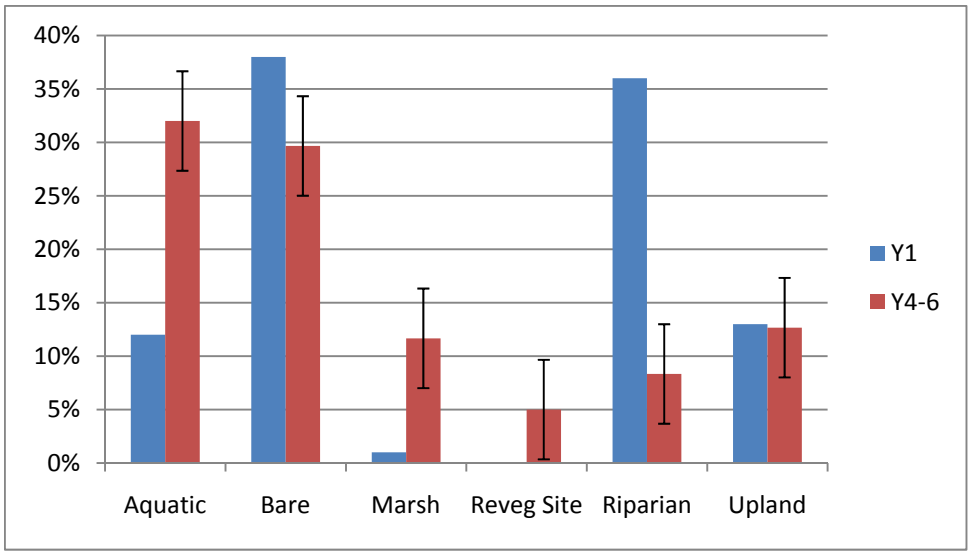

Figure 6. Percent cover by habitat type for the Bostick site in Y1 and Y4-6. Y4-6 represents the mean of Y4, Y5, and Y6 values for each habitat type, and error bars represent standard errors.

Figure 6 shows five of six habitat types differing substantially in Y4-6. Aquatic replaced riparian as a dominant habitat type with between 35% (Y4) and 29% (Y6) cover, while bare, continued to be co-dominant at between 35% (Y4) and 24% (Y6) cover (Figures 3 and 6).

Marsh cover increased, ranging from 9 to 14%, and was dominated by common reed, cattails and bulrush. Riparian habitat declined to 5% (Y4) following the clearing of salt cedar stands for weir construction but then increased to 15% (Y6) as revegetation sites and passively recruited Goodding willows on and below the weir matured. Upland cover remained the most similar to

Y1 at 10 to 15% but the plant community became more diverse as revegetation sites planted with honey mesquite and other native upland species matured. Reveg site cover ranged down from 6% (Y4) to 3% in (Y6) reflecting the maturation of the sites into their target habitat type and the addition of new sites.

3.2.2 Bird Communities

Total species richness was greater in Y1 overall and in the non-breeding season, but in the breeding season, total richness was higher in Y4-6 (Table 2). Overall and seasonally, total detections were greater in Y4-6 (Table 2). Both mean overall species richness and median abundance per census hour increased significantly from Y1 to Y4-6 (Table 3). Mean richness and median abundance per census hour also increased significantly in the breeding season, but no significant differences were found in the non-breeding season, even though median abundance increased by 300%.

	Y1			Y4-6	
Time Period	n	TR	TD	n	TR	TD
Overall	37	85	2662	11	77	3939
Breeding	20	56	749	6	65	1524
Nonbreeding	17	64	1913	5	53	2415

Table 2. Total richness (TR) and total detections (TD) for the overall, breeding and non-breeding periods during Y1 and Y4-6. For each time period, n is the number of censuses conducted; TR is the total number of unique species detected; and TD is total number of birds detected, adding all detections from all censuses.

	Y1	Y4-6		
Time Period	R/CH (±SE)	R/CH (±SE)	t	p
Overall	9.3 (± 0.51)	11.9 (± 0.58)	-2.630	0.01
Breeding	8.2 (± 0.66)	12.7 (± 0.53)	-3.524	0.002
Nonbreeding	10.5 (± 0.70)	10.9 (± 0.98)	-0.305	0.76
Time Period	**A/CH**	**A/CH**	**U**	**p**
Overall	31.4	120.6	41.0	<0.001
Breeding	23.5	109.1	0.0	<0.001
Nonbreeding	59.2	181.8	17.0	0.05

Table 3. Richness and abundance per census hour for the overall, breeding and non-breeding periods during Y1 and Y4-6. Richness per census hour (R/CH) was tested for significance with paired t-tests and values are means with standard errors (±SE). Abundance per census hour (A/CH) was tested for significance with Mann-Whitney rank sum tests and values are medians. Differences with $p < 0.05$ are considered significant.

Of the 104 species identified in the study area between the two periods, 58 were shared (Table 4), with 27 species unique to Y1 and 19 unique to Y4-6 (Table 5). Included in the 104 species are 18 deemed conservation priority species by the Nevada Comprehensive Bird Conservation Plan (Great Basin Bird Observatory [GBBO] 2010). Of these, total detections increased for 12 from Y1 to Y4-6 and decreased for 6.

Species with the highest relative abundances changed, with only one of the five most abundant species being shared for all time periods (Table 6). In Y1, the five most abundant species accounted for 52.9% of all detections, while in Y4-6 they accounted for 57.5%. However, in the breeding season, the five most abundant species accounted for only 43.5% of total detections in Y1, while in Y4-6 they accounted for 62.3%. In the non-breeding season the five most abundant species accounted for nearly 70% of all detections in Y1 and for 64.7% of all detections in Y4-6.

