2015 MIGRATORY WATERBIRD AND SHOREBIRD SURVEYS TO INFORM SOLAR ENERGY ZONE PLANNING, AVIAN IMPACT MINIMIZATION, AND SPECIES CONSERVATION IN THE SAN LUIS VALLEY, COLORADO

Prepared for:

U.S. Department of the Interior, Bureau of Land Management
Colorado Renewable Energy Program–Front Range District
San Luis Valley Public Lands Center
1803 West Hwy 160
Monte Vista, Colorado 81144

Submitted by

Animas Biological Studies
138 Overlook Drive
Durango, CO 81301

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INTRODUCTION

In 2012, the U.S. Department of the Interior (DOI) and U.S. Department of Energy (DOE) designated approximately 6600 ha (16,308 ac) of Bureau of Land Management (BLM) lands in the San Luis Valley (SLV) as Solar Energy Zones (SEZs) through the *Approved Resources Management Plan/Record of Decision (ROD) for Solar Energy Development in Six Southwestern States* (BLM 2012a). SEZs are solar energy development focus areas with high intensity solar radiation (>6.0 kw/m^2/day) and where land use priority includes generation of renewable energy to meet national energy diversification and climate change goals. The four SEZs in the SLV include: 1) De Tilla Gulch, approximately 4.3 km^2 (1,064 ac), located in Saguache County; 2) Los Mogotes East, approximately 10.7 km^2 (2,650 ac), located in Conejos County; 3) Antonito Southeast, approximately 39.4 km^2 (9,712 ac), also located in Conejos County; and 4) Fourmile East, approximately 11.7 km^2 (2,882 ac), located in Alamosa County (Fig. 1).

The SLV, with the Rio Grande and Conejos rivers and a wide array of wetland complexes, is a major migratory flyway for wetland birds protected under the Migratory Bird Treaty Act (16 U.S.C. 703–712). The *Draft/Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States* (BLM 2010, 2012b) identified direct and indirect effects of solar energy development on wildlife, primarily habitat loss/alteration, disturbance from human presence, temporary and chronic noise disturbance, and injuries and mortalities. Of particular concern to migratory birds is the potential for behavioral attraction to solar energy facilities that reflect the sun, which may result in injury or death via collisions with infrastructure, exposure to fire, and burning at standby points (McCrary et al. 1986). In 2014, the National Fish and Wildlife Forensics Laboratory released the findings of a study on bird mortality at three solar energy facilities using different solar technologies—photovoltaic, trough system with parabolic mirrors, and power tower—in southern California (Kagan et al. 2014). They reported injury and mortality at all three solar facilities from impact trauma (from collisions with solar panels), solar flux (resulting in burning), and predation. They documented mortality for 233 individual birds of 71 species, from a variety of taxa including waterbirds (e.g., grebes, coots, pelicans, cormorants, gulls) and shorebirds (e.g., avocets, herons, sandpipers).

To protect the diverse bird life in the SLV from impacts of solar energy facilities, the BLM contracted Animas Biological Studies (ABS) to conduct waterbird/shorebird surveys prior to the development of the four SEZs. The results of these surveys will inform the BLM on the diversity and abundance of migratory waterbirds and shorebirds using the SLV as well as to guide the development of mitigations and management recommendations for avian protection during construction and operation of proposed solar energy facilities.

STUDY AREA

The general study area is the SLV, a large, high desert, intermountain valley extending approximately 170 km long by 75 km wide, from south-central Colorado into north-central New Mexico (Fig. 1). In Colorado, the valley is bound on the east by the Sangre de Cristo Mountains and the west by the San Juan Mountains. The valley floor averages about 2345 m (~7,700 ft) and

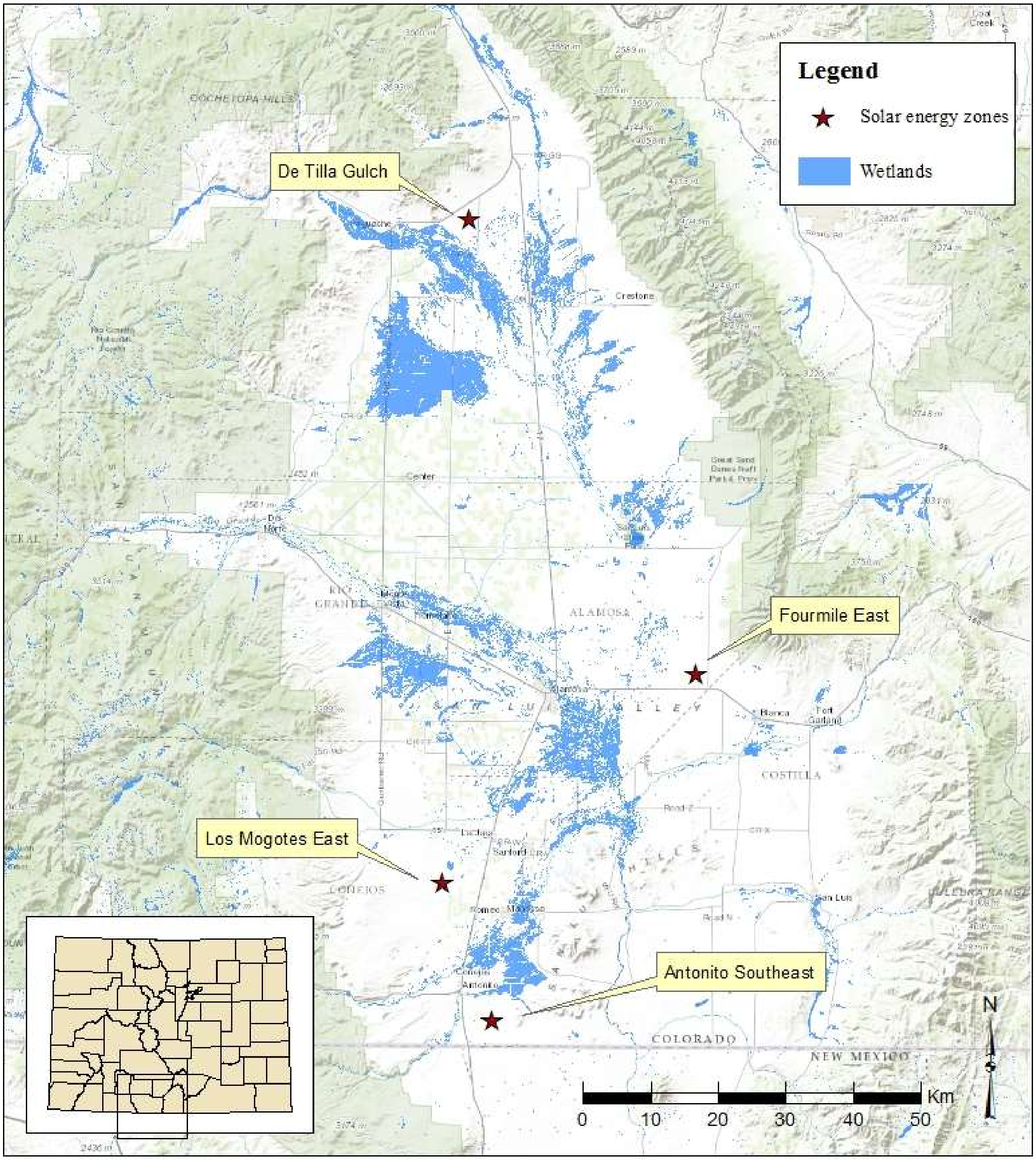

FIGURE 1.

Location of solar energy zones in the San Luis Valley.

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is nearly flat, with the exception of the San Luis Hills and the Great Sand Dunes. Land cover in the SLV, as described and mapped by the Southwest Regional GAP Analysis Project (Lowry et al. 2005), is dominated by semi-desert shrub-steppe, with greater than 25% perennial grasses and an open shrub and/or dwarf shrub component; greasewood (*Sarcobatus vermiculatus*) flats, dominated by greasewood and generally occurring in areas with saline soils, a shallow water table, and intermittent flooding; and agriculture, where pasture or crops account for more than 20% of vegetative cover. Additionally, a variety of wetlands and deep water habitats occur across the SLV, including riverine (rivers, streams, irrigation ditches), lacustrine (lakes/reservoirs), and palustrine (i.e., wet meadows, marshes, shallow ponds, playas) systems (Cowardin et al. 1979). The Rio Grande River is the most prominent water course, running southeasterly across the Colorado portion of the SLV. Numerous deep water lakes and reservoirs occur across the SLV, most designated as State Wildlife Areas (SWAs) managed by Colorado Parks and Wildlife (CPW). Marsh, wet meadow, shallow pond, and playa environments also occur on SWAs, BLM lands, and the SLV National Wildlife Refuge (NWR) complex, consisting of Alamosa, Baca, and Monte Vista NWRs.

In coordination with BLM biologists, we targeted four wetland habitat types with potential to attract the greatest diversity of migrating waterbirds and shorebirds. These included 1) shallow emergent wetlands, 2) wet meadows, 3) riparian areas, and 4) playas. By sampling a variety of wetland types of varying size, vegetative type/cover, and water level/flow, maximized data collection across a broad array of shorebird and waterbird species with potential to migrate and stopover in the SLV. While lacustrine habitats (i.e., lakes and reservoirs) also exist in the SLV and provide stopover habitat for migratory waterbirds/shorebirds, we determined (in consultation with BLM biologists) that species occurring at deep water sites also typically utilize emergent wetlands, playas, and riparian areas during spring and fall migration. Due to funding limitations, we omitted lacustrine habitats from consideration in this survey plan, instead focusing the effort across wetland habitats with potential to attract a greater number and diversity of species.

Our monitoring approach included surveying two representative sites per each of the four target wetland habitat types, multiple times across the spring and fall migratory periods. We selected representative survey sites, occurring on both federal and state lands, through coordination with the BLM as well as CPW and NWR biologists.

Shallow Emergent Wetlands

Shallow emergent wetlands include shallow ponds and marshes with short or tall herbaceous emergent vegetation, such as rushes (*Juncus* spp.), sedges (*Carex* spp.), bulrushes (*Scirpus* spp., *Schoenoplectus* spp.), and cattails (*Typha angustifolia*), and/or submergent or floating vegetation. While water levels may vary, shallow emergent wetlands may hold water year-round and provide critical migratory stopover, foraging, and nesting habitat for a variety of waterbirds (e.g., grebes, ducks, geese), wading birds (e.g., herons, egrets, ibises, cranes), and secretive marsh birds (e.g., bitterns, rails). Because they are permanent to semi-permanent wetlands, these habitats likely host the highest densities of migratory waterbirds and shorebirds in the SLV.

We selected Russell Lakes SWA and Monte Vista NWR as the two representative shallow emergent wetland study areas (Fig. 2). Russell Lakes SWA is an approximately 1218 ha wetland

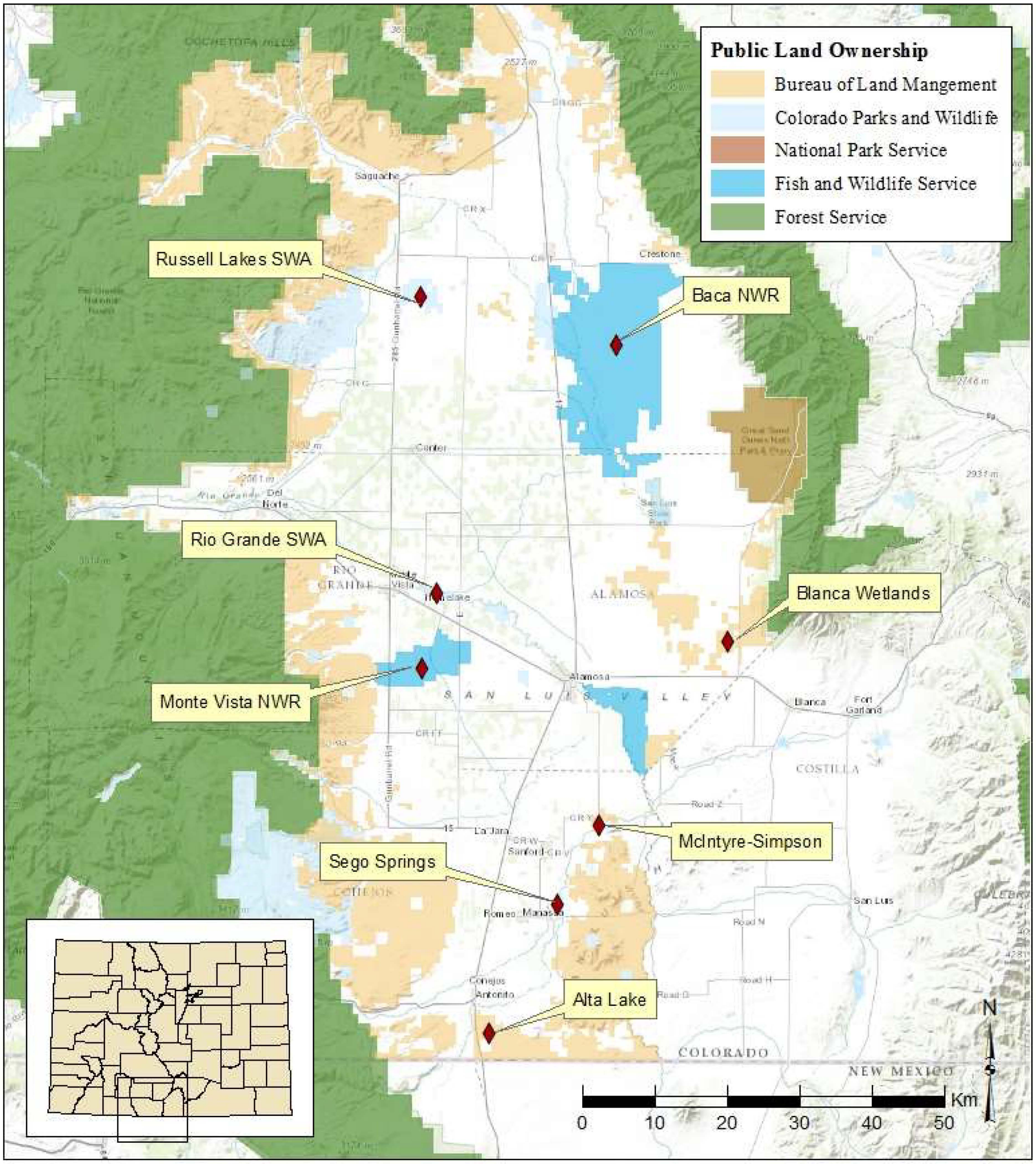

FIGURE 2.

Shorebird/Waterbird survey areas in the San Luis Valley, Alamosa, Conejos, Costilla, Rio Grande, and Saguache counties.

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complex comprised of shallow lakes and marshes, located about 40 km due north of Monte Vista and 16 km south of Saguache. The site includes almost 50 game management units (GMUs) of varying size and habitat type, including some upland (i.e., non-wetland) habitat. We selected a sample of five GMUs with shallow emergent wetland habitat for spring and fall migration surveys at Russell Lakes. Due to changes in water levels and available wetland habitats between the spring and fall migration periods, we did not sample the same GMUs during each season (Map 1 in Appendix A). The GMUs sampled ranged in size from approximately 8.6 to 86.2 ha. Monte Vista NWR, our second shallow emergent sampling area, is part of the San Luis Valley NWR complex comprising approximately 5991 ha of intensively managed habitat for a variety of waterbirds and shorebirds. The refuge is located approximately 10 km south of Monte Vista and includes both short and tall emergent wetlands. We selected two adjacent shallow emergent management units on Monte Vista NWR for study, totaling approximately 655 ha (Map 2 in Appendix A).

Wet Meadows

Wet meadows are seasonal and semi-permanent wetlands dominated by short emergent vegetation, such as sedges and mountain (baltic) rush (*Juncus arcticus*). Wet meadows are typically inundated with water in spring and early summer, during which time they provide important foraging and nesting opportunities to a variety of waterfowl, wading birds, and secretive marsh birds.

We selected BLM MacIntyre-Simpson Wetland Area and the Baca NWR for surveying wet meadow habitat in the SLV (Fig. 2). Baca NWR is a large (>37 000 ha) complex, encompassing wet meadows, playas, and shrublands, located west of Great Sand Dunes National Park, about 30 km north of Alamosa. There, we selected an area of upland and wet meadow habitat in the northern-central portion of the refuge collectively known as "Sheds". Sheds includes numerous management units with numerous flooded by Crestone Creek and/or Willow Creek, running west from the Sangre de Cristo Mountains (Map 3 in Appendix A). The approximate area of Sheds is 1624 ha. The MacIntyre-Simpson Wetland Area is located along the Conejos River, approximately 12 km east of La Jara. The site includes riparian and meadow habitat and is typically flooded in spring to support migrating waterbirds and shorebirds. We sampled wet meadows flooded by the Hemi and Los Ojos ditches, on the west side of the property, as well as Middle and Alamo ditches, on the east side of the property. The sampling area totaled approximately 237 ha (Map 4 in Appendix A).

Riparian Areas

Riparian habitats include rivers, streams, and creeks typically flanked by cottonwoods (*Populus* spp.), willows (*Salix* spp.), or other woody vegetation. Riparian corridors but may serve as stopover habitat for a variety of waterbirds and shorebirds. The woody margins around water courses are also suitable nesting habitat for shorebirds such as herons and egrets. The Rio Grande River is the most prominent water course in the SLV, but other notable rivers include the Conejos and Alamosa rivers, and San Luis and La Garita creeks. Irrigation ditches also provide narrow stringers of riparian habitat across the valley floor. We selected two representative riparian areas in the SLV for waterbird and shorebird surveys. The first site is the western portion of the Rio Grande SWA, an approximately 5 km corridor along the Rio Grande River, beginning about 5 km east of Monte Vista (Fig. 2). The site includes mature cottonwood overstory, understory vegetation of willows (dense in some areas), as well as sloughs and oxbows with emergent vegetation (Map 5 in Appendix A). Additionally, selected a riparian zone in the southern San Luis Valley along the Conejos River, Sego Springs SWA, an approximate 1.5 km stretch of riparian habitat located approximately 12 km southeast of La Jara, also dominated by mature cottonwoods and willows, with adjacent emergent wetland habitat (Map 6 in Appendix A).

Playas

Playas are flat-bottomed desert basins that form shallow lakes during periods of abundant waters. They are ephemeral wetlands, typically water covered during spring runoff, and then dry by early summer, depending on annual precipitation and snowpack conditions. SLV playas also hold water in mid- to late summer, during the monsoon season. The SLV includes an abundance of historic playas, some of which have been dry over the past decade due to extended drought conditions. However, one of the most extensive, historic playa environments in the SLV, the BLM's Blanca Wetlands, is currently managed to provide water during the critical migratory and breeding periods for waterbirds and shorebirds. A large (>3500 ha) complex with over 200 lakes, the site offers ideal opportunities for surveying playa habitats in this study. We selected Blanca Wetlands as the primary playa survey area. The site is located approximately 24 km southeast of Saguache and 24 km southwest of Crestone (Fig. 2). In coordination with the BLM, we selected a sample of five playa lakes of varying size (12–35 ha), water level, salinity, and extent and composition of shoreline habitat (Map 7 in Appendix A).

