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Managing Water in the West

2018 Report for the Los Lunas Habitat Restoration Project; 16 Years of Monitoring

2003

Los Lunas Restoration Site; Photo Station 1

2018

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

May 2019

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

2018 Report for the Los Lunas Habitat Restoration Project; 16 Years of Monitoring

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Introduction

Riparian cottonwood (*Populus* spp.) and willow (*Salix* spp.) forests are an important ecosystem in the Southwestern United States, providing fish and wildlife habitat, biodiversity, and watershed protection (Hultine et al. 2010). Native riparian habitat is used by a wide range of species and in the southwest about 60 percent of all vertebrate species and 70 percent of all threatened and endangered species are riparian obligates (Poff et al. 2012). Along the Middle Rio Grande in central New Mexico, the federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*; SWFL) and threatened western yellow-billed cuckoo (*Coccyzus americanus*; YBCU) are species of particular concern that are dependent on riparian habitat. The destruction of riparian habitats has caused severe declines in these populations, which exist only in fragmented and scattered locations throughout their historic range (USFWS 1997, USFWS 2013).

Native riparian communities, although once abundant, are declining and now comprise less than 2 percent of the land area in the west (Sprenger 1999, Poff et al. 2012). In Arizona and New Mexico, as much as 90 percent of riparian forests are estimated to have been lost because of various changes in land use (Ohmart and Anderson, 1986). Declines and degradation of native riparian habitat have been associated with a number of activities that have resulted in hydrologic changes. In the Middle Rio Grande, reservoir construction, regulation of surface flow, groundwater pumping, and water diversions have interfered with hydrological processes such as overbank flooding, floodplain scouring, and sediment deposition within floodplains (Sprenger 1999). These flood control structures and flow management regimes have prevented natural flooding necessary for cottonwood and willow regeneration (Dreesen et al. 2002) and have also led to sections of the riparian forest (“bosque”) being less hydrologically connected to the river than they were in the past, lowering the water table (Cartron et al. 2008). The reproductive biology of cottonwood and willow is strongly tied to fluvial processes (Stromberg 1993). In desert riparian areas, seedling establishment is dependent on late winter and early spring flood flows to deposit moist alluvium on sediment bars during the short period in early spring when native seeds are dispersed (Sprenger 1999, Muldavin et al. 2015). Seeds, which are only viable for several weeks, are reliant upon slowly receding flood flows and water tables so seedling roots can stay in contact with adequate soil moisture. Mature plants often become isolated on high floodplains some distance from the active channel but continue to remain hydrologically dependent on a shallow riparian water table (Stromberg 1993). Mature tree growth and maintenance depends on groundwater remaining above a depth of about 10 feet (ft) in the bosque (Cartron et al. 2008). For the establishment and development of younger age classes (those typically occupied by SWFLs) the groundwater levels must remain much higher – perhaps less than 5 ft based on data collected in association with the Bosque del Apache and Elephant Butte Sediment Plug Studies conducted on the Middle Rio Grande (Siegle et al. 2018a, Siegle et al. 2018b).

In addition, large areas of the Middle Rio Grande that were historically cottonwood forests have been invaded by exotic woody species, primarily saltcedar (*Tamarix* spp.).

Saltcedar, like cottonwood and willow, is dependent upon moist, bare substrates created by receding flood flows for initial germination and survival (Sprenger 1999). Unlike native species, however, saltcedar disperses seed throughout the growing season allowing greater opportunity to establish than native species. The establishment of exotics, along with a predominately dry floodplain that lacks scouring floods and slows decomposition, have magnified the potential of severe wildland fires because of the massive fuel loads produced (Dreesen et al. 2002, Cartron et al. 2008).

In April of 2000, an area of the bosque near Los Lunas, New Mexico suffered a severe fire that destroyed virtually all of the aboveground vegetation. This area thus presented a unique opportunity for native riparian forest restoration and was designated as the Los Lunas Habitat Restoration Project.

Project Background

Historically, the Los Lunas Habitat Restoration Project fulfilled requirements in one of eight reaches in which habitat restoration was to be conducted in accordance with Element J of the Reasonable and Prudent Alternative (RPA) within the June 2001 Biological Opinion (BO) issued by the U.S. Fish and Wildlife Service (USFWS 2001). Following the fire, the Los Lunas Restoration Site (LLRS) was selected as the first BO restoration area (Figure 1). The U.S. Bureau of Reclamation (Reclamation) Albuquerque Area Office and the U.S. Army Corps of Engineers Albuquerque District have acted as joint lead federal agencies on this project, and the Middle Rio Grande Conservancy District is the primary non-federal cooperator.

The primary objectives of the restoration project were to improve habitat conditions for the Rio Grande Silvery Minnow (*Hybognathus amarus*; minnow) and SWFL such that, in combination with other elements of the RPA, continued jeopardy to the two species could be avoided.

The design goals were to generate inundation of the project area at flows of greater than or equal to 2,500 cubic ft/second (cfs). For flows below 2,500 cfs, a variety of substrate elevations was integrated into the project design to allow for the inundation of certain regions at lower river stages. This included features such as a network of variable depth side and transverse channels designed to aid in minnow egg retention and provide shallow water/low velocity rearing habitat. In addition, the increased inundation frequency would begin the process of post-fire regeneration of high-value terrestrial habitats in portions within and adjacent to the restoration area to support the recovery of the SWFL.

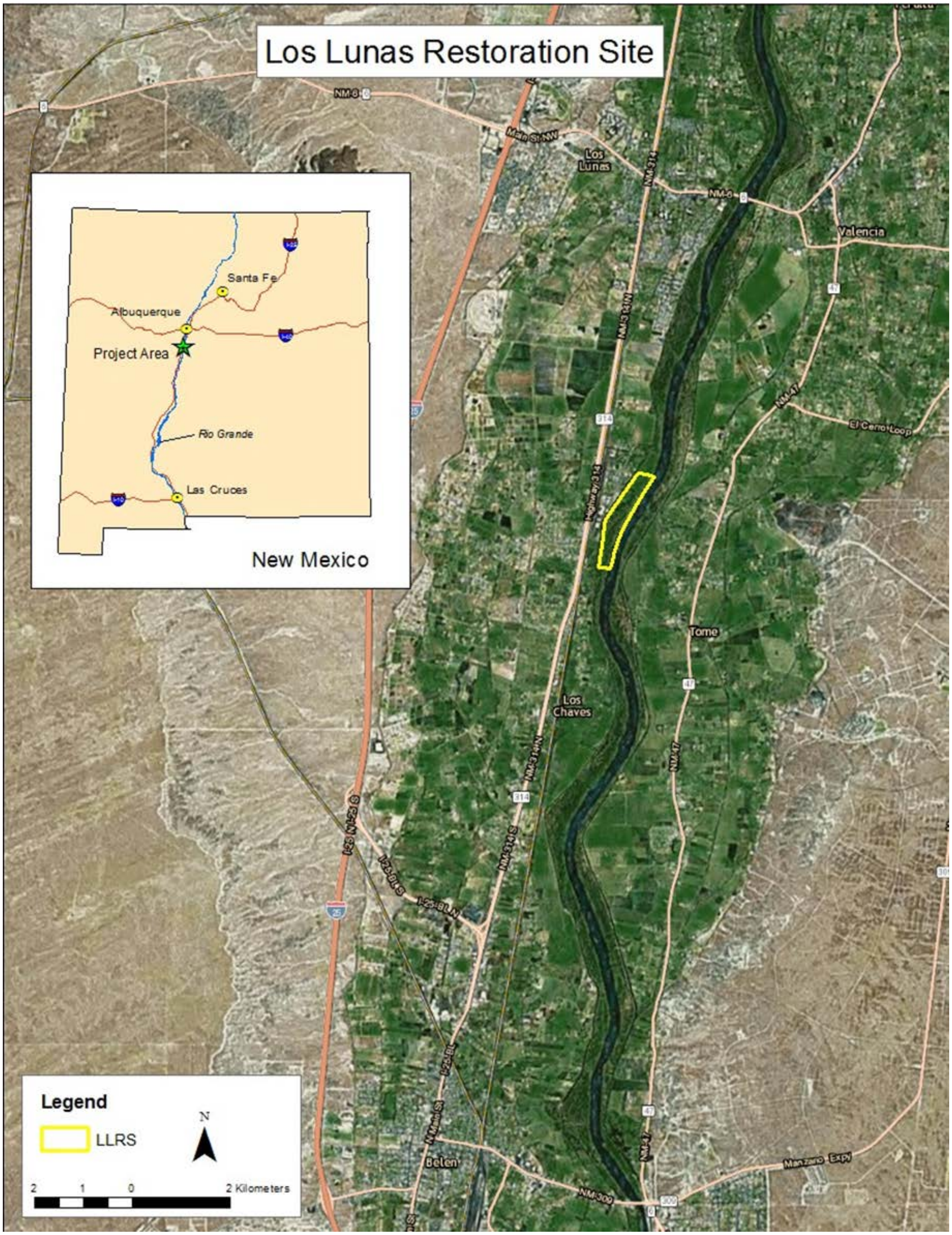


Figure 1. Location of the Los Lunas Restoration Site (LLRS) project area.

In April 2002, the initial phase of work began by removing approximately 1,400 jetty jacks and establishing access routes and a staging area. When construction was initiated, the site was largely dominated by thick stands of herbaceous and exotic regrowth. Vegetation was cleared and mulched within the overbank area, access roads, staging area, and disturbance areas next to the levee and root-wad berm. With the removal of jetty jacks completed, crews from Reclamation's Socorro Field Office began clearing, surveying, and excavating the flood plain. Specific areas within the site were revegetated using seed, potted shrubs, or cottonwood and willow poles.

Properly functioning riparian areas serve key roles in providing fish and wildlife habitat and preserving water quality and supply. Factors such as water table depth and fluctuation, soil texture, soil salinity, and browsing pressure from livestock and wildlife determine the success of restoration in creating a functioning riparian area (Dreesen et al. 2002). Reclamation's Technical Service Center (TSC) in Denver, Colorado has conducted avian, vegetation, and groundwater monitoring at LLRS since 2003. Although requirements of the BO have been met, this study is being continued to provide information for an adaptive management approach to creating and monitoring potential SWFL habitat. The YBCU was added to the federal Threatened and Endangered Species list after initiation of the LLRS project and therefore was not a primary focus for habitat restoration. Habitat requirements for the species have recently been included in this study following the development of a YBCU habitat suitability model (Siegle and Ahlers 2018) which stemmed from the existing SWFL habitat suitability model (Siegle and Ahlers 2017). Objectives of annual monitoring efforts were to:

- determine the success of restoration at the LLRS in establishing a productive cottonwood/willow riparian community, as well as characterizing factors that may have influenced the outcome;
- assess SWFL and YBCU habitat suitability/sustainability and identify those variables which contribute to the development of quality habitat;
- establish a potential timeframe in which a restored site develops into suitable SWFL and YBCU habitat under local environmental conditions; and
- provide information for other restoration efforts within the Middle Rio Grande and throughout the southwestern United States.

Methods

This comprehensive study was comprised of various types of monitoring including avian point counts and SWFL and YBCU surveys, vegetation transects and quantification plots, groundwater wells, and photo stations. Methodologies used are described below.

Avian Monitoring

Point Counts

Avian monitoring included 5-minute, 50-meter (m) fixed-radius point counts that were conducted 3 times/year during the peak breeding season (late-May to early-July). Point counts took place within two areas that were monitored over a 15-year study period from 2003 to 2018 (waypoint locations are listed in Appendix A). These areas – the Cleared/Overbank and Burned Areas – were located within the LLRS and are separated by a root-wad berm constructed during restoration activities. Only the Cleared/ Overbank Area was monitored for the duration of the study. Point counts were conducted in the Burned Area in 2003, 2004, and 2007 to 2018. The Cleared/Overbank and Burned Areas are described below:

Cleared/Overbank Area

> This restoration area, adjacent to the active river channel, was cleared and excavated to allow overbank flooding with natural regrowth comprised of primarily native vegetation. Monitoring was conducted at eight points from 2003 to 2006; points at this site were relocated and increased to 12 in 2007 so that: a) the points were more evenly distributed over the area; and b) all areas had the same sample size (Figure 2).

Burned Area

> This cottonwood gallery, burned in 2000 and adjacent to the Cleared/Overbank Area, experienced regrowth of mixed vegetation. Very little restoration activity took place in this area outside of planting mixed potted shrubs and cottonwood poles on the perimeter. Point counts were conducted in 2003 and 2004, and after a two year hiatus, monitoring was resumed in 2007 to provide a comparison site. Counts were conducted at seventeen points within this site in 2003 and 2004; points were relocated and decreased to 12 in 2007 so that: a) the points were more evenly distributed and were all within the restoration area; and b) all areas had the same sample size (Figure 2).

The table in Appendix B shows the groupings of individual bird species into guilds for analysis purposes as well as scientific names and codes of the bird species. This table serves as a reference for scientific names throughout the report.

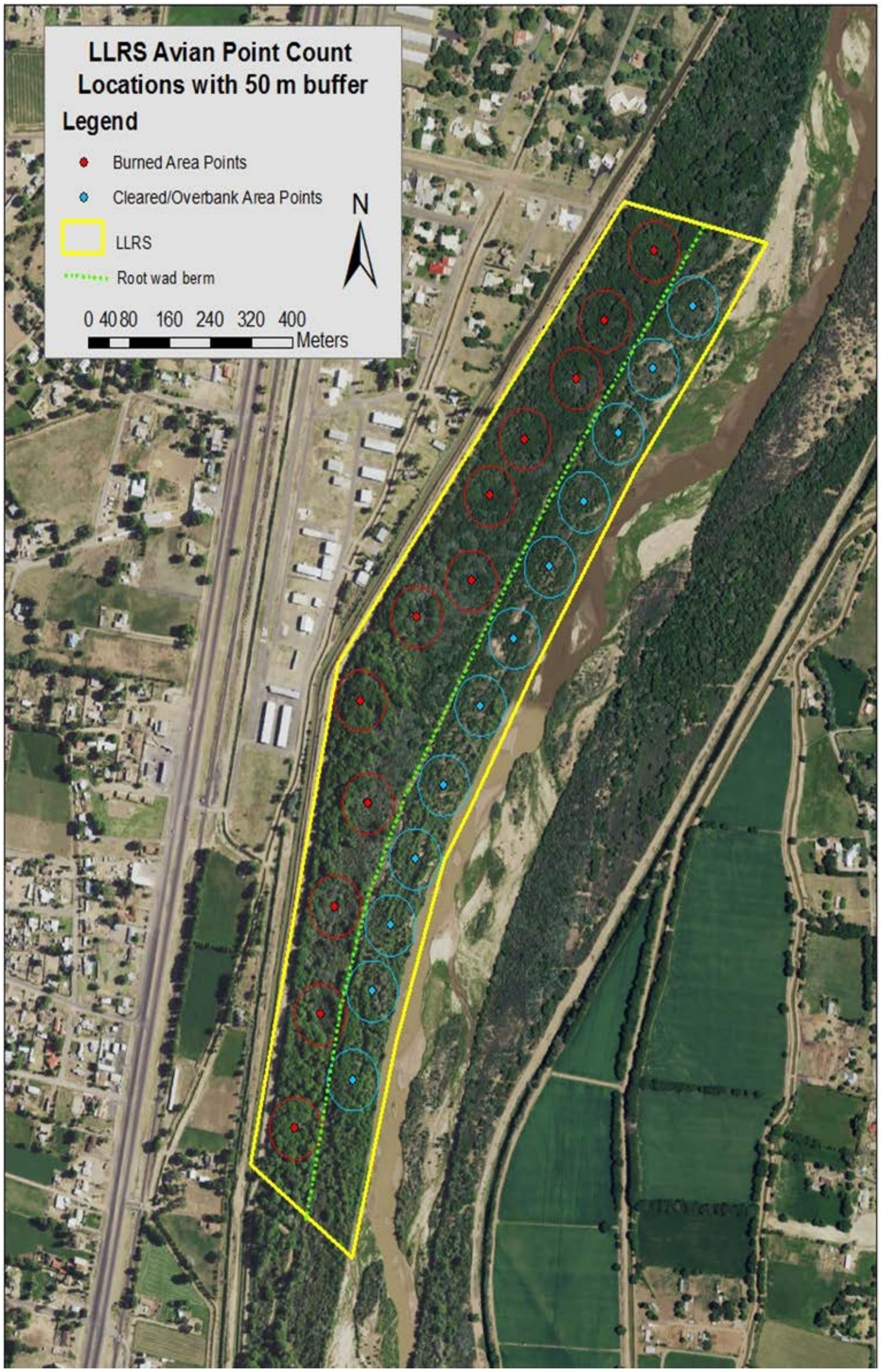


Figure 2. Cleared/Overbank and Burned Area point count locations at LLRS (NAIP 2014 natural color photography). A root wad berm separates the 2 areas.

Willow Flycatcher and Yellow-billed Cuckoo Surveys

Surveys were conducted for the SWFL and YBCU within the LLRS and on both sides of the river in adjacent sections. The project site falls within Reclamation's BL-25 survey site, which is within the Belen Reach between the Los Lunas (NM Hwy 6) and Belen (NM Hwy 309) bridges. These surveys were part of Reclamation's annual SWFL monitoring program conducted at selected sites along the Rio Grande from Bandelier National Monument to Elephant Butte Reservoir (Moore and Ahlers 2019).

Three presence/absence surveys were conducted per year for the SWFL from 2004 through 2018 in accordance with Sogge et al. (2010). Surveys included all willow flycatchers (WIFLs; *Empidonax traillii* spp.) but the subspecies of interest was the southwestern willow flycatcher (SWFL; *Empidonax traillii extimus*). All migrants were considered WIFLs while all resident territories were considered SWFLs.

Four presence/absence surveys were conducted annually for the YBCU in accordance with Halterman et al. (2015). Formal surveys along the Middle Rio Grande began in 2009 but were not initiated within the Belen Reach until 2014.

Vegetation Monitoring

Vegetation Transects

Vegetation sampling was conducted between mid- August and mid-September from 2003 through 2018. Twelve 50-m permanent transects were established at the LLRS between the root-wad berm and the river (the site referred to as the Cleared/Overbank Area in avian monitoring) to document the natural establishment of vegetation in this area (waypoint locations are listed in Appendix A). The area where transects were placed was not revegetated using seed or potted shrubs as were some areas within the restoration site. All transects were evenly distributed in the disturbed area and were oriented perpendicular to the river (Figure 3).

Cover and species composition were measured every 0.5 m along the 50 m transect. For understory measurements, the point-intercept method was used, which entailed recording the first "hit" for herbaceous plant species and for woody species under 1 m tall. If a plant was not intercepted, then bare soil or litter was recorded. As of 2007, the line-intercept method was used for measuring overstory cover. Canopy cover was measured along each transect by noting the point along the tape where the canopy began and the point at which it ended for each woody species over a meter tall. Because species overlapped in some cases, the sum of the cover for all species did not necessarily reflect the actual percentage of overstory cover along the tape. The percentage of the tape covered by overstory was also calculated. The height of the tallest plants within each continuous stretch of the same species was measured.

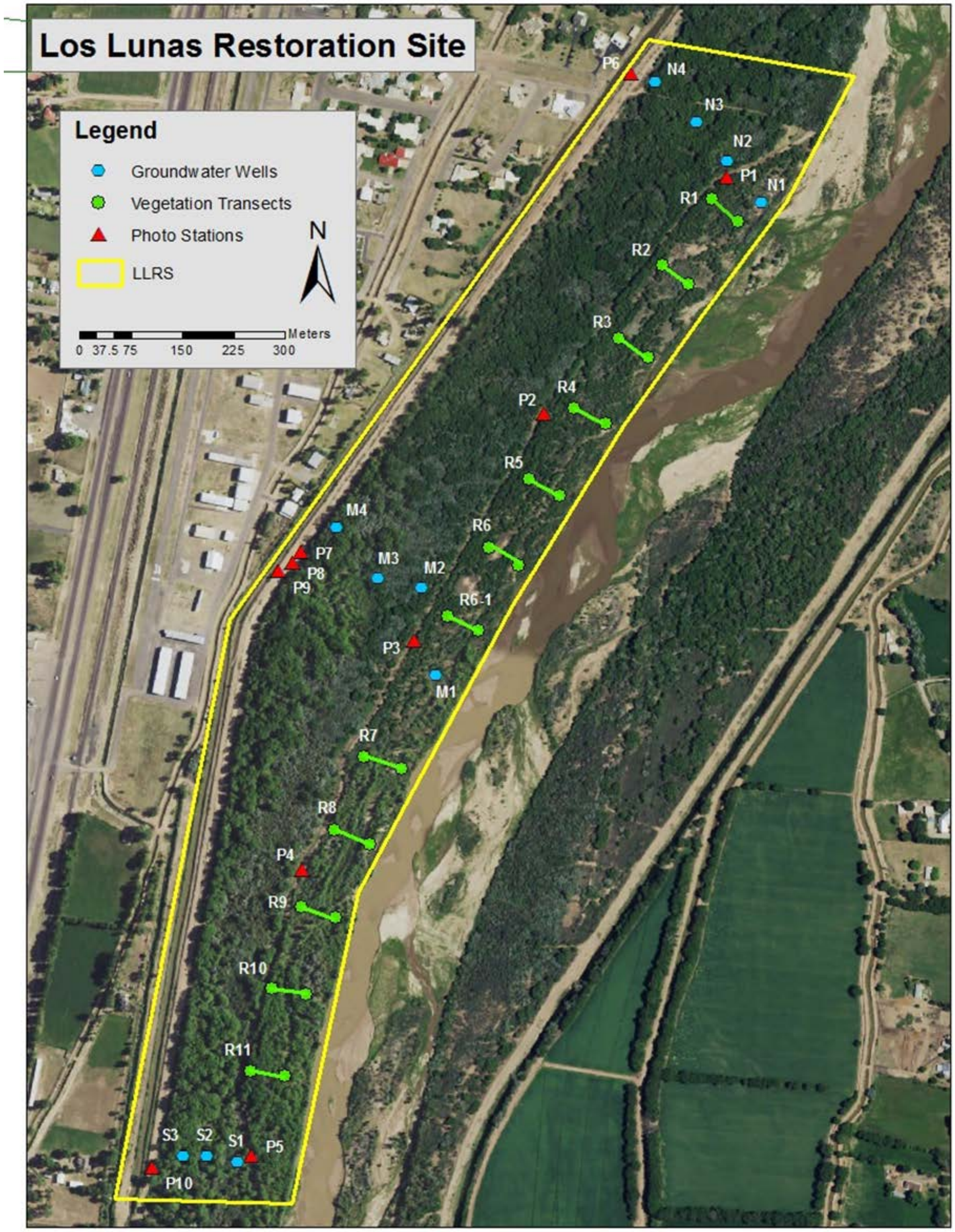


Figure 3 Vegetation transect, well, and photo station locations at LLRS (NAIP 2014 natural photography).

The methodology used for cover measurements was revised in 2007 to include a separate overstory measure (woody species > 1 m in height). Prior to 2007, the method used to collect understory cover was applied to all vegetation cover measurements, so that if a woody species was intercepted first, then this species was recorded as understory. As vegetation grew in height, the original methodology did not account for overstory as a separate layer, and understory vegetation cover was not fully captured. This phenomenon was first noticed in 2006; therefore understory shrub data from that year is probably more comparable to overstory data from 2007 to 2017.