	Y1			Y4-6		
Species	**TD**	**RA**	**RF**	**TD**	**RA**	**RF**
Gadwall	20	0.008	0.027	397	0.101	0.818
Mallard	88	0.033	0.514	421	0.107	1.000
Cinnamon Teal*	19	0.007	0.243	34	0.009	0.273
Common Merganser	3	0.001	0.081	4	0.001	0.273
Gambel's Quail*	79	0.030	0.405	94	0.024	0.636
Pied-billed Grebe	1	0.000	0.027	28	0.007	1.000
Double-crested Cormorant	1	0.000	0.027	44	0.011	0.727
Great Blue Heron	13	0.005	0.297	26	0.007	0.909
Great Egret	1	0.000	0.027	13	0.003	0.727
Snowy Egret*	2	0.001	0.054	23	0.006	0.636
Green Heron	1	0.000	0.027	10	0.003	0.455
Black-crowned Night-Heron	1	0.000	0.027	17	0.004	0.545
White-faced Ibis*	2	0.001	0.054	30	0.008	0.273
Osprey	3	0.001	0.081	3	0.001	0.273
Northern Harrier	1	0.000	0.027	1	0.000	0.091
Sharp-shinned Hawk	3	0.001	0.081	3	0.001	0.273
Red-tailed Hawk	4	0.002	0.108	1	0.000	0.091
American Coot	9	0.003	0.081	946	0.240	1.000
Killdeer	87	0.033	0.811	37	0.009	0.909
Greater Yellowlegs	6	0.002	0.054	13	0.003	0.545
Spotted Sandpiper	43	0.016	0.514	11	0.003	0.364
Least Sandpiper*	40	0.015	0.108	67	0.017	0.455
Long-billed Dowitcher*	2	0.001	0.027	13	0.003	0.273
Ring-billed Gull	24	0.009	0.054	186	0.047	0.273
White-winged Dove	1	0.000	0.027	1	0.000	0.091
Mourning Dove	51	0.019	0.378	35	0.009	0.455
Greater Roadrunner	3	0.001	0.081	2	0.001	0.182
Belted Kingfisher	3	0.001	0.081	6	0.002	0.545
Northern Flicker	21	0.008	0.270	1	0.000	0.091
Black Phoebe	61	0.023	0.649	19	0.005	0.636
Say's Phoebe	26	0.010	0.378	4	0.001	0.273
Western Kingbird	6	0.002	0.081	8	0.002	0.091
Loggerhead Shrike	4	0.002	0.081	1	0.000	0.091
Common Raven	13	0.005	0.270	2	0.001	0.091
Tree Swallow	6	0.002	0.054	2	0.001	0.091
Verdin	27	0.010	0.378	19	0.005	0.727
Bewick's Wren	53	0.020	0.514	6	0.002	0.455
Marsh Wren	18	0.007	0.243	31	0.008	0.818
Ruby-crowned Kinglet	21	0.008	0.216	11	0.003	0.273
Black-tailed Gnatcatcher	16	0.006	0.243	16	0.004	0.455
Crissal Thrasher	9	0.003	0.243	8	0.002	0.455
American Pipit	655	0.246	0.378	226	0.057	0.273
Orange-crowned Warbler	7	0.003	0.081	2	0.001	0.182
Yellow Warbler	6	0.002	0.108	6	0.002	0.273
Yellow-rumped Warbler	97	0.036	0.405	70	0.018	0.636
Common Yellowthroat	46	0.017	0.378	17	0.004	0.455
Wilson's Warbler	4	0.002	0.054	2	0.001	0.182
Abert's Towhee*	163	0.061	0.946	50	0.013	0.909
Brewer's Sparrow*	5	0.002	0.027	14	0.004	0.182
Song Sparrow	76	0.029	0.730	30	0.008	0.727
Lincoln's Sparrow	17	0.006	0.216	1	0.000	0.091
White-crowned Sparrow	382	0.144	0.459	167	0.042	0.455
Blue Grosbeak	35	0.013	0.243	2	0.001	0.091
Lazuli Bunting	3	0.001	0.054	4	0.001	0.091
Red-winged Blackbird	35	0.013	0.243	276	0.070	1.000
Great-tailed Grackle	7	0.003	0.108	163	0.041	0.909
Brown-headed Cowbird	81	0.030	0.324	15	0.004	0.455
House Finch	5	0.002	0.081	7	0.002	0.273
Total (58 species)	2416	0.907		3646	0.925	

Table 4. Species occurring in both Y1 and Y4-6 with total detections (TD), relative abundances (RA) and relative frequencies (RF). RA is defined as the proportion of individuals a species contributes to the total number of individuals detected. RF is defined as the proportion of censuses the species was detected out of all censuses conducted. Y1 = 37 censuses and 2662 TD. Y4-6 = 11 censuses and 3939 TD. See Appendix B for the status and foraging guild of each species. *Conservation priority species (GBBO 2010).

	Y1				Y4-6		
Species Name	**TD**	**RA**	**RF**	**Species Name**	**TD**	**RA**	**RF**
Northern Pintail*	2	0.001	0.027	American Wigeon	10	0.003	0.273
Prairie Falcon*	1	0.000	0.027	Northern Shoveler	6	0.002	0.273
Lesser Yellowlegs	3	0.001	0.027	Green-winged Teal	7	0.002	0.273
Wilson's Snipe	3	0.001	0.081	Redhead*	2	0.001	0.182
Northern Saw-whet Owl	1	0.000	0.027	Common Goldeneye	3	0.001	0.091
White-throated Swift*	6	0.002	0.054	Ruddy Duck	2	0.001	0.091
Western Wood-Pewee	3	0.001	0.054	Western Grebe*	6	0.002	0.273
Western Scrub-Jay	10	0.004	0.162	Least Bittern*	4	0.001	0.182
Pinyon Jay*	1	0.000	0.027	Black-necked Stilt*	4	0.001	0.091
Northern Rough-winged Swallow	14	0.005	0.135	American Avocet*	28	0.007	0.273
Bushtit	16	0.006	0.027	Virginia Rail	10	0.003	0.364
Blue-gray Gnatcatcher	3	0.001	0.054	Sora	3	0.001	0.273
Golden-crowned Kinglet	2	0.001	0.027	Common Moorhen	17	0.004	0.727
Phainopepla	3	0.001	0.027	Plumbeous Vireo	1	0.000	0.091
Lucy's Warbler*	6	0.002	0.135	Cliff Swallow	8	0.002	0.182
Palm Warbler	1	0.000	0.027	Rock Wren	7	0.002	0.273
MacGillivray's Warbler	1	0.000	0.027	Lark Sparrow	1	0.000	0.091
Yellow-breasted Chat	19	0.007	0.270	Western Tanager	2	0.001	0.091
Spotted Towhee	11	0.004	0.189	Yellow-headed Blackbird	172	0.044	0.273
Vesper Sparrow	1	0.000	0.027	**Total (19 species)**	293	0.074	
Black-throated Sparrow	1	0.000	0.027				
Savannah Sparrow	3	0.001	0.081				
Fox Sparrow	1	0.000	0.027				
Dark-eyed Junco	111	0.042	0.243				
Western Meadowlark	17	0.006	0.162				
Lesser Goldfinch	6	0.002	0.054				
House Sparrow	1	0.000	0.027				
Total (27 species)	247	0.093					