Additionally, we surveyed Alta Lake, a small (~4 ha) playa located on BLM lands within the Antonito Southeast SEZ, approximately 3.6 km north of the Colorado–New Mexico border (Fig. 2, Map 8 in Appendix A). Although only a single and small playa, its location within the SLV's largest SEZ renders it an important area to survey.

METHODS

SURVEY WINDOWS

The International Shorebird Survey (ISS) and the Program for Regional and International Shorebird Monitoring (PRISM) have established protocols for surveying shorebirds on their migratory stopover grounds (see http://ebird.org/content/iss/). Surveys consist of counts or estimates, depending on bird density, spread across the spring (mid-March–mid-June) and fall (mid-July–late October) migratory periods, with one survey conducted about every 10 days. Multiple visits spread across the migratory periods provide a broad understanding of waterbird and shorebird use of stopover habitats compared with only a single survey per season. Due to funding constraints, we followed a modified ISS/PRISM schedule for surveying migratory shorebirds and waterbirds in the SLV, to maximize the probability of encountering the greatest number of species and individuals at various wetland complexes across the spring and fall migratory periods. Length of waterbird/shorebird migration periods, as well as local water availability, varies from spring to fall; thus, our survey schedule also differed seasonally.

Spring Migration

Spring water levels in the SLV are typically higher than fall due to run-off from snowmelt as well as water management (by state and federal agencies) to benefit migratory and nesting waterbirds/shorebirds. Within family taxonomical groups, spring migration typically occurs more rapidly and over a shorter timeframe than fall, with peak waterfowl movement in March, and most other waterbirds and shorebirds migrating from mid-April through late May. However, spring leaf-out is delayed until late May due to the relatively high elevation. Considering these factors, our approach during spring migration included five field surveys at the shallow emergent and playa sites, and three field surveys in the wet meadow and riparian areas. We staggered spring surveys across five 2–3 week periods, from mid-March through mid-June (Table 1), to insure adequate sampling across the spectrum of migratory waterbirds/shorebirds using the SLV. Surveys occurred about 2–3 weeks apart. We visited shallow emergent wetlands and playas during all five survey periods (mid-March–late May) to accommodate peak migration of waterfowl (earlier than other waterbirds/shorebirds) as well as migration of other waterbirds, wading birds, and marsh birds (Table 1). Wet meadow and riparian surveys commenced in the third survey period (around mid-April) and continued through mid-June, coinciding with water management (wet meadow) and spring leaf-out (riparian) at selected survey sites (Table 1).

Fall Migration

Fall migration generally occurs over a longer time frame than spring, beginning in mid-July and continuing through late October; however, the bulk of individuals typically move through by the end of September. Some SLV wetlands may be dry in fall due to a combination of factors including low spring run-off, drought, and competing water demands from agriculture and human consumption. These include wet meadow habitats at Baca NWR and MacIntyre-Simpson, some shallow emergent habitats, and most playas in the SLV. Taking these factors (and available funding) into account, our approach to fall migration involved conducting four surveys in playa habitats, beginning in mid-July, and three surveys in shallow emergent and riparian areas, beginning in early August, with each survey approximately 2–3 weeks apart, similar to the spring schedule (Table 1).

SAMPLING APPROACH

We employed a combination of sampling methods within the varying wetland habitat types to collect data efficiently and effectively. These included area counts, point counts, and line transects (see below). We used binoculars and high-powered spotting scopes to view, identify, and count/estimate birds during each survey. All surveys were conducted during daylight hours. We identified individuals to family group and species, where possible. Identification to species was not possible for some individuals for the following reasons: 1) birds in large flocks were concealed by other birds; 2) vegetation or other physical features partially concealed some birds; 3) birds moved in and out of the study area too quickly for species identification; and 4) in fall, immature birds of several species may exhibit similar plumages.

Area Counts

We conducted area counts at Russell Lakes SWA shallow emergent habitat and all playa habitats

Table 1. Windows for shorebird/waterbird surveys during spring and fall migration in the San Luis Valley, 2015.

Season	Wetland Type	Survey Window/Survey Number				
		15–31 Mar	1–20 Apr	21 Apr–10 May	11–31 May	1–20 Jun
Spring	Shallow emergent	1	2	3	4	5
	Wet meadow	[a]	[a]	1	2	3
	Riparian	[a]	[a]	1	2	3
	Playa	1	2	3	4	5
		15–31 Jul	1–20 Aug	21 Aug–9 Sep	10–30 Sep	
Fall	Shallow emergent	[a]	1	2	3	
	Riparian	[a]	1	2	3	
	Playa	1	2	3	4	

[a] No survey conducted during this period

where we could clearly define our sampling area. We conducted area counts one or more viewing points per site and/or by slowly walking/driving along the edge of the habitat. We conducted direct counts at sites with relatively small numbers of birds (generally <100) or where birds exhibit little movement. In areas with greater bird abundance or bird movement, we employed an estimation method. The estimation method involved first counting a small number of birds (typically 10) in a large flock to develop a count image for 10 birds. Following, we applied the count image to the flock by 10's, counting up to 100 birds and developing a new count image for 100 birds. We applied the count image of 100 to the entire flock, or, for very large flocks, we continued to increase the count image to 500 or even 1,000 birds or more. Once we established a set count image appropriate for the flock, we estimated the number of birds in the flock visible at the viewing station.

We made every effort to produce as little disturbance as possible when conducting area counts. We minimized disturbance by following these guidelines: 1) we observed birds from a distance; 2) did not approach flocks directly; 3) we made as little noise as possible; and 4) we avoided sudden movements.

During field surveys in spring and fall, we estimated the proportion of each area count survey site we could not adequately view due to vegetative cover for extrapolation during data analysis (see Methods: Data Analysis and Reporting).

Line Transects

Wet meadows lend themselves well to sampling via line transect method because of their relative short-stature, openness, and accessible for pedestrian transects. Thus, we sampled the migratory population of shorebirds/waterbirds via line transect surveys following a distance sampling methodology (Buckland et al. 1993). After some field reconnaissance, we established three linear transects in wet meadow habitats on Baca NWR and MacIntyre-Simpson Wetland, totaling 3 km of transects at each site. We surveyed each site by slowly walking along transects and recording each bird observed. We measured the distance and radial bearing to each single bird or cluster of birds using a laser range-finder and compass. We anticipated the detection of a large number of birds and flocks, and to make data recording more efficient we assigned detections to a distance interval rather than reporting exact distances. Distance categories were as follows: 0–10 m, 11–25 m, 26–50 m, 51–100 m, 100–200 m, and >200 m.

In addition to line transects at wet meadow habitats, we also conducted one-sided line transects in shallow emergent habitat on Monte Vista NWR. Both of the selected management units on the refuge were too large to conduct accurate area counts. There, various levies flank emergent wetlands, providing appropriate conditions for walking straight line transects and sampling the habitats. We established six 0.5-km transects (totaling 3 km) flanking shallow emergent habitats to sample as much area as possible within the two management units. Survey methods followed wet meadow transects, except we only surveyed along one side of the line transect. We chose the one-side line transect instead of a standard line transect approach to account for the difficulty in detecting and recording a high density of birds/flocks that may flush in large numbers simultaneously on both sides of a transect. A standard line transect approach could have resulted in observers failing to detect or correctly identify some birds and/or recording imprecise distances or bearings.

Point Counts

Riparian areas lend themselves well to distance sampling because of their accessibility for pedestrian transects within the habitat and their; however, riparian corridors are rarely linear. Thus, riparian corridors are better-suited for point count rather than line transect surveys. Accordingly, we sampled the migratory population of shorebirds/waterbirds in selected riparian areas via point counts, following a distance sampling methodology (Buckland et al. 1993). Since visibility is often restricted in riparian areas due to woody vegetation and the meandering nature of water courses, we spaced survey points along riparian corridors at intervals of approximately 250 m. At each point, we identified and counted birds for a period of 5 minutes, measuring the distance (via rangefinder) and bearing (via compass) to each bird/flock from the point. We also recorded birds observed between points, though separated those data from point count data. Similar to line transects, we utilized pre-defined distance intervals rather than exact distances for bird detections. Distance categories were as follows: 0–10 m, 11–25 m, 26–50 m, 51–100 m, 100–200 m, and >200 m.

Supplemental Data

In addition to counting/estimating waterbirds and shorebirds at each study site, during field surveys we also noted individuals of species flying over survey areas or utilizing habitat adjacent to survey areas. We also recorded the presence (but not abundance) of other (non-waterbird/shorebird) avian species using or flying over each wetland site during the migration periods.

Using handheld GPS units, we recorded the locations of all sampling points, and transect start and end points. Additionally, we took representative photographs of each study area during each field visit.

DATA ANALYSIS AND REPORTING

We pooled area count data from each sampling unit for each site and calculated the total number of individuals, number of individuals per species, and number of individuals per family for each survey period and across all survey periods. We extrapolated our count data at Russell Lakes SWA and Blanca Wetlands to account for habitat not viewable within sampling areas during each survey. At Russell Lakes SWA, we were unable to adequately view 60% of the shallow emergent habitat in selected GMUs in spring and 45% in fall. At Blanca Wetlands, we were unable to adequately view 5% of playas during spring and fall surveys. Thus, we calculated an extrapolated total number of individuals, number of individuals per species, and number of individuals per family during each survey and across all survey periods. We then calculated an extrapolated mean per species and family across the spring and fall survey periods. Following that, we calculated mean bird density (birds/ha) for each species and family by dividing the extrapolated means by the total sampling area. We did not extrapolate data at Alta Lake because we were able to view the entire site unobstructed during each survey.

We analyzed line transect and point count data using program Distance (Thomas et al. 2010). We modeled the mean overall bird density (and abundance) across the spring and fall sampling periods as well as within each survey period (where possible, see Results). Additionally, we modeled mean density per species and family across spring and fall. For both line transect and point count data, we compared models integrating 1) half normal, 2) hazard rate, and 3) negative exponential detection functions, with cosine and/or simple polynomial adjustments. Preliminary analyses indicated the uniform detection function resulted in too many errors for reliable density and abundance estimates, so we eliminated the uniform detection function our analyses. For each analysis, we selected the best model using Akaike's Information Criterion (AIC); the model with the lowest AIC represents the most competitive model.

Because we surveyed only a sample of wetland habitats in the SLV, we extrapolated density and abundance estimates for the four wetland types defined in this study (shallow emergent, wet meadow, riparian, and playa) across the total area of these wetland types in the SLV. These data provide our best estimate of overall abundance of migratory waterbirds and shorebirds during spring and fall migration. We derived the area of SLV wetlands using GIS data from the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI; available at http://www.fws.gov/wetlands/index.html). The NWI identifies six wetland types in Colorado: 1) freshwater emergent wetland, 2) freshwater forested/scrub wetland, 3) freshwater pond, 4) lake, 5) riverine, and 6) other. The other category consists of shorelines of cobble, sand, mud, or organic/vegetative material. In ARCGIS, we clipped the NWI wetland layer to fit the approximate boundary of the SLV and calculated the total area of each of the six wetland types. Based on our clipped GIS layer, the total area of wetlands in the SLV is 87 473.1 ha, with 78 924.8 ha of freshwater emergent wetland, 2223.9 ha of freshwater forested/scrub wetland, 1377.2 ha of freshwater pond, 2490.7 ha of lake, 1947.8 ha of riverine, and 508.7 ha of cobble.

Our defined wetland habitats varied somewhat from the NWI categories; therefore, to extrapolate our data across the SLV appropriately, we examined the NWI map to determine proper placement of our defined wetland types into NWI categories. We determined that both the shallow emergent and wet meadow habitat types mostly overlapped the NWI's freshwater emergent wetland category; thus, we combined the shallow emergent and wet meadow habitat types extrapolated mean density across these sites to the known area of freshwater emergent wetland habitat across the SLV (78 924.8 ha). NWI classified most (i.e., large) playas as either freshwater lakes or shorelines (other); thus, we extrapolated bird density data from Blanca Wetlands to the known area of total freshwater lakes and shoreline habitat in the SLV (2999.4 ha). Due to its small size, we determined that Alta Lake probably better represented NWI-defined pond habitats rather than lakes; thus, we extrapolated data from this site to the known area of ponds across the SLV (1377.2 ha). We determined our riparian survey areas generally encompassed both the NWI's riverine and freshwater forested/scrub wetland classification; thus, we extrapolated the mean density of riparian areas across the know area of riverine and freshwater forest/scrub wetland in the SLV (4171.7 ha).

RESULTS

We detected individuals of 56 waterbird and shorebird species of 13 families during spring and fall surveys across the SLV in 2015. In spring, we observed 48 species and in fall we detected 44 species (Table 2, in Appendix B).

SPRING MIGRATION

Shallow Emergent Area Counts

Russell Lakes SWA

During five spring migration surveys at Russell Lakes, ABS biologists detected 5,483 individuals comprising 37 species of 11 families (mean=1,096.6 birds/survey). We detected the greatest number of individuals (2,498) during Survey 1 and the least (274) during Survey 5. Green-winged Teal (1,032; 18.8% of total detections), Sandhill Crane (1031; 18.6%) and Northern Shoveler (645; 11.7 %) comprised the three most abundant species detected across all spring surveys. The Anatidae family by far comprised the majority (64.0%) of total detections.

Extrapolated data estimates a low of 685 birds in the five GMUs during Survey 5 and a high of 7,370 birds during Survey 1 (mean=2,741.5 birds/survey; Table 3 in Appendix B). Overall density of waterbirds and shorebirds in the five GMUs ranged from a low of 3.92 birds/ha (Survey 5) to a high of 42.16 birds/ha (Survey 1; mean density=15.68 birds/ha). Table 3 (in Appendix B) provides extrapolated total, mean, and mean density estimates per species at Russell Lakes SWA across the spring migration period. Figure 3 (in Appendix B) shows the mean density per family across spring migration.

Shallow Emergent and Wet Meadow Line Transects

Monte Vista NWR

Across five surveys at Monte Vista NWR, we tallied 680 detections of 26 species and nine families of waterbirds/shorebirds. For all three model sets analyzed in program Distance (i.e., stratified by survey period, species, and family), the best model estimating bird density included the negative exponential function plus a simple polynomial adjustment (Table 4 in Appendix B). Overall density of waterbirds/shorebirds was highest during Survey 1 (34.01 birds/ha) and lowest during Survey 5 (8.13 birds/ha), similar to the pattern at Russell Lakes SWA. Mean density across spring migration was 18.97 birds/ha (Table 5 in Appendix B). Table 6 (in Appendix B) provides mean density and abundance estimates per species across all spring surveys, and Figure 4 (in Appendix B) shows the mean density per family across spring surveys. Cinnamon Teal, Mallard, and Sandhill Crane had the highest mean densities across the spring migration period, though Sandhill Cranes were only detected at Monte Vista NWR during Survey 1, at the tail end of their migration through the SLV. The family Anatidae again had the highest density (62%) during spring migration.

MacIntyre-Simpson Wetland Area

Across three spring migration surveys (Survey Periods 3–5) at MacIntyre-Simpson Wetland Area, we tallied 166 detections, with 19 species of shorebirds/waterbirds from six families. Unlike Monte Vista NWR, the best model function and adjustment terms varied for the three model sets analyzed in program Distance (Table 7 in Appendix B). The best model for data stratified by survey period included a half normal function with a cosine adjustment. For data stratified by family, the best model included hazard rate function with a simple polynomial adjustment, and for data stratified by species, the best model was the half normal function with simple polynomial adjustment.

Overall density of waterbirds/shorebirds was considerably lower at MacIntyre-Simpson Wetland Area compared with Monte Vista NWR and Russell Lakes SWA, ranging from 1.46 birds/ha during Survey 3 (Survey Period 5) to 2.60 birds/ha during Survey 2 (Survey Period 4); mean density across the three surveys was 2.03 birds/ha (Table 8 in Appendix B). Table 9 (in Appendix B) provides mean density and abundance estimates per species across spring surveys, and Figure 5 (in Appendix B) shows mean density per family across spring surveys. Species with the highest density estimates included Wilson's Phalarope, Cinnamon Teal, Mallard, and Blue-winged Teal. The family Anatidae accounted for the majority (58%) of bird density.

Baca NWR

We recorded only 31 detections during three spring migration surveys (Survey Periods 3–5) at Baca NWR, totaling 12 species of four families (Table 10 in Appendix B). Consequently, the Distance analyses produced critical errors and unreliable density estimates. To produce a more reliable density estimate for Baca NWR, we pooled the data from all three line transect sites and stratified by site. This analysis produced an overall density estimate for Baca NWR across the spring survey period but did not allow for estimates within each period. In the pooled analysis, the best model estimating density at Baca NWR included the hazard rate function with simple polynomial adjustment term (AIC=2,920.56). Overall density was 0.53 birds/ha (cv=62.15; df=33.16; 95% CI, 0.17–1.70), corresponding to an abundance estimate of 126 birds in the sampling area over the three surveys.

Playa Area Counts

Blanca Wetlands

During five spring migration surveys, we detected 11,464 individuals of 39 species and 10 families (mean=2,292.8 birds/survey). We detected the greatest number of individuals (5,484) during Survey 2 and the least (442) during Survey 5. Ruddy Duck (3,589; 31.3%), Green-winged Teal (1,164; 10.2%), and Gadwall (1,125; 9.8%) were the most abundant species detected. Anatidae comprised the majority (82.0%) of total spring detections.

Extrapolated data estimates a low of 465 birds present in the five playa lakes at Blanca Wetlands during Survey 5 and a high of 5,773 during Survey 2 (mean=2,413 birds/survey; Table 11 in Appendix B). Overall density of waterbirds and shorebirds ranged from a low of 4.32 birds/ha (Survey 5) to a high of 53.60 birds/ha (Survey 2; mean density=22.41 birds/ha). Table 11 (in Appendix B) provides extrapolated totals, mean, and mean density estimate per species at Blanca Wetlands across the spring migration period. Figure 6 (in Appendix B) shows the mean density per family across spring migration.

Alta Lake

The much smaller Alta Lake yielded only 14 individuals of six species and three families during three spring surveys (playa was dry in survey periods 4 and 5), an average of 4.67 individuals per survey day (Table 12 in Appendix B). Green-winged Teal (5) was the most frequently detected species. Anatidae (8) made up 57.1% of total detections (Figure 7 in Appendix B). Waterbird/shorebird density (Survey Periods 1–3 only) ranged from a low of 0.60 birds/ha during Survey 3 to a high of 1.20 birds/ha in Survey 2 (mean=0.93 birds/ha).