Vegetation Quantification Plots

Between 2004 and 2006, Reclamation gathered and analyzed vegetation data from 112 SWFL nest sites within the Middle Rio Grande (Moore 2007). To assess the suitability of developing habitat for breeding SWFLs within LLRS, Reclamation gathered similar vegetation data from 2015 to 2018 at sites that appeared suitable for breeding SWFLs but were currently unoccupied (Figure 4). Three plots were measured within the Cleared/Overbank Area in 2015 through 2018. Three plots were added to the study and measured within the Burned Area from 2016 to 2018.

Most of the data collected from 2004 to 2006 in association with the 112 nests represented habitat of exceptional quality for SWFL breeding that was located in the delta of Elephant Butte Reservoir. These habitat conditions may not be achievable in the Los Lunas area, which is approximately 100 miles upstream of the delta, experiences entirely different hydrological conditions, and is populated by different plant species. To provide a representative comparison for the LLRS, 22 nests from the original study that were located within the Sevilleta/La Joya, Bosque del Apache, and Tiffany Reaches – which have similar conditions - were analyzed separately and used as comparison data (i.e. Reference Site).

In the original study, 27 vegetation variables were evaluated. For the LLRS study, variables were reassessed to include only those in which methodology proved to be repeatable over time as well as those that appeared to be the most valuable for measuring SWFL habitat quality. These determinations were made after using the original nest data set for several years of analysis. Reassessment resulted in the inclusion of 24 vegetation variables in vegetation quantification plot analysis; methods used in data collection of the 24 variables are described below.

Methods were adapted from BBIRD protocol (Martin et al. 1997) and similar studies conducted by the New Mexico Natural Heritage Program along the Rio Grande (DeRagon et al. 1995, Ahlers and White 1997, Stoleson and Finch 1999) with input from the University of New Mexico (Peter Stacey, pers. comm.).

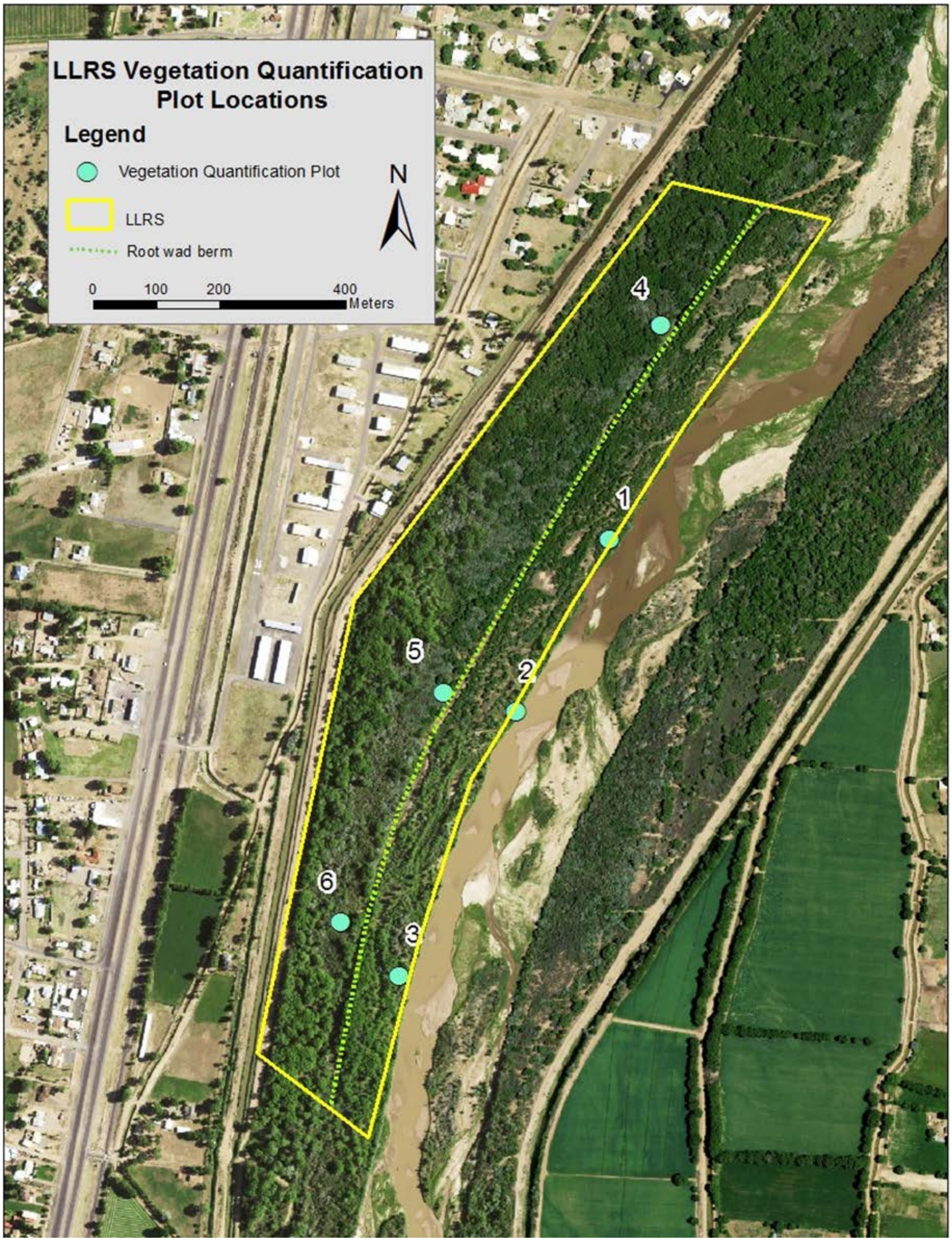
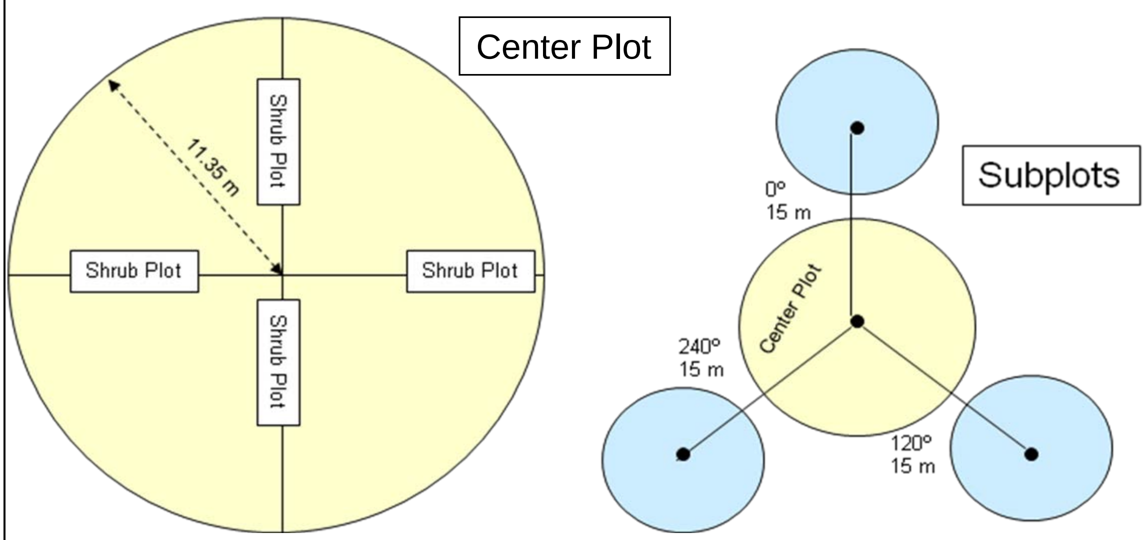


Figure 4. Locations of vegetation quantification plots in the Cleared/Overbank Area (1-3) and in the Burned Area (4-6).

Vegetation and habitat data were collected within an 11.35-m radius plot (0.04 hectare (ha) BBIRD-type plot) centered below the nest substrate in the original study, or in this case a selected substrate within the assessment site (Figure 5). All trees within the center plot were tallied by species. Stems were considered trees when diameter at breast height (DBH) was greater than 5 centimeters (cm). Average stem density, species and size class composition, and average height by species were computed for these plots. Trees were divided into three DBH classes: Class I consisted of trees 5 cm to 9.9 cm DBH, Class II consisted of trees 10 cm to 19.9 cm, and Class III consisted of trees 20 cm or greater.



Center plots
- Count and measure all trees (>5 cm DBH) within 11.36 m radius (0.04 ha) circular plot by species, height, and DBH class
- Count shrub stems by species (0.5 to 5 cm DBH) within 4 1x4 m rectangular plots located at random distance (< 7.25 m) from center along 4 cardinal directions

Subplots:
- Canopy cover estimate for 3 height zones (0 – 3 m, 3 – 6 m, >6 m) within 5 m radius of plot center

Figure 5. Vegetation quantification plot layout

Shrubs were measured in four 1 x 4 m shrub plots located at random distances less than 7.35 m from the plot center along each of four radii in cardinal directions. Shrub stems were defined as having a DBH between 0.5 cm and 5 cm. All shrub stems within each shrub plot were counted by species. Stem densities and species composition were computed. It should be noted that all stems encountered at breast height within the 1 x 4 m shrub plots were counted, not necessarily just those that were rooted, which is the traditional measure of stem density. Birds most likely respond to plant densities rather than individual plant numbers; therefore, vertical stems, not individual plants, were counted (Martin et al. 1997).

Three additional subplots, each with a 5 m radius, were established adjacent to each center plot (Figure 5). Subplots were used to gather canopy cover visual estimates, which were made within each of three canopy layers (0 to 3 m, 3 to 6 m, and >6 m). Estimates were attained using a Daubenmire ranking of 0 to 6 where 0 = 0 percent cover, 1 = 1 to 10 percent, 2 = 11 to 25 percent, 3 = 26 to 50 percent, 4 = 51 to 75 percent, 5 = 76 to 90 percent, and 6 = greater than 90 percent cover (the midpoint for each of these ranges was used for analysis purposes). If a subplot fell partially or entirely within an area designated as non-habitat for SWFLs (in this case the river channel), it was excluded from measurements. For center plots, the quarter of the plot (as measured from each cardinal direction) that fell in non-habitat, such as open water, was excluded from data collection.

Groundwater Monitoring

Eleven groundwater monitoring wells were installed along three transects running perpendicular to the river: four wells on the northern end of the site, four in the center, and three on the southern end (Figure 3; waypoint locations are listed in Appendix A). All wells were installed using the Army Corps of Engineers (2000) methodology. Wells averaged 5.0 ft in depth, with the groundwater depth at a range of 2.0 to 4.0 ft below the surface at the time of installation. Eight wells were installed in June 2003 and the remaining westernmost three were installed July 2004. The eleven wells were manually monitored every month from date of installment to 2010.

In June 2011, HOBO Water Level Loggers were installed in nine of the wells and hydrologic measurements were discontinued in two of the westernmost wells. Loggers were attached to the well cap via a braided stainless steel wire and programmed to collect readings every two hours. Data from loggers provides a much more detailed record of groundwater fluctuations than the previous method of collecting data just once a month. Most importantly, the duration of water table depths at critical levels can be determined and correlations to surface flows can be derived.

Photo Stations

Ten permanent photo stations were established throughout the study area (Figure 3; waypoint locations are listed in Appendix A). Digital photographs were taken between mid-August and mid-September from 2003 through 2018 to visually document vegetation height, density, species composition, and overall site development. Annual photos were compared to evaluate visible changes over time.

Data Analysis

SigmaPlot statistical software was used to evaluate trends in abundance of pooled avian species guilds and in total plant cover over time. Primer-e statistical software was used to generate Multi-dimensional Scaling (MDS) configurations which were used to examine both avian and plant species composition over time and between plots. MDS ordination ranks species similarities and the associated configuration can be interpreted in terms of relative similarity of samples to each other (Clarke et al. 2014).

For avian data analysis, pooled species guilds were categorized based predominately on nesting habitat and included canopy, cavity, dense shrub, edge, ground shrub, mid-story, open, and water birds. Migrants were also documented but were not included in statistical analysis. Simple linear regressions were used to test for significant relationships between the abundance of birds and year (i.e., time; Nur et al. 1999). To compare bird abundance between areas by year, the Student's t-test was used for normally distributed data and the Mann-Whitney nonparametric test of medians was used for data that were not normally distributed.

Total percent plant cover (i.e., actual cover estimate) was statistically analyzed for understory and overstory vegetation. Relative percent cover was determined for understory life-forms (i.e., native or introduced shrubs <1 m in height, grasses and grass-like species, and forbs). Relative cover is cover of a species or life-form expressed as a percentage of total vegetation.

To evaluate any statistically significant changes within vegetation cover over time, a Repeated Measures Analysis of Variance (ANOVA) was used on normally distributed data, while Friedman Repeated Measure ANOVA on Ranks was used for data that was not normally distributed. A multiple comparison test to evaluate statistically significant differences between individual years was also carried out using Bonferroni t-test for normal distributions and Tukey's test for non-normal distributions.

To compare the LLRS vegetation quantification assessment sites to selected SWFL nest sites, each dataset was pooled separately and mean values were compared. If LLRS mean values were within 0.5 standard deviations of means calculated in selected sites from the original study, these parameters were considered suitable for nesting SWFLs. Because protocol was designed to measure habitat on a point-in-time basis, not to look for trends in specific variables over time, only data collected in 2018 was compared to the original nest data for this report.

Results

Avian Monitoring

Point Counts

Cleared/Overbank Area

Table C-1 in Appendix C provides data on the relative abundance of individual bird species for the Cleared/Overbank Area by year. The % Plots column shows the percentage of points in which the species was documented within this area. The Mean and SD columns represent the mean number and standard deviation of detections per point for the species.

There were 68 breeding bird species and 16 migrant species detected in the Cleared/ Overbank Area during the point counts conducted from 2003 to 2018. During the first few years of monitoring, common breeding species (based on abundance and detection frequency) were red-winged blackbirds, blue grosbeaks, killdeer, western kingbirds, and brown-headed cowbirds. Common species by 2018 were yellow-breasted chats, spotted towhees, black-headed grosbeaks, mourning doves, and black-chinned hummingbirds. These results are illustrated in the shade plot in Figure 6, which shows the average number of birds detected per point (relative abundance) of the most abundant species (generally > 8 detections over the course of monitoring). The darker shades in each cell represent higher abundance at that sample point.

Species composition was analyzed using a Bray-Curtis similarity matrix which examines the similarity in the collection of species detected between years. Statistical analysis found a significant difference in the composition of species over time ($R=0.554$, $P<0.001$) within the Cleared/Overbank Area. Pairwise testing identified the highest similarities between years 2003 and 2004, between years 2012, 2013, and 2014, and between 2016 and 2017. For the most part, these results are illustrated in the Multi-dimensional Scaling (MDS) configuration in Figure 7 (note that the configuration may not exactly represent statistical results because MDS analysis uses means, unlike pairwise testing, and therefore variances may differ). MDS ordination ranks similarities and the associated configuration can be interpreted in terms of relative similarity of samples to each other (Clarke et al. 2014). For example, in this case it can be interpreted that the collection of species in 2005 and 2006 was less similar than all other years of monitoring and began to have less variation starting in about 2011. The mix of species changed continually over time and began to become more similar starting in 2010 or 2011. Stress is the measure of distortion in the configuration. A stress factor of <0.5 gives an excellent representation; MDS analysis of this data had a stress of 0.07. The length and change in direction of the line between years illustrates the degree and relative change in species composition each year (e.g., starting in 2003 and ending in 2018).

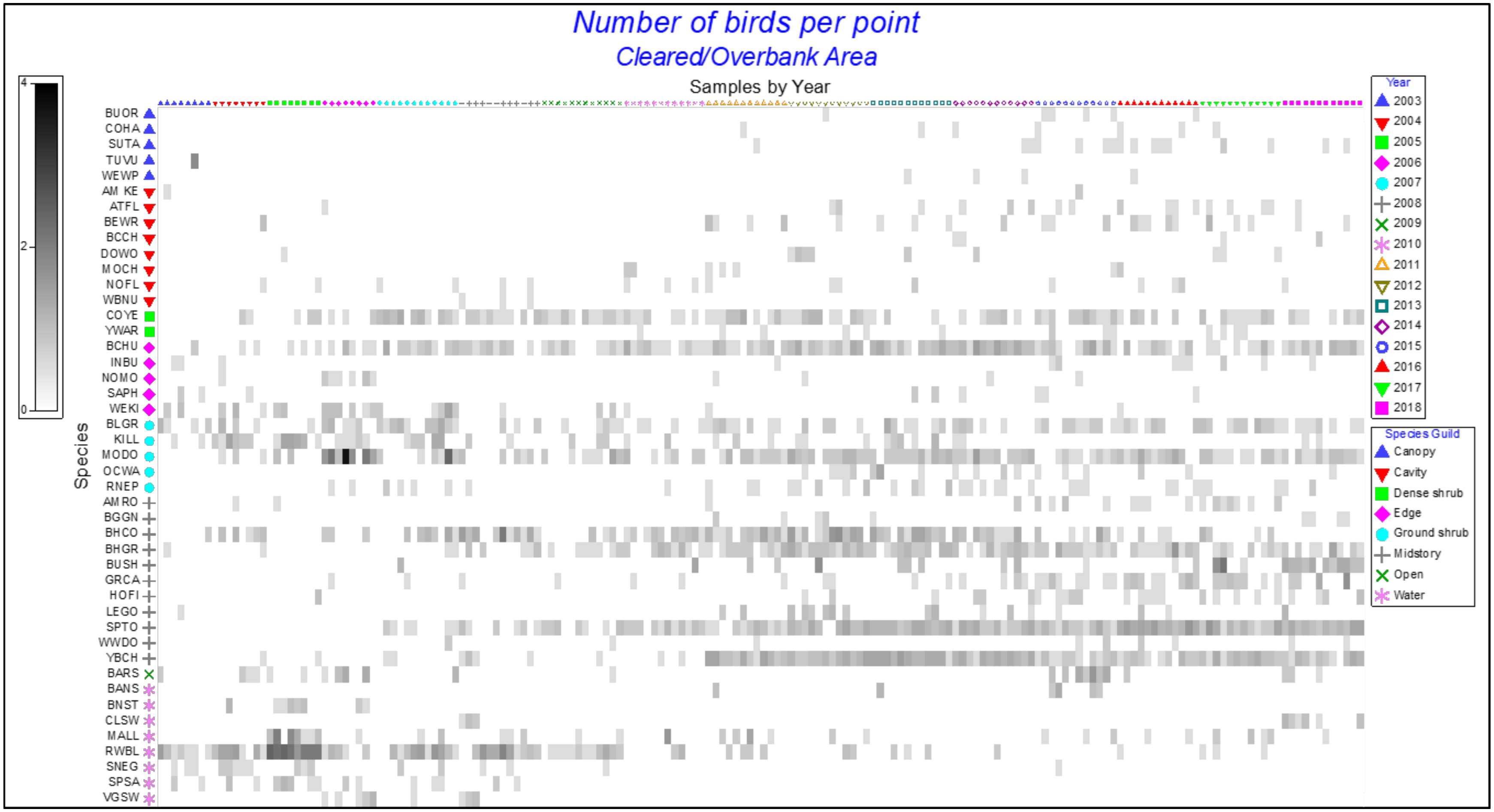


Figure 6. Shade plot of the most abundant species detected in the Cleared/Overbank Area by sample and year; darker shades in each cell represent higher abundance of that species. See Appendix B for species codes.

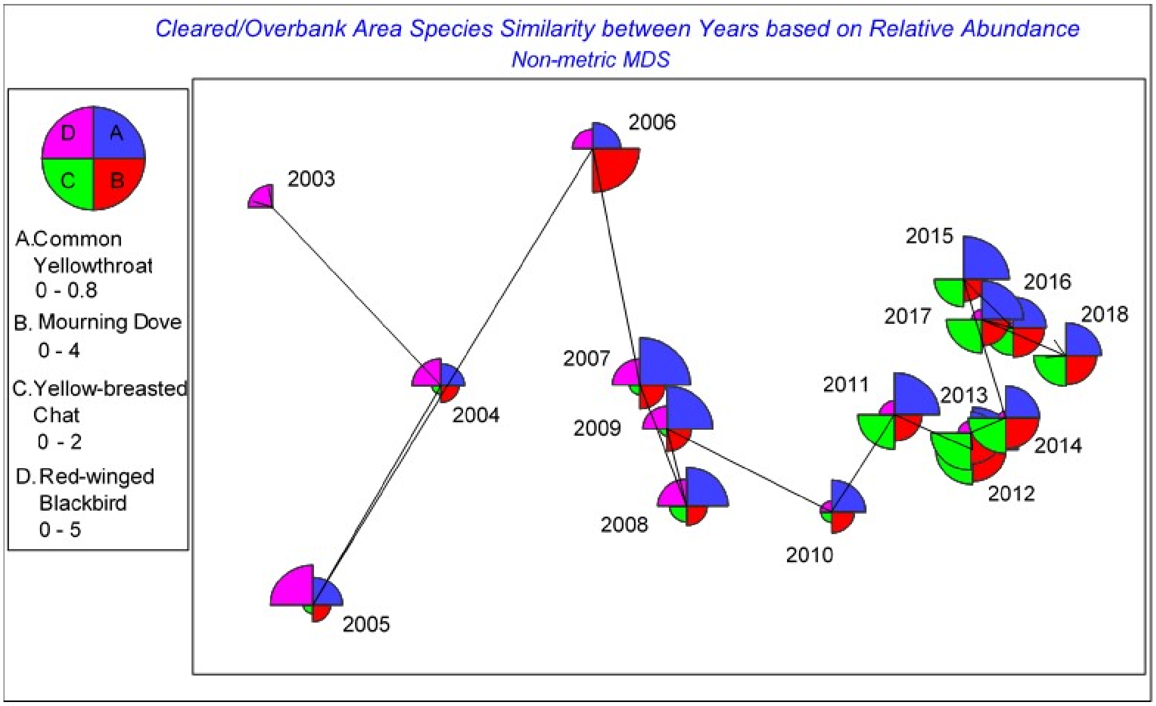


Figure 6. MDS ordination of 16 years of square root transformed species abundance data based on Bray-Curtis similarities within the Cleared/Overbank Area (stress=0.07). Overlay circles associated with each year represent relative abundance of 4 of the species detected.

Size of overlay circles associated with each year represent abundance of 4 species, each of which was a species detected in 4 common guilds. In this case abundance of yellow-breasted chats (midstory guild) increased with time while abundance of red-winged blackbirds (water guild) decreased with time after peaking in 2005.

Table D-1 in Appendix D provides means and totals by species guilds for the Cleared/Overbank Area. Totals for the numbers of species within each guild accounted for all species detected during all three point count periods per year. Totals for the number of birds within each guild were calculated by averaging the number of birds detected at each point over the three point count periods and then summing all point averages. Note that sample sizes were not always the same and therefore notequally comparable between. Mean and SD are the mean number and standard deviation of detections per point within each species guild.