Table 5. Species unique to Y1 or Y4-6 with total detections (TD), relative abundances (RA) and relative frequencies (RF). RA is defined as the proportion of individuals a species contributes to the total number of individuals detected. RF is defined as the proportion of censuses the species was detected out of all censuses conducted. Y1 = 37 censuses and 2662 TD. Y4-6 = 11 censuses and 3939 TD. See Appendix B for the status and foraging guild of each species. * Conservation priority species (GBBO 2010).

Y1-Overall	**TD**	**RA**	**RF**	**Y4-6-Overall**	**TD**	**RA**	**RF**
American Pipit	655	0.246	0.378	American Coot	946	0.240	1.000
White-crowned Sparrow	382	0.144	0.459	Mallard	421	0.107	1.000
Abert's Towhee	163	0.061	0.946	Gadwall	397	0.101	0.818
Dark-eyed Junco	111	0.042	0.243	Red-winged Blackbird	276	0.070	1.000
Yellow-rumped Warbler	97	0.036	0.405	American Pipit	226	0.057	0.273
Total	1408	0.529		**Total**	2266	0.575	
Y1-Breeding	**TD**	**RA**	**RF**	**Y4-6-Breeding**	**TD**	**RA**	**RF**
Brown-headed Cowbird	81	0.108	0.600	American Coot	420	0.276	1.000
Mallard	78	0.104	0.850	Yellow-headed Blackbird	172	0.113	0.500
Abert's Towhee	73	0.097	0.900	Red-winged Blackbird	151	0.099	1.000
Mourning Dove	49	0.065	0.650	Mallard	149	0.098	1.000
Common Yellowthroat	45	0.060	0.650	Least Sandpiper	58	0.038	0.500
Total	326	0.435		**Total**	950	0.623	
Y1-Non-Breeding	**TD**	**RA**	**RF**	**Y4-6-Non-Breeding**	**TD**	**RA**	**RF**
American Pipit	655	0.342	0.824	American Coot	526	0.218	1.000
White-crowned Sparrow	375	0.196	0.941	Gadwall	353	0.146	1.000
Dark-eyed Junco	111	0.058	0.530	Mallard	272	0.113	1.000
Abert's Towhee	90	0.047	1.000	American Pipit	226	0.094	0.600
Yellow-rumped Warbler	90	0.047	0.701	Ring-billed Gull	186	0.077	0.600
Total	1321	0.691		**Total**	1563	0.647	

Table 6. The five most abundant species in Y1 and Y4-6 overall and in the breeding and non-breeding seasons. Relative abundances (RA) is defined as the proportion of individuals a species contributes to the total number of individuals detected during the given time period. Relative frequency (RF) is defined as the proportion of censuses the species was detected out of all censuses conducted during the given time period. Y1 = 37 censuses and 2662 total detections (TD). Y4-6 = 11 censuses and 3939 TD.

Overall, guild richness and composition remained constant between Y1 and Y4-6 with the same 14 guilds detected (Table 7). Ten guilds were detected in the breeding season in Y1 and 14 were detected in the non-breeding season. In Y4-6, 12 guilds were detected in each season, although the composition of those guilds changed slightly. The seasonal differences related to the appearance of a few aerial guilds. Of the guilds, six were classified as aquatic, three as land, and

		Overall gRF				Breeding gRF				Non-Breeding gRF			
	Foraging Guild	Y1	Y4-6	z	p	Y1	Y4-6	z	p	Y1	Y4-6	z	p
Aerial	Aerial Forage	0.22	0.18	-0.18	0.86	0.25	0.33	-0.12	0.90	0.18	n/d	0.27	0.79
Aerial	Aerial Pursuit	0.11	0.27	0.87	0.38	n/d	0.33	1.81	0.70	0.24	0.20	-0.44	0.66
Aerial	High Patrol	0.11	0.09	-0.40	0.69	n/d	n/d	n/a	n/a	0.24	0.20	-0.44	0.66
Aerial	Low Patrol	0.03	0.09	0.07	0.94	n/d	n/d	n/a	n/a	0.06	0.20	0.08	0.94
Aerial	Swoops	0.08	0.09	-0.52	0.61	n/d	0.17	0.33	0.74	0.18	n/d	0.27	0.79
Land	Foliage Glean	0.95	1.00	-0.07	0.94	0.90	1.00	-0.67	0.95	1.00	1.00	n/a	n/a
Land	Ground Glean	1.00	1.00	n/a	n/a	1.00	1.00	n/a	n/a	1.00	1.00	n/a	n/a
Land	Hawks	0.84	0.64	1.02	0.31	0.70	0.33	1.14	0.25	1.00	1.00	n/a	n/a
Aquatic	Dabbles	0.54	1.00	2.44	0.02	0.85	1.00	0.28	0.78	0.18	1.00	2.84	0.01
Aquatic	High Dives	0.14	0.73	3.49	<0.001	0.15	0.67	1.98	0.05	0.12	0.80	2.44	0.02
Aquatic	Probes	0.22	0.91	3.81	<0.001	0.20	0.83	2.37	0.02	0.24	1.00	2.54	0.01
Aquatic	Stalk and Strike	0.38	1.00	3.28	0.001	0.40	1.00	2.12	0.03	0.35	1.00	2.04	0.04
Aquatic	Surface Dips	0.30	1.00	3.76	<0.001	0.45	1.00	1.92	0.06	0.12	1.00	3.18	0.001
Aquatic	Surface Dives	0.11	1.00	5.23	<0.001	0.10	1.00	3.69	<0.001	0.12	1.00	3.18	0.001