Riparian Area Point Counts

Rio Grande SWA and Sego Springs SWA

Low encounter rate at Sego Springs SWA ($n \leq 20$ detections in spring and fall) precluded analysis of this site separately; thus, we pooled the data from the two riparian sites and modeled mean bird density across the spring and fall seasons as well as bird density within each survey period. We detected 14 species of six families of waterbirds/shorebirds (from 69 total detections) during three spring migration surveys (Survey Periods 3–5) at Rio Grande and Sego Springs SWAs. The detection function and adjustment terms for the best models estimating bird density stratified by survey period, family, and species varied for the three model sets analyzed. The best model for survey period included a negative exponential function with either a simple polynomial or cosine adjustment (both adjustments faired equally well). For data stratified by family and species, the hazard rate function with either a simple polynomial or cosine adjustment represented the best models (Table 13 in Appendix B).

Density of waterbirds and shorebirds was considerably lower at the riparian sites compared with shallow emergent wetlands and playas but similar to wet meadows. Overall density for pooled data at Rio Grande and Sego Springs SWAs ranged from a low of 2.65 birds/ha during Survey 2

(Survey Period 4) to a high of 5.97 birds/ha during Survey 3 (Survey Period 5). Mean density across the three surveys was 3.61 birds/ha (Table 14 in Appendix B). Table 15 (in Appendix B) provides mean density and abundance estimates per species across spring surveys, and Figure 8 (in Appendix B) shows mean density per family across spring surveys. Species with the highest density estimates included Canada Goose, Green-winged Teal, and Common Merganser. Density per family was more evenly distributed across families in riparian areas: Scolopacidae, 29%; Anatidae, 21%, Charadriidae, 20%, Phalacrocoracidae, 20%; and Rallidae, 10%.

FALL MIGRATION

Shallow Emergent Area Counts

Russell Lakes SWA

During three fall migration surveys at Russell Lakes SWA, we detected 1,325 individuals of 29 species and eight families (mean=345.5 birds/survey). We detected almost or more than twice as many birds (634) during Survey 3 (Fall Survey Period 4) than during Survey 1 (385) or Survey 2 (305). American Coot (527; 39.8%) and Blue-winged Teal (327; 24%) were the most abundant species. Anatidae comprised ~43% of detections, while Rallidae made up 40%.

Extrapolated data estimates a low of 545 birds (Survey 2) in the five GMUs and a high of 1,132 birds during Survey 3 (mean=616.96 birds/survey; Table 16 in Appendix B). Overall density of waterbirds and shorebirds in the five GMUs ranged from a low of 2.61 birds/ha (Survey 2) to a high of 5.43 birds/ha (Survey 3; mean density=2.96 birds/ha). Table 16 (in Appendix B) provides extrapolated totals, means, and mean density estimate per species at Russell Lakes SWA across the fall migration period. Figure 9 (in Appendix B) shows the mean density per family across fall migration.

Shallow Emergent Line Transects

In three fall surveys at Monte Vista National Wildlife refuge, we tallied 212 detections of 21 species and seven families. The best model estimating bird density stratified by survey period included the negative exponential function plus a simple polynomial adjustment (Table 17 in Appendix B). For both model sets stratified by family and by species, the best model estimating density included a hazard rate detection function with a simple polynomial adjustment term (Table 16 in Appendix B).

Overall density of waterbirds/shorebirds was highest (26.02 birds/ha) during Survey 1 (Fall Survey Period 2) and lowest during Survey 2 (18.13 birds/ha). Mean density across spring migration was 21.13 birds/ha (Table 18 in Appendix B). Table 19 (in Appendix B) provides mean density and abundance estimates per species across all fall surveys, and Figure 10 (in Appendix B) shows the mean density per family across fall surveys. Blue-winged Teal, Mallard, and American Coot had the highest mean densities across the spring migration period. The family Anatidae again had the highest density (59%) during fall migration.

Playa Area Counts

Blanca Wetlands

During four fall migration surveys at Blanca Wetlands, we identified 17,025 individuals of 38 species and 10 families (mean=4,256.3 birds/survey). We detected the greatest number of individuals (7,631) during Survey 4 and the least (1,012) during Survey 1. American Coot (4,127; 24.2%), Wilson's Phalarope (2,919; 17.1%), Blue-winged Teal (2,119; 12.5%), and Ruddy Duck (2,113; 12.4%) were the most abundant species detected. Anatidae made up 48% of detections; Rallidae, 24 %; and Scolopacidae, 19%.

Extrapolated data estimates a low of 1,065 birds in the five playa lakes during Survey 1 and a high of 8,033 during Survey 4 (mean=4,480 birds/survey; Table 20 in Appendix B). Overall density of waterbirds and shorebirds ranged from a low of 9.89 birds/ha (Survey 1) to a high of 74.58 birds/ha (Survey 4; mean density=41.60 birds/ha). Table 20 (in Appendix B) provides extrapolated totals, mean, and mean density estimate per species at Blanca Wetlands across spring migration. Figure 11 (in Appendix B) shows the mean density per family across spring migration.

Alta Lake

Alta Lake was dry during the fall migration periods; therefore, no birds were detected.

Riparian Area Point Counts

We detected nine species of five families during fall migration surveys in Rio Grande and Sego Springs SWAs. Detections (36) totaled about half that of spring migration (69). Due to small sample size, results from program Distance are less reliable than results from spring surveys. For all three model sets analyzed (i.e., stratified by survey period, family, and species), the best model estimating bird density included the half normal function with a simple polynomial adjustment (Table 21 in Appendix B).

Overall density of waterbirds/shorebirds was highest (5.08 birds/ha) during Survey 1 (Fall Survey Period 2) and lowest (0.79 birds/ha) during Survey 3 (Fall Survey Period 4). Mean density across fall migration was 2.17 birds/ha (Table 22 in Appendix B). Table 23 (in Appendix B) provides mean density and abundance estimates per species across fall migration; Figure 12 (in Appendix B) shows the mean density per family across fall surveys. Common Merganser, Spotted Sandpiper, and Canada Goose had the highest mean densities across the spring migration period. The family Anatidae comprised 45% of detections while Scolopacidae comprised 40%.

EXTRAPOLATED ABUNDANCE OF WATERBIRDS/SHOREBIRDS

Based on our density estimates from shallow emergent, wet meadow, playa, and riparian sampling, we estimate a total of approximately 6.65 million waterbirds/shorebirds moving through the SLV during spring migration, ranging from a low of 393,240 in Survey Period 5 to a high of approximately 3.08 million in Survey Period 1 (Table 24). During fall migration, we estimate a total of approximately 3.54 million migrating waterbirds/shorebirds, with a low of just under 30,000 in Survey Period 1 and a high of about 1.30 million during Survey Period 2 (Table 25).

Table 24. Extrapolated abundance of waterbirds and shorebirds during spring migration surveys in the San Luis Valley, 2015.

	Density Estimate (No. birds/ha)				SLV Abundance Estimate				
Survey Period	**Emergent/ Wet Meadow**[a]	**Playa/ Lake**	**Playa/ Pond**	**Riparian**[a]	**Emergent/ Wet Meadow**[a]	**Playa/ Lake**	**Playa/ Pond**	**Riparian**[a]	**Total**
1	38.084	24.493	1.000	[b]	3,005,791	73,464	1377.2	[b]	3,080,632
2	21.764	53.599	1.200	[b]	1,717,723	160,765	1652.64	[b]	1,880,141
3	8.205	20.251	0.600	3.431	647,566	60,741	826.32	14,314	723,448
4	6.794	9.383	[b]	2.648	536,202	28,143	[b]	11,047	575,391
5	4.503	4.320	[b]	5.970	355,376	12,957	[b]	24,906	393,240
Pooled Mean	9.303	22.410	0.933	3.610	734,235	67,217	826	15,060	1,330,570
Total					6,262,659	336,071	3,856	50,266	6,652,852

[a] Mean density estimate across sampling sites

[b] No survey conducted during this survey period

Table 25. Extrapolated abundance of waterbirds and shorebirds during fall migration surveys in the San Luis Valley, 2015.

	Density Estimate (No. birds/ha)			SLV Abundance Estimate			
Survey Period	**Shallow Emergent**[a]	**Playa/ Lake**	**Riparian**[a]	**Shallow Emergent**[a]	**Playa/ Lake**	**Riparian**[a]	**Total**
1	[b]	9.891	[b]	[b]	29,667	[b]	29,667
2	14.664	41.646	5.085	1,157,336	124,913	21,211	1,303,460
3	10.526	40.278	1.560	830,775	120,809	6,508	958,092
4	12.935	74.583	0.787	1,020,894	223,705	3,281	1,247,880
Pooled Mean	18.406	41.599	2.165	1,452,650	124,773	9,032	884,775
Total				3,009,004	499,094	31,001	3,539,099

[a] Mean density estimate across sampling sites

[b] No survey conducted during this survey period

DISCUSSION

Our data confirm that the SLV serves as an important flyway for a diverse array of migratory waterbirds and shorebirds in both spring and fall, providing stopover and staging habitat for millions of birds each season. Most species observed in this study breed in Colorado, though we reported a number of species that only migrate through the state on their way to more northerly breeding grounds in spring, and/or more southerly wintering grounds in fall. These include Common Goldeneye, Greater Yellowlegs, Lesser Yellowlegs, Marbled Godwit, Sanderling, Baird's Sandpiper, Long-billed Dowitcher, Short-billed Dowitcher, Red-necked Phalarope, Bonaparte's Gull, and Ring-billed Gull. Our data suggest the abundance of waterfowl (Anatidae) generally far outnumbers other waterbird and shorebird groups at shallow emergent, wet meadow, and playa environments, especially during spring migration; however, these habitats also support a diversity of waterbird and shorebird family groups and species. Generally, shallow emergent and large playa habitats supported the highest density and diversity of waterbirds/shorebirds and seem to represent the most critical habitat type for migrating birds in both spring and fall. While wet meadows and riparian areas also provide important stopover habitat for a variety of species, considerably lower density estimates suggest migratory waterbirds and shorebirds rely less on these habitat types during migration.

Though our data are based on sound sampling techniques across a range of wetland habitat types, deriving species diversity and accurate estimates of abundance of migratory waterbirds and shorebirds poses a number of challenges. First, due to the size of the study area and scope of work, we were only able to sample two sites per habitat type, and at each site sample a subset of available wetlands. Likely, we missed detecting some species not present at our sampling locations but at other wetlands within the SLV. Additionally, extrapolating abundance estimates across the area of wetlands in the SLV (as defined by the NWI) assumes wetlands of the same classification are relatively uniform across the SLV. In reality, variation in water level and vegetation from site-to-site and year-to-year, in addition to wetland patch size, may influence presence/absence and density of species. Without more detailed habitat maps and current data on water levels and vegetation, we cannot determine with certainty how well the area of extrapolation aligns with our sampling sites. Nonetheless, our extrapolation method using NWI data represents the best possible estimate of abundance across such a large landscape.

Length of stopover poses another challenge to abundance estimation for migratory waterbirds and shorebirds. Due to limited funding availability, we developed survey windows approximately twice the length (~20 days) of those recommended by ISS/PRISM (10 days). Little information exists on length of waterbird and shorebird stopover duration in the SLV, and this study did not address this. Likely, stopover duration for most individuals did not align with the duration of our survey windows. Consequently, we may have underestimated density and abundance for some species and overestimated these metrics for others.

Finally, our sampling approach may have influenced differences in overall abundance estimates between the spring and fall migratory periods. We extrapolated abundance from five survey periods in spring, but only four in fall, the latter period ending in September. Though the bulk of individual waterbirds and shorebirds probably moves through the SLV by the end of September, fall migration continues into October, and our fall abundance estimate does not take into account the late phase of migration. Our abundance estimate in spring was almost twice that in fall, possibly due, in part, to these differences in sampling between the two seasons.

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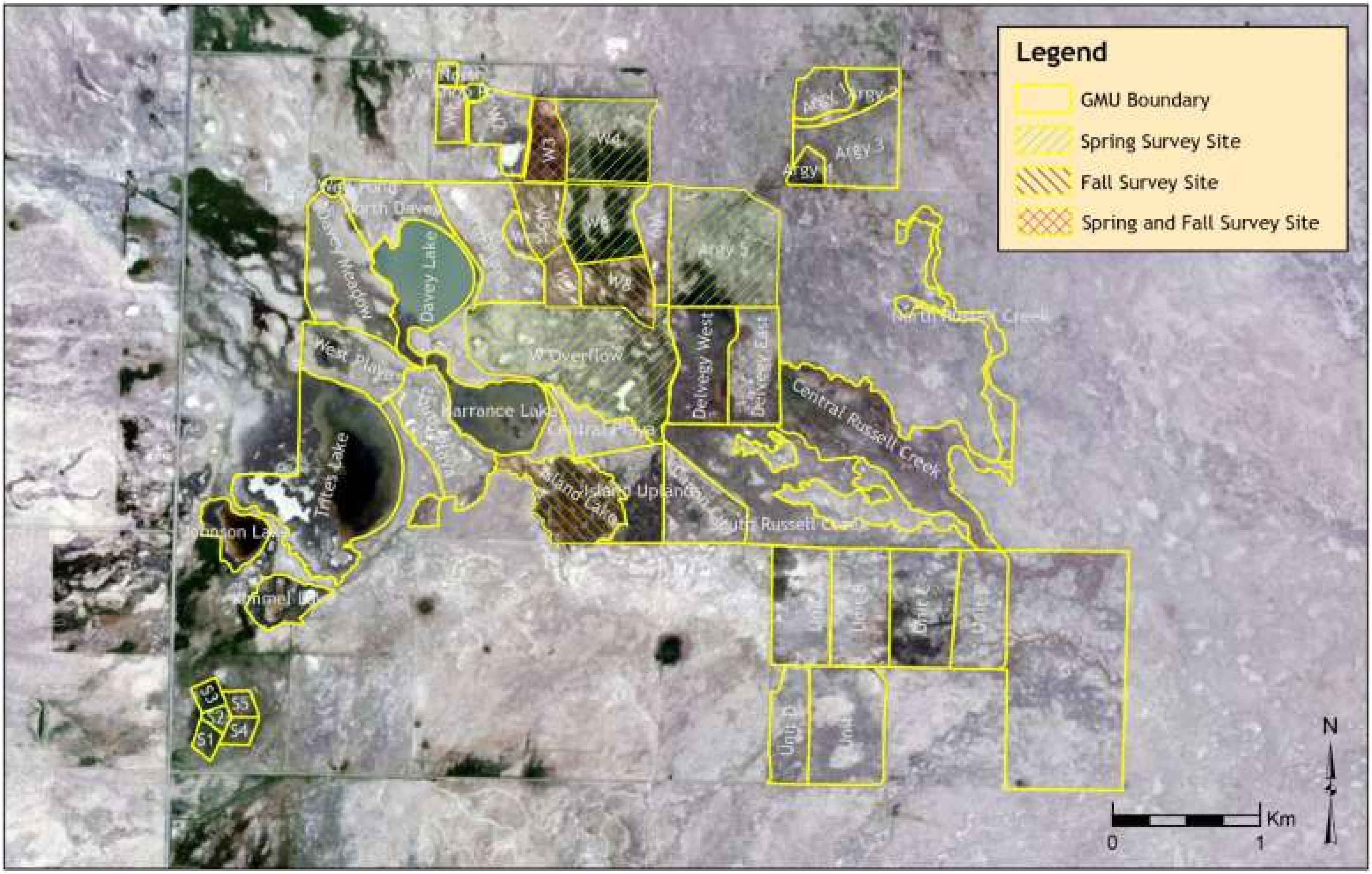
APPENDIX A.

SURVEY AREA MAPS

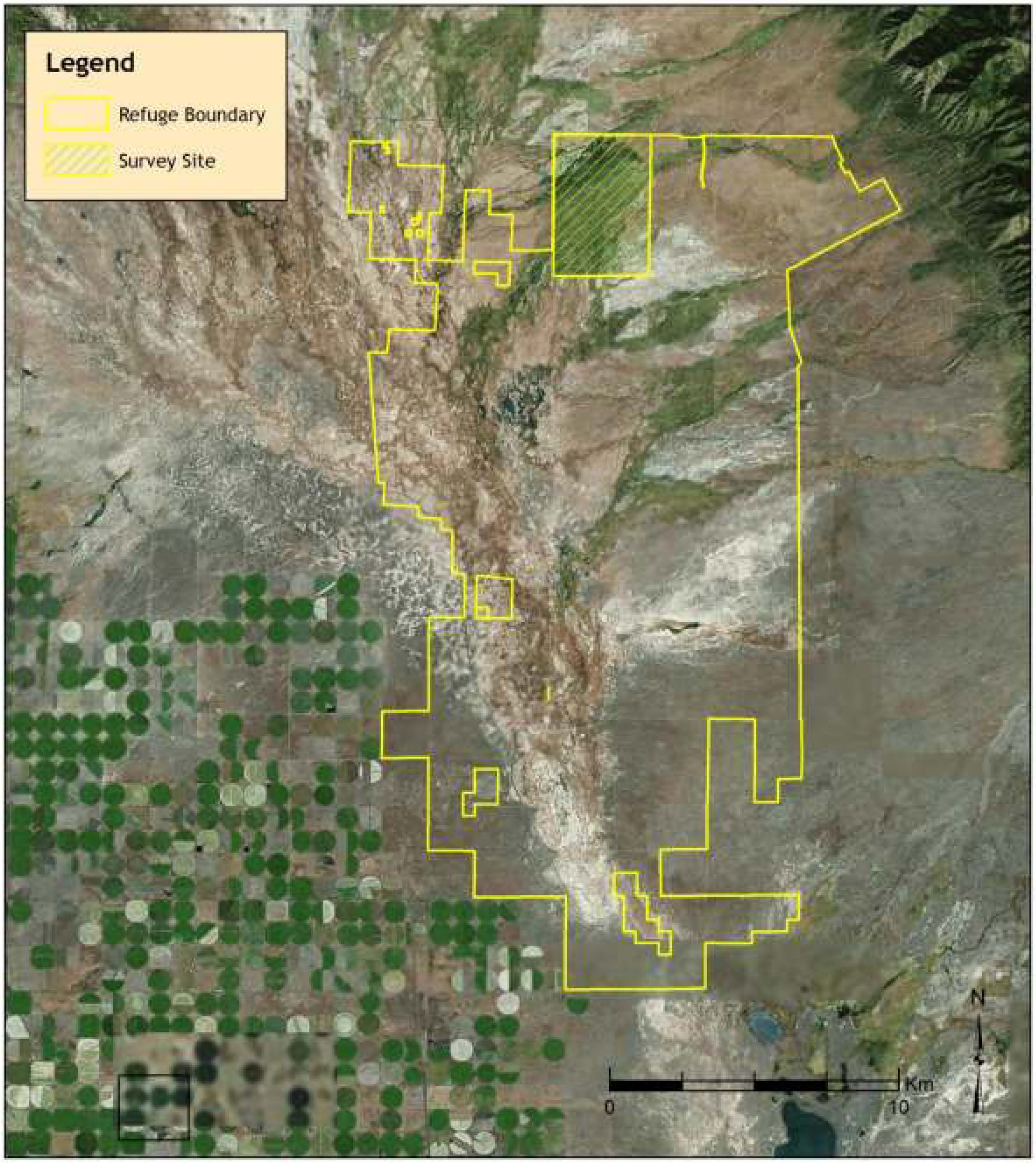


MAP 1. Game Management Units surveyed for waterbirds/shorebirds during spring and fall migration surveys at Russell Lakes State Wildlife Area.