The mean number of birds per point represents relative abundance (Nur et al. 1999), which is graphed by species guild over time in Figure 8. The total number of species detected during point counts represents species richness, graphed by guild over time in Figure 9. Since 2010, the most common species guilds based on relative abundance were midstory and ground shrub birds (Figure 8). There was an increase in both relative abundance and species richness among total birds over the monitoring period (ie. 2003 vs. 2018). Both variables increased in 2011 after a downward trend since around 2007. As of 2018, relative abundance increased a bit following a gradual decrease since 2012 and species richness was below 2011 levels.

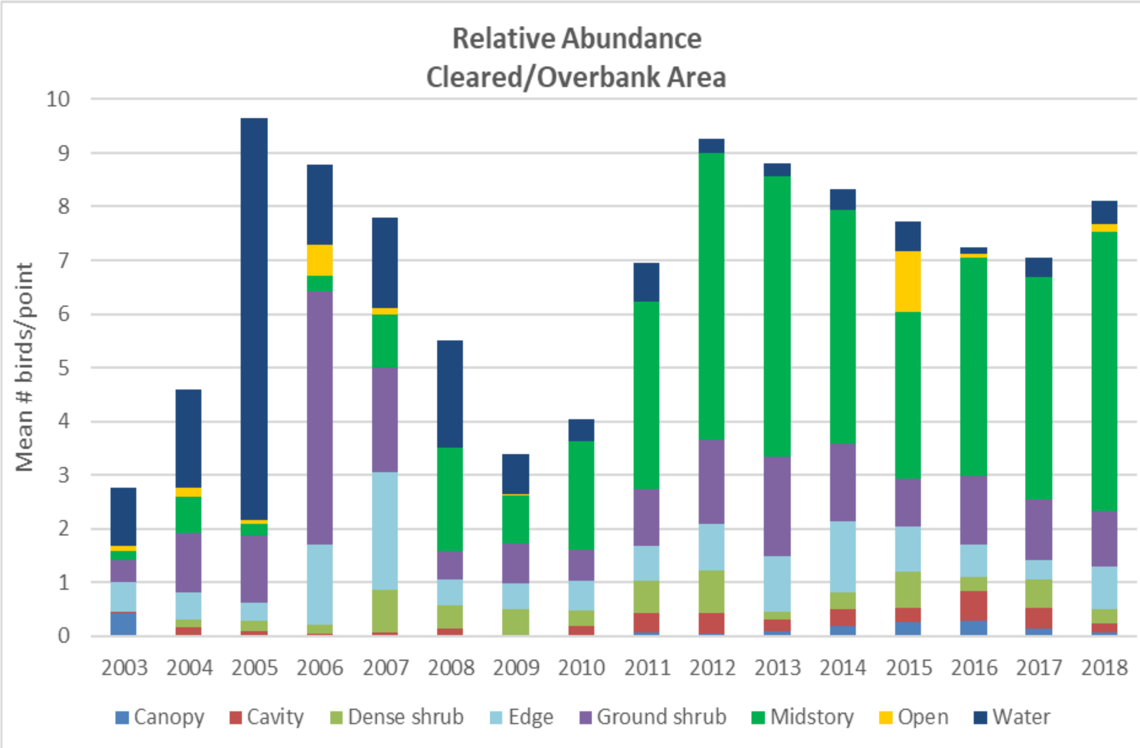


Figure 7. Relative abundance by species guilds in the Cleared/Overbank Area over time.

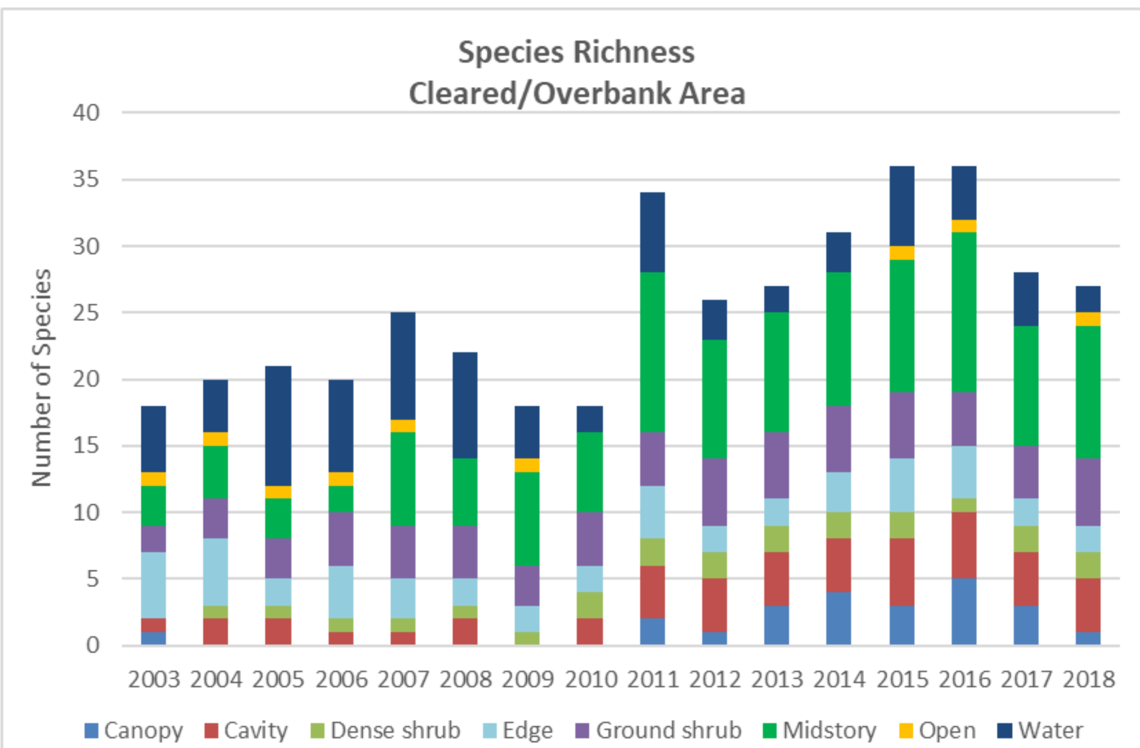


Figure 8. Species richness by species guilds in the Cleared/Overbank Area over time.

Simple linear regression analysis identified a significant relationship ($P<0.05$) between relative abundance of birds and year among the total number of birds and in the cavity, mid-story, and water bird guilds (Table 1). Total birds, cavity, and mid-story guilds showed an increasing trend; among water birds there was a decreasing trend. Coefficients of determination (R^2 values) represent the percent of variation in abundance that can be explained by time. Although the P-value identified a difference in abundance over time for certain bird guilds, low R^2 values indicated relatively weak relationships for all but the mid-story bird guild (Figure 10). An R^2 value of 0.5600 indicated a moderately strong relationship between year and relative abundance among mid-story birds.

Table 1. P and R^2 values for simple linear regression analysis between year and relative abundance by guild in the Cleared/Overbank Area. Alpha=0.05.

Cleared/Overbank area 2003 to 2018		
Guilds	**F(df), P-value**	**Coeffiecient of Determination [R^2]**
Total birds	F(1) = 16.76, P <0.001	0.0879
Canopy birds	F(1) = 2.03, P= 0.156	0.0115
Cavity birds	F(1) = 15.60, P <0.001	0.0823
Dense shrub birds	F(1) = 2.29, P= 0.132	0.0130
Edge birds	F(1) = 4.50, P= 0.503	0.0026
Ground shrub birds	F(1) = 1.03, P= 0.311	0.0059
Mid-story birds	F(1) = 221.33, P <0.001	0.5600
Open birds	F(1) = 5.95, P= 0.442	0.0034
Water birds	F(1) = 53.65, P <0.001	0.2360

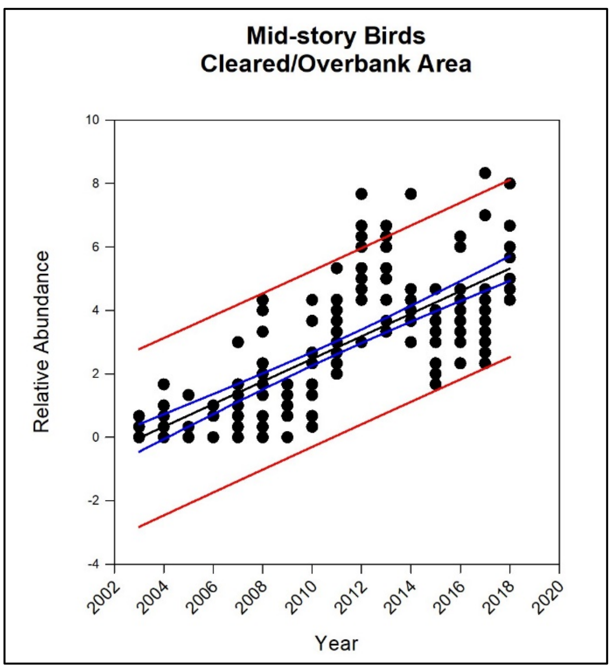


Figure 9. Linear trend in average number of mid-story birds per point in relation to year in the Cleared/Overbank Area. Points represent mean number of observations in 3 repetitions at each point, blue line represents best-fitting trend, and red lines represent 95% confidence intervals.

Burned Area

Table C-2 (Appendix C) shows relative abundance of individual species for the Burned Area by year. A total of 67 breeding bird species and 10 migrant species were detected in this area in 2003, 2004, and 2007 through 2018. The most common species detected in 2003 and 2004 (based on abundance and detection frequency) were turkey vultures, black-chinned hummingbirds, mourning doves, brown-headed cowbirds, spotted towhees, and yellow-breasted chats. By 2018 the most common species included yellow-breasted chats, spotted towhees, mourning doves, Bewick’s wren, and black-headed grosbeaks. The shade plot in Figure 11 shows the average number of birds detected per point (relative abundance) of the most abundant species over the course of monitoring. The darker shades in each cell represent higher abundance at that sample point. The pattern in species detections in the Burned Area appears to be more consistent over time than in the Cleared/Overbank Area (Figure 6) where there are varied breaks in species’ detections over time.

Statistical analysis found a significant difference in species composition over time (R=0.304, P<0.001) within the Burned Area. Pairwise testing identified the highest species similarities between years 2003 and 2008; 2012 and 2009 through 2014; and 2013 and 2014. These results are generally illustrated in the MDS configuration in Figure 12. The line between years illustrates relative change in species composition each year starting in 2003 and ending in 2018 with no data for years 2005 and 2006. In the Burned Area, MDS ordination shows the mix of species in 2003, 2008, and 2015 through 2018 to be somewhat different from other years. This configuration had a stress of 0.1, which indicates an excellent representation. Size of overlay circles associated with each year represent abundance of 4 species, each of which was a species detected in the 4 common guilds. It appeared that while mourning dove and yellow-breasted chat abundance remained fairly stable, detections of Bewick’s wren increased and detections of black-chinned hummingbirds decreased throughout the monitoring period. Species similarity analysis was the same done for Cleared/Overbank species composition, which is described in more detail above.

Means and totals by species guilds for the Burned Area are shown in Table D-2 (Appendix D). Relative abundance and species richness are graphed in Figures 13 and 14, respectively. Relative abundance has varied over the years, resulting in an overall decrease in the average number of birds detected from 2003 (8.40) to 2018 (5.78; Table D-2, Figure 13). Species richness has also been variable over the study period but the number of species detected did not change considerable from 2003 (30) to 2018 (28).

In simple linear regression of abundance in relation to year only the open bird guild showed a significant trend in the relative abundance of birds detected, with the number of birds decreasing over time (Table 2). However, a relatively low R^2 value (0.1750) indicated weak relationships between abundance and year.

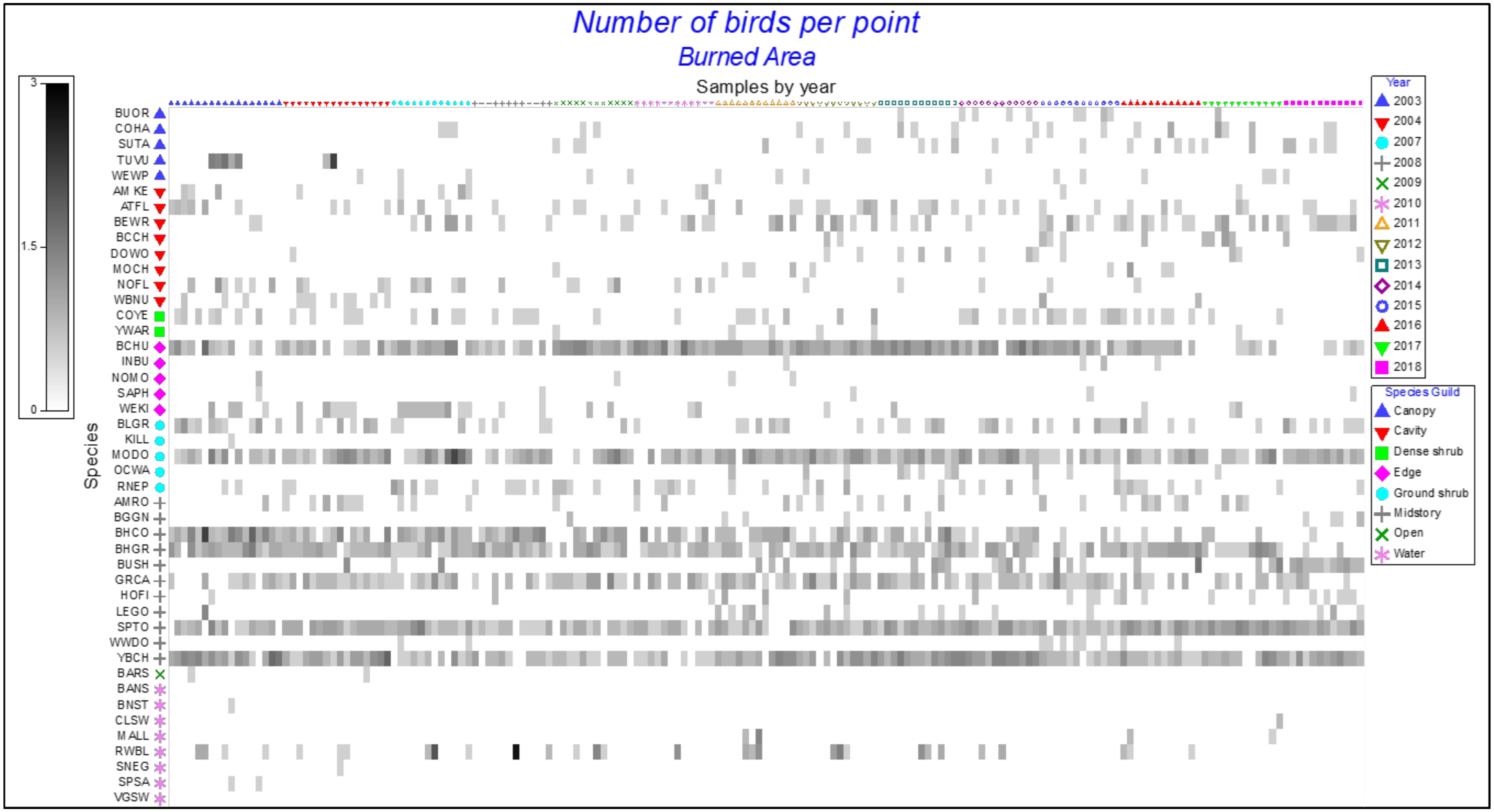


Figure 10. Shade plot of the most abundant species detected in the Burned Area by sample and year; darker shades in each cell represent higher abundance of that species. See Appendix B for species code.

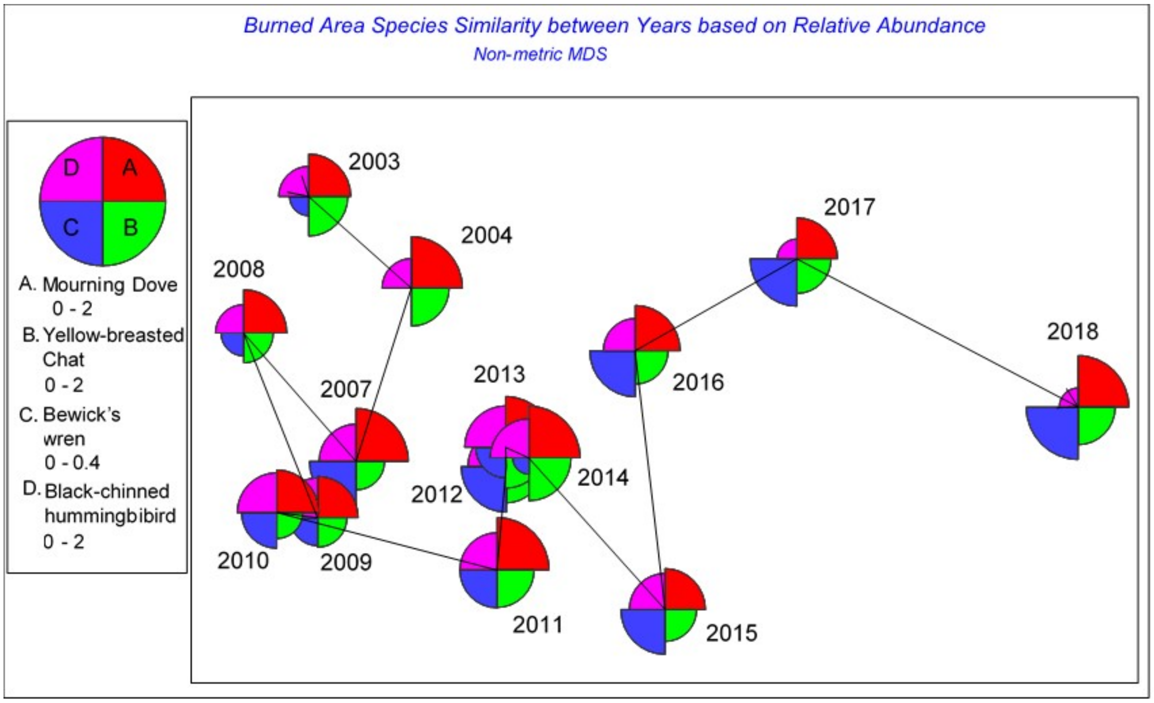


Figure 11. MDS ordination of 14 years of square root transformed species abundance data based on Bray Curtis similarities within the Burned Area (stress=0.1). Overlay circles associated with each year represent relative abundance of 4 of the species detected.

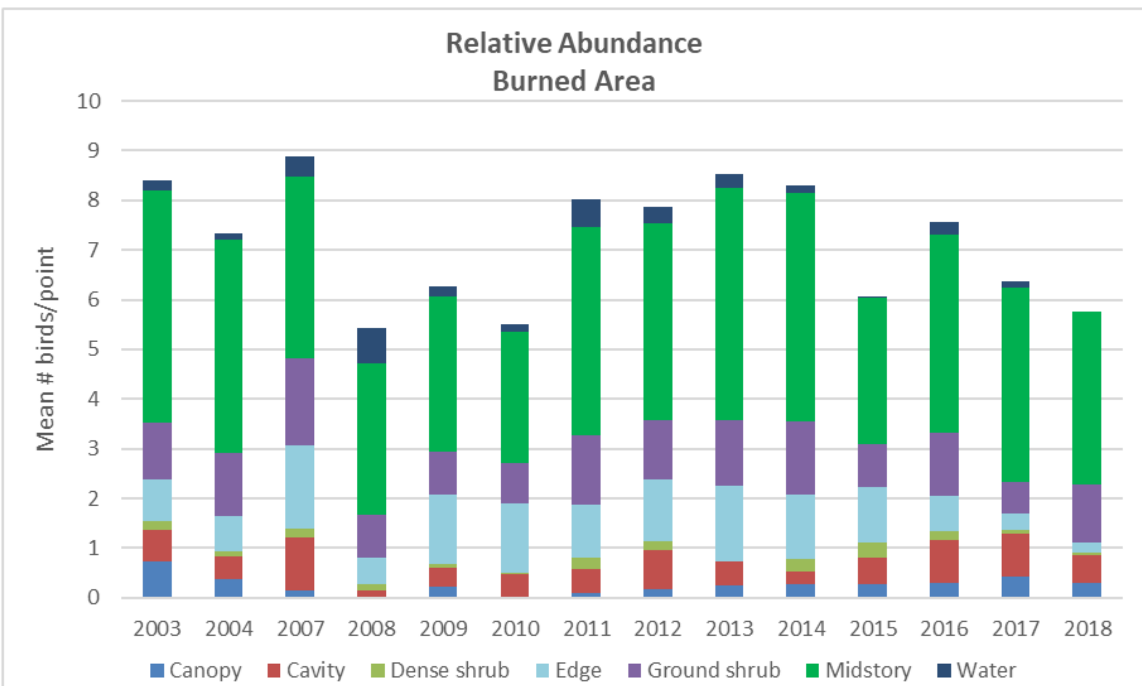


Figure 12. Relative abundance by species guilds in the Burned Area over time.

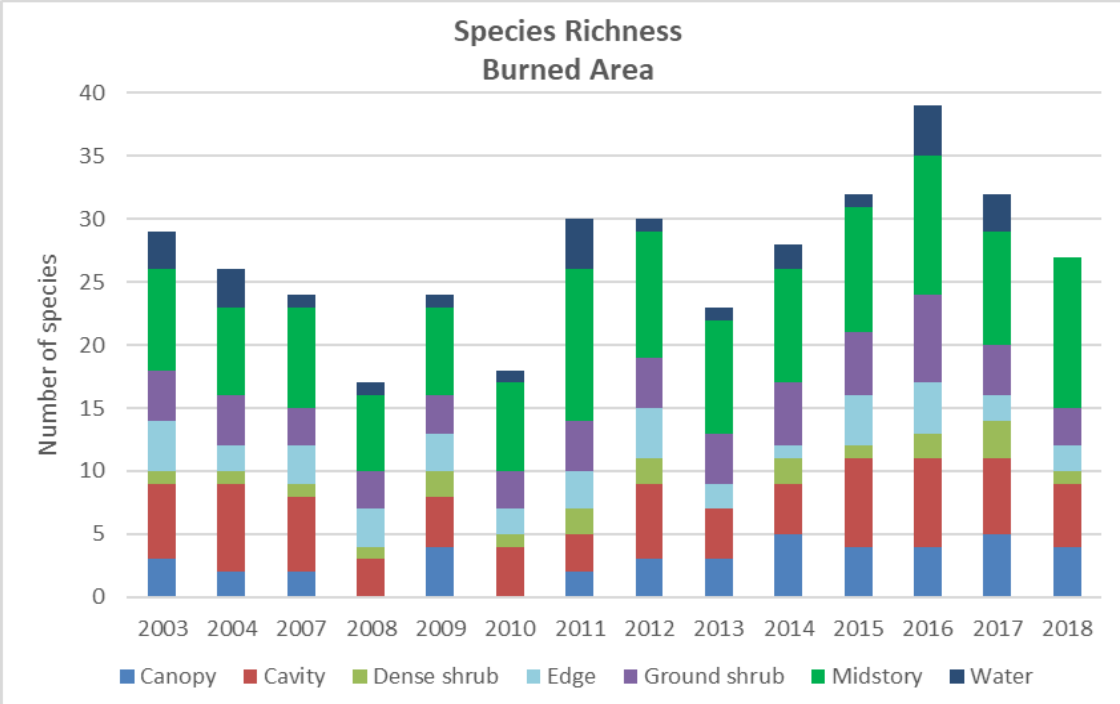


Figure 13. Species richness by species guilds in the Burned Area over time.