Table 7. Overall, breeding, and non-breeding guild relative frequency (gRF) for the 14 guilds detected in Y1 and Y4-6. gRF is defined as the proportion of censuses the guild was detected out of all censuses conducted in the given time period. n/d = not detected. n/a = not applicable. Differences with $p < 0.05$ are considered significant. Y1 = 37 censuses, Y4-6 = 11 censuses.

five as aerial. The ground glean guild was the only guild to be detected during every census in each time period. The relative frequency of the six aquatic guilds increased significantly from Y1 to Y4-6, both overall and in the non-breeding season (Table 7). The relative frequency of four of the six aquatic guilds also increased significantly in the breeding season. No significant differences were found for the eight land and aerial guilds either overall or across seasons. Relative abundances for several guilds also changed significantly (Table 8). Relative abundances of five of the six aquatic guilds increased significantly overall and in the non-breeding season; four of the six increased significantly in the breeding season. The land-based guilds, foliage glean, ground glean, and hawks underwent significant declines in relative abundance, as did the aerial-foraging guild. Ground glean remained the dominant guild in terms of relative abundance. Swoops declined significantly only in the breeding season. The other aerially-based guilds and high dives experienced no significant change in any period.

Guild species richness and abundance per census hour could only be reliably compared for the land-based guilds (Table 9). Foliage glean experienced no significant change in either measure, for which both are medians. While ground glean mean species richness per census hour did not change significantly, median abundance per census hour increased significantly in Y4-6. Hawks experienced a significant decrease in mean species richness per census hour, and a substantial but not significant decrease in median abundance.

3.3 Summary of the Six-Year Study

Including data from the Sunrise site, six years of data collected at the Bostick site, and all flyovers (ten species), 136 species were detected over the course of the study. An additional five species were recorded adjacent to the sites or in the Wash area while traveling to or from the

		Overall gRA				Breeding gRA				Non-Breeding gRA			
	Foraging Guild	Y1	Y4-6	z	p	Y1	Y4-6	z	p	Y1	Y4-6	z	p
Aerial	Aerial Forage	0.010	0.003	3.74	<0.001	0.017	0.007	2.19	0.03	0.007	n/d	3.78	<0.001
Aerial	Aerial Pursuit	0.002	0.001	0.52	0.60	n/d	0.001	0.24	0.81	0.002	0.000	1.16	0.25
Aerial	High Patrol	0.002	0.000	1.35	0.18	n/d	n/d	n/a	n/a	0.002	0.000	1.16	0.25
Aerial	Low Patrol	0.000	0.000	-0.44	0.66	n/d	n/d	n/a	n/a	0.001	0.000	-0.55	0.58
Aerial	Swoops	0.002	0.000	1.73	0.08	n/d	0.001	-0.36	0.72	0.003	n/d	2.06	0.04
Land	Foliage Glean	0.105	0.039	10.58	<0.001	0.135	0.032	9.18	<0.001	0.093	0.043	6.56	<0.001
Land	Ground Glean	0.775	0.411	29.21	<0.001	0.610	0.402	9.32	<0.001	0.840	0.417	28.23	<0.001
Land	Hawks	0.036	0.008	80.09	<0.001	0.043	0.000	4.57	<0.001	0.033	0.005	6.82	<0.001
Land	Dabbles	0.041	0.210	19.24	<0.001	0.131	0.131	-0.04	0.97	0.006	0.260	23.31	<0.001
Aquatic	High Dives	0.002	0.002	-0.24	0.81	0.004	0.003	0.16	0.88	0.002	0.002	0.03	0.98
Aquatic	Probes	0.006	0.025	5.68	<0.001	0.013	0.047	3.95	<0.001	0.003	0.011	2.73	0.01
Aquatic	Stalk and Strike	0.007	0.024	5.13	<0.001	0.012	0.026	2.04	0.04	0.005	0.022	4.61	<0.001
Aquatic	Surface Dips	0.011	0.255	26.77	<0.001	0.032	0.307	14.91	<0.001	0.002	0.222	21.67	<0.001
Aquatic	Surface Dives	0.002	0.023	6.86	<0.001	0.003	0.031	4.25	<0.001	0.002	0.017	4.87	<0.001

Table 8. Overall, breeding, and non-breeding guild relative abundance (gRA) for the 14 guilds detected in Y1 and Y4-6. gRA is defined as the proportion of individuals a guild contributes to the total number of individuals detected during the given time period. n/d = not detected. n/a = not applicable. 0.000 shown for gRA if value <0.0005. Differences with p < 0.05 are considered significant. Y1 = 2662 total detections (TD), Y4-6 = 3939 TD.

sites on survey days, resulting in a total of 141 species from 47 families (Appendix B). Of these, 49 species (34.8%) were year-round residents, 21 (14.9%) were summer residents, 28 (19.9%) were winter residents, 37 (26.2%) were migrants, 4 (2.8%) were introduced and 2 (1.4%) were accidental; status follows Titus and Van Dooremolen (2010). An additional guild was also detected - the hover and glean guild.