Animas Biological Studies

MAP 2. Management Units surveyed for waterbirds/shorebirds at Monte Vista National Wildlife Area.

Animas Biological Studies



MAP 3. Wet meadow areas surveyed for waterbirds and shorebirds at Baca National Wildlife Refuge.

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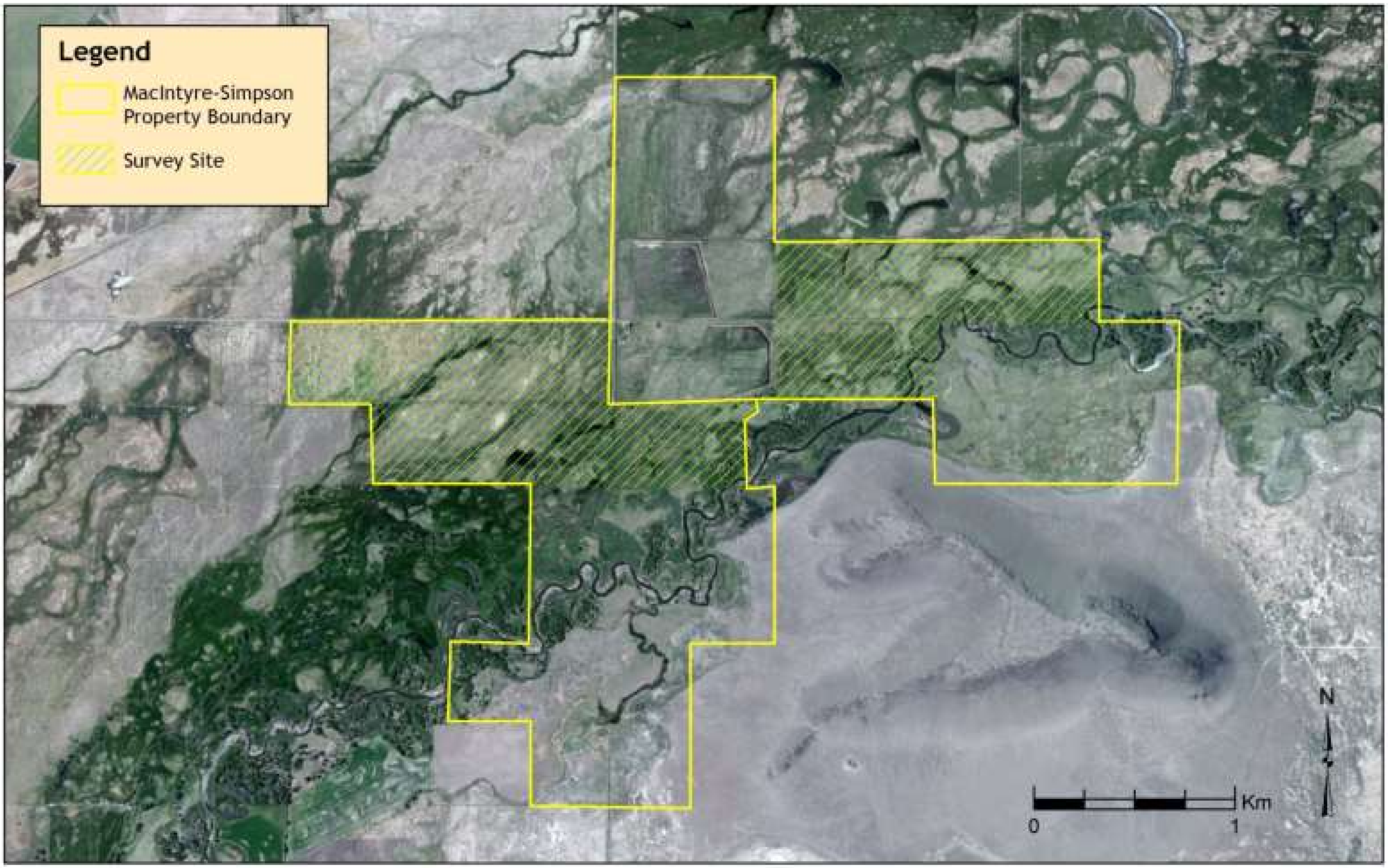

MAP 4. Wet meadow areas surveyed for migratory waterbirds and shorebirds on the BLM MacIntyre-Simpson property.

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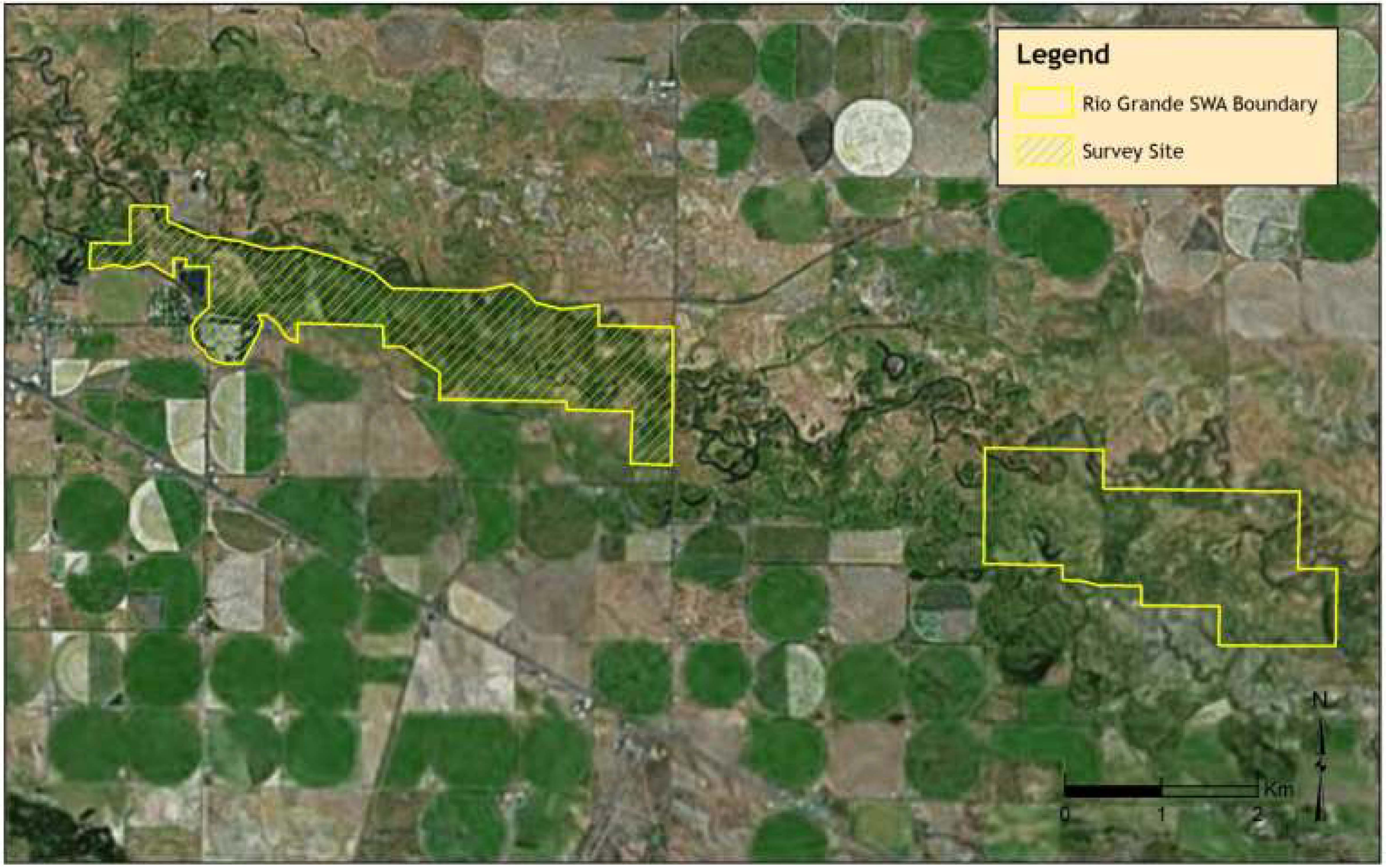

MAP 5. Riparian corridor surveyed for migratory waterbirds and shorebirds at Rio Grande State Wildlife Area.

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MAP 6. Riparian corridor surveyed for migratory waterbirds and shorebirds at Sego Springs State Wildlife Area.

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MAP 7. Playa lakes surveyed for migratory waterbirds and shorebirds at Blanca Wetlands Area.

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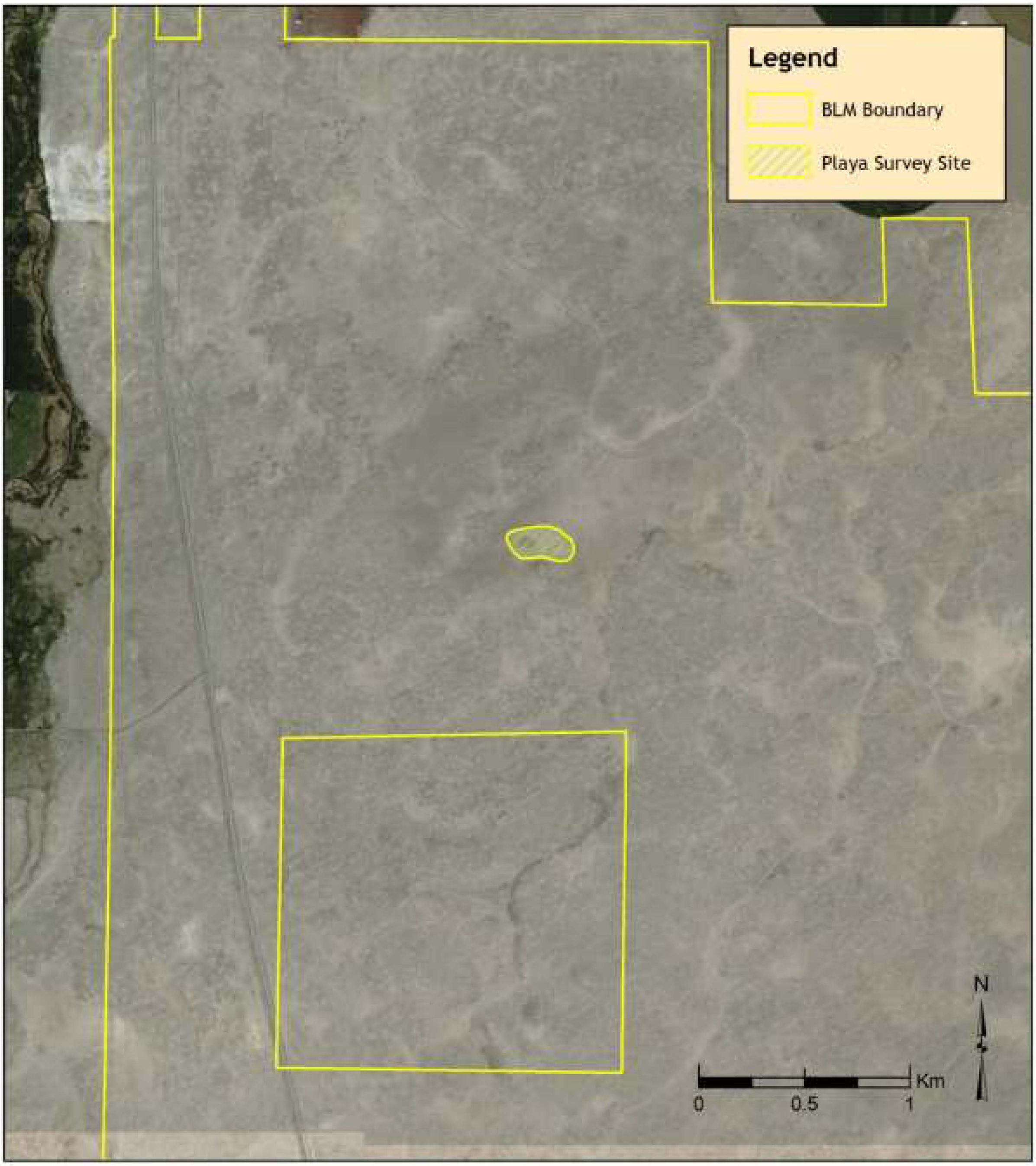

MAP 8. Alta Lake playa, surveyed for migratory waterbirds and shorebirds.

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APPENDIX B.

TABLES AND GRAPHS

Table 2. List of waterbird and shorebird species detected during spring and fall migration surveys at San Luis Valley wetlands, 2015.

Species	Family	Spring	Fall
Canada Goose	Anatidae	X	X
Gadwall	Anatidae	X	X
American Wigeon	Anatidae	X	X
Mallard	Anatidae	X	X
Blue-winged Teal	Anatidae	X	X
Cinnamon Teal	Anatidae	X	X
Northern Shoveler	Anatidae	X	X
Northern Pintail	Anatidae	X	X
Green-winged Teal	Anatidae	X	X
Canvasback	Anatidae	X	X
Redhead	Anatidae	X	X
Ring-necked Duck	Anatidae	X	
Lesser Scaup	Anatidae	X	X
Bufflehead	Anatidae	X	
Common Goldeneye	Anatidae	X	
Common Merganser	Anatidae	X	
Ruddy Duck	Anatidae	X	X
Common Loon	Gaviidae	X	
Pied-billed Grebe	Podicipedidae	X	X
Eared Grebe	Podicipedidae	X	X
Western Grebe	Podicipedidae	X	X
Clark's Grebe	Podicipedidae	X	
Double-crested Cormorant	Phalacrocoracidae	X	
American White Pelican	Pelecanidae	X	X
American Bittern	Ardeidae	X	X
Great Blue Heron	Ardeidae	X	X
Snowy Egret	Ardeidae		X
Cattle Egret	Ardeidae	X	
Black-crowned Night-Heron	Ardeidae	X	X
White-faced Ibis	Threskiornithidae	X	X
Virginia Rail	Rallidae	X	X
Sora	Rallidae	X	X
American Coot	Rallidae	X	X
Sandhill Crane	Gruidae	X	
Black-necked Stilt	Recurvirostridae	X	X
American Avocet	Recurvirostridae	X	X

Species	Family	Spring	Fall
Snowy Plover	Charadriidae	X	
Killdeer	Charadriidae	X	X
Spotted Sandpiper	Scolopacidae	X	X
Greater Yellowlegs	Scolopacidae		X
Willet	Scolopacidae	X	X
Lesser Yellowlegs	Scolopacidae		X
Long-billed Curlew	Scolopacidae		X
Marbled Godwit	Scolopacidae	X	
Sanderling	Scolopacidae		X
Baird's Sandpiper	Scolopacidae		X
Short-billed Dowitcher	Scolopacidae	X	X
Long-billed Dowitcher	Scolopacidae	X	X
Wilson's Snipe	Scolopacidae	X	X
Wilson's Phalarope	Scolopacidae	X	X
Red-necked Phalarope	Scolopacidae	X	X
Bonaparte's Gull	Laridae	X	
Franklin's Gull	Laridae		X
Ring-billed Gull	Laridae	X	X
California Gull	Laridae		X
Foster's Tern	Laridae	X	X

Table 3. Extrapolated total, mean, and mean density of waterbird and shorebirds detected during spring migration surveys at Russell Lakes SWA, 2015.

Species	Extrapolated Totals						Mean	Mean Density
	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total		(No. birds/ha)
Canada Goose	140	65	53	15	18	290	58.00	0.332
Gadwall	70	35	90	45	25	265	53.00	0.303
American Wigeon	235	278	45	8	0	565	113.00	0.646
Mallard	390	125	143	95	60	813	162.50	0.930
Blue-winged Teal	0	43	28	43	5	118	23.50	0.134
Cinnamon Teal	328	253	250	130	95	1,055	211.00	1.207
Northern Shoveler	843	510	160	58	43	1,613	322.50	1.845
Northern Pintail	143	103	8	3	0	255	51.00	0.292
Green-winged Teal	1,878	558	65	20	60	2,580	516.00	2.952
Canvasback	25	0	0	0	0	25	5.00	0.029
Redhead	0	30	308	80	138	555	111.00	0.635
Ring-necked Duck	58	0	0	0	0	58	11.50	0.066
Lesser Scaup	0	48	3	13	3	65	13.00	0.074
Bufflehead	45	20	53	0	0	118	23.50	0.134
Ruddy Duck	23	25	108	30	60	245	49.00	0.280
Unknown Duck	163	5	0	0	0	168	33.50	0.192
Pied-billed Grebe	3	13	5	0	5	25	5.00	0.029
Eared Grebe	0	0	5	15	0	20	4.00	0.023
Western Grebe	0	0	0	5	0	5	1.00	0.006
American White Pelican	0	3	0	0	0	3	0.50	0.003
American Bittern	0	0	8	8	5	20	4.00	0.023
Great Blue Heron	0	0	0	5	3	8	1.50	0.009
Cattle Egret	0	0	5	0	0	5	1.00	0.006
Black-crowned Night-Heron	0	0	3	0	5	8	1.50	0.009
White-faced Ibis	0	18	268	20	20	325	65.00	0.372

Species	Extrapolated Totals Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total	Mean	Mean Density (No. birds/ha)
Virginia Rail	0	0	0	3	0	3	0.50	0.003
Sora	0	0	23	15	10	48	9.50	0.054
American Coot	343	243	473	278	48	1,383	276.50	1.582
Sandhill Crane	2,578	0	0	0	0	2,578	515.50	2.949
Black-necked Stilt	0	0	73	28	23	123	24.50	0.140
American Avocet	0	20	28	35	30	113	22.50	0.129
Killdeer	0	0	0	13	13	25	5.00	0.029
Willet	0	0	3	0	0	3	0.50	0.003
Spotted Sandpiper	0	0	0	3	0	3	0.50	0.003
Long-billed Dowitcher	0	3	0	0	0	3	0.50	0.003
Wilson's Phalarope	0	0	53	10	15	78	15.50	0.089
Bonaparte's Gull	0	0	8	3	5	15	3.00	0.017
Foster's Tern	0	25	0	0	0	25	5.00	0.029
Unknown Gull	35	0	0	0	0	35	7.00	0.040
Unknown	75	0	0	0	0	75	15.00	0.086
Total	7,370	2,418	2,260	975	685	13,708	2,741.50	15.684