Table 2. P and R^2 values for simple linear regression analysis between year and relative abundance by guild in the Burned Area. Alpha=0.05.

Burned Area 2003, 2004, 2007 - 2018		
Guilds	**F(df), P-value**	**Coeffecient of Determination [R^2]**
Total birds	F(1) = 5.53, P= 0.020	0.0306
Canopy birds	F(1) = 0.76, P= 0.383	0.0044
Cavity birds	F(1) = 0.24, P= 0.622	0.0014
Dense shrub birds	F(1) = 0.05, P= 0.832	0.0003
Edge birds	F(1) = 3.41, P= 0.066	0.0191
Ground shrub birds	F(1) = 0.52, P= 0.471	0.0030
Mid-story birds	F(1) = 2.47, P= 0.118	0.0139
Water birds	F(1) = 0.96, P= 0.329	0.0055

Comparisons between Monitoring Areas

MDS ordination of species similarity including both monitoring areas is shown in Figure 15 (stress = 0.08). This perspective demonstrates that relative to the Cleared/Overbank Area, the Burned Area did not undergo large changes in species composition. During the first years of monitoring the two areas had very different mixes of species and with time, the Cleared/Overbank Area approached the Burned Area in similarity of the species matrix. Statistical comparison determined there was a significant difference when comparing both plots across all years (R=0.410, P<0.001) and when comparing all years across both plots (R=0.420, P<0.001). Using pairwise testing between individual years and including both plots, no significant differences in species composition between 2012, 2013, and 2014 were identified.

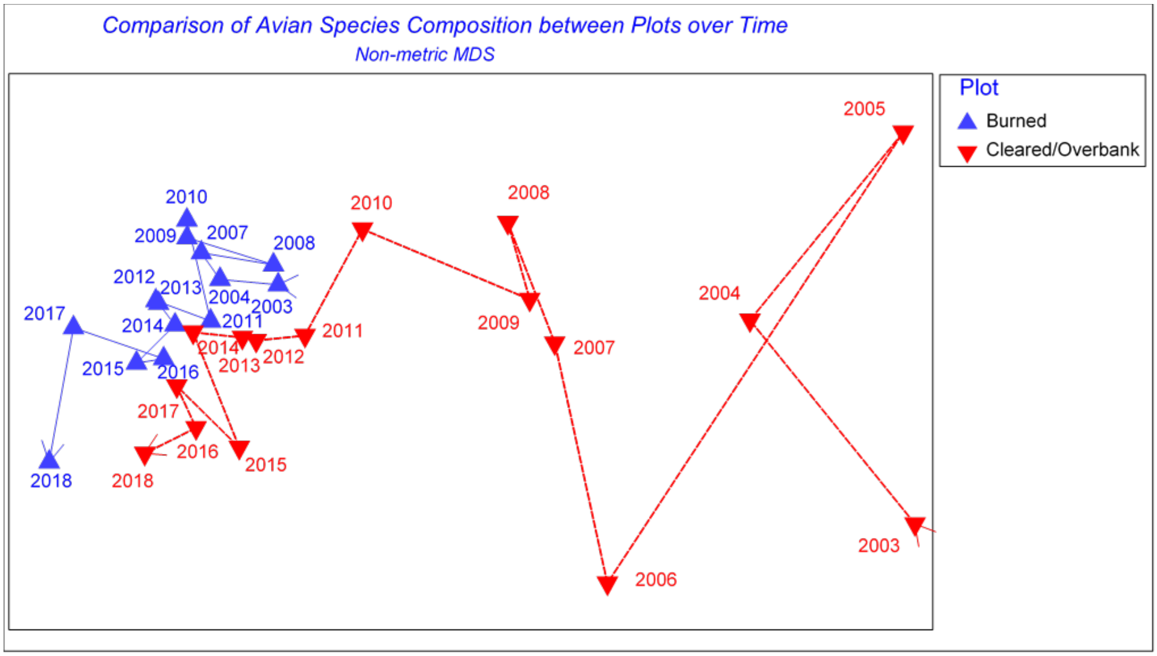


Figure 14. MDS ordination based on 16 years of square root transformed species abundance data and Bray-Curtis similarities for both the Cleared/Overbank and Burned Areas; 2D stress=0.08.

Relative abundance was statistically compared between the two monitoring areas by years in which they were both sampled and by species guilds (see Table 3 for statistical results and P-values). In 2005 and 2006, the Cleared/ Overbank Area was the only site in which point counts were performed, therefore no comparisons between plots were made. Statistical comparisons between areas over time show that the Burned Area generally had a significantly greater number of total birds through 2010. Since that time, the Cleared/Overbank Area has either been statistically equal or significantly greater in relative abundance of total birds than the Burned Area. In the early years of monitoring, the Burned Area usually had higher abundance of cavity, edge, and mid-story birds while the Cleared/Overbank Areas had higher abundance of dense shrub and water birds. By 2010, relative abundance within all guilds was either statistically equal or significantly higher in the Cleared/Overbank Area with a few exceptions; relative abundance of edge birds was still significantly higher in the Burned Area in 2010, 2011, and 2013, and relative abundance of cavity nesters was significantly higher in the Burned Area in 2017 and 2018.

Comparisons of trendlines and R^2 values for relative abundance and species richness between both monitoring sites are shown in Figures 16 and 17, respectively. Note that analysis conducted here was based on one number – the average number of birds or species detected per year – unlike analysis within each area and each guild, in which data from all points were used. Therefore, results differ slightly. The Cleared/Overbank Area showed an increasing trendline for relative abundance and species richness (with a relatively high R^2 value of 0.6468 or strong slope in species richness) over time while the Burned Area generally showed decreasing trends.

Table 3. Statistical comparisons of relative abundance between areas by year and guild. Alpha = 0.05.

Year	Guilds								
	Total birds	Canopy birds	Cavity birds	Dense shrub birds	Edge birds	Ground shrub birds	Mid-story birds	Open birds	Water birds
2003	P<0.001[1] Cleared<Burned	P=0.275[2]	P=0.006[2] Cleared<Burned	No dense shrub spp. in Cleared	P=0.329[2]	P=0.057[1]	P<0.001[2] Cleared<Burned	P=0.578[2]	P<0.001[2] Cleared>Burned
2004	P=0.004[1] Cleared<Burned	No canopy spp. in Cleared	P=0.045[2] Cleared<Burned	P=0.938[2]	P=0.346[1]	P=0.660[1]	P<0.001[2] Cleared<Burned	P=0.059[2]	P<0.001[2] Cleared>Burned
2007	P=0.032[2] Cleared<Burned	No canopy spp. in Cleared	P=0.002[2] Cleared<Burned	P=0.005[2] Cleared>Burned	P=0.016[1] Cleared<Burned	P=1.00[2]	P<0.001[1] Cleared<Burned	No open spp. in Burned plot	P=0.006[2] Cleared>Burned
2008	P=0.953[2]	No canopy spp. in Cleared	P=1.00[2]	P=0.015[1] Cleared>Burned	P=0.879[1]	P=0.119[1]	P=0.019[1] Cleared<Burned	No open spp. in any plot	P<0.001[2] Cleared>Burned
2009	P=0.001[2] Cleared<Burned	No canopy spp. in Cleared	No cavity spp. in Cleared	P<0.001[2] Cleared>Burned	P<0.001[1] Cleared<Burned	P=0.704[1]	P<0.001[1] Cleared<Burned	No open spp. in Burned plot	P=0.004[2] Cleared>Burned
2010	P=0.033[1] Cleared<Burned	No canopy spp. in any plot	P=0.105[2]	P=0.010[2] Cleared>Burned	P=0.003[2] Cleared<Burned	P=0.309[1]	P=0.130[1]	No open spp. in any plot	P=0.328[2]
2011	P=0.069[1]	P=0.596[2]	P=0.668[2]	P=0.016[1] Cleared>Burned	P=0.017[1] Cleared<Burned	P=0.117[1]	P=0.098[1]	No open spp. in any plot	P=0.200[2]
2012	P=0.032[1] Cleared>Burned	P=0.031[2] Cleared<Burned	P=0.063[1]	P=0.006[2] Cleared>Burned	P=0.090[1]	P=0.290[1]	P=0.007[1] Cleared>Burned	No open spp. in any plot	P=0.801[2]
2013	P=0.601[1]	P=0.313[2]	P=0.133[2]	No dense shrub spp. in Burned	P=0.024[1] Cleared<Burned	P=0.067[1]	P=0.293[1]	No open spp. in any plot	P=0.614[2]
2014	P=0.966[1]	P=0.493[1]	P=0.672[1]	P=0.901[2]	P=0.920[1]	P=0.929[1]	P=0.170[2]	No open spp. in any plot	P=0.569[2]
2015	P = 0.006[2] Cleared>Burned	P = 0.834[1]	P=0.170[1]	P = 0.030[1] Cleared>Burned	P=0.218[1]	P=0.997[1]	P=0.367[2]	No open spp. in Burned plot	P=0.007[2] Cleared>Burned
2016	P = 0.609[1]	P = 0.828[1]	P=0.238[1]	P=0.349[1]	P=0.411[1]	P=0.992[1]	P=0.847[1]	No open spp. in Burned plot	P=0.525[2]
2017	P = 0.364[1]	P = 0.180[2]	P=0.037[2] Cleared<Burned	P<0.001[1] Cleared>Burned	P=0.926[2]	P=0.067[1]	P=0.931[2]	No open spp. in any plot	P=0.255[2]
2018	P<0.001[1] Cleared>Burned	P = 0.121[2]	P=0.014[2] Cleared<Burned	P=0.010[2] Cleared>Burned	P<0.001[1] Cleared>Burned	P=0.486[1]	P<0.001[1] Cleared>Burned	No open spp. in Burned plot	P=0.003[2] Cleared>Burned

[1] Student's t-test; [2] Mann-Whitney test of medians.

Highlighted boxes indicate significant difference at the 95-percent confidence level

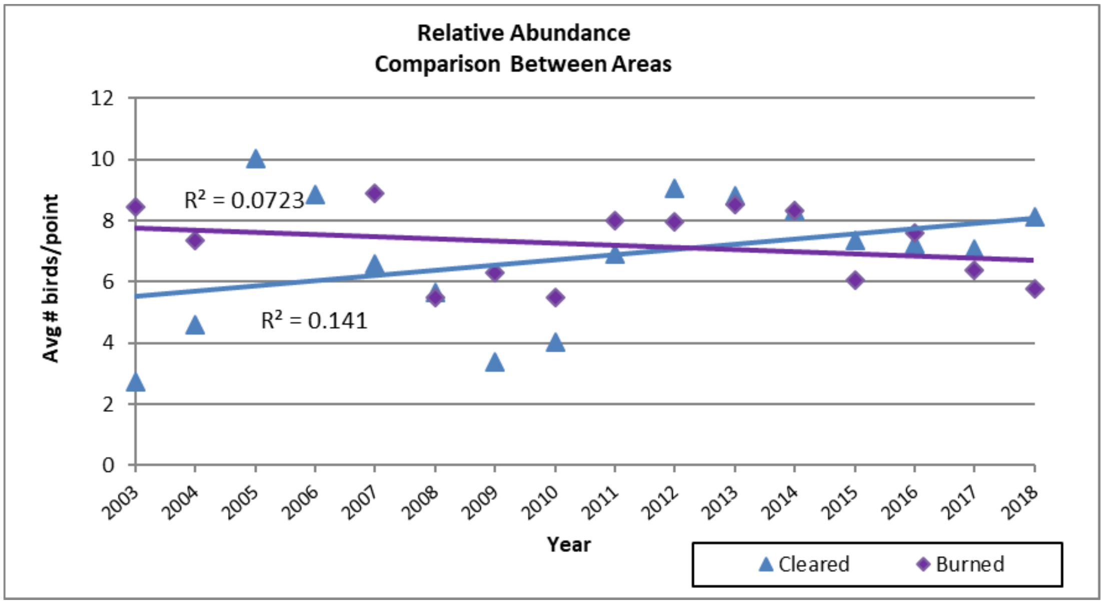


Figure 15. Trendlines and R^2 values for relative abundance over time in the Cleared/Overbank Area (2003-2018) and Burned Area (2003, 2004, 2007-2018).

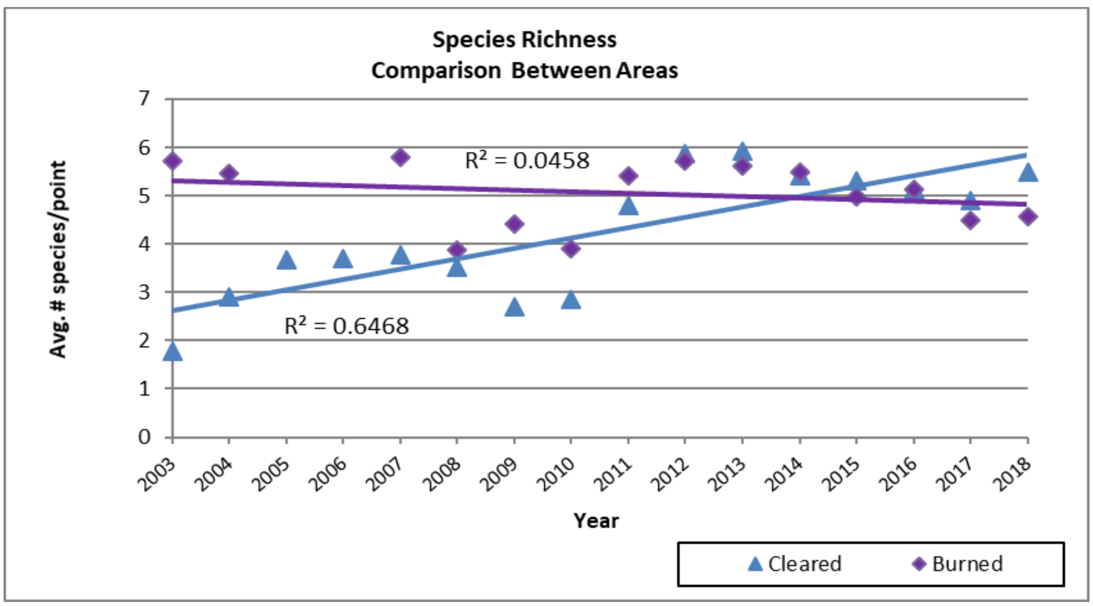


Figure 16. Trendlines and R^2 values for species richness over time in the Cleared/Overbank Area (2003-2018) and Burned Area (2003, 2004, 2007-2018)

As can be seen on the graphs, in terms of actual values the Burned Area had consistently higher numbers of birds and species than the Cleared/Overbank Area for a number of years following the onset of monitoring. For example, in 2003 the relative abundance of total birds was 8.45 in the Burned Area compared to 2.75 in the Cleared/Overbank Area. This trend continued through 2011; in 2014 the Cleared/Overbank Area was equal to the Burned Area with both areas having an average relative abundance of 8.31. By 2018, the number of birds detected in the Cleared/ Overbank Area (8.11) was higher than in the Burned Area (5.78; Tables D-1 and D-2).

Willow Flycatcher and Yellow-billed Cuckoo Surveys

Willow flycatcher survey forms and maps are shown in Appendix E. In 2018, four migrant WIFLs were detected within Survey Site BL-25, all of which were within the LLRS project site. There was a total of 10 migrant WIFLs detected in areas adjacent to the LLRS between the Los Lunas and Belen bridges within Reclamation's Belen survey reach; three territories were identified within this area (one pair and two pairs with nests; Figure 18). Figure 18 also shows SWFL habitat suitability based on a model created for the Middle Rio Grande using 2016 vegetation maps (Siegle and Ahlers 2017). Most of the area between bridges was categorized as Unsuitable SWFL habitat with patches of Moderately Suitable habitat. The majority of the LLRS project area is classified as Moderately Suitable but the northwest corner (within the Burned Area) is considered Unsuitable.

Yellow-billed cuckoo survey forms are also shown in Appendix E. There were no detections in either the LLRS or the BL-25 Survey Site in 2018. There were four YBCU detections between the Los Lunas and Belen bridges but no territories were identified (Figure 19). Figure 19 also shows YBCU habitat suitability based on a model created for the Middle Rio Grande using 2016 vegetation maps (Siegle and Ahlers 2018). Suitable YBCU habitat comprised almost half of the vegetated areas mapped between bridges (48 percent) and most of the habitat in LLRS project area was classified as Suitable.

Vegetation Monitoring

Vegetation Transects

Of the two areas included in avian point count monitoring, the Cleared/Overbank Area was the only site where vegetation monitoring was conducted throughout the entire study. As such, no comparisons were made between areas; only between years. In 2005 and 2006, survivorship of mixed shrub and cottonwood pole plantings was monitored at locations throughout the LLRS. Monitoring of plantings was discontinued once mortality/survivorship was documented. Fifty-four percent of the 160 mixed shrubs originally counted in 2005 at this site had survived by 2006 (Siegle 2007). New Mexico olive and Goodding's willow were the most successful species among the transplanted shrubs. The vast majority of cottonwood poles located within monitoring plots died (72 percent mortality). Based on recent observation, enough cottonwood poles were planted to result in long-term success of some trees but most cottonwoods onsite are due to natural regeneration.

Eighty-two annual and perennial plant species were detected in under- and overstory measurements during 16 years of vegetation sampling. Common and scientific names of these species are listed in Table F-1 in Appendix F. Species richness (total number of plants detected in the under- and overstory) at the site increased from 18 species detected in 2003 to 33 species in 2018, peaking at 44 in 2010 (Figure 20). As the graph displays, the majority of the species detected were native in all years.

Figure 17. SWFL detections and habitat suitability in the vicinity of LLRS within the Belen survey site (NAIP 2016 natural color photography).

Figure 18. YBCU detections and habitat suitability in the vicinity of LLRS within the Belen survey site (NAIP 2016 natural color photography).

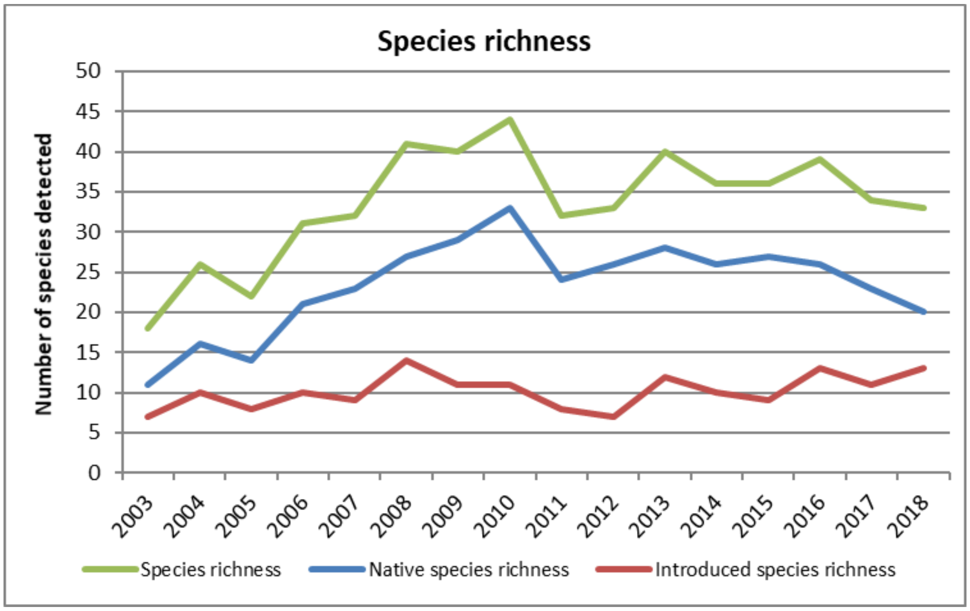


Figure 19. Plant species richness from 2003 to 2018.

Total percent cover by individual species, life-form (i.e., native or introduced shrubs < 1m, grasses, and forbs) and cover type (i.e., plants, litter, bare ground) of those species found in the understory layer are shown in Table F-2 in Appendix F.

Table 4 shows results from statistical tests comparing total cover over time for a number of understory and overstory vegetation parameters. There were significant changes identified in all cases ($P<0.05$). The multiple comparisons column summarizes years in which changes were identified, although every difference between each individual year was not included in this table to simplify interpretation of overall results.

Average total plant cover in the understory layer was variable over the course of monitoring, reaching a high of 79.5 percent in 2008 (Table F-2, Appendix F and Figure 22). From 2011 to 2018, total plant cover significantly decreased to levels comparable to those observed when monitoring began in 2003, which resulted in no difference between the first and last years of monitoring although plant cover was significantly higher from 2004 to 2010 (Table 4 and Figure 21). Total cover of plant litter was 4.4 percent in 2003 and remained relatively stable until 2007. Since 2008 litter cover has generally increased and peaked at 67.8 percent cover in 2012. Total litter cover was significantly less in the early years than in the later years (approximately 2010 to 2018) of monitoring. Total cover of bare ground decreased significantly over the monitoring period, from 63.5 percent in 2003 to 5.3 percent in 2017; bare ground was significantly higher in 2003 than in all other years (Table 4 and F-2, Appendix F).

Table 4. Statistical results analyzing total vegetation cover over time for various parameters. Alpha =0.05.

Total % cover	RM ANOVA[1] Test statistic(df), P-value	Multiple comparison[2] Summary of significant differences between years
Understory layer (2003-2018)		
Plant	F(15)=26.72, P<0.001	2004-2010 > other years
Litter	F(15)=69.33, P<0.001	2003-2009 < 2010-2018
Bare	X^2(15)=132.10, P<0.001	2003>other years
Native understory	F(15)=20.11, P<0.001	2003 < 2004-2010; 2005-2010> 2011-2015
Introduced understory	X^2(15)=83.37, P<0.001	2004-2006 > 2015-2018
Overstory layer (2007-2018)		
Native overstory	X^2(11)=85.06, P<0.001	2007<other years
Introduced overstory	X^2(11)=101.86, P<0.001	2007-2012 < 2014-2018
Total overstory	F(11)=50.01, P<0.001	2007-2013 < 2014-2018

[1] RM ANOVA = One-way Repeated Measures ANOVA for normally distributed data (test stat=F), Friedmann Repeated Measures ANOVA on Ranks for non-normal distributions (test stat X^2)

[2] Multiple comparison = Bonferroni t-test for normally distributed data, Tukey test for non-normal distributions.