	Guild Species Richness/Census Hour				Guild Abundance/Census Hour			
Guild	Y1	Y4-6	U or t	p	Y1	Y4-6	U	p
Foliage Glean	1.33	1.33	223.0	0.64	3.40	4.00	190.5	0.76
Ground Glean	5.46 (± 0.31)	4.62 (± 0.28)	1.41	0.17	21.10	44.90	101.0	0.01
Hawks	0.71 (± 0.07)	0.34 (± 0.09)	2.54	0.01	1.50	0.57	264.0	0.14

Table 9. Guild species richness and abundance per census hour for three land-based guilds. If tested for significance with paired t-tests, values are means with standard errors (±SE). If tested for significance with Mann-Whitney rank sum tests, values are medians. Differences with p < 0.05 are considered significant.

4.0 DISCUSSION

4.1 Y4-6

Five of the six new species detected in Y4-6 were waterfowl or secretive marsh birds. This highlights the aquatic nature of the habitat during these years, both the presence of open water and of emergent marsh. Least bittern not only appeared for the first time, but a juvenile that appeared too young to have dispersed was observed, meaning that the species was likely nesting on-site. In addition, a Virginia rail was observed with young in the cattails on the weir in 2006. These observations, coupled with the first detections of sora on the site, point to the increase in emergent wetland habitat in the final years of the study.

The substantial increase in mean abundance from the breeding season to the non-breeding season was due to large influxes of overwintering birds. Several of the species present in winter often appeared in flocks of 50 to 200 or more birds. Such numbers were recorded for gadwall, mallard, American coot, ring-billed gull, American pipit, and white-crowned sparrow. While some of these species are considered year-round residents, their numbers increase in winter.

4.2 Comparing Communities: Y1 and Y4-6

4.2.1 Habitat

Results from the habitat analysis show the dramatic shift in percent cover by habitat types following weir construction and revegetation. While bare remained co-dominant, aquatic habitats replaced riparian as the other dominant type, increasing in cover by nearly 300%. Riparian did not recover to its Y1 extent while this study was still ongoing, but did increase from its low of 5% to 15% as a result of revegetation efforts. Another important change is that the dominant species comprising that cover became Goodding willow (a native species), as compared to nonnative salt cedar. Recent research has shown that salt cedar does provide habitat for birds (Sogge et al. 2008, van Riper et al. 2008). However, riparian areas that have a native woody component still yield increased avian diversity (van Riper et al. 2008). It should be noted that while cover of riparian habitat decreased overall, it was to the benefit of not only aquatic habitat, but also marsh habitat, which increased from providing only nominal cover to 15% cover by the end of the study.

4.2.2 Bird Communities

That fewer total species were detected overall in Y4-6 as compared to Y1 is not surprising given that far fewer censuses (less than 30%) were conducted. More visits to a site provide more opportunities to detect species, especially rare species that may only be recorded in an area a few times a year or even less. Yet, in the breeding season more total species were detected in Y4-6 than in Y1. Noting the reduced number of site visits also makes the large increase in total detections in all seasons in Y4-6 of interest. Simply, more birds were present at Bostick following the installation of the weir and subsequent creation of the impoundment and revegetation. This is also shown by changes in mean richness and median abundance per census hour. Overall, mean richness per census hour increased by 2.6 species and median abundance per census hour increased by nearly 90 individuals; both increases being statistically significant and indicating increased avian diversity following weir construction. Along with the changes to the community for the overall time period, significant increases of both measurements also occurred in the breeding season. In the non-breeding season, mean richness per census hour remained approximately the same, but median abundance per census hour increased by more than 300%, indicating an increase in the value of the site for overwintering birds. Although the increase was not found to be statistically significant, the p-value was at the threshold of significance (0.05). These increases indicate a more diverse avian community following weir installation.

Additional changes in the bird community pre-and post-weir construction and habitat modification can be found by looking at the most abundant species recorded in each period. The American coot and gadwall, both aquatic habitat obligates, were rarely recorded on the site in Y1, but became two of the most abundant species in Y4-6. In fact, four of the five most abundant species changed between the two time periods both overall and in the breeding and non-breeding season. In Y1 overall, the five most abundant species were all landbirds, yet in Y4-6, the three most abundant species were waterbirds, and the fourth (red-winged blackbird) while still a landbird, was a common wetland associate. The fifth was the American pipit, which was shared between the two periods. It should be noted here that of the five most abundant breeders, American coot detections decline dramatically later in spring and in summer,

suggesting that breeding is actually limited on the Wash. While common in off-channel wetlands in the Wetlands Park, coot nesting has not been documented on the main channel in several years (D. Van Dooremolen, pers. obs.). Also, the least sandpiper is a common migrant but not a breeder.

Other changes also highlight the shift from land dominance to water. Two summer resident species often associated with salt cedar, Lucy's warbler and yellow-breasted chat (Hunter et al. 1988), were commonly detected during the breeding season in Y1 but were absent in Y4-6. Other landbirds such as northern flicker, Lincoln's sparrow, and blue grosbeak declined in detections (Table 4). On the other hand, in Y1, pied-billed grebe was detected on only one census, but in Y4-6 the species was recorded on every census (Table 4). Others such as snowy egret, common moorhen (not present in Y1) and marsh wren also saw their relative frequency and detections increase (Tables 4 and 5). Likewise, two other marsh obligate species, least bittern and Virginia rail that were not detected in Y1, were not only detected in Y4-6, but were confirmed to be breeding. The least bittern and Lucy's warbler are listed as conservation priority species in the Nevada Comprehensive Bird Conservation Plan (GBBO 2010) and the least bittern is also a covered species under the Lower Colorado River Multi-Species Conservation Plan (2004).