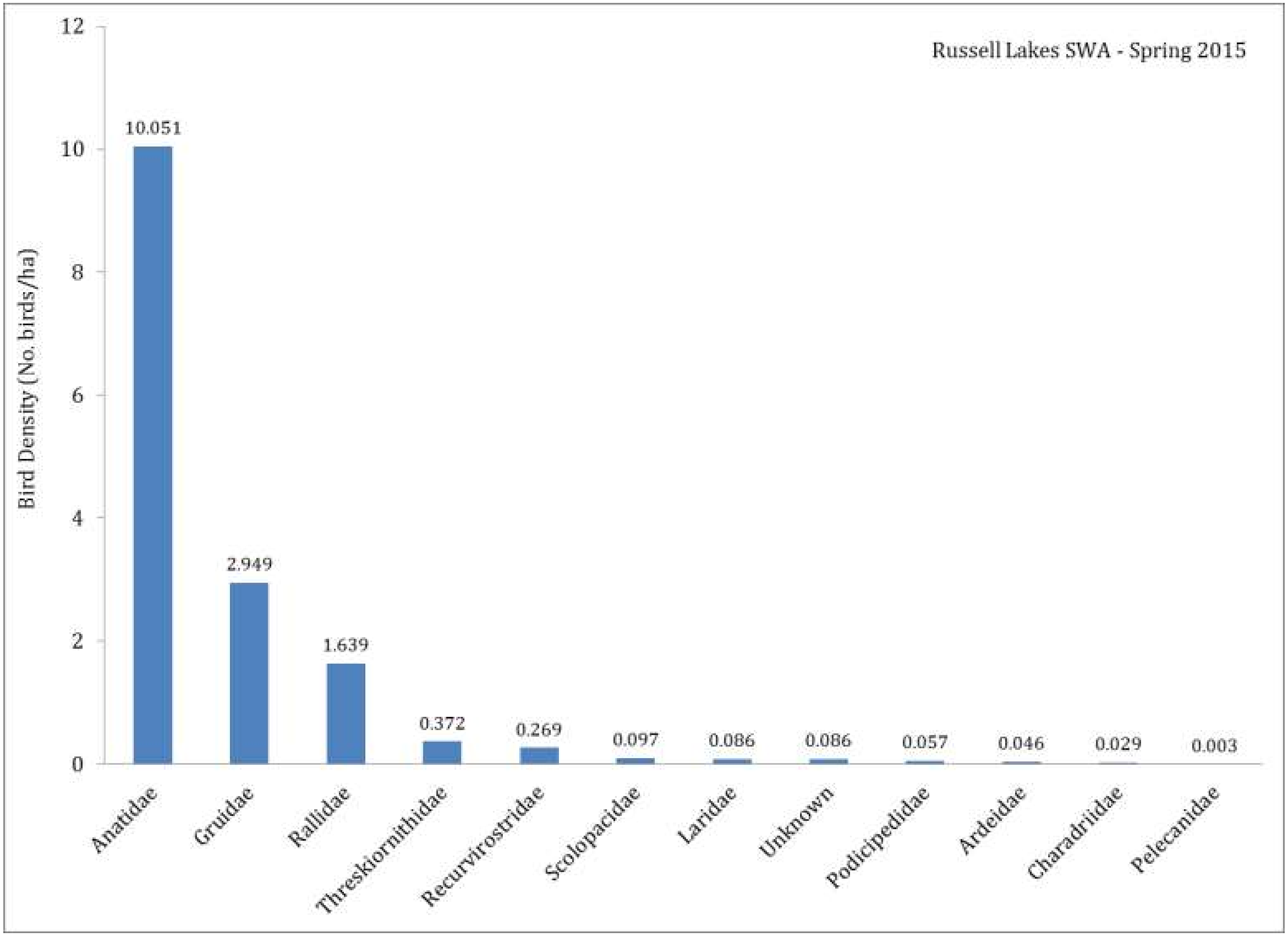

Figure 3. Mean density of waterbird and shorebird families across spring migration surveys at Russell Lakes SWA, 2015.

Table 4. Models estimating density of shorebirds and waterbirds during spring migration surveys at Monte Vista NWR, 2015.

Stratification	Model	No. of Param.	AIC	Delta AIC	Density Estimate	CV	95% CI LCL	95% CI UCL
Survey Period	Neg. Exp. + Poly.	9	2,241.377	0.000	18.974	0.289	8.635	41.692
	Neg. Exp.+ Cos.	8	2,241.851	0.474	19.152	0.276	9.022	40.655
	Haz. Rate + Poly.	15	2,249.277	7.900	18.472	0.297	8.249	41.364
	Half Norm. + Poly.	11	2,267.824	26.447	15.049	0.317	6.367	35.569
	Half Norm. + Cos.	6	2,293.487	52.110	13.268	0.299	5.893	29.875
	Haz. Rate + Cos.	10	2,296.190	54.813	15.599	0.327	6.439	37.788
Family	Neg. Exp. + Poly.	11	2,224.844	0.000	22.268	0.195	14.847	33.397
	Neg. Exp.+ Cos.	9	2,229.593	4.749	23.037	0.191	15.514	34.210
	Haz. Rate + Poly.	20	2,232.967	8.123	2.210	0.680	0.533	9.163
	Half Norm. + Poly.	13	2,246.269	21.425	3,762.656	7.645	0.000	1.241E+14
	Half Norm. + Cos.	10	2,267.545	42.701	3,760.962	7.648	0.000	1.244E+14
	Haz. Rate + Cos.	18	2,275.923	51.079	16.521	0.147	12.296	22.198
Species	Neg. Exp. + Poly.	36	2,214.666	0.000	22.303	0.186	15.083	32.980
	Haz. Rate + Poly.	64	2,224.896	10.230	1,010.004	6.774	0.000	2.980E+12
	Neg. Exp.+ Cos.	29	2,229.991	15.325	22.821	0.181	16.349	34.709
	Half Norm. + Poly.	32	2,240.722	26.056	3,762.088	7.646	0.000	1.242E+14
	Haz. Rate + Cos.	55	2,248.084	33.418	18.045	0.131	0.388	1.150
	Half Norm. + Cos.	27	2,251.660	36.994	139.317	0.996	25.285	767.602

Table 5. Overall density and abundance estimates for waterbird and shorebird species during spring migration surveys at Monte Vista NWR, 2015.

Survey Period	Density Estimate	95% CI LCL	95% CI UCL	%CV	df	Abundance Estimate	95% CI LCL	95% CI UCL
Survey 1	34.01	21.04	54.97	22.74	14.4	29,177	18,049	47,166
Survey 2	29.70	21.14	41.72	16.39	19.7	25,481	18,138	35,795
Survey 3	9.70	6.80	13.86	16.79	14.5	8,326	5,830	11,892
Survey 4	12.20	8.86	16.80	15.83	32.6	10,467	7,599	14,416
Survey 5	8.13	4.60	14.39	27.45	16.2	6,978	3,943	12,348
Pooled Mean	18.97	8.64	41.69	28.93	4.0	16,280	7, 409	35,772

Table 6. Mean density and abundance of waterbird and shorebird species detected across spring migration surveys at Monte Vista NWR, 2015.

Species	Density Estimate	95% CI LCL	95% CI UCL	%CV	df	Abundance Estimate	95% CI LCL	95% CI UCL
Canada Goose	0.910	0.478	1.734	32.990	54.370	3,905	2,050	7,438
Gadwall	0.678	0.333	1.379	36.630	57.840	2,908	1,429	5,916
American Wigeon	0.819	0.314	2.132	50.640	55.290	3,512	1,348	9,148
Mallard	3.693	2.082	6.550	29.080	47.350	15,843	8,932	28,100
Blue-winged Teal	0.719	0.308	1.682	44.350	54.730	3,085	1,319	7,214
Cinnamon Teal	3.978	2.636	6.002	20.820	64.660	17,066	11,310	25,750
Northern Shoveler	0.908	0.525	1.570	28.100	87.510	3,895	2,252	6,737
Northern Pintail	0.093	0.002	4.819	179.060	2.830	397	8	20,672
Green-winged Teal	1.021	0.383	2.724	52.200	63.130	4,381	1,643	11,684
Redhead	0.555	0.261	1.178	38.930	54.670	2,381	1,122	5,055
Ring-necked Duck	0.042	0.011	0.157	71.520	28.070	181	48	674
Bufflehead	0.081	0.019	0.349	81.280	27.070	348	81	1,498
Ruddy Duck	0.422	0.194	0.917	40.270	53.970	1,809	832	3,936
Pied-billed Grebe	0.081	0.014	0.475	94.900	10.740	347	59	2,037
Eared Grebe	0.001	0.000	0.008	100.000	28.000	6	1	33
American Bittern	0.084	0.009	0.824	124.490	7.110	361	37	3,536
Black-crowned Night-Heron	0.576	0.159	2.079	70.520	39.990	2,470	684	8,920
White-faced Ibis	0.604	0.157	2.321	72.770	23.950	2,593	675	9,958
Virginia Rail	0.139	0.011	1.829	102.940	3.280	596	45	7,847
Sora	0.337	0.175	0.651	33.370	37.000	1,446	749	2,793
Amerian Coot	2.162	1.523	3.070	17.750	81.580	9,277	6,534	13,171
Sandhill Crane	3.181	0.405	25.010	116.910	10.220	13,646	1,736	107,290
American Avocet	0.216	0.105	0.443	36.780	43.650	927	452	1,902
Killdeer	0.607	0.324	1.136	32.010	52.820	2,604	1,391	4,872
Wilson's Snipe	0.113	0.020	0.626	84.440	7.410	483	87	2,687

Species	Density Estimate	95% CI LCL	UCL	%CV	df	Abundance Estimate	95% CI LCL	UCL
Wilson's Phalarope	0.260	0.093	0.731	54.900	47.170	1,117	398	3,135

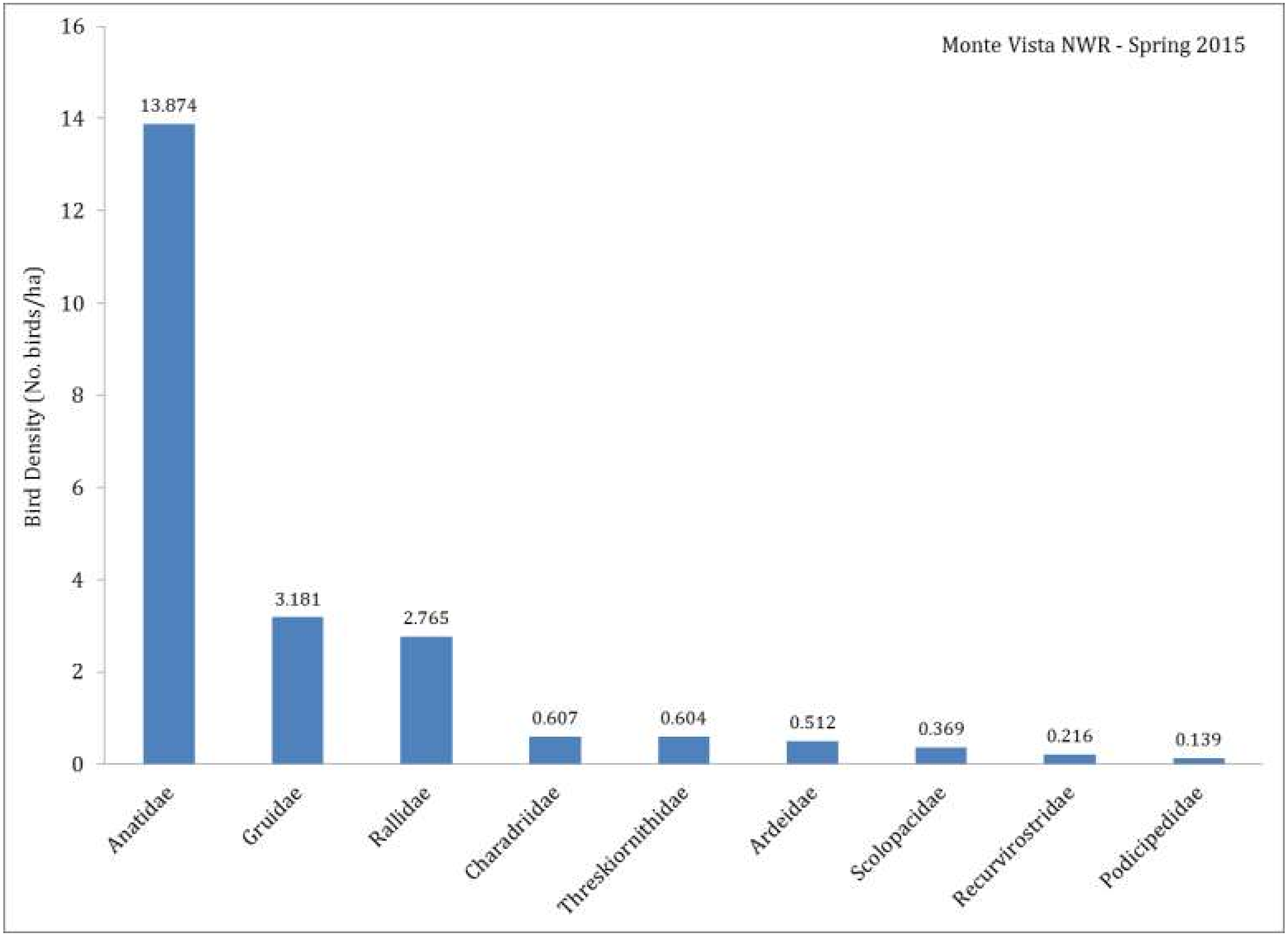

Figure 4. Mean density of waterbird and shorebird families across spring migration surveys at Monte Vista NWR, 2015.

Table 7. Models estimating density of waterbirds and shorebirds during spring migration surveys at MacIntyre-Simpson Wetland Area, 2015.

Stratification	Model	No. of Param.	AIC	Delta AIC	Density Estimate	CV	95% CI LCL	95% CI UCL
Survey Period	Half Norm. + Cos.	5	556.953	0.000	2.028	0.163	1.011	4.066
	Neg. Exp. + Cos.	5	557.709	0.757	2.386	0.190	1.062	5.360
	Neg. Exp. + Poly.	5	557.741	0.788	2.389	0.188	1.073	5.320
	Half Norm. + Poly.	3	561.132	4.180	1.811	0.224	0.699	4.692
	Haz. Rate + Poly.	8	561.726	4.773	2.121	0.139	1.168	3.852
	Haz. Rate + Cos.	6	563.562	6.610	1.920	0.167	0.941	3.916
Family	Haz. Rate + Poly.	14	555.664	0.000	2.001	0.168	1.437	2.786
	Half Norm. + Poly.	8	555.729	0.066	1.963	0.148	1.462	2.635
	Half Norm. + Cos.	8	555.977	0.314	1.955	0.150	1.450	2.635
	Haz. Rate + Cos.	12	556.798	1.135	1.824	0.155	1.344	2.476
	Neg. Exp. + Cos.	8	556.879	1.215	2.471	0.167	1.778	3.434
	Neg. Exp. + Poly.	8	556.968	1.305	2.490	0.167	1.793	3.459
Species	Half Norm. + Poly.	20	535.135	0.000	2.304	0.180	1.600	3.317
	Half Norm. + Cos.	20	535.352	0.217	2.359	0.180	1.639	3.395
	Neg. Exp. + Poly.	24	540.347	5.212	3.126	0.205	2.073	4.713
	Neg. Exp. + Cos.	23	546.626	11.491	3.357	0.204	2.236	5.040
	Haz. Rate + Cos.	38	548.809	13.674	2.051	0.167	1.475	2.851
	Haz. Rate + Poly.	38	548.809	13.674	2.051	0.167	1.475	2.851

Table 8. Overall density and abundance estimates for waterbird and shorebird species during spring migration surveys at MacIntyre-Simpson Wetland Area, 2015.

Survey Period	Density Estimate	95% CI LCL	95% CI UCL	%CV	df	Abundance Estimate	95% CI LCL	95% CI UCL
Survey 1	1.981	1.172	3.349	26.37	37.8	953	564	1611
Survey 2	2.605	1.658	4.092	20.27	9.3	1253	797	1968
Survey 3	1.457	0.704	3.015	30.18	5.8	701	339	1450
Pooled Mean	2.028	1.012	4.066	16.27	2.0	975	487	1956

Table 9. Mean density and abundance of waterbird and shorebird species detected across spring migration surveys at MacIntyre-Simpson Wetland Area, 2015.