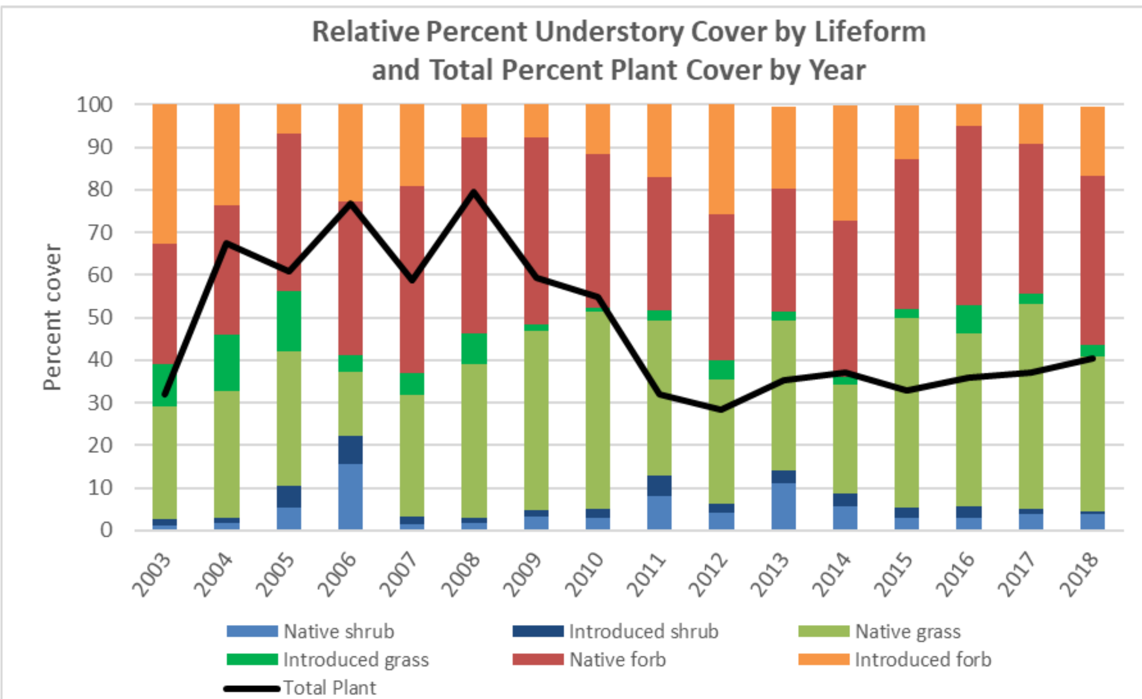


Figure 20. Relative percent cover by life-form and total plant cover (black line) in the understory layer from 2003 to 2018.

Relative plant cover by life-form in the understory from 2003 to 2018 is shown in Figure 21. Native and introduced forbs and native grasses have been the predominant life-forms throughout monitoring with some shift in proportions from year to year. Understory shrub cover in 2006 (the year before measuring overstory as a separate layer) was higher than other years (Figure 21 and Table F-2). Shrubs over 1 m tall were still recorded in the understory yet this was the point that shrubs began reaching greater heights. All size classes of shrubs were included in 2006, which most likely led to higher values for understory shrubs than was truly representative. The regeneration of woody species, as represented by shrub cover in the understory layer, has remained stable over time with coyote willow and saltcedar typically the most common shrub species detected (Table F-2). Native and introduced shrub species were relatively close in cover values, with native species generally having slightly higher cover in the understory layer. Native woody species (particularly coyote willow and cottonwood) have been more successful in maturing to the overstory layer.

Total percent cover, frequency of detection and average height of overstory species (woody species > 1 m in height) are listed in Table F-3, Appendix F; Figure 22 summarizes relative cover of the six most common species out of a total of eight detected. The total cover of all species is also included and represented by the black line. Height estimates were gathered by measuring the tallest plants within a continual expanse per species and therefore do not represent average heights of the stand but provide a consistent comparison from year to year.

The total cover of native overstory species was significantly lower in 2007 (30.6 percent) than in other years and total native cover was 90.6 percent by 2018 (Tables 4 and F-3). Rio Grande cottonwood has continued to be the dominant woody species in the overstory canopy followed by coyote willow (Table F-3 and Figure 23). Total cover of introduced woody species was significantly greater in the later years of the study (approximately 2014 to 2018) than in earlier years and ranged from 4.9 percent in 2007 to 31.9 percent in 2018 (Tables 4 and F-3). This increase appears to be due to an increase in Russian olive, which has expanded from 1.1 percent total cover in 2007 to 21.5 percent in 2018 while saltcedar has remained relatively stable ranging from 5.7 to 9.7 total percent cover over the years (Table F-3). The overall transect canopy cover when accounting for overlap of species was significantly greater from 2014 to 2018 than in previous years, peaking at 90.4 percent in 2017 (Tables 4 and F-3 and Figure 22). Total canopy cover has followed a similar pattern to native overstory species since native species make up the majority of overstory canopy.

Figure 23 shows the frequency of detection (*i.e.,* the percentage of transects in which the species was documented) for the six most common overstory species. This data provides information on the distribution of the plant species. Cottonwood, coyote willow, and saltcedar were found in most transects over the monitoring period. Goodding's willow was typically detected in approximately a quarter of the transects, though peaked at 60 percent frequency in 2009. Frequency of Siberian elm has been gradually increasing since 2011 but remained relatively low. The most noticeable change has been in the spread of Russian olive, which was only found in 17 percent of plots in 2007 and was detected in all transects by 2016.

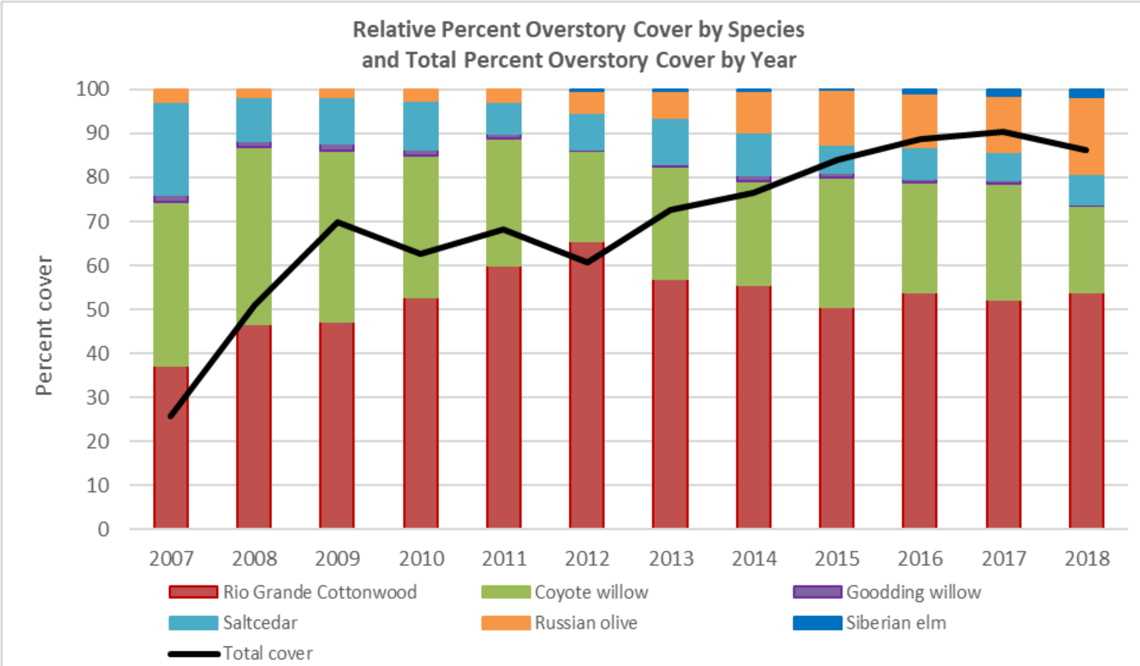


Figure 21. Total percent cover of overstory species (woody species > 1 m) by species from 2007 to 2018.

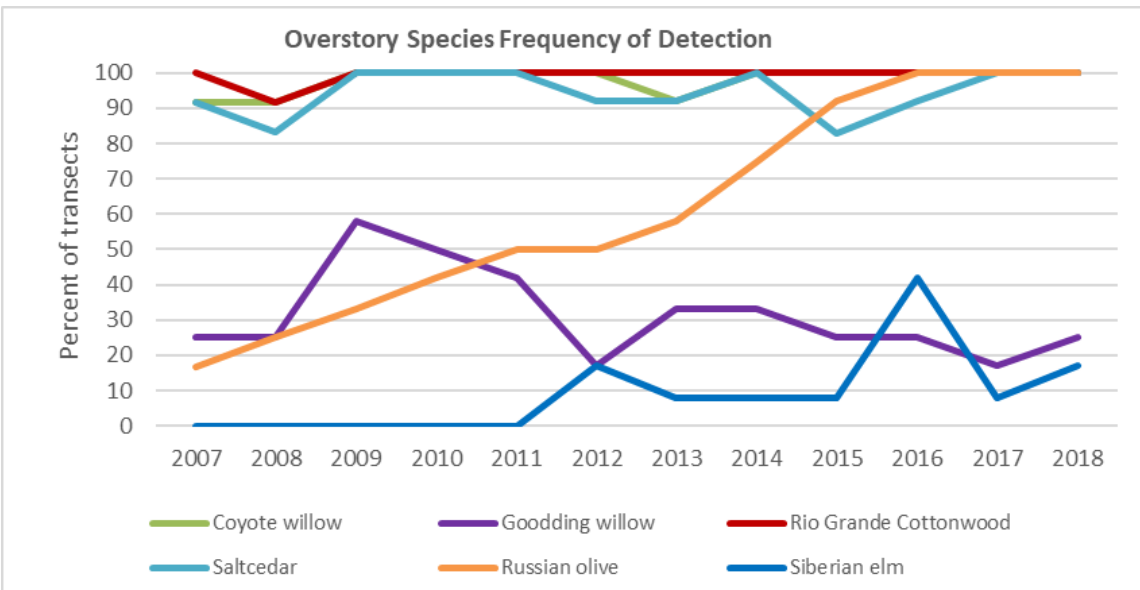


Figure 22. Percentage of transects in which overstory species were detected from 2007 to 2018.

Analysis using a Bray-Curtis similarity matrix was used to compare both understory and overstory plant species composition. In the understory, a significant difference in the species matrix was identified between years ($R=0.614$, $P<0.001$); pairwise testing identified the highest similarities between years 2011 through 2015 and 2018. In general, these results are illustrated in the MDS configuration in Figure 24. In this case it can be interpreted that the plant species mix in 2005 was less similar than that of all other years of monitoring. There was also a large difference in the collection of species detected from

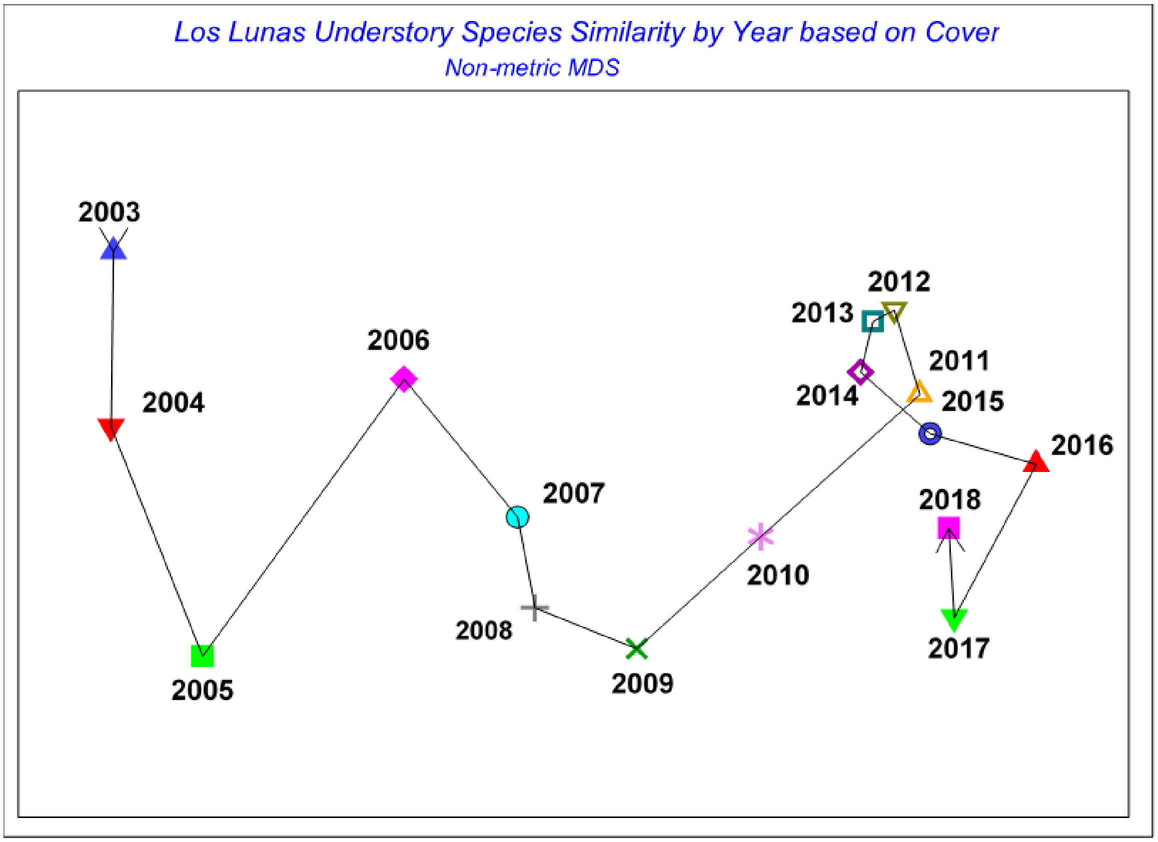


Figure 23. MDS ordination of 16 years of understory plant species 4th root transformed cover data based on Bray-Curtis similarities (stress=0.06).

when monitoring began to the present. Stress is the measure of distortion in the configuration. A stress factor of <0.5 gives an excellent representation; MDS analysis of understory species data had a 2-demensional stress factor of 0.06. The line between years illustrates the degree and relative change in species composition each year (i.e., a very continual progression from 2003 to 2018 with the species matrix becoming more similar beginning around 2011).

A significant difference was also identified for overstory species composition between years (R=0.288, P<0.001); pairwise testing found the highest similarities in the species mix from about 2013 through 2018. Figure 25 shows the MDS ordination for overstory species (stress = 0.01), which generally illustrates relatively large differences in composition in earlier years as compared to later years, becoming closer in distance (i.e. more similar) starting around 2009. Size of overlay circles associated with each year represent average percent cover of the 4 dominant overstory species each year. Total cover of the 4 species has increased with time, with generally less of an increase in saltcedar cover than in the other species.

Perennial pepperweed – a noxious weed ¬ has been documented at LLRS over the years but occurrence of the species has decreased. By 2018, only small patches throughout the site were observed. Russian olive is another invasive plant detected within the site; cover of this species has expanded over time.

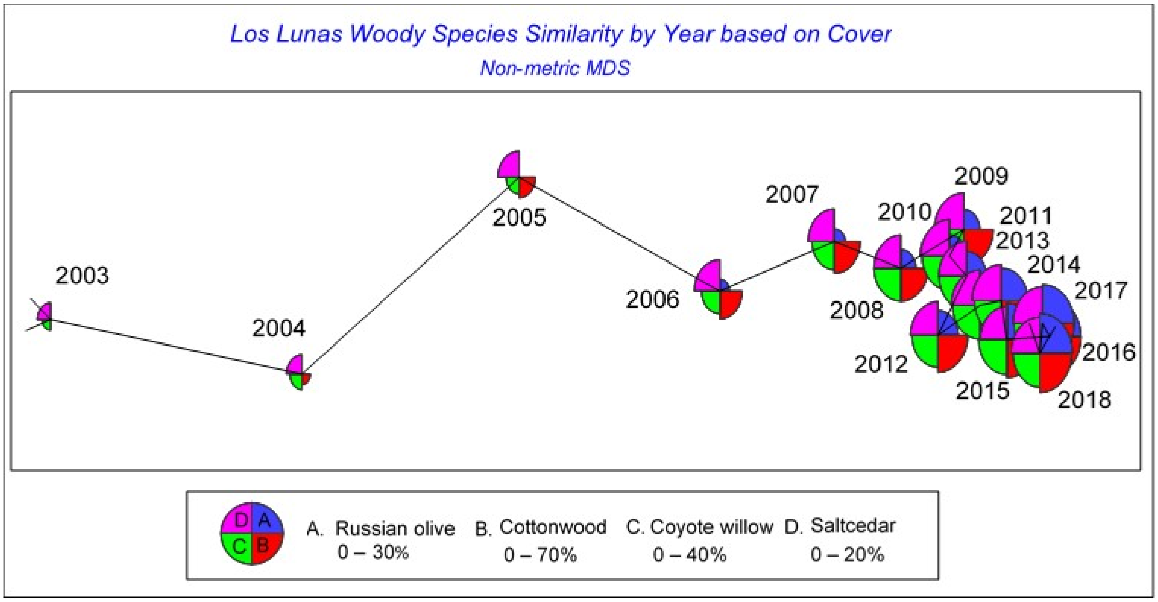


Figure 24. MDS ordination of 16 years of woody plant species 4th root transformed cover data based on Bray-Curtis similarities (stress=0.01). Overlay circles associated with each year represent percent cover of 4 dominant overstory species.

Vegetation Quantification Plots

Mean values of data collected at LLRS sites that were within 0.5 standard deviations of mean values collected at selected nest sites (i.e. reference sites selected from the original 112 nest sites to represent what are probably the most feasible conditions for the LLRS) were considered "suitable" for breeding SWFLs. Because the selected nest sites did not represent optimal habitat conditions, interpretation of this data required applying professional knowledge in some cases. Of the 24 variables analyzed in this study, 11 (46 percent) were similar to reference site values in both the Cleared/Overbank Area and the Burned Area (values highlighted in red in Table 5), although the variables that were similar were not always the same for both areas.

In the Cleared/Overbank Area, vegetation cover in the 3-6 m interval and the composition of trees in size Class 2 (10-19.9 cm DBH) met "suitable" criteria as compared to the reference sites (Table 5). Cover in the 0-3 and greater than 6 m interval, as well as the composition of trees in size Class 3 (greater than 20 cm DBH) were found to be too high, while composition of trees in size Class 1 (5-9.9 cm DBH) were found to be too low to qualify as "suitable" SWFL habitat. Tree stem density, trees species composition, and tree heights generally met suitability standards of the selected nest sites however the percentage of cottonwood in species composition in the Cleared/Overbank Area was much higher than in the reference sites. No saltcedar was detected in the tree layer within the Cleared/Overbank Area, which resulted in composition of this species being too low to be considered suitable. This outcome was related to the reference sites that were used; the selected sites had a much higher percentage of saltcedar than optimal habitat, such as that found in the delta in the original study. Ideally, a low percentage of saltcedar would not be considered a limiting factor in habitat suitability.

Table 5. Summary of data gathered at SWFL nest sites (2004 to 2006) and LLRS sites (2018). Values in parentheses following nest means are "suitable" habitat ranges (+/- 0.5 sd). Red values for LLRS sites are within "suitable" range compared to nest reference sites in selected reaches.

Vegetation parameter	Selected Reaches Nest sites mean (n = 22)	LLRS Cleared/OB Area 2018 mean (n = 3)	LLRS Burned Area 2018 mean (n = 3)
Mean Cover Value (%)			
0 – 3 m	37.5 (29.1 to 45.9)	46.6	37.6
3 – 6 m	37.4 (28.7 to 46.2)	29.4	57.6
>6 m	13.9 (8.9 to 18.8)	24.2	39.3
Shrub Stem Density (#/m2)	5.6 (4.1 to 7.2)	2.7	1.6
Shrub Species Composition %			
Goodding's willow	1.4 (0 to 3.9)	0	0
Coyote willow	16.9 (3.4 to 30.4)	70.4	41.5
Rio Grande cottonwood	2.3 (0.8 to 6.4)	19.0	0
Saltcedar	50.24 (28.6 to 71.9)	2.7	14.4
Russian olive	26.3 (11.0 to 41.5)	7.2	44.1
Tree Stem Density (#/ha)	2,782 (1,979 to 3,586)	2432	1459
Tree Size Class Composition %			
Class 1 (5-9.9 cm DBH)	78.7 (71.0 to 86.4)	41.0	61.5
Class 2 (10-19.9 cm DBH)	18.9 (12.5 to 25.3)	17.0	23.3
Class 3 (≥ 20 cm DBH)	2.4 (0.8 to 4.0)	42.0	15.2
Tree Species Composition %			
Goodding's willow	5.5 (0 to 12.3)	0.3	12.7
Coyote willow	0.8 (0 to 2.2)	0	0
Both willow species	6.3 (0 to 13.1)	0.3	12.7
Rio Grande cottonwood	7.4 (0 to 14.9)	41.3	1.3
Saltcedar	49.1 (28.6 to 69.7)	0	58.6
Russian olive	37.2 (17.2 to 57.2)	21.4	42.2
Average Tree Height (m)			
Goodding's willow	9.5 (8.3 to 10.7)	8.3	10.5
Coyote willow	6.6 (6.0 to 7.2)	NA	NA
Rio Grande cottonwood	8.8 (7.6 to 10.0)	8.5	13.5
Saltcedar	6.8 (5.9 to 7.6)	NA	6.5
Russian olive	7.2 (6.5 to 7.8)	7.3	6.7

Habitat quality within the Burned Area was determined to be similar to the Cleared/Overbank Area with a few differences in the variables that met suitability criteria. Vegetation cover within the 0-3 m interval fell within the range considered to be suitable but cover in the 3-6 m interval did not. Tree density was found to be lower than in the reference sites. The percentage of Goodding's willow in the tree species composition (12.7 percent) of the Burned Area was too high to meet suitability standards. This result, however, can also be attributed to the reference sites that were used, which were characterized by a much lower percentage of Goodding's willow than is typical in optimal SWFL habitat where this plant species is a very desirable component. As discussed, the selected sites were chosen based on vegetation development that has the most potential at the LLRS site. The abundance of Goodding's willow in the upper reaches of the MRG is much less than in the delta of Elephant Butte Reservoir (where the majority – but not all – nests are detected). Realistically, it is unlikely that cover and density of this species would be too high to provide suitable SWFL breeding habitat.

Groundwater Monitoring

Monthly Well Monitoring

Regular monthly well monitoring began in September 2004. The depth (in inches) below the ground surface to water at each well for each reading from June 2004 to October 2010 is summarized in Table G-1 in Appendix G. Data were used to create hydrographs that also included river discharge at the Rio Grande floodway in San Acacia, New Mexico (2003 to 2007) and at the Bosque Farms gauge (2008 to 2010; Figure H-1 in Appendix H). Discharge data collected near Los Lunas show flows in the Rio Grande are typically highest around April and May and lowest from July to September.

Within each transect (North, Middle, South as shown in Figure 3) groundwater levels varied. Water level within all wells was at ground surface level when discharges peaked around 4,600 cfs in May and June 2005. Wells along the South transect showed the largest differences in groundwater depth between wells compared to the Middle and North transects. The well nearest to the river (S1) was the shallowest and was rarely dry during monthly monitoring (Table G-1 in Appendix G). Groundwater at this well was less than 10 inches from the surface when discharges were greater than around 3,100 cfs and groundwater more than 50 inches from the surface when discharge fell below about 400 cfs. Well S2 (Figure 3) was typically dry at 61.5 inches during summer months (July-September) when river levels generally drop below 400 cfs.

The water table along the Middle transect was the shallowest measured, with Wells M1 – M3 rarely dry during monthly monitoring. The two wells nearest the river (M1 and M2) reached surface level when discharge was above approximately 3,200 cfs. The three wells nearest the river (M1-3) were relatively similar in groundwater depth, with groundwater at 15 inches or less from the surface when discharges were between 2,000 and 2,500 cfs. These wells only fell to more than 50 inches from the surface when the river was essentially dry.