Guild analyses provide another view of the change in the bird community. The relative frequency of all six aquatic guilds increased significantly, changing from less than 0.25 to 1.00 in some cases. Interestingly, the frequency of the land-based and aerially-based guilds did not decline significantly over the same period. This indicates that the habitat modifications yielded increased guild richness per census. The changes in relative abundance of the guilds also highlight the shift to more hydric conditions. The relative abundance of the majority of aquatic guilds increased significantly both overall and across the seasons, while the relative abundance of the more land-based guilds (foliage glean, ground glean, and hawks) decreased significantly (although ground glean remained the dominant guild throughout the study). While they became a smaller component of the overall community (i.e., their relative abundance decreased), their median abundance per census hour either experienced no significant change or, as in the case of ground glean, significantly increased. The lack of significant differences in the relative abundance of most of the aerial-based foraging guilds is likely related to them being comprised largely of raptors. Detections of these birds on any census in any time period was typically rare (due to the discarding of pure flyovers) and limited to one or at most two birds.

4.3 Summary of the Six-Year Study and Management Implications

The final bird list completes the species inventory first initiated in Van Dooremolen (2005). The results from this study helped lead to the initiation of targeted marsh bird surveys in the breeding season and year-round aquatic bird counts on the Wash. The former targets inconspicuous marsh bird species, including the least bittern and federally endangered Yuma clapper rail, while the latter records aquatic-dependent species at most weir sites and off-channel wetlands within the Clark County Wetlands Park (through which the Wash flows). Data from the study were also used in the creation of the Las Vegas Wash Wildlife Management Plan (part of the original impetus for this study) that was completed in March 2008.

The study results indicate that weir construction, impoundment creation and revegetation increase avian diversity on-site, largely by increasing aquatic and marsh bird richness and abundance and increasing their temporal use of the site. Overall mean species richness and median abundance per census hour increased significantly following construction of Bostick Weir. Likewise, the significant increase in the relative frequency of aquatic guilds while the other guilds experienced no significant decline indicates increased temporal use of the site by a greater diversity of guilds. Of the three land-based guilds, only hawks (the least rich and abundant of the three) experienced a significant decline in species richness per census hour and a substantial decline in abundance, and abundance actually increased for the others (significantly for ground glean). This implies that the benefits to the aquatic guilds (and by association waterbirds) were generally not detrimental to the other guilds, which are dominated by landbirds.

It should be noted though that these results do not take into account differences in detection probabilities between the various guilds. While it is generally assumed that birds are more easily detected and counted in open habitats (such as open water) versus more vegetated habitats, birds associated with densely vegetated habitats may be undercounted (Bibby and Buckland 1987 c*ited in* Bibby et al. 2000). In Y1, the largest stand of salt cedar was on the south bank of the Wash, but the survey path was on the north. It is likely that not all birds present in that stand were counted, resulting in underestimated abundances for the foliage glean and ground glean guilds, if not other landbird dominated guilds. However this may be balanced out by the similar impact to detectability caused by the large stands of Goodding willow that developed on the weir in Y4-6 and were also never surveyed from the interior.

While most guilds either benefitted or at least were not negatively impacted by the habitat modifications, there were some negative impacts at the species level, with several species of landbird declining or disappearing from the site in Y4-6; however, this was balanced by several species of aquatic and marsh birds that appeared or increased. Of the 18 conservation priority species (GBBO 2010) detected, total detections increased for two-thirds and decreased for only one-third, indicating that there were net benefits.

The main objective of the habitat modifications described in this report was not bird restoration. The primary purpose of the weir construction program is to stabilize the Wash, and the primary purpose of revegetation conducted following weir construction is compliance, conducted to fulfill section 404 and 402 permit mitigation requirements. What the data collected during the Las Vegas Wash Bird Census show is that these management efforts can meet compliance obligations while also benefitting wildlife.

5.0 LITERATURE CITED

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Appendix A

Abundance Estimates for All Species Detected in Y4-6

Species Name	Overall	Breeding	Non-Breeding
American Coot	216	216	202
American Pipit	200	0	200
Yellow-headed Blackbird	152	152	0
Ring-billed Gull	120	0	120
Gadwall	115	26	115
Mallard	110	51	110
Red-winged Blackbird	96	53	96
Great-tailed Grackle	89	8	89
White-crowned Sparrow	76	0	76
Yellow-rumped Warbler	32	4	32
Least Sandpiper	30	30	8
Gambel's Quail	28	27	28
White-faced Ibis	28	28	0
Mourning Dove	22	22	0
Tree Swallow	20	2	20
Cinnamon Teal	18	18	0
American Avocet	17	17	0
Double-crested Cormorant	15	11	15
Northern Rough-winged Swallow	15	0	1
Killdeer	12	3	12
Brewer's Sparrow	11	11	3
Snowy Egret	10	3	10
Abert's Towhee	9	9	7
Long-billed Dowitcher	8	4	8
Song Sparrow	8	4	8
Western Kingbird	8	8	0
Black-crowned Night-Heron	7	2	7
Common Moorhen	7	7	1
Common Yellowthroat	7	7	0
Marsh Wren	7	4	7
Black-tailed Gnatcatcher	6	3	6
Brown-headed Cowbird	6	6	0
Black Phoebe	5	5	3
Cliff Swallow	5	5	0
Pied-billed Grebe	5	5	5
Ruby-crowned Kinglet	5	0	5
Spotted Sandpiper	5	5	1
American Wigeon	4	4	3
Black-necked Stilt	4	4	0
Great Blue Heron	4	4	4
Green Heron	4	4	2
Lazuli Bunting	4	4	0
Rock Wren	4	0	4
Verdin	4	4	4
Common Goldeneye	3	0	3
Greater Yellowlegs	3	1	3
Green-winged Teal	3	0	3
House Finch	3	2	3
Least Bittern	3	3	0
Northern Shoveler	3	1	3
Virginia Rail	3	3	3