Species	Density Estimate	95% CI LCL	95% CI UCL	%CV	df	Abundance Estimate	95% CI LCL	95% CI UCL
Canada Goose	0.033	0.010	0.105	58.660	14.630	222	70	710
Gadwall	0.097	0.020	0.461	82.210	12.470	654	137	3,108
American Wigeon	0.008	0.001	0.065	114.770	10.040	57	7	440
Mallard	0.359	0.211	0.613	26.820	35.720	2,420	1,418	4,130
Blue-winged Teal	0.311	0.050	1.956	90.920	6.960	2,097	334	13,174
Cinnamon Teal	0.419	0.215	0.814	33.600	33.930	2,819	1,450	5,479
Northern Shoveler	0.095	0.040	0.229	44.990	30.030	641	267	1,541
Green-winged Teal	0.092	0.034	0.249	51.800	27.800	617	227	1,676
Redhead	0.094	0.024	0.364	71.970	19.600	636	165	2,451
Ruddy Duck	0.015	0.003	0.083	95.130	13.000	99	17	558
Pied-billed Grebe	0.001	0.000	0.007	95.130	13.000	8	1	47
Eared Grebe	0.004	0.001	0.021	95.130	13.000	25	4	140
American Bittern	0.001	0.000	0.008	101.800	13.000	8	1	51
Virginia Rail	0.001	0.000	0.007	95.130	13.000	8	1	47
Sora	0.032	0.010	0.097	56.350	15.290	215	70	656
American Coot	0.118	0.033	0.422	68.420	27.080	797	223	2,840
Killdeer	0.032	0.011	0.095	54.930	14.850	215	72	642
Wilson's Snipe	0.129	0.071	0.232	29.090	22.170	866	479	1,563
Wilson's Phalarope	0.462	0.203	1.053	42.320	35.660	3,113	1,367	7,093

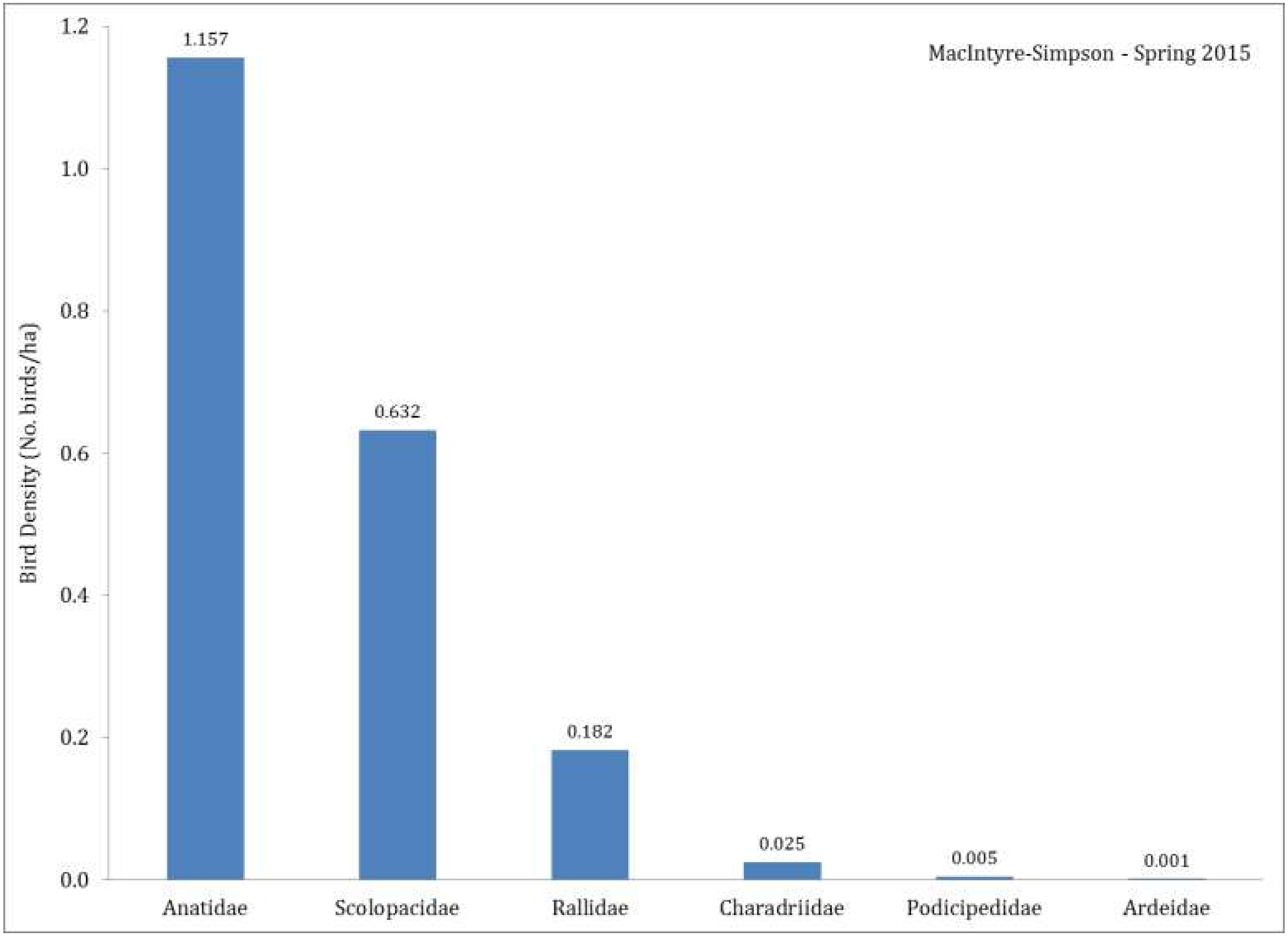

Figure 5. Mean density of waterbird and shorebird families across spring migration surveys at MacIntyre-Simpson Wetland Area, 2015.

Table 10. Waterbird and shorebird families and species detected during spring migration surveys at Baca NWR, 2015.

Family	Species	Survey 1	Survey 2	Survey 3
Anatidae	Canada Goose		X	
Anatidae	Gadwall		X	X
Anatidae	Mallard	X	X	
Anatidae	Blue-winged Teal	X		
Anatidae	Cinnamon Teal	X		
Anatidae	Northern Shoveler	X		
Anatidae	Northern Pintail	X		
Anatidae	Green-winged Teal	X	X	
Rallidae	Sora		X	X
Scolopacidae	Wilson's Snipe	X		
Scolopacidae	Wilson's Phalarope		X	X
Laridae	Ring-billed Gull	X		

Table 11. Extrapolated total, mean, and mean density of waterbirds and shorebirds detected during spring migration surveys at Blanca Wetlands, 2015.

Species	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total	Mean	Mean Density (No. birds/ha)
	Extrapolated Totals							
Canada Goose	43	38	29	32	18	160	32.00	0.297
Gadwall	112	658	264	120	31	1,184	409.09	3.798
American Wigeon	216	446	59	11	0	732	252.73	2.347
Mallard	273	11	4	13	19	319	110.18	1.023
Blue-winged Teal	0	7	17	0	0	24	8.36	0.078
Cinnamon Teal	28	66	60	23	5	183	63.27	0.587
Northern Shoveler	335	422	69	23	13	862	297.82	2.765
Northern Pintail	297	81	2	0	0	380	131.27	1.219
Green-winged Teal	740	444	28	1	12	1,225	423.27	3.930
Canvasback	0	0	0	1	0	1	0.36	0.003
Redhead	38	2	35	87	53	215	74.18	0.689
Ring-necked Duck	0	2	0	0	0	2	0.73	0.007
Lesser Scaup	0	200	40	5	0	245	84.73	0.787
Bufflehead	273	203	32	6	0	514	177.45	1.648
Common Goldeneye	5	0	0	0	0	5	1.82	0.017
Common Merganser	0	0	0	0	3	3	1.09	0.010
Ruddy Duck	6	2,613	766	262	131	3,778	1,305.09	12.118
Unknown Duck	7	47	6	0	0	61	21.09	0.196
Common Loon	2	0	0	0	0	2	0.73	0.007
Pied-billed Grebe	0	0	56	3	0	59	20.36	0.189
Eared Grebe	0	0	37	111	19	166	57.45	0.533
Western Grebe	1	2	0	4	1	8	2.91	0.027
Clark's Grebe	0	0	2	1	0	3	1.09	0.010
American Bittern	0	0	0	1	0	1	0.36	0.003
Black-crowned Night-Heron	0	0	0	2	1	3	1.09	0.010

Species	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total	Mean	Mean Density (No. birds/ha)
	Extrapolated Totals							
Sora	0	0	1	0	0	1	0.36	0.003
American Coot	52	282	259	118	56	766	264.73	2.458
Black-necked Stilt	0	0	0	1	0	1	0.36	0.003
American Avocet	0	243	104	88	42	478	165.09	1.533
Killdeer	0	3	2	1	5	12	4.00	0.037
Spotted Sandpiper	0	0	2	0	3	5	1.82	0.017
Marbled Godwit	0	0	11	0	0	11	3.64	0.034
Short-billed Dowitcher	0	0	6	0	0	6	2.18	0.020
Wilson's Phalarope	0	0	252	33	1	285	98.55	0.915
Red-necked Phalarope	0	0	5	15	0	20	6.91	0.064
Unknown Sandpiper	0	0	0	1	0	1	0.36	0.003
Bonaparte's Gull	0	0	7	13	0	20	6.91	0.064
Ring-billed Gull	0	0	15	31	54	99	34.18	0.317
Forster's Tern	0	0	9	4	0	14	4.73	0.044
Unknown Gull	0	1	0	0	0	1	0.36	0.003
Unknown	211	0	0	0	0	211	72.73	0.675
Total	2,638	5,773	2,181	1,011	465	12,067	2,413.47	22.41

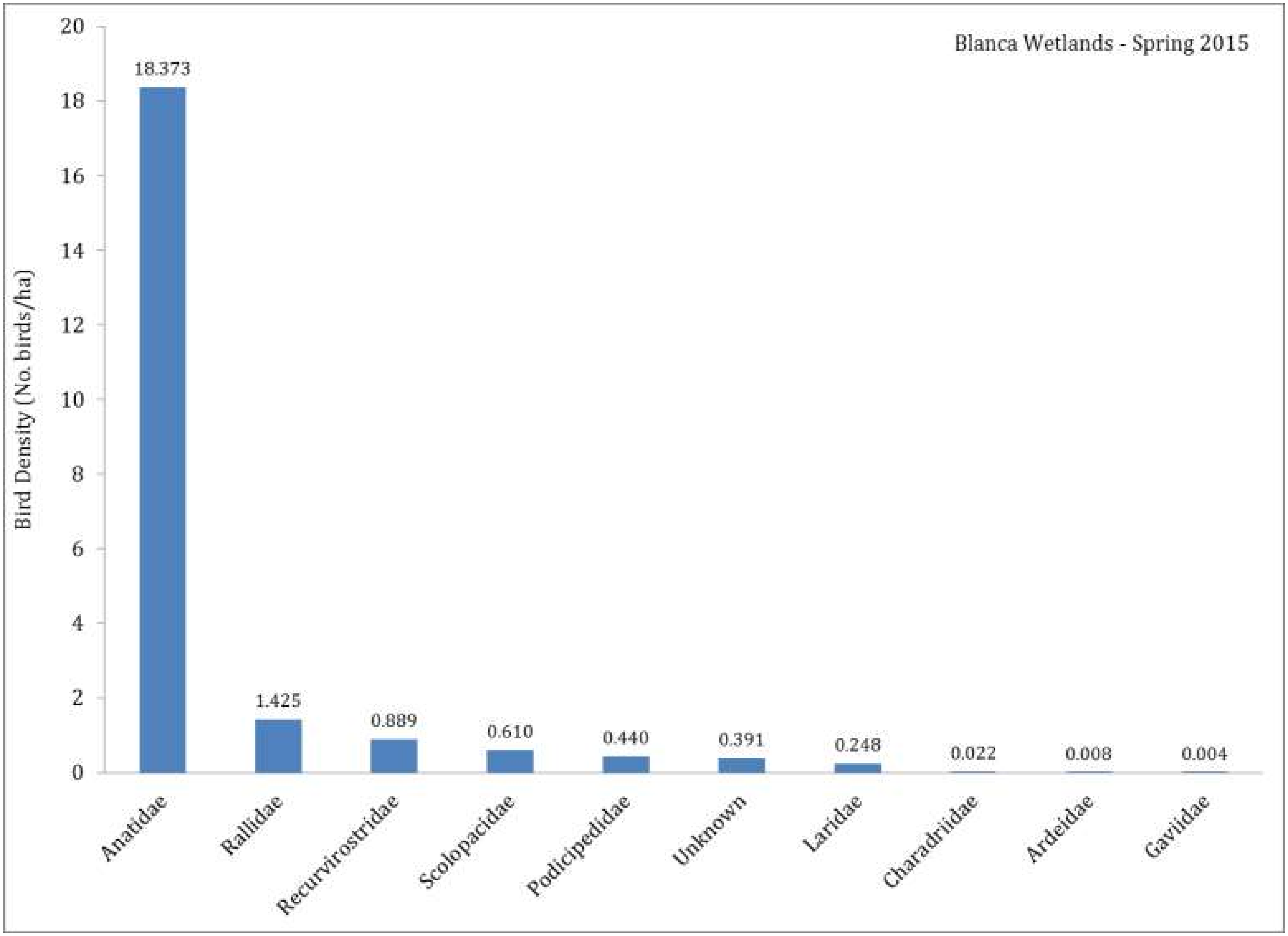

Figure 6. Mean density of waterbird and shorebird families across spring migration surveys at Blanca Wetlands, 2015.

Table 12. Total, mean, and density of waterbirds and shorebirds detected during spring migration surveys at Alta Lake, 2015.

Species	Survey 1	Survey 2	Survey 3	All Surveys	Mean Density (No. birds/ha)
Mallard	2	0	0	2	0.667
Northern Pintail	1	0	0	1	0.333
Green-winged Teal	2	3	0	5	1.667
Snowy Plover	0	2	0	2	0.667
Killdeer	0	1	1	2	0.667
Unknown Sandpiper	0	0	2	2	0.667
Total	5	6	3	14	4.667

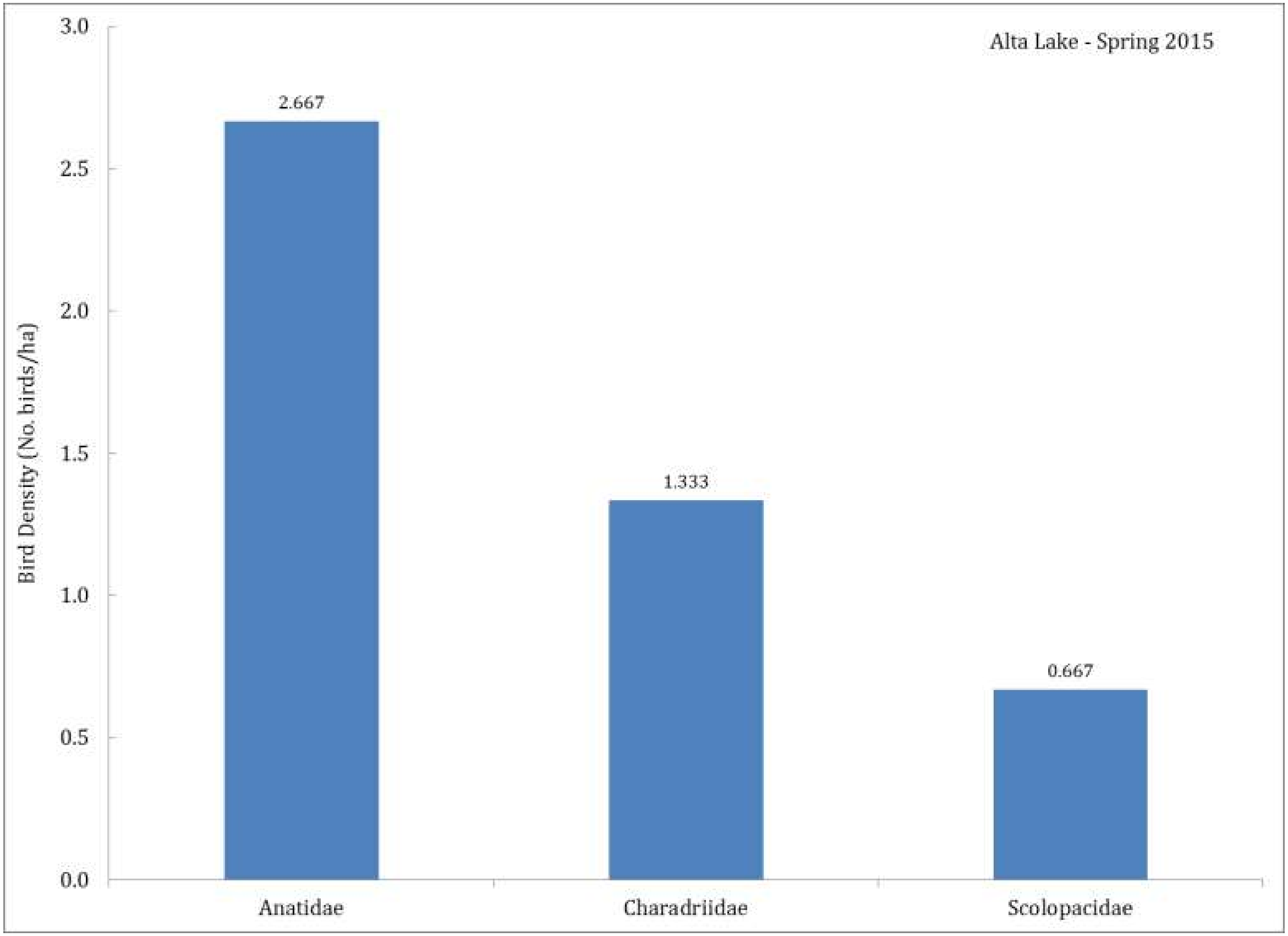

Figure 7. Mean density of waterbird and shorebird families across spring migration surveys at Alta Lake, 2015.

Table 13. Models estimating density of waterbirds and shorebirds during riparian spring migration surveys at Rio Grande and Sego Springs SWAs, 2015.

Stratification	Model	No. of. Param.	AIC	Delta AIC	Density Estimate	CV	95% CI LCL	95% CI UCL
Survey Period	Neg. Exp. + Poly.	3	222.425	0.000	3.610	0.258	2.172	6.002
	Neg. Exp. + Cos.	3	222.425	0.000	3.610	0.258	2.172	6.002
	Haz. Rate + Poly.	6	225.991	3.566	1.855	0.278	1.077	3.196
	Haz. Rate + Cos.	6	225.991	3.566	1.855	0.278	1.077	3.196
	Half Norm. + Cos.	5	233.898	11.473	1.384	0.244	0.856	2.238
	Half Norm. + Poly.	3	237.210	14.784	1.016	0.204	0.677	1.523
Family	Haz. Rate + Poly.	12	34.534	0.000	8.556	0.434	3.755	19.493
	Haz. Rate + Cos.	12	34.534	0.000	8.556	0.434	3.755	19.493
	Half Norm. + Poly.	6	37.755	3.221	6.371	0.426	2.836	14.310
	Half Norm. + Cos.	6	37.755	3.221	6.371	0.426	2.836	14.310
	Neg. Exp. + Cos.	6	37.863	3.329	6.901	0.449	2.952	16.134
	Neg. Exp. + Poly.	6	37.863	3.329	6.901	0.449	2.952	16.134
Species	Haz. Rate + Poly.	28	22.147	0.000	21.080	0.298	11.875	37.419
	Haz. Rate + Cos.	28	22.147	0.000	21.080	0.298	11.875	37.419
	Neg. Exp. + Poly.	14	35.943	13.797	13.771	0.387	6.524	29.067
	Neg. Exp. + Cos.	14	35.943	13.797	13.771	0.387	6.524	29.067
	Half Norm. + Poly.	14	36.415	14.268	12.807	0.383	6.157	26.642
	Half Norm. + Cos.	14	36.415	14.268	12.807	0.383	6.157	26.642

Table 14. Overall density and abundance estimates for waterbird and shorebird species during spring migration surveys at Rio Grande and Sego Springs SWA, 2015.

	Density	95% CI				Abundanc	95% CI	
Survey Period	**Estimate**	**LCL**	**UCL**	**%CV**	**df**	**Estimate**	**LCL**	**UCL**
Survey 1	3.431	1.871	6.291	30.95	54.48	721	393	1,321
Survey 2	2.648	1.319	5.317	35.54	39.86	556	277	1,117
Survey 3	5.970	1.726	20.658	65.54	21.53	1,254	362	4,338
Pooled Mean	3.610	2.172	6.002	25.77	54.16	758	456	1,260

Table 15. Mean density and abundance of waterbird and shorebird species detected across spring migration surveys at Rio Grande and Sego Springs SWA, 2015.