Unlike the South and Middle transects, groundwater in the two wells nearest the river along the North transect where soils were sandy (N1 and N2) was generally deeper than in the two westernmost wells (N3 and N4). Clay soils at wells N3 and N4 most likely created shallow water table conditions and Well N3 was only dry in September 2003 and 2004 during monthly monitoring. When river discharge was between 3,200 and 3,500 cfs, groundwater depth was less than 10 inches from the surface in the shallower wells while the deeper wells were between 12 and 17 inches from the surface. The two shallower wells – N3 and N4 – only fell below 42 inches from the surface when the river was essentially dry.

Data Logger Well Monitoring

In June 2011, HOBO data loggers were installed. Groundwater data and river discharge at the gauge near Bosque Farms from June 2012 to August 2018 are graphed and included in Appendix H. Conditions were much dryer from 2011 to 2013 in the region, with peak flows only reaching about 1,700 cfs in April 2012. Flows rarely exceeded 750 cfs and the water table never reached the surface during this period.

Wells showed similar patterns in relative groundwater depth when comparing data from HOBO water level loggers with monthly data. Groundwater continued to be deepest at Wells S2, N1 and N2 with wells dry when river levels dropped below about 100 cfs. Well S2 was dry for most of the September 2012 to September 2013 period. All wells were dry from approximately August to November 2012. A missing HOBO logger in Well N1 resulted in no data from September 2012 to September 2014.

In July 2013, monsoons and associated increases in river discharge led to responses in groundwater level in all wells, though depths to groundwater and the length of time wells held water varied. Flows were much more consistent in 2014, with several peaks between 750 and 1000 cfs. The river was never dry and all wells held water throughout the year with the exception of Well S2 (groundwater present only when flows peaked) and Well N2 (rarely dry during summer months). Loggers were refurbished and not operating from December 2014 through February 2015; therefore no data are available over this period.

Flows were also fairly continual in both 2015 and 2016 with highest flows much higher than in recent years – between 1,500 and 3,000 cfs. All wells held water during the monitoring period with the exception of Well S2, which was typically dry at 5.1 ft when flows fell below around 250 cfs. Wells M1, M3, N3, and S1 were less than 1.0 ft from the surface when flows peaked at 3,000 cfs in 2015. The Well M2 logger malfunctioned and no data were available for 2015. Loggers from Wells M1, M3, N1, N3, and S1 were missing in 2016 and no data were available until October 28, 2016.

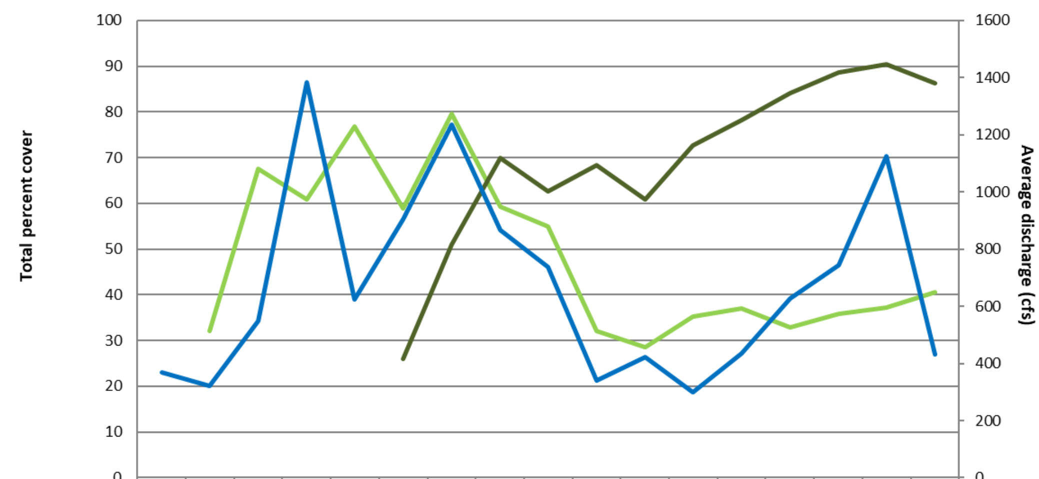
River discharge was higher in 2017 than in the other years in which data loggers were employed, with flows ranging from 2,200 to 4,500 cfs between mid-March and mid-June and ranging from 500 to 1,500 cfs from November 2016 to March 2017. All of the M and S well sites were flooded when flows reached between 3,500 and 4,500 cfs; groundwater in Well N-3 was near the surface at these same flow levels and groundwater in Wells N-1 and N-2 were between 1.0 and 2.0 ft from the surface. Wells M1-3 and N3 held water throughout the year; the other wells were typically dry in September and October 2016 and throughout the month of July 2017.

Finally, flows in 2018 were similar to 2015 and 2016 in that the highest discharge was recorded at 3,000 cfs and the river flowed throughout the year between 100 and 1000 cfs. Average annual discharge in 2018 (432 cfs) was closer to the 2014 value (436 cfs) than to the 2015 (627 cfs) and 2016 (745 cfs) average discharge rates. Most wells held water over the data collection period at depths ranging from 2 to 5 ft from the surface with the exception of Wells S-1, S-2, and N-1, which were dry from March or May until

September 2018 when flows fell below 500 cfs. Well M-2 was shallowest, with depths ranging from 1 to 3 ft.

The level of groundwater at the LLRS correlated closely with flows in the river, indicating a hydrologic regime influenced by the riverine system at the site (Appendices G and H). River discharge (which represents groundwater levels because the two were so closely linked) and vegetative cover are graphed in Figure 26.

Data loggers provided enough detail to discern diurnal fluctuations in the water table. Figure 27 shows two examples of these fluctuations during relatively dry conditions from September 2013 through August 2014 (A) and during wetter conditions from September 2016 through August 2017 (B). Groundwater fluctuated anywhere from 0.3 to 18.0 inches/day from 2013 to 2014 and from 0.2 to 8.4 inches/day from 2016 to 2017 at Well M2.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Avg understory cover		32.1	67.5	60.9	76.9	58.8	79.5	59.3	55.0	32.0	28.5	35.3	37.1	32.9	35.9	37.3	40.5
Avg overstory cover						25.9	51.1	70.0	62.7	68.3	60.8	72.6	78.2	84.1	88.6	90.4	86.3
Avg. annual discharge	368	322	547	1382	625	905	1236	867	739	341	421	298	436	627	745	1125	432

Figure 25. Hydrologic year (Oct–Sept) average discharge (cfs) in the Rio Grande at San Acacia (2002-2007) and at Bosque Farms (2008-2018), and the average total percent plant cover in transects at the LLRS. Restoration occurred in 2002; vegetation monitoring began in 2003. Overstory was not a separate cover measurement until 2007.

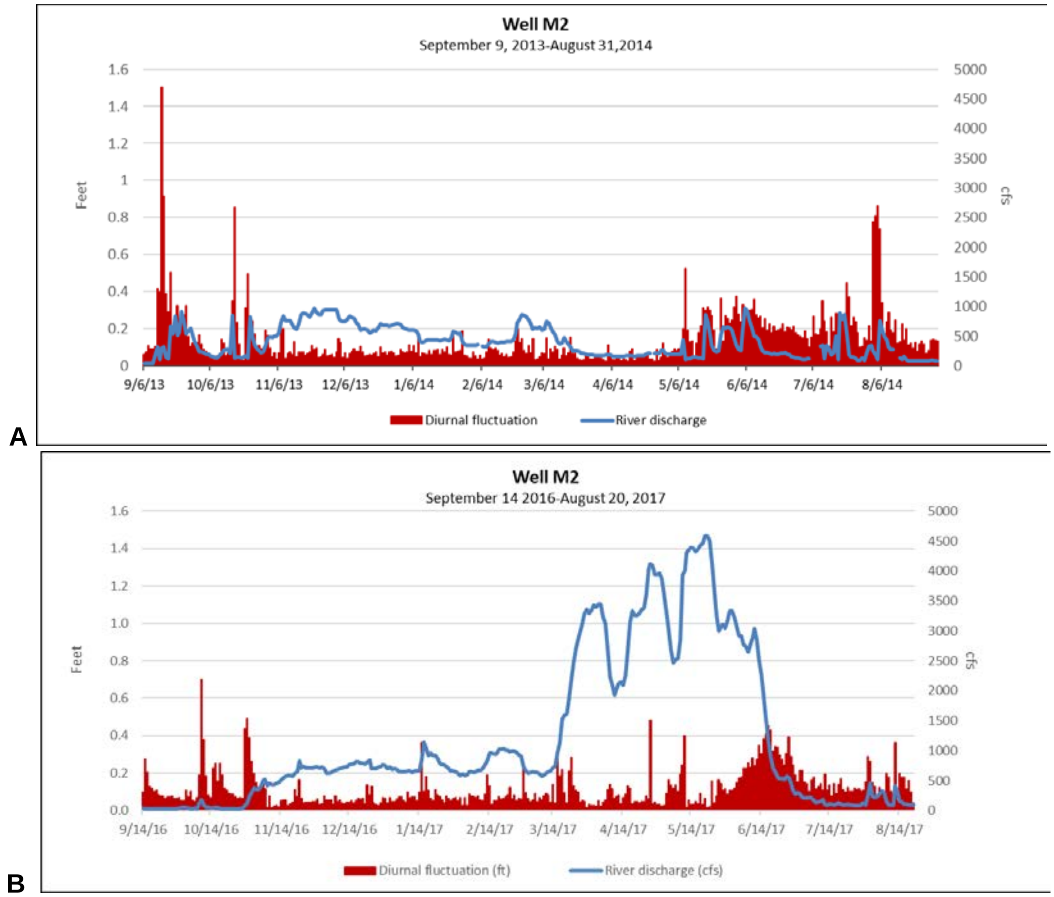


Figure 26. Examples of diurnal fluctuation (ft) within Well M2 and average discharge (cfs) in the Rio Grande at Bosque Farms, New Mexico from September through August (A) 2013-2014 and (B) 2016 – 2017.

Discussion

Avian Monitoring

Point Counts

Cleared/Overbank Area

Using the Burned Area for comparison, it appeared that desirable bird habitat developed over time within the Cleared/Overbank Area. By 2007, which was 5 years following restoration activities, the Cleared/Overbank Area had significantly higher numbers of dense shrub birds than the Burned Area. In 2008 – 6 years after restoration – relative abundance became either statistically equal or greater than the Burned Area within all guilds except the mid-story guild, which had consistently greater abundance in the Burned Area. By 2010, relative abundance of mid-story species was equal between the two areas and remained equal to or greater than the Burned Area through 2018. The total number of birds in the Cleared/Overbank Area was equal to or greater than in the Burned Area beginning in 2011. Species composition also became very similar between the two areas beginning in 2011 (Figure 16). From 2014 – 12 years following restoration – to 2018, the Cleared/Overbank Area was statistically equal or significantly greater than the Burned Area in relative abundance of all bird guilds.

Increasing trends in relative abundance and species richness for cavity, dense shrub, and mid-story species guilds were consistent with the development of vegetation within the Cleared/Overbank Area, i.e., as the cover and height of vegetation have increased (see Figure 28), so have the number and types of birds. Decreasing trends for opening and water birds were also consistent with habitat development patterns for these guilds; as the more open habitat required for these species has been replaced with denser vegetation, numbers of these birds have decreased.

Although most of the bird guilds in the Cleared/Overbank Area showed significant changes during the monitoring period, only relative abundance in the mid-story guild was found to show a strong statistically significant relationship with time ($R^2 = 0.5600$), increasing from 2003 to 2018 (Table 1). The brown-headed cowbird was the most abundant species detected among mid-story birds until 2009, when the mean number of cowbirds detected per point dropped considerably. The brown-headed cowbird uses brood parasitism as a breeding strategy, which can reduce the productivity of host nests. Therefore, its decline may have been beneficial to other avian host species. Other mid-story species (e.g., black-headed grosbeaks, spotted towhees, and yellow-breasted chats) have increased, replacing the brown-headed cowbird as the dominant species in this guild. From 2003 to 2018, relative abundance of mid-story species increased from 0.17 to 5.22 birds/point and species richness increased from 3 to 10 (Table D-1), which are favorable trends for this site. The mid-story bird guild is an important indicator for both the SWFL and YBCU because these species use mid-story nesting habitat.

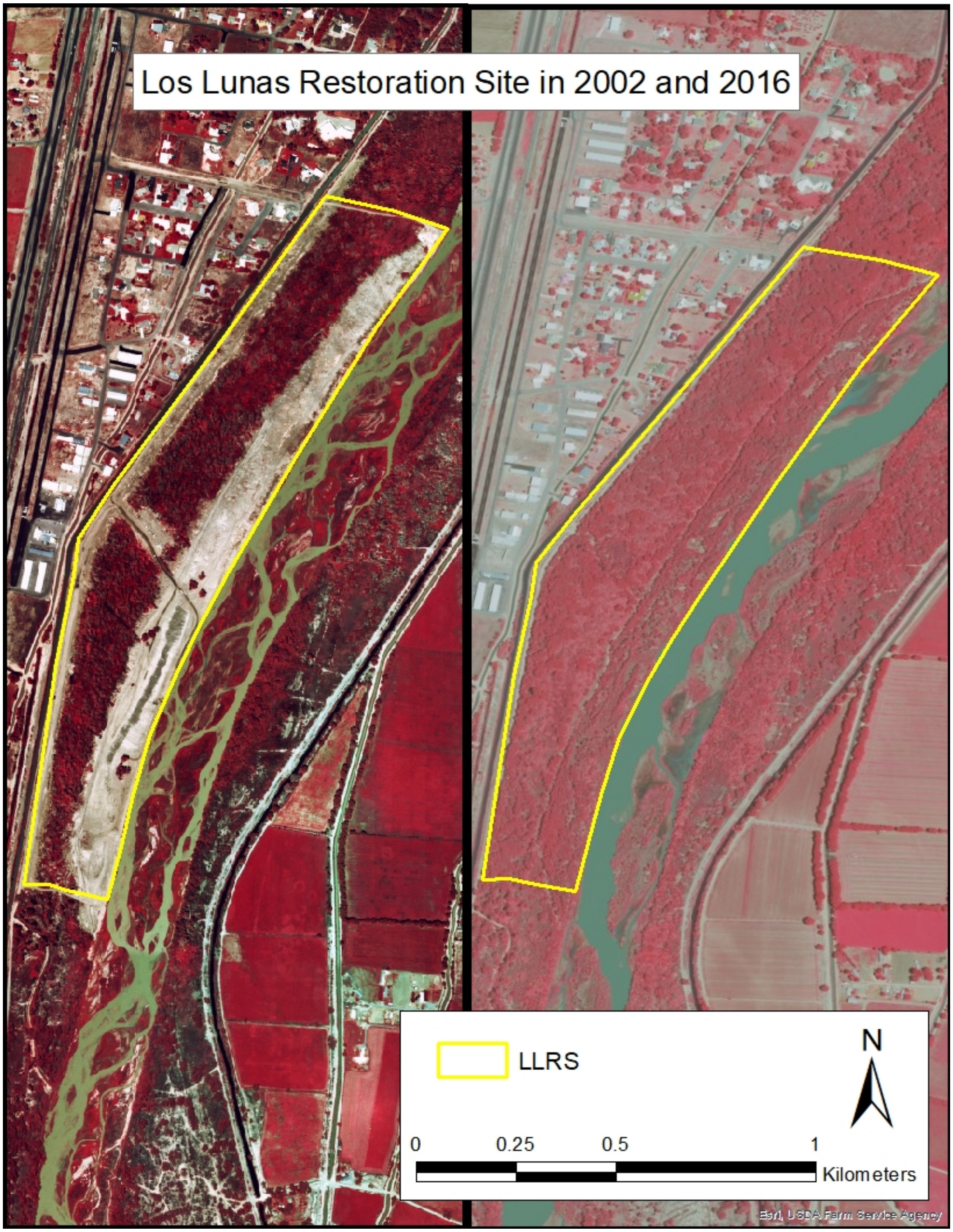


Figure 27. Development of vegetation at the LLRS as seen in 2002 immediately after the site was cleared (left) and in 2016 (right).

While the total number of birds in the Cleared/Overbank Area increased significantly from 2.75 birds/point in 2003 to 8.11 birds/point in 2018, only a weak linear relationship (R^2 =0.0879) was identified due to changing habitat and fluctuating bird abundance. Relative abundance both increased and decreased over the study period as some habitat types declined while others became more developed. The number of total birds was closely linked to the number of water birds in this area until approximately 2009 (Figure 9). For example, the number of water birds peaked in 2005, when the LLRS was flooded, as did total number of birds. As vegetation in this area developed, habitat was less conducive to water birds. From 2009 to 2018, relative abundance of total birds closely correlated with the trend in mid-story birds (Figure 9).

Burned Area

Results for the Burned Area were variable, indicating increasing and decreasing trends in both relative abundance and species richness among bird guilds, although none of the guilds showed exceptionally strong statistically significant relationships between abundance and year. This suggested that changes in bird populations may not have been strictly temporal and could have been caused by other factors affecting the site. A number of cottonwood snags have fallen since point counts were initiated, which changed the habitat somewhat and could be related to decreases in canopy birds detected. Relative abundance of mid-story birds was relatively high (4.69 birds/point) in 2003, three years after the fire. The average number of mid-story birds detected per point consistently decreased through 2010 when relative abundance was 2.64 (Table D-2 and Figure 14). This was approximately the same period that mid-story bird abundance in the Cleared/Overbank Area began to steadily increase. Relative abundance of mid-story birds has increased since then, ranging from 4.19 birds/point in 2011 to 3.47 in 2018. The relatively high abundance of birds in this guild within both areas could be related to the development of habitat within the entire project area that is attracting more mid-story species in general. The total number of birds within the Burned Area has decreased over the monitoring period, from 8.89 birds/point in 2003 to 5.78 in 2018.

Willow Flycatcher and Yellow-billed Cuckoo Surveys

It appeared that suitable habitat existed within sites adjacent to LLRS between the Los Lunas and Belen bridges based on the occurrence of one SWFL territory in 2011, 2012, and 2013 and three territories in 2018 (Moore and Ahlers 2019). Associated nests were successful in producing fledglings in 2012 and 2013; nest outcomes were unknown in 2018. Much of the riparian habitat in the Belen survey reach is suitable as stopover habitat for migrating WIFLs as confirmed by presence/absence surveys. The number of resident SWFL territories detected within the entire reach has increased from 0 in 2009 to 20 in 2018. The majority of 2018 SWFL territories were found roughly 12 miles downstream of LLRS. This comprises the closest breeding population that could serve as a source for SWFL dispersal into the LLRS, where breeding SWFLs have not yet been detected.

Since formal surveys began in 2014, one YBCU was detected within the LLRS project site in both 2014 and 2015 and two YBCUs were detected within the entire survey site in each of those years. There were 41 YBCU detections within the entire Belen Reach in 2018; the nearest to the LLRS was approximately 1.5 RM upstream. Seven territories were estimated to occur in the reach with the nearest located around 9.5 RM downstream. The presence of YBCU indicated the species was using habitat near the LLRS, but perhaps not for breeding purposes.

Vegetation Monitoring

Vegetation Transects

A number of factors are important to the success of cottonwood/willow riparian forest restoration. These factors include soil conditions, such as salinity levels and texture, availability of native seed source, timing of high flows and flooding, and groundwater depth.

Alluvium texture is of primary importance in determining which plant species will succeed (Dreesen et al. 2002). Lotic systems are characterized by fast moving water that deposits coarse alluvium of low fertility and high aeration. In contrast, lentic systems deposit fine alluvium (silts and clays) with higher fertility and less aeration. In general, lotic systems are conducive to the establishment of woody riparian trees and shrubs, while lentic systems are suitable for herbaceous wetland and marsh plants. The LLRS is a lotic system, as is the Middle Rio Grande bosque in general, although there are microsites where herbaceous wetland plants have established in depressions where silts and clays have deposited. In a restoration project on the Bosque del Apache National Wildlife Refuge (BDANWR), downstream of the LLRS, there was virtually no cottonwood germination in areas dominated by clay soils (> 65% clay), while regeneration of native species was greatest in sand deposits resulting from secondary channel development (Sprenger 1999) indicative of lotic systems.

Native species dominate the LLRS, particularly in the overstory, with cottonwood, coyote willow, and Goodding's willow present in the forest canopy. In the monitoring area, these species naturally re-established, indicating that a sufficient seed source was available on site. These species continue to regenerate, as is represented by shrub cover in the understory layer. Saltcedar and Russian olive are also re-establishing at the site. Saltcedar appeared to be outcompeted by native willows and cottonwood which is a very positive outcome considering that saltcedar dominated the site when it was cleared, meaning there was an abundant seed source and resprouting potential for this species. The total percent cover of saltcedar after 16 years of monitoring was 0.3 percent in the understory (an indicator of the rate of regeneration) and 8.5 percent in the overstory, which is relatively low compared to other areas adjacent to the site. Evidence of *Diorhabda* spp. was detected in and around the LLRS in 2014 (Figure 29) and was apparent in photographs from photo stations 7 through 9 in 2016 (Appendix I) but interestingly not in photos from 2017 and 2018. This beetle was released in 2001 at

Figure 28. Evidence of *Diorhabda*, a biological control beetle that was released in the Southwest to manage saltcedar, was first observed in the LLRS in 2014.

several sites across the Southwest as a biological control for saltcedar and is spreading into areas beyond its predicted range, including the Middle Rio Grande. The effects from *Diorhabda* could potentially reduce saltcedar, an outcome that monitoring would detect. Saltcedar that fell within the vegetation transects did not show signs of beetle forage from 2014 to 2018. Russian olive, another introduced species, has increased in cover overtime and composed an average of 22 percent total overstory cover in 100 percent of the transects in 2018. The spread of this species at the site appears to be more of a concern than that of saltcedar, and control may be warranted.

Of course, although a local natural seed source is important to successful restoration, it must be combined with hydrologic conditions optimum for cottonwood and willow regeneration and establishment. A restoration site in the urban Albuquerque reach of the Middle Rio Grande used a design similar to the one implemented at LLRS by incorporating natural hydrologic processes; 10,000 cottonwoods/ha established at this site following overbank flooding as compared to a higher site out of reach of flooding in which no trees established following the same event (Muldavin et al. 2015). Not only is overbank flooding necessary, it must be timed with germination of willow and cottonwood seedlings. Investigations at the BDANWR proved that natural recruitment of willow and cottonwood was possible subsequent to over-bank flooding during peak river flows in late May and early June (Sprenger 1999). Flooding conditions at LLRS were apparently conducive to natural recruitment of native species, especially from 2005 to 2009 when average annual discharge rates were relatively high compared to other years (Figure 27). Water table decline should not exceed 1.2 inches per day for seedling recruitment and survival (Segelquist et al. 1993, Lines 1999, Taylor 2000, Shafroth et al.