Western Grebe	3	2	3
Yellow Warbler	3	3	0
Bewick's Wren	2	2	1
Blue Grosbeak	2	2	0
Common Merganser	2	1	2
Common Raven	2	2	0
Crissal Thrasher	2	2	2
Great Egret	2	2	2
Northern Harrier	2	0	2
Ruddy Duck	2	2	0
Say's Phoebe	2	2	1
Western Tanager	2	2	0
White-throated Swift	2	2	0
Belted Kingfisher	1	1	1
Greater Roadrunner	1	1	0
Lark Sparrow	1	1	0
Lincoln's Sparrow	1	0	1
Loggerhead Shrike	1	1	0
Northern Flicker	1	0	1
Orange-crowned Warbler	1	0	1
Osprey	1	1	1
Plumbeous Vireo	1	1	0
Redhead	1	1	1
Red-tailed Hawk	1	0	1
Sharp-shinned Hawk	1	1	1
Sora	1	1	1
Violet-Green Swallow	1	1	0
White-winged Dove	1	1	0
Wilson's Warbler	1	1	0
Total	1623	826	1252

Appendix B

Final Las Vegas Wash Bird Census Species List

The list includes all bird species detected over the course of the study (2000-2006), including birds from both the Sunrise and Bostick sites, flyovers, and species detected outside of site boundaries on study days. Species names and order follow the AOU Checklist for North American Birds, 7th edition, and supplements through 2010.

Common Name	Scientific Name	Status*	Foraging Guild
Canada Goose	*Branta canadensis*	W	Surface Dips
Domestic Goose	*Anser anser domesticus*	I	Surface Dips
Wood Duck	*Aix sponsa*	W	Dabbles
Gadwall	*Anas strepera*	W	Dabbles
American Wigeon	*Anas americana*	W	Dabbles
Mallard	*Anas platyrhynchos*	R	Dabbles
Cinnamon Teal	*Anas cyanoptera*	R	Surface Dips
Northern Shoveler	*Anas clypeata*	W	Surface Dips
Northern Pintail	*Anas acuta*	W	Dabbles
Green-winged Teal	*Anas crecca*	W	Ground Glean
Redhead	*Aythya americana*	W	Surface Dives
Common Goldeneye	*Bucephala clangula*	W	Surface Dives
Common Merganser	*Mergus merganser*	W	Surface Dives
Ruddy Duck	*Oxyura jamaicensis*	R	Surface Dives
Gambel's Quail	*Callipepla gambelii*	R	Ground Glean
Pied-billed Grebe	*Podilymbus podiceps*	R	Surface Dives
Eared Grebe	*Podiceps nigricollis*	W	Surface Dives
Western Grebe	*Aechmophorus occidentalis*	W	Surface Dives
Clark's Grebe	*Aechmophorus clarkii*	W	Surface Dives
Double-crested Cormorant	*Phalacrocorax auritus*	R	Surface Dives
Least Bittern	*Ixobrychus exilis*	S	Stalk and Strike
Great Blue Heron	*Ardea herodias*	R	Stalk and Strike
Great Egret	*Ardea alba*	R	Stalk and Strike
Snowy Egret	*Egretta thula*	R	Stalk and Strike
Green Heron	*Butorides virexcens*	R	Stalk and Strike
Black-crowned Night-Heron	*Nycticorax nycticorax*	R	Stalk and Strike
White-faced Ibis	*Plegadis chihi*	M	Probes
Turkey Vulture	*Cathartes aura*	S	High Patrol
Osprey	*Pandion haliaetus*	M	High Dives
Northern Harrier	*Circus cyaneus*	R	Low Patrol
Sharp-shinned Hawk	*Accipiter striatus*	R	Aerial Pursuit
Cooper's Hawk	*Accipiter cooperii*	R	Aerial Pursuit
Red-shouldered Hawk	*Buteo lineatus*	W	Low Patrol
Swainson's Hawk	*Buteo swainsoni*	M	High Patrol
Red-tailed Hawk	*Buteo jamaicensis*	R	High Patrol
American Kestrel	*Falco sparverius*	R	Swoops
Merlin	*Falco columbarius*	M	Aerial Pursuit
Peregrine Falcon	*Falco peregrinus*	R	Aerial Pursuit
Prairie Falcon	*Falco mexicanus*	R	Aerial Pursuit
Virginia Rail	*Rallus limicola*	R	Probes
Sora	*Porzana carolina*	M	Ground Glean
Common Moorhen	*Gallinula chloropus*	R	Surface Dips
American Coot	*Fulica americana*	R	Surface Dips
Killdeer	*Charadrius vociferus*	R	Ground Glean
Black-necked Stilt	*Himantopus mexicanus*	S	Probes