Species	Density Estimate	95% CI LCL	95% CI UCL	%CV	df	Abundance Estimate	95% CI LCL	95% CI UCL
Canada Goose	3.351	0.936	12.000	69.75	37.0	2,965	828	10,620
American Wigeon	1.675	0.310	9.051	100.00	37.0	1,483	274	8,010
Mallard	0.976	0.120	7.911	124.65	13.0	864	107	7,001
Cinnamon Teal	1.675	0.310	9.051	100.00	37.0	1,483	274	8,010
Green-winged Teal	3.351	0.620	18.103	100.00	37.0	2,965	549	16,021
Common Merganser	3.351	0.936	12.000	69.75	37.0	2,965	828	10,620
Ruddy Duck	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Double-crested Cormorant	1.675	0.310	9.051	100.00	37.0	1,483	274	8,010
Great Blue Heron	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Sora	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
American Coot	0.838	0.155	4.526	100.00	37.0	741	137	4,005
Killdeer	1.675	0.310	9.051	100.00	37.0	1,483	274	8,010
Spotted Sandpiper	2.513	0.600	10.526	77.30	19.1	2,224	531	9,315
Wilson's Snipe	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]

[a] Too few detections to estimate density for this species

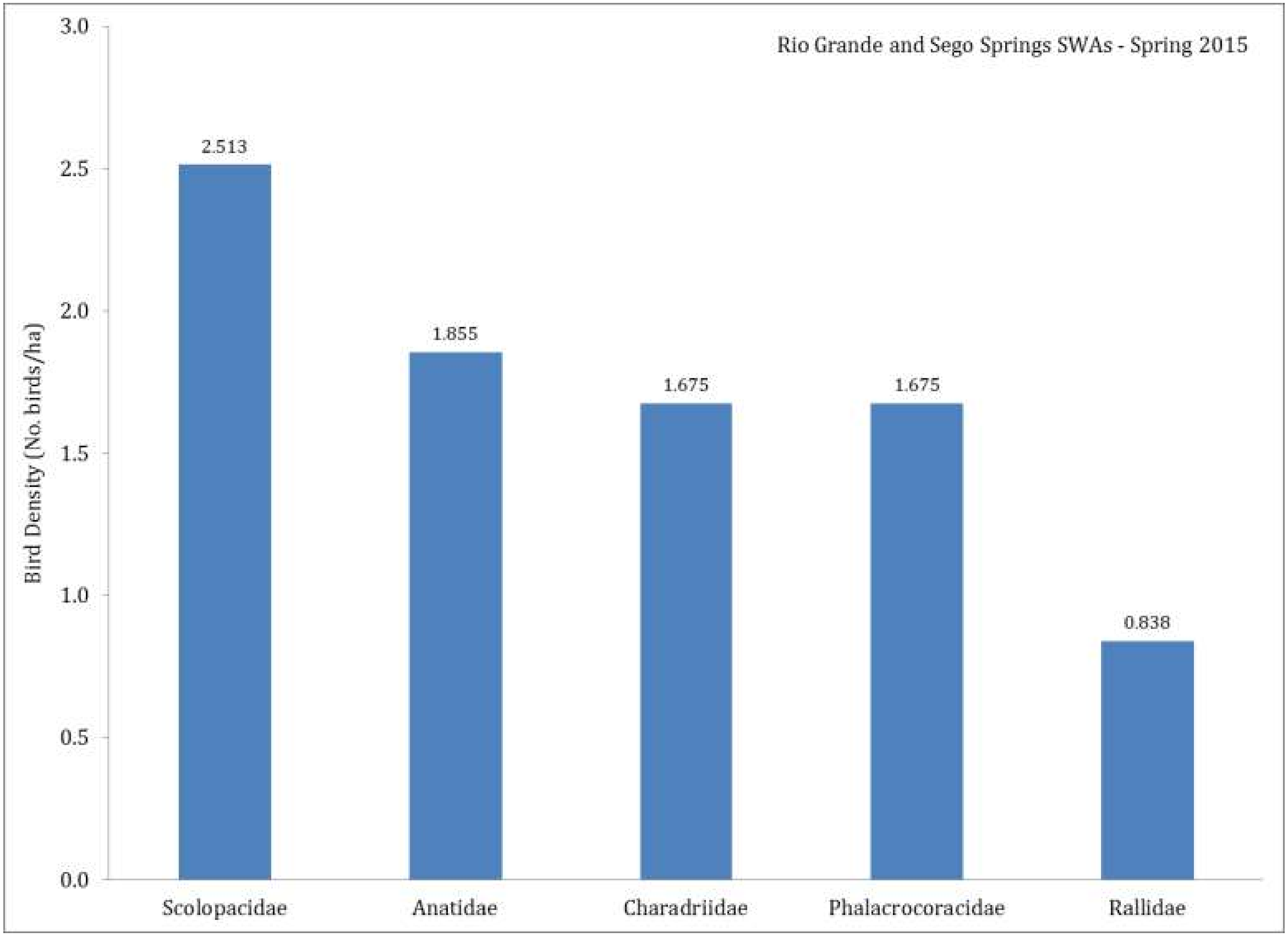

Figure 8. Mean density of waterbirds and shorebird families across spring migration surveys at Rio Grande and Sego Springs SWAs, 2015. Note: too few detections existed to estimate density of the family Ardeidae.

Table 16. Extrapolated total, mean, and mean density of waterbirds and shorebirds detected during fall migration surveys at Russell Lakes SWA, 2015.

Species	Extrapolated Total Survey 1	Survey 2	Survey 3	Total	Mean	Mean Density (No. birds/ha)
Gadwall	154	0	32	186	61.90	0.297
American Wigeon	0	0	13	13	4.17	0.020
Mallard	5	2	64	71	23.81	0.114
Blue-winged Teal	0	141	443	584	194.64	0.933
Cinnamon Teal	66	7	5	79	26.19	0.126
Northern Pintail	0	0	2	2	0.60	0.003
Green-winged Teal	4	4	0	7	2.38	0.011
Canvasback	2	0	5	7	2.38	0.011
Redhead	14	0	5	20	6.55	0.031
Ruddy Duck	7	7	29	43	14.29	0.068
Pied-billed Grebe	7	25	34	66	22.02	0.106
Western Grebe	0	2	0	2	0.60	0.003
American Bittern	9	0	0	9	2.98	0.014
Great Blue Heron	2	0	0	2	0.60	0.003
Snowy Egret	14	5	13	32	10.71	0.051
Black-crowned Night-Heron	4	0	11	14	4.76	0.023
White-faced Ibis	66	104	27	196	65.48	0.314
Sora	0	7	2	9	2.98	0.014
American Coot	263	241	438	941	313.69	1.503
Black-necked Stilt	11	0	0	11	3.57	0.017
American Avocet	2	0	0	2	0.60	0.003
Killdeer	14	0	0	14	4.76	0.023
Greater Yellowlegs	5	0	0	5	1.79	0.009
Lesser Yellowlegs	14	0	0	14	4.76	0.023
Long-billed Dowitcher	0	0	4	4	1.19	0.006

Species	Survey 1	Survey 2	Survey 3	Total	Mean	Mean Density (No. birds/ha)
			Extrapolated Total			
Wilson's Phalarope	27	0	0	27	8.93	0.043
Red-necked Phalarope	0	0	7	7	2.38	0.011
Total	689	545	1132	2366	788.69	**3.780**

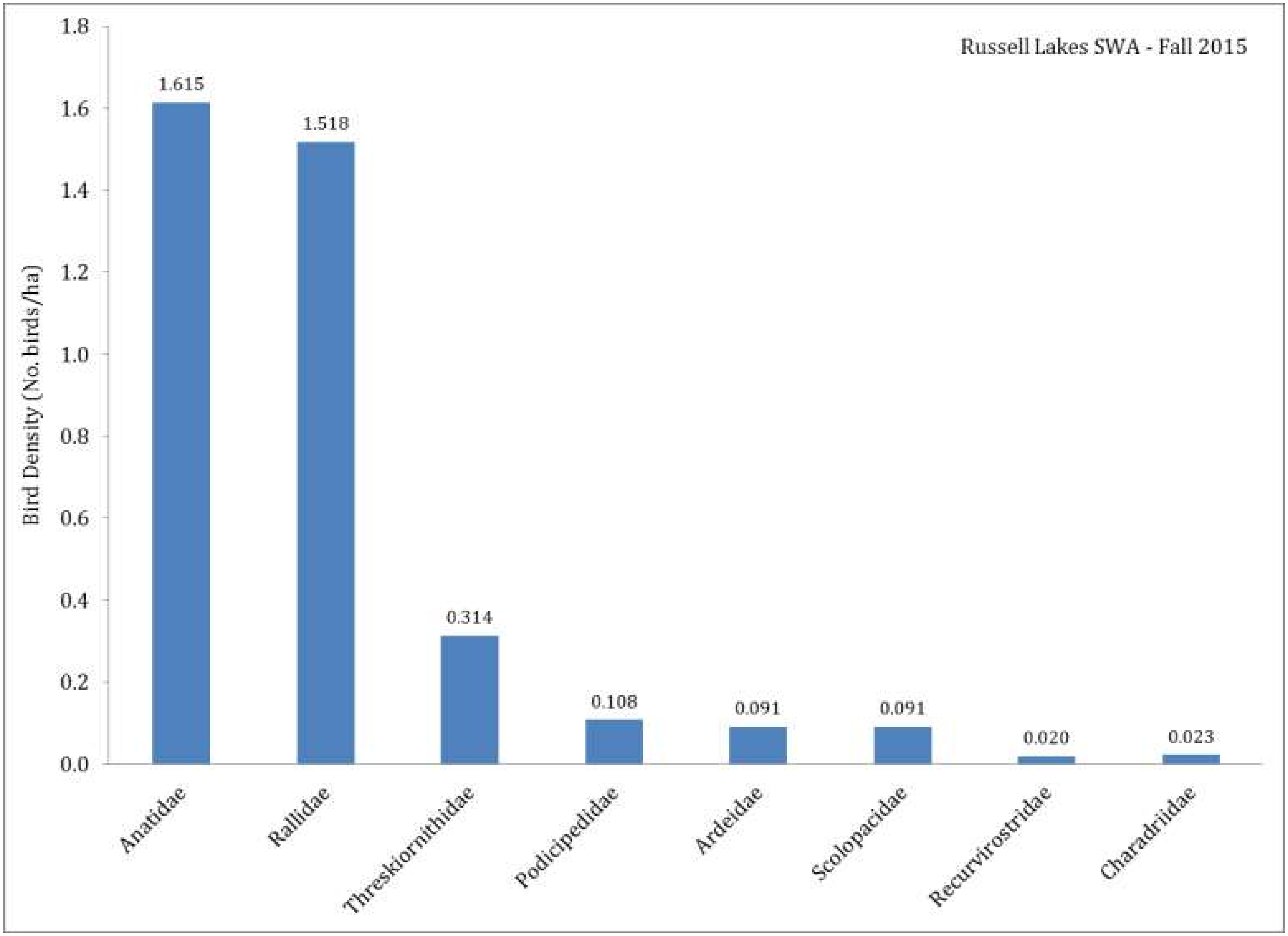

Figure 9. Mean density of waterbird and shorebird families across fall migration surveys at Russell Lakes SWA, 2015.

Table 17. Mean density and abundance of waterbird/shorebird species detected across fall migration surveys at Monte Vista NWR, 2015.

Stratification	Model	No. of. Param.	AIC	Delta AIC	Density Estimate	CV	95% CI LCL	95% CI UCL
Survey Period	Neg. Exp. + Poly.	4	664.433	0.000	21.131	0.185	14.517	30.758
	Haz. Rate + Poly.	7	664.774	0.341	18.766	0.189	12.761	27.597
	Neg. Exp. + Cos.	3	665.398	0.965	22.351	0.180	15.463	32.306
	Haz. Rate + Cos.	6	666.063	1.630	18.711	0.186	12.775	27.406
	Half Norm. + Poly.	4	688.779	24.346	14.597	0.177	10.124	21.044
	Half Norm. + Cos.	3	689.000	24.567	14.379	0.176	9.974	20.730
Family	Haz. Rate + Poly.	18	658.150	0.000	19.351	0.168	13.902	26.937
	Haz. Rate + Cos.	16	658.269	0.119	19.466	0.167	14.012	27.043
	Half Norm. + Poly.	12	662.543	4.393	17.206	0.148	12.846	23.045
	Neg. Exp. + Poly.	12	667.041	8.891	22.021	0.163	15.976	30.353
	Neg. Exp. + Cos.	8	672.192	14.042	22.170	0.161	16.138	30.454
	Half Norm. + Cos.	8	693.535	35.385	14.014	0.145	10.532	18.646
Species	Haz. Rate + Poly.	46	611.229	0.000	19.645	0.247	12.021	32.104
	Haz. Rate + Cos.	46	611.229	0.000	19.645	0.247	12.021	32.104
	Half Norm. + Cos.	27	645.671	34.442	19.268	0.204	12.855	28.881
	Neg. Exp. + Poly.	27	646.084	34.855	29.371	0.269	17.154	50.289
	Half Norm. + Poly.	28	646.759	35.530	19.367	0.204	12.935	28.998
	Neg. Exp. + Cos.	23	650.974	39.745	29.898	0.265	17.608	50.766

Table 18. Overall density and abundance estimates for waterbird and shorebird species during fall migration surveys at Monte Vista NWR, 2015.

	Density	95% CI				Abundance	95% CI	
Survey Period	**Estimate**	**LCL**	**UCL**	**%CV**	**df**	**Estimate**	**LCL**	**UCL**
Survey 1	26.024	11.388	59.472	33.56	5.3	22,329	9,771	51,027
Survey 2	18.442	9.2299	36.85	32.91	13.1	15,824	7,919	31,617
Survey 3	20.444	11.579	36.095	28.98	57.9	17,541	9,935	30,969
Pooled Mean	21.131	14.517	30.758	18.46	27.3	18,131	12,456	26,391

Table 19. Mean density and abundance of waterbirds and shorebirds detected across fall migration surveys at Monte Vista NWR, 2015.

Species	Density Estimate	%CV	df	95% CI LCL	95% CI UCL	Abundance Estimate	95% CI LCL	95% CI UCL
Gadwall	0.013	101.980	14.810	0.002	0.081	34	6	208
Mallard	2.239	50.030	50.150	0.867	5.786	5,764	2,231	14,893
Blue-winged Teal	5.618	34.890	42.020	2.835	11.134	14,462	7,298	28,658
Cinnamon Teal	0.027	107.700	13.870	0.004	0.175	69	10	452
Northern Shoveler	0.145	76.080	11.150	0.033	0.642	374	85	1,653
Northern Pintail	0.003	100.000	14.000	0.000	0.016	7	1	41
Green-winged Teal	0.013	90.790	4.690	0.002	0.102	34	4	262
Redhead	0.013	100.000	14.000	0.002	0.080	34	6	205
Ruddy Duck	4.780	81.740	19.280	1.071	21.333	12,305	2,757	54,912
Unknown Duck	0.005	100.000	14.000	0.001	0.032	14	2	82
Pied-billed Grebe	0.027	105.090	2.870	0.002	0.446	69	4	1,148
Eared Grebe	0.005	100.000	14.000	0.001	0.032	14	2	82
Western Grebe	0.008	75.850	11.930	0.002	0.035	21	5	90
American Bittern	0.053	83.070	10.080	0.011	0.268	137	27	689
Black-crowned Night-Heron	0.904	108.900	19.110	0.142	5.747	2,326	366	14,794
White-faced Ibis	0.610	43.990	28.870	0.258	1.442	1,570	664	3,712
Virginia Rail	0.005	100.000	14.000	0.001	0.032	14	2	82
Sora	0.394	46.220	21.960	0.158	0.981	1,014	407	2,526
American Coot	4.769	30.840	40.510	2.594	8.769	12,276	6,677	22,571
Killdeer	0.003	100.000	14.000	0.000	0.016	7	1	41
Spotted Sandpiper	0.003	100.000	14.000	0.000	0.016	7	1	41
Wilson's Snipe	0.003	100.000	14.000	0.000	0.016	7	1	41
Unknown	0.003	100.000	14.000	0.000	0.016	7	1	41
Pooled Total	19.645	24.740	44.150	12.021	32.104	50,566	30,942	82,635

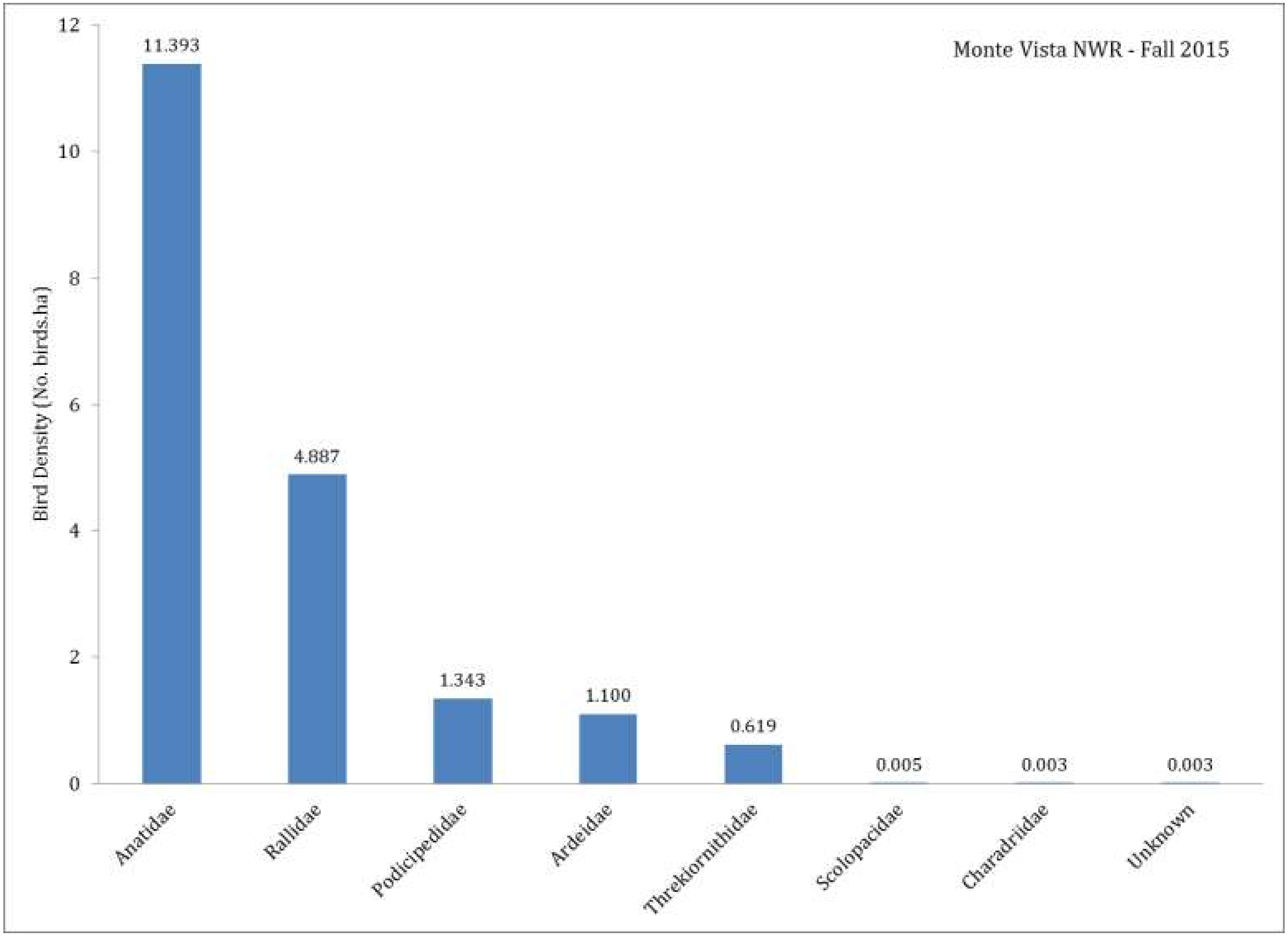

Figure 10. Mean density of waterbird and shorebird families across fall migration surveys at Monte Vista NWR, 2015.