2000), a criterion that was presumably met. Cottonwood and willow seedlings were detected early in the study, starting in 2003 which was the first year of vegetation monitoring. Establishment of woody species, however, was especially evident during the 2006 growing season, the year after extremely high river flows and prolonged flooding on site. The length of inundation from flooding also affects the ability of plants to germinate and sustain. Mortality of cottonwood seedlings completely submerged for 30 days was 100 percent in studies by Sprenger, et al (2001). Coyote willow, on the other hand, was found to survive after 2 months of inundation in New Mexico (USDA, NRCS 1998). Monthly groundwater well data collected early in this study did not provide enough detail to determine how long flooded conditions persisted at the LLRS. From 2011 to 2014, when more complete groundwater data was collected with HOBO logger instruments, no flooding occurred. Hydraulic modeling of the LLRS determined that discharge of 2,500 cfs (design goal) would cause extensive inundation of the site (Kissock 2010). The M1 well site was flooded for approximately 4 days in May 2015 when flows reached approximately 2,700 cfs. The Well M2 site was inundated for almost 3 weeks in June 2016 when flows sustained between 2,200 and 3,900 cfs, and again in 2017 when discharge rates sustained above 2,200 cfs from mid- March to mid-June and reached as high as 4,500 cfs (Appendix H). All of the M and S well sites were inundated in 2017, but the M2 Well site was flooded for the longest duration. Well M2 was located near the pond in the center of the project site where the water table was higher on average.

Depth to groundwater plays a key role in determining which riparian species will succeed in a restored site. The primary rooting zone for obligate riparian plants is the capillary fringe above the water (Dreesen et al. 2002). The thickness of the capillary fringe is controlled by soil texture, with finer textured alluvium having a broad zone of unsaturated soil with high moisture content. A thicker capillary fringe zone has a greater water content however it also has lower aeration resulting from less air-filled pores. Because woody riparian species generally require highly aerated soils, suitable restoration sites generally have a thin capillary fringe with lower water content but more air filled pores. Groundwater conditions at the LLRS are discussed in the Groundwater Monitoring section below.

Vegetation Quantification Plots

Based on observation, some portions of the Cleared/Overbank and Burned Areas may have developed riparian vegetation of suitable height, density, and structure to provide breeding habitat for the SWFL. Both avian and vegetation monitoring have indicated that the area has been productive in terms of developing native overstory inhabited by mid-story canopy birds, indicating SWFLs could potentially occupy the LLRS. Unfortunately, it is difficult to accurately assess the habitat suitability of a site for breeding SWFLs based solely on visual observations since the factors that appear to influence site selection are numerous and variable. Vegetation quantification data was collected within the LLRS in 2018 in an effort to evaluate habitat for SWFL breeding (Figure 4).

In 2007, sites in the Burned Area of LLRS were compared to similar data collected from sites downstream where SWFL nests were known to occur (Moore 2009). At that time, vegetation at the Los Lunas site was found to be denser and of a younger age-class than sites where SWFL breeding took place. It was determined that the Los Lunas site would more closely approximate occupied SWFL breeding habitat in “a few growing seasons.” Based on visual observation, small isolated patches of vegetation likely reached structural suitability around 2010 within the Burned Area.

In 2015, three plots in the Cleared/Overbank Area were established and compared to selected nest sites sampled in 2004 through 2006 to determine the status of suitable SWFL breeding habitat within LLRS. In 2016, the vegetation quantification study was augmented to include three plots in the Burned Area.

Current conditions derived from 2018 data indicate the Cleared/ Overbank Area did not provide optimal SWFL habitat, particularly in relation to characteristics of the shrub layer and to tree cover and size (Table 5). Stem density in the shrub layer was low compared to the selected reference sites. Goodding’s willow was the only shrub species to meet suitability standards in composition, although results of this variable were misleading due to the reference sites used. The selected reference sites were chosen based on vegetation types that were more similar to potential development at the LLRS site and were characterized by a much lower percentage of willow species than is typical in optimal habitat. Consequently, Goodding’s willow met criteria at 0 percent of the composition. Similarly, Goodding’s willow in the tree layer met species composition criteria at 0.3 percent while saltcedar composition was considered to be too low at 0 percent. Importance of these species was not adequately represented by results; it is unlikely that cover and density of saltcedar would be too low and ideally Goodding’s willow would be a larger component in providing quality SWFL breeding habitat. Conversely, the high percentage of cottonwood in species composition was accurately identified as a limiting factor in this analysis.

In general, the vegetation in the Cleared/Overbank Area was more dense in the 0-3 m and greater than 6 m cover intervals and in the greater than 20 cm DBH size class than in reference sites, all indications that the stand may have been more mature than vegetation in occupied nest sites. On the other hand, the percentage of trees in the midrange of size and height (i.e. 10 to 19.9 cm DBH and 3 to 6 m tall) met criteria of reference nest sites, which could be correlated with the dominance of mid-story birds in the stand.

Vegetation quantification data collected within the Burned Area in 2018 was comparable to Cleared/Overbank data and suggested that although many conditions were met, SWFL habitat was not necessarily ideal. The biggest differences between the two sites were tree species composition, cover by layer, and overall tree density. Composition of all species were similar to reference site values with the exception of Goodding’s willow, which at 12.7 percent of the composition, was considered too high to be suitable habitat. Again, this was a result of reference site conditions in which Goodding’s willow was poorly represented; it is doubtful that cover and density of this species would be too high to provide suitable SWFL breeding habitat. Another difference between the two areas was that percent cover in the understory layer (0-3 m) met suitability criteria whereas the percent cover in the upper 2 layers was too high. Also, tree stem density was too low to meet reference site suitability.

Although almost half of vegetation variables were met in both avian monitoring areas, species composition, high cover of trees greater than 6 m, and low proportion of trees in the smallest and largest size classes were common factors that appeared to limit habitat quality in the LLRS (Table 5). The high percentage of cottonwood in the Cleared/Overbank Area may inhibit development of optimum SWFL habitat in the likelihood that the site matures into a cottonwood gallery. However, cottonwood is a desirable component in YBCU habitat and may attract the species to the LLRS, most of which is already categorized as suitable YBCU breeding habitat (Figure 19). The amount of vegetation quantification plot data collected was limited (n= 3 per area), although plots were initially located in habitat that appeared to be a good representation of suitable SWFL habitat.

Southwestern willow flycatcher habitat suitability modeling in 2016 determined the LLRS site to be mostly Moderately Suitable (approximately 77 acres) with some Unsuitable (approximately 42 acres within the Burned Area) based on Hink and Ohmart (1984) vegetation classification (Figure 20; Siegle and Ahlers 2017). The Cleared/ Overbank Area was characterized as a cottonwood overstory (15-40 ft average) with coyote willow and saltcedar in the understory. Vegetation types in the Burned Area were more variable, with cottonwood 15-40 ft over Russian olive and saltcedar in the northern portion; vegetation in the southern portion was classified as cottonwood greater than 40 ft over Goodding’s willow-coyote willow and as Russian olive-saltcedar 15-40 ft over coyote willow. All vegetation types within the LLRS were estimated to have aerial cover greater than 50 percent. The drawback with using Hink and Ohmart classification is that the density and structure by layer is unknown based solely on the label. In this case, the vegetation quantification data provided detailed information. Both types of data appear to indicate that although conditions provide fairly good SWFL habitat there are still limitations.

Groundwater Monitoring

Groundwater depth at the LLRS correlated closely to Rio Grande flows (Appendices G and H), indicating that connectivity between the shallow aquifer and the river is still functioning despite management activities that could potentially impact hydrologic processes such as channelization, regulation of surface flow, groundwater pumping, and water diversions. Because flows influenced the water table depth, total percent plant cover also correlated with river discharge rates (Figure 26). There were shifts in understory vegetation composition (see 2005 and 2006 in Figure 21) as well as noticeable increases in growth in 2006 following the extended period of inundation in 2005. Flooded conditions led to germination and establishment of riparian plants (especially coyote willow and cottonwood as demonstrated in Table F-2, Appendix F). The relatively high discharge rates in 2008 did not lead to long periods of inundation, but did result in a high water table. These conditions provided plant available water and allowed for increased plant cover that year. Yearly discharge rates decreased after 2008 but steadily increased from 2014 to 2017; vegetative cover has generally followed a similar pattern.

Overstory cover remained somewhat stable from 2009 to 2013 despite decreasing discharge rates. This would suggest that by 2009, cottonwood and willow had developed a deep enough root system to sustain declines in the water table. Regardless, based on well monitoring data, it is unlikely that groundwater at the site has fallen below the crucial depth of around 10 ft necessary to sustain woody riparian species (Cartron et al. 2008). Most wells, which average around 5 ft in depth, were only occasionally dry, which indicated that the water table was relatively shallow at the site. On the other hand, vegetation did appear to be affected by prolonged dry conditions at the site. From 2010 to 2012, overstory foliage was observed to be rather sparse and leaves were dropping earlier than expected. This is supported by overstory cover values, which did not notably increase from 2009 to 2012. From 2013 to 2017 overstory cover has been gradually increasing along with increasing discharge rates although annual discharge decreased in 2018 with a slight dip in overstory cover.

The three wells nearest to the river and within (or near) the vegetation monitoring site show that groundwater is deeper in the northern section of the site. Groundwater depth did not appear to have a direct correlation with overstory vegetation cover, which was relatively consistent throughout transects. There was a small effect on species composition based on Hink and Ohmart vegetation types. Saltcedar was prevalent enough to be included in understory classification in the southern section where the water table is shallower. These results imply that although the water table falls below well depth more frequently in the north, differences in groundwater depth are not great enough to result in large variability in vegetation.

Data from the HOBO water level loggers were collected every two hours from June 2011 through August 2018, which captured diurnal fluctuations in the water table (Figure 28). Diurnal fluctuation in shallow water tables is attributed to groundwater consumption by phreatophytes such as willow and cottonwood (Shah et al. 2007). The significant evapotranspiration (ET; evaporation from open water or soil and transpiration from vegetation) of phreatophytic plants influences the behavior of interconnected surface and groundwater systems. The water table, which declines rapidly during daylight due to ET, partially recovers at night. The recovery in the evening and night hours is attributed to lateral and vertical groundwater flow to the discharge area (Shah et al. 2007). As Figure 28 shows, in many cases a spike in river discharge also caused a spike in diurnal fluctuation, indicating that river flows were controlling fluctuations in well depth. In general, diurnal fluctuations were highest during the growing season (approximately May through September), which is a representation of plant ET at the site.

Groundwater depths can influence the ET of surrounding plant species. Transpiration by mature cottonwood is unaffected when the water table is within 3 m of the surface (Cleverly et al. 2006). When groundwater is drawn down deeper, transpiration declines with increasing crown dieback. Goodding’s willow is found in habitats similar to those of cottonwood; therefore Goodding’s willow ET is expected to respond to groundwater depth in the same manner as cottonwood (Cleverly et al. 2006). Conversely, coyote willow can tolerate dryer conditions, much like saltcedar, and ET from coyote willow is expected to respond more like saltcedar. Saltcedar transpiration is not dependent on a specific depth to groundwater as it is in cottonwood (Cleverly et al. 2006), although when changes occur in groundwater levels, saltcedar ET generally increases as groundwater falls deeper.

Data collected at LLRS is not specific enough to correlate individual wells with surrounding plant species. Another limitation is that wells do not go to depths that are found to inhibit ET of cottonwood and Goodding’s willow. Nonetheless, patterns in diurnal fluctuations are apparent. There is an increase in diurnal fluctuation during the growing season regardless of river discharge/groundwater levels, a phenomenon demonstrated in Figure 27 which includes both a wet and dry scenario. The most noticeable difference between the 2 conditions is that there are greater spikes in fluctuations when river flows are lower (i.e. water table is deeper).

Photo Stations

Photo Stations 1 through 5 were located along the berm and face east toward the river in the Cleared/Overbank Area where vegetation transects are located. Photos taken at these stations show considerable and steady growth in regenerating willow and cottonwood. In 2006, following flooded conditions in 2005, the establishment of woody species appears stable. By 2009, a definite overstory has developed. From about 2010 through 2012, foliage is noticeably affected by dry conditions and there is not an obvious growth in overstory species. In photos taken at Stations 6 through 10, which are located along the road and face east toward the Burned Area, the density of standing dead cottonwoods in the burned forest has noticeably decreased over the years as the growth of regenerating understory has increased. This is the area in which cottonwood poles were planted in 2004, and a healthy stand of cottonwoods is developing in this area. Saltcedar is also evident in many of the photos. In 2016 photos, foliar impacts to saltcedar from *Diorhabda* were distinct.

From 2010 to 2012, it was observed that leaves were already turning yellow and beginning to fall during monitoring in early to mid-September, which may have been due to an extended period of low precipitation and associated declines in river discharge (Figure 26). This condition is apparent in photos from these years. By 2013, despite continued drought, foliage is fuller and greener (which was supported by data that showed an increase in overstory cover this year).

Conclusion and Recommendations

Avian Monitoring

Conclusions

Avian relative abundance and species richness data have been collected for a 16-year study period at the LLRS in riparian habitat along the Middle Rio Grande. Monitoring has tracked the development of the avian population and of SWFL habitat suitability in the restoration area where established stands of native riparian vegetation bordering high flow channels was the desired future condition of restoration.

There were decreasing trends in relative abundance of total birds in both avian monitoring areas from approximately 2005 to 2009; overall, bird detections have decreased in the Burned Area (from 8.45 to 5.78) and increased in the Cleared/Overbank Area (from 2.75 to 8.11) from 2003 to 2018. Species richness has increased in both monitoring areas. The reasons for decreases mid-study are unknown, but regardless, and despite an insignificant decline in Burned Area bird abundance, riparian habitat in the LLRS currently appears to be supporting diverse avian populations.

The abundance and diversity of breeding cavity, dense shrub, ground shrub, and mid-story bird species in the Cleared/Overbank Area have increased during monitoring, resulting in an overall increase in total bird abundance. The mid-story guild serves as an indicator for SWFL and YBCU habitat. Since 2010, the number of mid-story species detections per point in the Cleared/Overbank has been either statistically equal to or greater than the Burned Area. The avian population in both areas (restored and burned) are dominated by mid-story bird species which suggests that vegetation shows potential for providing SWFL and/or YBCU habitat. Although the two species nest in mid-story habitat, specific requirements in vegetative conditions differ.

Based on avian data collected in this study, mid-story habitat became established by approximately 2010. Using the LLRS as a reference, it appears that it is possible for SWFL and/or YBCU habitat to develop within 8 years following restoration activities in the Middle Rio Grande. These results are dependent on environmental conditions that are favorable for successful restoration, as were present during development of this site. Using hydraulic and geospatial analysis, Kissock (2010) determined that the LLRS is "sustainable by continuing to provide habitat to endangered species targeted for habitat restoration (i.e. SWFL and minnow)."

Based on vegetation data collected specific to SWFL habitat, by 2018 certain variables related to overstory species composition and structure were not comparable to occupied nesting sites (nonetheless many conditions were met). Although samples were limited (n=3), this data does provide a general idea of limitations in SWFL habitat at LLRS. Avian point counts show an abundance of mid-story species, however, it is possible that vegetative conditions conducive to SWFL habitat in particular may not develop. On the other hand, it appears that habitat conditions may be conducive to breeding YBCU. Over the past several years, SWFLs and YBCU's have established territories in relatively close proximity to the LLRS, which could increase likelihood that they occupy the site in the future.

Important trends identified in avian studies at LLRS were the development of a diverse bird population and an increasing abundance of mid-story bird species, which provides a valuable measure of the success of restoration in developing terrestrial habitat to support the recovery of threatened and endangered avian species.

Recommendations

Requirements of the BO have been met, however this study continues to provide an information source for creating and monitoring riparian habitat. Further avian monitoring will help to determine if the LLRS can continue to sustain habitat for most bird guilds, especially for mid-story species that include the SWFL and YBCU. It is also important to document occurrence of breeding SWFLs at the LLRS to determine if suitable habitat has in fact developed, which was one of the objectives for restoration of this site. Although YBCUs were not a listed species when studies at the LLRS were initiated and therefore were not a focus in habitat restoration, it is important to document their presence and track development of suitable habitat, which appears to be a potential at this site.

Vegetation Monitoring

Conclusions

Vegetation monitoring data are being used to document:

1) the natural establishment of riparian vegetation in the disturbed areas
2) the establishment of wetland vegetation in depression areas
3) the possible establishment of noxious weeds and recolonization of exotics, and
4) rates of vegetation development for future SWFL restoration efforts.

Success of riparian restoration at the LLRS could also serve as a reference for other restoration sites along the Middle Rio Grande.

Riparian vegetation has successfully established in the Cleared/Overbank Area. Native species dominated the overstory and included coyote willow, Goodding's willow, and Rio Grande cottonwood. The wetland indicator status of both willow species is "facultative wetland" (i.e., usually occur in wetlands but may occur in nonwetlands) based on the National Wetland Plant List for the Arid West (USDA NRCS 2014). In the understory layer, native species also dominated the vegetation, although were not necessarily considered riparian plants. The native grass vine mesquite, for example, was the most common understory species detected at the site and is in the “upland” wetland indicator category. Plant species found in depressions, however, were categorized as “obligate wetland” (i.e. almost always occurs in wetlands, e.g., common spikerush) or as “facultative wetland” (e.g., fragrant flatsedge, Baltic rush, common reed, and sword-leaved rush). Saltcedar, although present at the site, had relatively low cover values (<10 percent) over the monitoring period and did not appear to be competitive with native overstory species. Russian olive, on the other hand, has spread throughout the LLRS over the monitoring period. This species has the potential to become problematic and treatment should be considered.

Prichard et al. (1998) developed a comprehensive assessment of criteria useful in judging riparian area condition and attributes that constitute a proper functioning condition for lotic areas. The vegetation attributes of a proper functioning riparian system include:

1) the age class distribution of the riparian plant community indicates the recruitment of young individuals and the maintenance of older individuals;
2) the species composition of the riparian area is diverse;
3) the characteristic soil moisture of a riparian-wetland area is indicated by the species present;
4) species with root masses capable of protecting against high flow events are present on the streambanks;
5) the condition of the riparian plant community is healthy and robust;
6) vegetative cover is sufficient to protect streambanks and dissipate energy during high flow events; and,
7) the riparian plant community can provide sufficient large woody debris to act as an agent to modify the hydrology if necessary for proper functioning.

When evaluating the LLRS using these attributes, most of these criteria appear to have been met. Tree and shrub species detected in the understory layer are an indication that woody species are regenerating at the site and have been throughout monitoring. A diverse composition of riparian species, including willow, cottonwood, sedges, and rushes, are present (the limitation in this attribute as it relates to SWFL habitat is a dominance of cottonwood). The condition of vegetation appears healthy. Even during drought conditions, canopy cover maintained at a stable rate, which also indicates that woody vegetation has reached rooting depths that can sustain a deeper and fluctuating water table. Woody debris is present in the form of downed cottonwood as a result of the fire in 2000. High energy flows and prolonged inundation occurred in 2005 and flooding was again recorded for short periods in 2015 and 2016 and for months in 2017; the site appeared to withstand these events without major impacts.

Conditions that are important to the success of riparian restoration, which include groundwater depth, timing of high flows and flooding, native seed source, competition from exotics, and soil conditions (i.e., texture and salinity levels) have all been conducive to development of healthy, native riparian habitat. In conjunction with favorable conditions, the techniques used for restoring the site can also be deemed successful thus far. The success of restoration at this site can largely be attributed to a design that integrated natural hydrologic processes; banks were lowered to allow for overbank flooding and channels created to slow flood waters and encourage sediment deposition (Muldavin et al. 2015). Kissock (2010) predicted that the LLRS would require maintenance in the future due to greater than critical sheer stress values, resulting in a tendency towards erosion. At this point in the study, erosion does not appear to be problematic.

Important trends identified in vegetation studies at LLRS were the development of a diverse plant community in which native species dominate; long-term success in vegetation that, for the most part, naturally established at the site; an increasing population of invasive Russian olive; and potentially limited development of vegetative variables condusive to SWFL breeding habitat although the site appears to have potential to develop suitable YBCU breeding habitat.

Recommendations

Although requirements of the BO have been met, the LLRS study remains a valuable source of vegetation data and for this reason, continued monitoring is recommended. This study is unique in that extensive data sets have been collected over a relatively long period of time, providing information in a region where successful restoration sites are rare. For example, Reclamation is currently realigning the river channel within the BDANWR. Data from LLRS have been used to estimate vegetation development with regards to age, height and size classes for mitigation and restoration purposes associated with this project.

Continuous monitoring will help to determine if vegetation regeneration persists and if established vegetation sustains varying environmental conditions at the site. If sampling endures, LLRS continues to provide a reference for examining trends and evaluating success in desert riparian restoration sites throughout the southwestern United States.

Vegetation monitoring has also played a part in assessing SWFL and YBCU breeding habitat suitability. Creating habitat for federally listed threatened and endangered species was the impetus for restoration at this site and therefore assessing development and subsequent decline of breeding habitat is an important objective. Based on current vegetation data, LLRS shows promising potential as suitable YBCU habitat.

Based on general observation and supported by cover data, Russian olive has noticeably spread throughout the area. A number of Siberian elm seedlings and saplings were also observed in 2015 and 2016. These species are both listed as “Class C Species” on the New Mexico Department of Agriculture (NMDA) Noxious Weed List. Continued monitoring will track the advancement of these species; regardless, control is recommended, particularly that of Russian olive. Development of native vegetation within LLRS has been successful and an important goal in the restoration effort should be to sustain native habitat. The cost associated with treating invasive species is recognizably a consideration in management of LLRS; however, this expense is low compared to resources spent restoring the site to a desirable, functional ecosystem. It would be unfortunate to see habitat quality decrease with the spread of invasive species.

Groundwater Monitoring

Conclusions

Data from monitoring wells were used to correlate the development and extent of wetland/riparian type vegetation at the restoration site. These data have been instrumental in interpreting long-term development of plant communities at the LLRS. The depth of the water table has a large effect on the continued success of cottonwood and willow. For example, Hultine et al. (2010) found that cottonwood has a greater sensitivity to interannual reductions in water availability, while willow is more sensitive to longer periods of soil water depletion.

It appears that the water table at the LLRS is relatively shallow, which has been important in recruiting and establishing stands of cottonwood and willow. Most of the wells, all of which averaged around 5 ft in depth, held water throughout the majority of the year. Based on groundwater data and on the development of healthy native vegetation, it is unlikely that that the water table falls to depths that are detrimental to the success of woody riparian species. Vegetation did, however, appear to show stress from dry conditions in recent years.

Trends in groundwater levels have been closely linked to river flows, which in turn are driven by precipitation patterns. An understanding of the connectivity of groundwater and river discharge at the site is important for determining likely trends in vegetation and fish and wildlife habitat.

Recommendations

Data from water level loggers is useful in determining groundwater effects on developing vegetation and associated wildlife habitat at the site, as well as evaluating the connectivity of groundwater and surface water flows. Groundwater monitoring should continue to be collected in association with vegetation monitoring for the duration of the study.

Photo Stations

Conclusions

Shifts in plant composition and growth stages of regenerating willow and cottonwood have been observed over the 16 years of monitoring. Photos have provided an important record of the changing vegetation, including the timing of certain stages in development. Of all the methods of data collection used, photographic documentation has probably presented the clearest account of the changes at the LLRS.

Recommendations

Trends in the vegetation should continue to be captured through photos for the duration of the study.