American Avocet	*Recurvirostra americana*	M	Probes
Spotted Sandpiper	*Actitis macularius*	S	Ground Glean
Greater Yellowlegs	*Tringa melanoleuca*	M	Probes
Lesser Yellowlegs	*Tringa flavipes*	M	Probes
Western Sandpiper	*Calidris mauri*	M	Ground Glean
Least Sandpiper	*Calidris minutilla*	M	Ground Glean
Long-billed Dowitcher	*Limnodromus scolopaceus*	M	Probes
Wilson's Snipe	*Gallinago gallinago*	M	Probes
Ring-billed Gull	*Larus delawarensis*	R	Ground Glean
Rock Pigeon	*Columba livia*	I	Ground Glean
White-winged Dove	*Zenaida asiatica*	S	Ground Glean
Mourning Dove	*Zenaida macroura*	R	Ground Glean
Greater Roadrunner	*Geococcyx californianus*	R	Ground Glean
Northern Saw-whet Owl	*Aegolius acadicus*	M	Swoops
Lesser Nighthawk	*Chordeiles acutipennis*	S	Aerial Forage
Vaux's Swift	*Chaetura vauxi*	M	Aerial Forage
White-throated Swift	*Aeronautes saxatalis*	S	Aerial Forage
Black-chinned Hummingbird	*Archilochus alexandri*	S	Hover and Glean
Anna's Hummingbird	*Calypte anna*	R	Hover and Glean
Broad-tailed Hummingbird	*Selasphorus platycercus*	M	Hover and Glean
Belted Kingfisher	*Megaceryle alcyon*	M	High Dives
Northern Flicker	*Colaptes auratus*	W	Ground Glean
Western Wood-Pewee	*Contopus sordidulus*	M	Hawks
Black Phoebe	*Sayornis nigricans*	R	Hawks
Say's Phoebe	*Sayornis saya*	R	Hawks
Ash-throated Flycatcher	*Myiarchus cinerascens*	S	Hover and Glean
Cassin's Kingbird	*Tyrannus vociferans*	M	Hawks
Western Kingbird	*Tyrannus verticalis*	S	Hawks
Loggerhead Shrike	*Lanius ludovicianus*	W	Swoops
Plumbeous Vireo	*Vireo plumbeus*	M	Foliage Glean
Warbling Vireo	*Vireo gilvus*	M	Foliage Glean
Western Scrub-Jay	*Aphelocoma californica*	A	Ground Glean
Pinyon Jay	*Gymnorhinus cyanocephalus*	A	Ground Glean
Common Raven	*Corvus corax*	R	Ground Glean
Horned Lark	*Eremophila alpestris*	R	Ground Glean
Tree Swallow	*Tachycineta bicolor*	M	Aerial Forage
Violet-Green Swallow	*Tachycineta thalassina*	M	Aerial Forage
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	S	Aerial Forage
Bank Swallow	*Riparia riparia*	M	Aerial Forage
Cliff Swallow	*Petrochelidon pyrrhonota*	S	Aerial Forage
Barn Swallow	*Hirundo rustica*	M	Aerial Forage
Verdin	*Auriparus flaviceps*	R	Foliage Glean
Bushtit	*Psaltriparus minimus*	R	Foliage Glean
Rock Wren	*Salpinctes obsoletus*	R	Foliage Glean
Bewick's Wren	*Thryomanes bewickii*	R	Ground Glean
Marsh Wren	*Cistothorus palustris*	R	Ground Glean
Blue-gray Gnatcatcher	*Polioptila caerulea*	R	Foliage Glean
Black-tailed Gnatcatcher	*Polioptila melanura*	R	Foliage Glean
Ruby-crowned Kinglet	*Regulus calendula*	W	Foliage Glean
Golden-crowned Kinglet	*Regulus satrapa*	W	Foliage Glean
Mountain Bluebird	*Sialia currucoides*	W	Swoops

Hermit Thrush	*Catharus guttatus*	M	Ground Glean
American Robin	*Turdus migratorius*	W	Ground Glean
Northern Mockingbird	*Mimus polyglottos*	R	Ground Glean
Crissal Thrasher	*Toxostoma crissale*	R	Ground Glean
European Starling	*Sturnus vulgaris*	I	Ground Glean
American Pipit	*Anthus rubescens*	W	Ground Glean
Cedar Waxwing	*Bombycilla cedrorum*	W	Foliage Glean
Phainopepla	*Phainopepla nitens*	R	Foliage Glean
Orange-crowned Warbler	*Oreothlypis celata*	W	Foliage Glean
Lucy's Warbler	*Oreothlypis luciae*	S	Foliage Glean
Yellow Warbler	*Dendroica petechia*	S	Foliage Glean
Yellow-rumped Warbler	*Dendroica coronata*	M	Foliage Glean
Palm Warbler	*Dendroica palmarum*	M	Ground Glean
MacGillivray's Warbler	*Oporornis tolmiei*	M	Foliage Glean
Common Yellowthroat	*Geothlypis trichas*	S	Foliage Glean
Wilson's Warbler	*Wilsonia pusilla*	M	Foliage Glean
Yellow-breasted Chat	*Icteria virens*	S	Foliage Glean
Spotted Towhee	*Pipilo maculatus*	W	Ground Glean
Abert's Towhee	*Melozone aberti*	R	Ground Glean
Chipping Sparrow	*Spizella passerina*	M	Ground Glean
Brewer's Sparrow	*Spizella breweri*	R	Ground Glean
Vesper Sparrow	*Pooecetes gramineus*	M	Ground Glean
Lark Sparrow	*Chondestes grammacus*	M	Ground Glean
Black-throated Sparrow	*Amphispiza bilineata*	S	Ground Glean
Savannah Sparrow	*Passerculus sandwichensis*	W	Ground Glean
Fox Sparrow	*Passerella iliaca*	M	Ground Glean
Song Sparrow	*Melospiza melodia*	R	Ground Glean
Lincoln's Sparrow	*Melospiza lincolnii*	M	Ground Glean
White-crowned Sparrow	*Zonotrichia leucophrys*	W	Ground Glean
Dark-eyed Junco	*Junco hyemalis*	W	Ground Glean
Western Tanager	*Piranga ludoviciana*	M	Foliage Glean
Black-headed Grosbeak	*Pheucticus melanocephalus*	M	Foliage Glean
Blue Grosbeak	*Passerina caerulea*	S	Ground Glean
Lazuli Bunting	*Passerina amoena*	M	Ground Glean
Indigo Bunting	*Passerina cyanea*	S	Foliage Glean
Red-winged Blackbird	*Agelaius phoeniceus*	R	Ground Glean
Western Meadowlark	*Sturnella neglecta*	R	Ground Glean
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	S	Ground Glean
Brewer's Blackbird	*Euphagus cyanocephalus*	W	Ground Glean
Great-tailed Grackle	*Quiscalus mexicanus*	R	Ground Glean
Brown-headed Cowbird	*Molothrus ater*	R	Ground Glean
Bullock's Oriole	*Icterus bullockii*	S	Foliage Glean
House Finch	*Carpodacus mexicanus*	R	Ground Glean
Lesser Goldfinch	*Spinus psaltria*	R	Foliage Glean
House Sparrow	*Passer domesticus*	I	Ground Glean

***Status Codes:**

R - year-round resident
M - migrant
S - summer visitant
W - winter visitant
A - accidental