Table 20. Extrapolated total, mean, and mean density of waterbirds and shorebirds detected during fall migration surveys at Blanca Wetlands, 2015.

Species	Extrapolated Total Survey 1	Survey 2	Survey 3	Survey 4	Total	Mean	Mean Density (No. birds/ha)
Canada Goose	20	6	7	0	34	8.42	0.078
Gadwall	280	480	1,826	336	2,922	730.53	6.783
American Wigeon	2	0	0	205	207	51.84	0.481
Mallard	1	0	4	0	5	1.32	0.012
Blue-winged Teal	0	20	136	2,075	2,231	557.63	5.178
Cinnamon Teal	46	25	0	11	82	20.53	0.191
Northern Shoveler	0	44	6	41	92	22.89	0.213
Northern Pintail	0	9	4	25	39	9.74	0.090
Green-winged Teal	2	53	77	446	578	144.47	1.341
Canvasback	9	0	0	3	13	3.16	0.029
Redhead	3	7	0	55	65	16.32	0.151
Lesser Scaup	0	0	0	2	2	0.53	0.005
Ruddy Duck	342	47	354	1,481	2,224	556.05	5.163
Unknown Duck	158	0	0	4	162	40.53	0.376
Pied-billed Grebe	23	2	1	8	35	8.68	0.081
Eared Grebe	1	47	9	3	61	15.26	0.142
Western Grebe	0	0	6	6	13	3.16	0.029
American White Pelican	3	0	0	0	3	0.79	0.007
American Bittern	0	1	0	1	2	0.53	0.005
Great Blue Heron	0	0	0	1	1	0.26	0.002
White-faced Ibis	7	1	16	0	24	6.05	0.056
Sora	1	0	0	0	1	0.26	0.002
American Coot	4	99	1,177	3,064	4,344	1,086.05	10.084
Black-necked Stilt	0	5	0	0	5	1.32	0.012
American Avocet	77	474	460	194	1,204	301.05	2.795

Species	Survey 1	Survey 2	Survey 3	Survey 4	Total	Mean	Mean Density (No. birds/ha)
	Extrapolated Total						
Killdeer	1	1	6	0	8	2.11	0.020
Spotted Sandpiper	1	1	0	0	2	0.53	0.005
Greater Yellowlegs	0	0	26	7	34	8.42	0.078
Willet	0	1	0	0	1	0.26	0.002
Lesser Yellowlegs	0	186	0	0	186	46.58	0.432
Long-billed Curlew	0	2	0	0	2	0.53	0.005
Sanderling	0	0	0	4	4	1.00	0.010
Baird's Sandpiper	2	0	0	0	2	0.53	0.005
Short-billed Dowitcher	0	0	3	0	3	0.79	0.007
Wilson's Phalarope	22	2,886	140	24	3,073	768.16	7.132
Unknown Sandpiper	4	26	42	4	77	19.21	0.169
Franklin's Gull	1	0	0	0	1	0.26	0.002
Ring-billed Gull	39	56	36	34	164	41.05	0.381
California Gull	14	0	0	0	14	3.42	0.032
Forster's Tern	0	0	0	1	1	0.26	0.002
Unknown Gull	0	3	0	0	3	0.79	0.007
Total	1,065	4,485	4,338	8,033	17,921	4,480.26	41.599

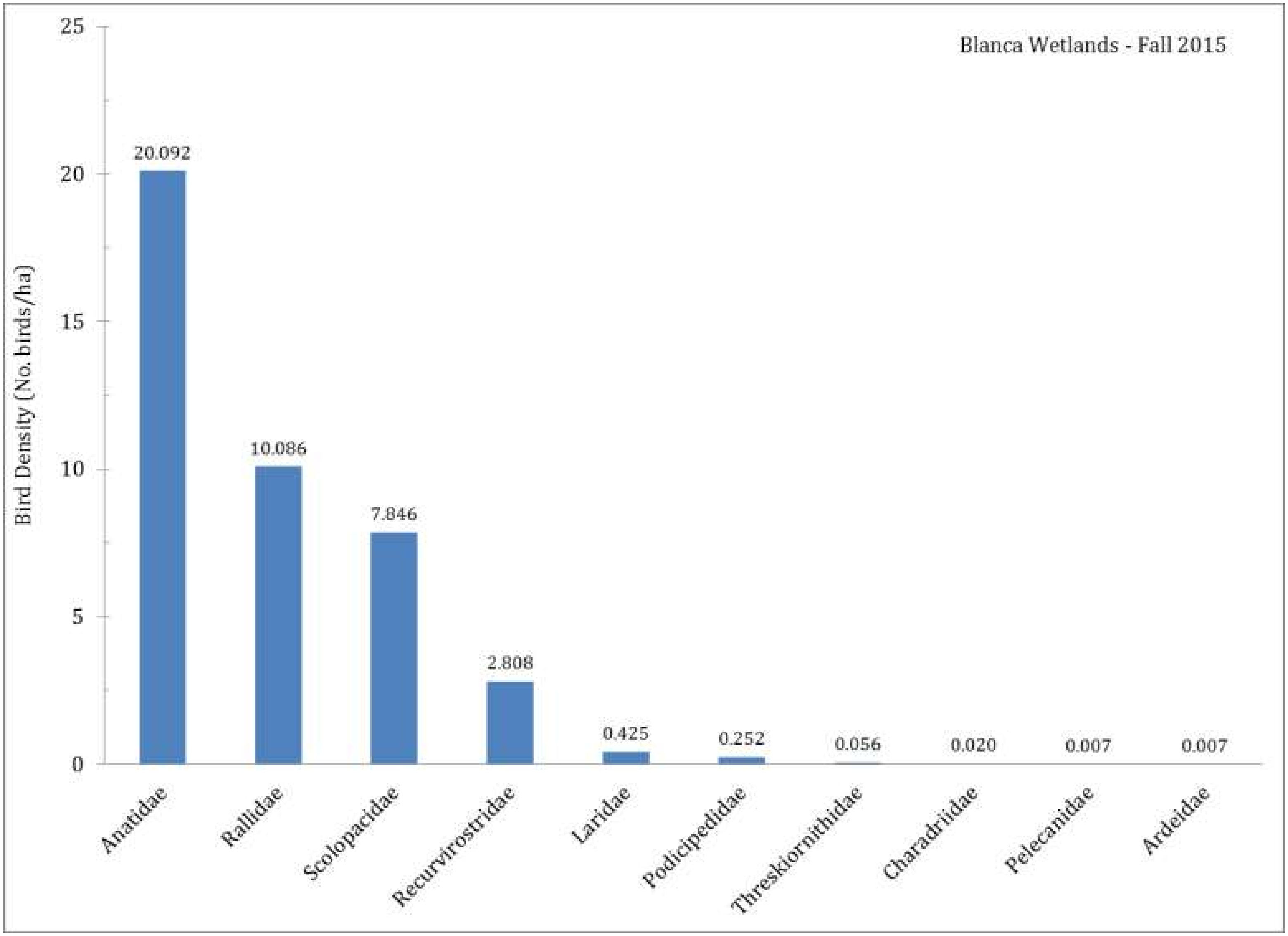

Figure 11. Mean density of waterbird and shorebird families across fall migration surveys at Blanca Wetlands, 2015.

Table 21. Mean density and abundance of waterbirds and shorebirds detected across fall migration surveys in riparian habitat at Rio Grande and Sego Springs SWAs, 2015.

Stratification	Model	No. of. Param.	AIC	Delta AIC	Density Estimate	CV	95% CI LCL	95% CI UCL
Survey Period	Half Norm. + Poly.	5	85.544	0.000	2.165	0.374	1.030	4.550
	Neg. Exp. + Poly.	5	85.819	0.275	4.278	0.650	1.211	15.111
	Half Norm. + Cos.	3	86.617	1.073	2.777	0.311	1.495	5.157
	Haz. Rate + Poly.	7	88.666	3.122	2.340	0.715	0.532	10.296
	Haz. Rate + Cos.	6	88.793	3.248	2.240	0.428	0.928	5.406
	Neg. Exp. + Cos.	3	94.116	8.571	20.516	1.029	3.240	129.897
Family	Half Norm. + Poly.	8	78.744	0.000	2.530	0.318	1.357	4.718
	Half Norm. + Cos.	5	80.889	2.145	2.607	0.311	1.417	4.795
	Neg. Exp. + Poly.	9	81.914	3.170	4.433	0.484	1.748	11.241
	Haz. Rate + Cos.	10	83.416	4.672	1.737	0.294	0.974	3.098
	Haz. Rate + Poly.	10	83.416	4.672	1.737	0.294	0.974	3.098
	Neg. Exp. + Cos.	5	88.420	9.676	5.864	0.424	2.583	13.310
Species	Half Norm. + Poly.	12	71.295	0.000	5.625	0.914	0.518	61.031
	Half Norm. + Cos.	10	73.440	2.145	5.701	0.902	0.538	60.356
	Neg. Exp. + Poly.	14	75.006	3.711	5.749	0.405	2.558	12.919
	Haz. Rate + Cos.	20	77.284	5.989	2.730	0.426	1.172	6.361
	Haz. Rate + Poly.	20	77.284	5.989	2.730	0.426	1.172	6.361
	Neg. Exp. + Cos.	10	80.451	9.156	6.019	0.353	3.028	11.966

Table 22. Overall density and abundance estimates for waterbird and shorebird species during fall migration surveys at Rio Grande and Sego Springs SWAs, 2015.

	Density			95% CI		Abundance	95% CI	
	Estimate	**CV**	**df**	**LCL**	**UCL**	**Estimate**	**LCL**	**UCL**
Survey 1	5.085	52.100	16.36	1.8	14.343	1,068	379	3,012
Survey 2	1.560	49.690	21.98	0.6	4.133	328	124	868
Survey 3	0.787	93.940	14.84	0.1	4.292	165	30	901
Pooled Mean	2.165	37.410	26.76	1.0	4.550	455	216	956

Table 23. Mean density and abundance of waterbirds and shorebirds detected across fall migration surveys at Rio Grande and Sego Springs SWAs, 2015.

	Density	95% CI				Abundance	95% CI	
Species	**Estimate**	**LCL**	**UCL**	**CV**	**df**	**Estimate**	**LCL**	**UCL**
Canada Goose	0.849	0.155	4.659	100.00	29.0	751	137	4123
Mallard	0.084	0.014	0.514	87.09	6.3	74	12	454
Blue-winged Teal	0.106	0.019	0.582	100.00	29.0	94	17	515
Cinnamon Teal	0.106	0.019	0.582	100.00	29.0	94	17	515
Common Merganser	2.993	0.074	120.330	168.70	3.0	2,648	66	106,490
Unknown Duck	0.106	0.019	0.582	100.00	29.0	94	17	515
Great Blue Heron	0.142	0.078	0.259	30.20	34.7	126	69	229
American Coot	0.106	0.019	0.582	100.00	29.0	94	17	515
Killdeer	0.106	0.019	0.582	100.00	29.0	94	17	515
Spotted Sandpiper	1.027	0.467	2.256	40.22	33.9	909	414	1,996

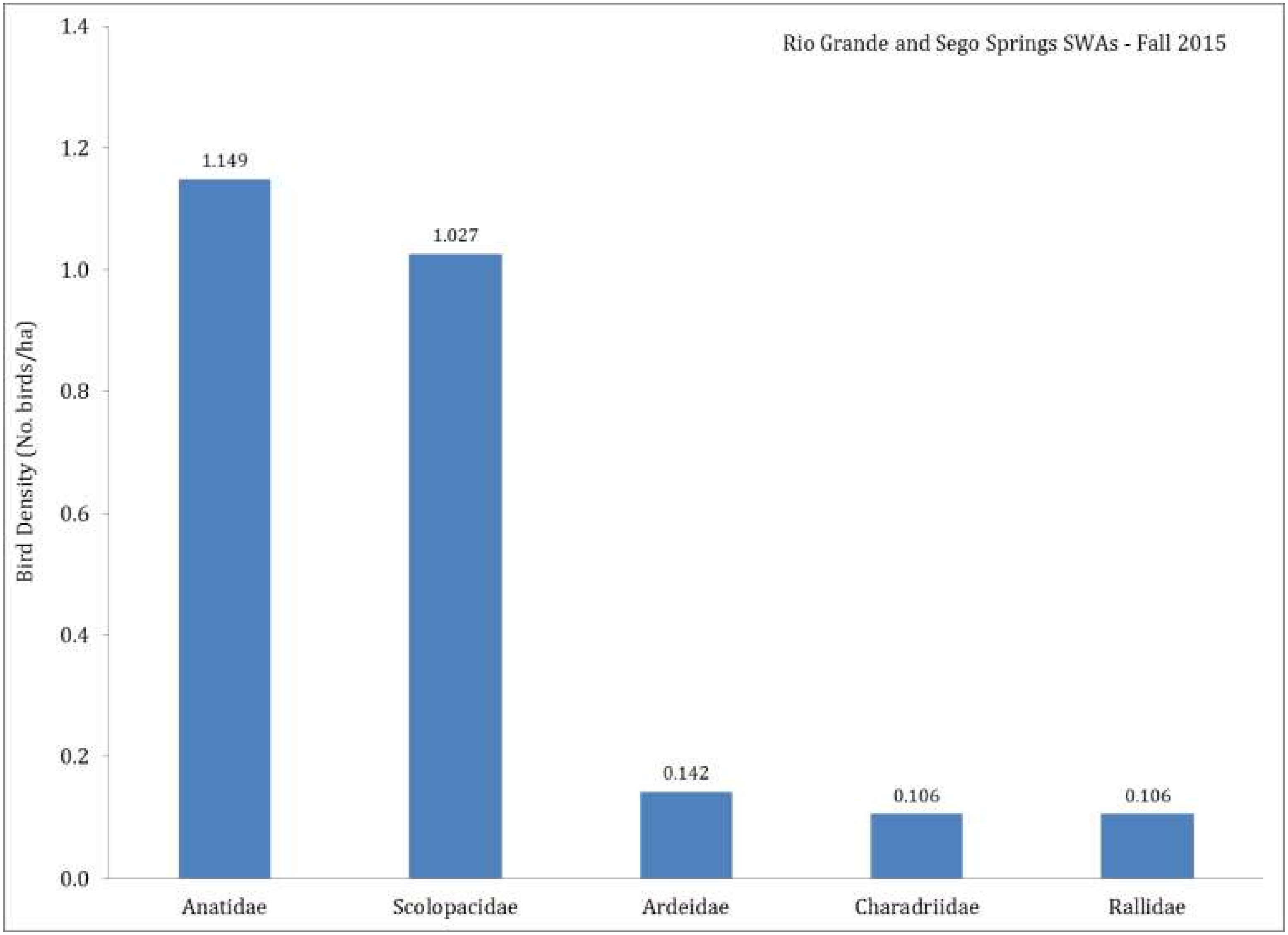

Figure 12. Mean density of waterbird and shorebird families across fall migration surveys at Rio Grande and Sego Springs SWAs, 2015.

APPENDIX C.

REPRESENTATIVE PHOTOS OF HABITATS AND BIRDS

Shallow emergent habitat at Russell Lakes SWA, 30 March 2015

Shallow emergent habitat at Russell Lakes SWA, 3 June 2015

Shallow emergent habitat at Russell Lakes SWA, 7 May 2015

Shallow emergent habitat at Russell Lakes SWA, 10 August 2015

Shallow emergent habitat at Russell Lakes SWA, 21 May 2015

Shallow emergent habitat at Russell Lakes SWA, 22 September 2015

Shallow emergent habitat at Monte Vista NWR, 31 March 2015

Shallow emergent habitat at Monte Vista NWR, 1 June 2015

Shallow emergent habitat at Monte Vista NWR, 14 April 2015

Shallow emergent habitat at Monte Vista NWR, 11 August 2015

Shallow emergent habitat at Monte Vista NWR, 22 May 2015

Shallow emergent habitat at Monte Vista NWR, 23 September 2015

Wet meadow at MacIntyre-Simpson Wetland Area, 1 May 2015

Wet meadow habitat at Baca NWR, 30 April 2015

Wet meadow at MacIntyre-Simpson Wetland Area, 20 May 2015

Wet meadow habitat at Baca NWR, 21 May 2015

Wet meadow at MacIntyre-Simpson Wetland Area, 3 June 2015

Wet meadow habitat at Baca NWR, 3 June 2015

Playa habitat at Blanca Wetlands, 26 March 2015

Playa habitat at Blanca Wetlands, 22 July 2015

Playa habitat at Blanca Wetlands, 8 May 2015

Playa habitat at Blanca Wetlands, 10 August 2015

Playa habitat at Blanca Wetlands, 3 June 2015

Playa habitat at Blanca Wetlands, 22 September 2015

Playa habitat at Alta Lake, 25 March 2015

Playa habitat at Alta Lake, 15 April 2015

Playa habitat at Alta Lake, 19 May 2015

Riparian habitat at Rio Grande SWA, 28 April 2015

Riparian habitat at Rio Grande SWA, 19 August 2015

Riparian habitat at Rio Grande SWA, 28 April 2015

Riparian habitat at Rio Grande SWA, 10 September 2015

Riparian habitat at Rio Grande SWA, 19 May 2015

Riparian habitat at Sego Springs SWA, 29 April 2015

Riparian habitat at Sego Springs SWA, 10 September 2015

Riparian habitat at Sego Springs SWA, 19 May 2015

Riparian habitat at Sego Springs SWA, 2 June 2015

Sandhill Cranes at Monte Vista NWR, 31 March 2015

Forster's Tern at Russell Lakes SWA, 7 May 2015

Buffleheads and American Coots at Monte Vista NWR, 31 March 2015

American Bittern at Russell Lakes SWA, 7 May 2015

Yellow-headed Blackbird at Monte Vista NWR, 14 April 2015

American Avocet at Blanca Wetlands, 8 May 2015

Blue-winged Teal at Blanca Wetlands, 8 May 2015

Wilson's Phalarope at MacIntyre-Simpson Wetland Area, 3 June 2015

Western Grebe at Russell Lakes SWA, 21 May 2015

Snowy Egret and White-faced Ibis at Russell Lakes SWA, 22 September 2015

White-faced Ibis at Russell Lakes SWA, 21 May 2015

Ruddy Ducks at Monte Vista NWR, 23 September 2015