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APPENDIX A

WAYPOINT LOCATIONS FOR AVIAN POINT COUNTS, VEGETATION TRANSECTS, GROUNDWATER MONITORING WELLS, AND PHOTO STATIONS

All coordinates are in NAD83, Zone 13

Avian Point Count Waypoints

Point	Easting (X)	Northing (Y)
LL1-01	340970	3848075
LL1-02	340874	3847961
LL1-03	340818	3847867
LL1-04	340717	3847768
LL1-05	340649	3847675
LL1-06	340612	3847536
LL1-07	340505	3847477
LL1-08	340395	3847340
LL1-09	340410	3847172
LL1-10	340345	3847004
LL1-11	340316	3846827
LL1-12	340267	3846641
LL2-01	341046	3847985
LL2-02	340969	3847883
LL2-03	340900	3847777
LL2-04	340833	3847665
LL2-05	340766	3847559
LL2-06	340696	3847442
LL2-07	340630	3847332
LL2-08	340558	3847202
LL2-09	340502	3847081
LL2-10	340454	3846973
LL2-11	340418	3846865
LL2-12	340380	3846720

Vegetation Transect Waypoints

Transect	x	y
R1A	341053	3847958
R1B	341015	3847992
R2A	340981	3847867
R2B	340943	3847895
R3A	340923	3847761
R3B	340880	3847789
R4A	340860	3847665
R4B	340814	3847687
R5A	340793	3847560
R5B	340749	3847584
R6A	340734	3847459
R6B	340691	3847484
R6-1A	340674	3847363
R6-1B	340630	3847384
R7A	340563	3847162
R7B	340508	3847180
R8A	340516	3847052
R8B	340465	3847073
R9A	340466	3846945
R9B	340417	3846961
R10A	340424	3846834
R10B	340374	3846842
R11A	340392	3846715
R11B	340342	3846723

Groundwater Well Waypoints

Well	x	y
N1	341087	3847987
N2	341037	3848047
N3	340992	3848103
N4	340933	3848162
M1	340613	3847298
M2	340592	3847425
M3	340529	3847439
M4	340469	3847513
S1	340324	3846590
S2	340280	3846598
S3	340245	3846598

Photo Station Waypoints

Photo Station	x	y
P-1	341038	3848023
P-2	340771	3847679
P-3	340582	3847349
P-4	340419	3847015
P-5	340345	3846598
P-6	340898	3848173
P-7	340416	3847477
P-8	340404	3847462
P-9	340384	3847449
P-10	340200	3846582

APPENDIX B

BIRD SPECIES DETECTED DURING POINT COUNTS AND ASSOCIATED HABITAT GUILDS

Species code	Species	Scientific name	Canopy	Cavity	Dense shrub	Edge	Ground shrub	Mid-story	Open-ing	Urban	Water	Migrant
AMAV	American avocet	*Recurvirostra americana*									X	
AMCR	American crow	*Corvus brachyrhynchos*				X						
AMPI	American pipit	*Anthus rubescens*					X					
AM KE	American kestrel	*Falco sparverius sparverius*		X								
AMRO	American robin	*Turdus migratorius*						X				
ATFL	Ash-throated flycatcher	*Myiarchus cinerascens*		X								
BAOW	Barn owl	*Tyto alba*				X						
BARS	Barn swallow	*Hirundo rustica*							X			
BANS	Bank swallow	*Riparia riparia*									X	
BEVI	Bell's vireo	*Vireo bellii*			X							
BEWR	Bewick's wren	*Thryomanes bewickii*		X								
BLPH	Black phoebe	*Sayornis nigricans*									X	
BCCH	Black-capped chickadee	*Poecile atricapillus*		X								
BCHU	Black-chinned hummingbird	*Archilochus alexandri*				X						
BCNH	Black-crowned night heron	*Nycticorax nycticorax*									X	
BHGR	Black-headed grosbeak	*Pheucticus melanocephalus*						X				
BNST	Black-necked stilt	*Himantopus mexicanus*									X	
BLGR	Blue grosbeak	*Guiraca caerulea*					X					
BGGN	Blue-gray gnatcatcher	*Polioptila caerulea*						X				
BWTE	Blue-winged teal	*Anas discors*									X	
BRBL	Brewer's blackbird	*Euphagus cyanocephalus*										X
BTHU	Broadtailed hummingbird	*Selasphorus platycercus*										X
BHCO	Brown-headed cowbird	*Molothrus ater*						X				
BUOR	Bullock's oriole	*Icterus bullockii*	X									

Species code	Species	Scientific name	Canopy	Cavity	Dense shrub	Edge	Ground shrub	Mid-story	Open-ing	Urban	Water	Migrant
BUSH	Bushtit	*Psaltriparus minimus*						X				
CAGO	Canada goose	*Branta canadensis*									X	
CAFI	Cassin's finch	*Carpodacus cassinii*										X
CAVI	Cassin's vireo	*Vireo cassinii*										X
CAEG	Cattle egret	*Bubulcus ibis*										X
CHRA	Chihuahuan raven	*Corvus cryptoleucus*				X						
CLSW	Cliff swallow	*Petrochelidon pyrrhonota*									X	
COGR	Common grackle	*Quiscalus quiscula*				X						
CORA	Common raven	*Corvus corax*				X						
COYE	Common yellowthroat	*Geothlypis trichas*			X							
COHA	Cooper's hawk	*Accipiter cooperii*	X									
DOWO	Downy woodpecker	*Picoides pubescens*		X								
DUFL	Dusky flycatcher	*Empidonax oberholseri*										X
EUST	European starling	*Sturnus vulgaris*		X								
GADW	Gadwall	*Anas strepera*										X
GAQU	Gambel's quail	*Callipepla gambelii*					X					
GRCA	Gray catbird	*Dumetella carolinensis*						X				
GREG	Great egret	*Ardea alba*										X
GBHE	Great-blue heron	*Ardea herodias*									X	
GHOW	Great-horned owl	*Bubo virginianus*	X									
GTGR	Great-tailed grackel	*Quiscalus mexicanus*									X	
GRHE	Green heron	*Butorides virescens*									X	
GTTO	Green-tailed towhee	*Pipilo chlorusus*					X					
HAWO	Hairy woodpecker	*Picoides villosus*		X								
HAFL	Hammond's flycatcher	*Empidonox hammondii*										X
HOFI	House finch	*Carpodacus mexicanus*						X				
INBU	Indigo bunting	*Passerina cyanea*				X						
KILL	Killdeer	*Charadrius vociferus*					X					

Species code	Species	Scientific name	Canopy	Cavity	Dense shrub	Edge	Ground shrub	Mid-story	Open-ing	Urban	Water	Migrant
LBWO	Ladder-backed woodpecker	*Picoides scalaris*		X								
LASP	Lark sparrow	*Chondestes grammacus*					X					
LABU	Lazuli bunting	*Passerina amoena*										X
LEGO	Lesser goldfinch	*Carduelis psaltria*						X				
LISP	Lincolns sparrow	*Melospiza lincolnii*					X					
LBHE	Little blue heron	*Egretta caerulea*										X
LOSH	Loggerhead shrike	*Lanius ludovicianus*				X						
LUWA	Lucy's warbler	*Vermivora luciae*										X
MGWA	MacGillivray's warbler	*Ardea alba*										X
MALL	Mallard	*Anas platyrhynchos*									X	
MOCH	Mountain chickadee	*Poecile gambeli*		X								
MODO	Mourning dove	*Zenaida macroura*					X					
NOFL	Northern flicker	*Colaptes auratus*		X								
NOMO	Northern mockingbird	*Mimus polyglottos*				X						
NRWS	Northern rough-winged swallow	*Stelgidopteryx serripennis*									X	
OCWA	Orange-crowned warbler	*Vermivora celata*					X					
PHAI	Phainopepla	*Phainopepla nitens*										X
PLVI	Plumbeous vireo	*Vireo plumbeus*						X				
RTHA	Red-tailed hawk	*Buteo jamaicensis*	X									
RWBL	Red-winged blackbird	*Agelaius phoeniceus*									X	
RNPH	Ring-necked pheasant	*Phasianus colchicus*					X					
ROPI	Rock pigeon	*Columba livia*								X		
SAPH	Say's phoebe	*Sayornis saya*				X						
SNEG	Snowy egret	*Egretta thula*									X	
SWFL	Southwestern willow flycatcher	*Empidonax traillii*						X				

Species code	Species	Scientific name	Canopy	Cavity	Dense shrub	Edge	Ground shrub	Mid-story	Open-ing	Urban	Water	Migrant
SPSA	Spotted sandpiper	*Actitis macularia*									X	
SPTO	Spotted towhee	*Pipilo maculatus*						X				
SUTA	Summer tanager	*Piranga rubra*	X									
SWHA	Swainson's hawk	*Buteo swainsoni*	X									
TOWA	Townsend's warbler	*Dendroica townsendi*										X
TRES	Tree swallow	*Tachycineta bicolor*		X								
TUVU	Turkey vulture	*Cathartes aura*	X									
UNSW	Unidentified swallow										X	
VESP	Vesper sparrow	*Pooecetes gramineus*										X
VGSW	Violet-green swallow	*Tachycineta thalassina*									X	
WAVI	Warbling vireo	*Vireo gilvus*						X				
WEKI	Western kingbird	*Tyrannus verticalis*				X						
WESO	Western screech owl	*Otus kennicottii*		X								
WETA	Western tanager	*Piranga ludoviciana*	X									
WEWP	Western wood pewee	*Contopus sordidulus*	X									
WBNU	White-breasted nuthatch	*Sitta carolinensis*		X								
WWDO	White-winged dove	*Zenaida asiatica*						X				
WIWA	Wilson's warbler	*Wilsonia pusilla*										X
WODU	Wood duck	*Aix sponsa*										X
YWAR	Yellow warbler	*Dendroica petechia*			X							
YBCH	Yellow-breasted chat	*Icteria virens*						X				
YRWA	Yellow-rumped warbler	*Dendroica coronata*						X				

APPENDIX C

RELATIVE ABUNDANCE OF INDIVIDUAL BIRD SPECIES BY AREA

Table C-1.—Relative abundance of individual bird species in the Cleared/overbank area from 2003 to 2010.

Cleared/overbank area	2003 n=24		2004 n=24		2005 n=24		2006 n=24		2007 n=36		2008 n=36		2009 n=36		2010 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Canopy birds																
Turkey vulture	4.2	0.42 (2.04)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cavity birds																
American kestrel	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Ash-throated flycatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Bewick's wren	0.0	0.00 (0.00)	8.3	0.13 (0.45)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Downy woodpecker	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mountain chickadee	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.11 (0.40)
Northern flicker	0.0	0.00 (0.00)	4.2	0.04 (0.20)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	8.3	0.08 (0.28)
White-breasted nuthatch	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Dense shrub birds																
Common yellowthroat	0.0	0.00 (0.00)	12.5	0.13 (0.34)	16.7	0.21 (0.51)	16.7	0.17 (0.38)	61.1	0.81 (0.86)	36.1	0.42 (0.60)	47.2	0.50 (0.56)	25.0	0.25 (0.44)
Yellow warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Edge birds																
Common raven	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.21 (1.02)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-chinned hummingbird	4.2	0.08 (0.41)	8.3	0.08 (0.28)	12.5	0.13 (0.34)	29.2	0.33 (0.56)	38.9	0.58 (0.84)	33.3	0.47 (0.77)	33.3	0.36 (0.54)	44.4	0.53 (0.65)
Indigo bunting	8.3	0.08 (0.28)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Loggerhead shrike	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Northern mockingbird	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	29.2	0.38 (0.71)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Say's phoebe	8.3	0.13 (0.45)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Cleared/overbank area	2003 n=24		2004 n=24		2005 n=24		2006 n=24		2007 n=36		2008 n=36		2009 n=36		2010 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Western kingbird	12.5	0.21 (0.59)	25.0	0.29 (0.55)	16.7	0.21 (0.51)	37.5	0.58 (0.88)	16.7	0.36 (0.90)	2.8	0.03 (0.17)	5.5	0.11 (0.46)	2.8	0.03 (0.17)
Ground shrub birds																
Blue grosbeak	20.8	0.33 (0.70)	2.1	0.29 (0.62)	4.2	0.04 (0.20)	25.0	0.46 (0.93)	44.4	0.69 (0.89)	13.9	0.14 (0.35)	13.9	0.17 (0.45)	11.1	0.11 (0.32)
Killdeer	8.3	0.08 (0.28)	37.5	0.67 (1.20)	37.5	0.96 (1.60)	20.8	0.25 (0.53)	22.2	0.42 (0.94)	5.6	0.08 (0.37)	8.3	0.17 (0.56)	5.6	0.11 (0.52)
Mourning dove	0.0	0.00 (0.00)	16.7	0.17 (0.38)	12.5	0.25 (0.74)	45.8	3.92 (7.63)	25.0	0.69 (2.08)	19.4	0.28 (0.66)	25.0	0.42 (0.87)	25.0	0.33 (0.63)
Ring-necked pheasant	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	14.9	0.14 (0.35)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Midstory birds																
American robin	0.0	0.00 (0.00)	4.2	0.04 (0.20)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-headed grosbeak	4.2	0.04 (0.20)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	19.4	0.28 (0.61)	22.2	0.22 (0.42)	33.3	0.50 (0.81)
Brown-headed cowbird	8.3	0.08 (0.28)	29.2	0.54 (0.98)	0.0	0.00 (0.00)	12.5	0.25 (0.68)	25.0	0.50 (1.00)	50.0	1.17 (1.75)	8.3	0.17 (0.61)	36.1	0.61 (0.96)
Bushtit	0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.00	0.00 (0.00)	2.8	0.11 (0.67)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.17 (1.00)
Gray catbird	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	5.6	0.06 (0.23)
House finch	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.13 (0.61)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Lesser goldfinch	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Spotted towhee	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.00	0.00 (0.00)	16.7	0.19 (0.47)	25.0	0.28 (0.51)	33.3	0.39 (0.60)	55.6	0.64 (0.64)
Southwestern willow flycatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.00	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
White-winged dove	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.00	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Yellow-breasted chat	0.0	0.00 (0.00)	4.2	0.04 (0.20)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	13.9	0.17 (0.45)	2.8	0.03 (0.17)	5.6	0.06 (0.23)
Open birds																
Barn swallow	4.2	0.08 (0.41)	16.7	0.17 (0.38)	8.3	0.08 (0.28)	2.1	0.58 (1.32)	2.8	0.11 (0.67)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)

Cleared/overbank area	2003 n=24		2004 n=24		2005 n=24		2006 n=24		2007 n=36		2008 n=36		2009 n=36		2010 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Water birds																
American avocet	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-crowned night heron	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-necked stilt	0.0	0.00 (0.00)	4.2	0.17 (0.82)	25.0	0.42 (0.83)	8.3	0.13 (0.45)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Blue-winged teal	0.0	0.00 (0.00)	0.0	0.00 (0.00)	12.5	0.21 (0.66)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cliff swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.17 (0.61)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Great-blue heron	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.5	0.06 (0.23)	0.0	0.00 (0.00)
Great-tailed grackle	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mallard	0.0	0.00 (0.00)	0.0	0.00 (0.00)	33.3	1.46 (3.16)	4.2	0.04 (0.20)	5.6	0.11 (0.52)	8.3	0.11 (0.40)	5.5	0.06 (0.23)	2.8	0.22 (1.33)
Northern rough-winged swallow	12.5	0.13 (0.34)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.17 (0.61)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Red-winged blackbird	4.2	0.67 (1.13)	50.0	1.21 (1.50)	95.8	4.63 (1.79)	33.3	0.46 (0.78)	47.2	1.11 (1.69)	55.6	1.28 (1.60)	41.7	0.58 (0.81)	8.3	0.17 (0.70)
Snowy egret	12.5	0.13 (0.34)	20.8	0.29 (0.62)	12.5	0.21 (0.59)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Spotted sandpiper	12.5	0.13 (0.34)	12.5	0.17 (0.48)	37.5	0.46 (0.66)	8.3	0.13 (0.45)	8.3	0.08 (0.28)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Unidentified swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	25.0	0.33 (0.64)	2.8	0.08 (0.50)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Violet-green swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	25.0	0.38 (0.71)	2.8	0.03 (0.17)	8.3	0.17 (0.61)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Migrants																
Brewer's blackbird	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.00	0.00 (0.00)	0.00	0.00 (0.00)	2.8	1.25 (7.50)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cassin's finch	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cattle egret	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.25 (1.22)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Gadwall	0.0	0.00 (0.00)	0.0	0.00 (0.00)	4.2	0.13 (0.61)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Cleared/overbank area	2003 n=24		2004 n=24		2005 n=24		2006 n=24		2007 n=36		2008 n=36		2009 n=36		2010 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Lazuli bunting	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Little blue heron	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Lucy's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Table C-1.(cont'd)—Relative abundance of individual bird species in the Cleared/overbank area from 2011 to 2018.

Cleared/overbank area	2011 n=36		2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Canopy birds																
Bullock's oriole	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	11.1	0.11 (0.32)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cooper's hawk	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Summer tanager	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	11.1	0.11 (0.32)	13.9	0.14 (0.35)	8.3	0.08 (0.28)	5.6	0.06 (0.23)
Swainson's hawk	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Western tanager	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western wood pewee	0.0	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cavity birds																
American kestrel	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Ash-throated flycatcher	0.0	0.00 (0.00)	5.6	0.08 (0.37)	2.8	0.03 (0.17)	13.9	0.14 (0.35)	5.6	0.06 (0.23)	13.9	0.06 (0.23)	11.1	0.11 (0.32)	2.8	0.03 (0.17)
Bewick's wren	16.7	0.22 (0.54)	2.8	0.03 (0.17)	8.3	0.08 (0.28)	2.8	0.06 (0.33)	11.1	0.11 (0.32)	16.7	0.19 (0.47)	8.3	0.17 (0.70)	5.6	0.06 (0.23)
Black-capped chickadee	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.06 (0.33)
Downy woodpecker	0.0	0.00 (0.00)	13.9	0.22 (0.59)	2.8	0.06 (0.33)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	2.8	0.03 (0.17)
Ladder-backed woodpecker	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Cleared/overbank area	2011 n=36		2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Mountain chickadee	8.3	0.08 (0.28)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Northern flicker	2.8	0.03 (0.17)	5.6	0.06 (0.23)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Western screech-owl	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Dense shrub birds																
Bell's vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Common yellowthroat	47.2	0.56 (0.65)	41.7	0.58 (0.77)	11.1	0.11 (0.32)	22.2	0.28 (0.57)	47.2	0.56 (0.69)	19.4	0.28 (0.61)	30.6	0.42 (0.69)	25.0	0.28 (0.51)
Yellow warbler	5.5	0.06 (0.23)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	11.1	0.11 (0.32)	0.0	0.00 (0.00)
Edge birds																
American crow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Black-chinned hummingbird	41.7	0.56 (0.73)	55.6	0.83 (0.85)	66.7	0.92 (0.77)	72.2	1.28 (1.11)	44.4	0.67 (0.86)	33.3	0.44 (0.73)	25.0	0.28 (0.51)	50.0	0.72 (0.81)
Indigo bunting	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	8.3	0.08 (0.28)	8.3	0.08 (0.28)	2.8	0.03 (0.17)
Northern mockingbird	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Say's phoebe	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.11 (0.46)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western kingbird	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Ground shrub birds																
American pipit	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Blue grosbeak	25.0	0.33 (0.63)	13.9	0.22 (0.59)	22.2	0.33 (0.72)	19.4	0.25 (0.55)	27.8	0.39 (0.69)	27.8	0.36 (0.64)	38.9	0.53 (0.74)	22.2	0.25 (0.50)
Killdeer	8.3	0.11 (0.40)	8.3	0.08 (0.28)	19.4	0.31 (0.71)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)
Lincoln's sparrow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Mourning dove	36.1	0.53 (0.84)	55.6	0.86 (0.87)	55.6	0.78 (0.80)	55.6	0.83 (0.88)	25.0	0.31 (0.58)	50.0	0.75 (0.87)	38.9	0.50 (0.74)	52.8	0.61 (0.64)

Cleared/overbank area	2011 n=36		2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Orange-crowned warbler	0.00	0.00 (0.00)	13.9	0.17 (0.45)	13.9	0.25 (0.65)	11.1	0.14 (0.42)	8.3	0.08 (0.28)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Ring-necked pheasant	8.3	0.08 (0.28)	22.2	0.22 (0.42)	19.4	0.19 (0.40)	16.7	0.17 (0.38)	8.3	0.08 (0.28)	8.3	0.08 (0.28)	8.3	0.08 (0.28)	8.3	0.08 (0.28)
Midstory birds																
American robin	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	13.9	0.19 (0.52)	11.1	0.11 (0.32)	25.0	0.28 (0.51)	11.1	0.11 (0.32)
Black-headed grosbeak	38.9	0.50 (0.70)	66.7	0.92 (0.77)	61.1	0.75 (0.69)	50.0	0.64 (0.72)	44.4	0.61 (0.77)	41.7	0.61 (0.87)	25.0	0.28 (0.51)	75.0	1.19 (0.82)
Blue-gray gnatcatcher	5.5	0.08 (0.37)	5.6	0.08 (0.37)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Brown-headed cowbird	41.7	0.78 (1.07)	66.7	1.28 (1.21)	58.3	1.03 (1.16)	41.7	0.67 (0.93)	16.7	0.36 (1.10)	11.1	0.14 (0.42)	16.7	0.25 (0.60)	33.3	0.44 (0.73)
Bushtit	5.5	0.14 (0.59)	8.3	0.25 (0.84)	11.1	0.25 (0.77)	5.6	0.17 (0.74)	2.8	0.03 (0.17)	5.6	0.08 (0.37)	11.1	0.67 (2.47)	13.9	0.50 (1.63)
Gray catbird	2.8	0.03 (0.17)	5.6	0.06 (0.23)	5.6	0.06 (0.23)	11.1	0.14 (0.42)	25.0	0.28 (0.51)	30.6	0.47 (0.81)	30.6	0.36 (0.59)	13.9	0.19 (0.52)
House finch	0.0	0.00 (0.00)	5.6	0.08 (0.37)	2.8	0.03 (0.17)	8.3	0.17 (0.56)	13.9	0.19 (0.52)	13.9	0.14 (0.35)	16.7	0.17 (0.38)	2.8	0.11 (0.67)
Lesser goldfinch	5.5	0.14)0.59)	25.0	0.47 (0.88)	8.3	0.17 (0.56)	8.3	0.14 (0.54)	2.8	0.03 (0.17)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Plumbeous vireo	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Spotted towhee	41.7	0.50 (0.65)	66.7	1.06 (0.89)	94.4	1.31 (0.58)	69.4	1.03 (0.84)	63.9	0.81 (0.71)	88.9	1.76 (0.96)	58.3	1.08 (1.08)	83.3	1.28 (0.85)
White-winged dove	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	5.6	0.06 (0.23)
Yellow-breasted chat	80.5	1.19 (0.79)	75.0	1.17 (0.85)	91.7	1.61 (0.80)	75.0	1.31 (0.95)	47.2	0.53 (0.61)	41.7	0.56 (0.73)	69.4	1.03 (0.81)	86.1	1.25 (0.81)
Yellow-rumped warbler	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Open birds																
Barn swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	25.0	0.81 (1.74)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	8.3	0.14 (0.49)
Water birds																
Bank swallow	2.8	0.08 (0.50)	0.0	0.00 (0.00)	2.8	0.11 (0.67)	0.0	0.00 (0.00)	13.9	0.33 (0.86)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Cleared/overbank area	2011 n=36		2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Black-crowned night heron	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Black phoebe	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Canada goose	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.31 (1.09)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cliff swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	16.7	0.39 (0.99)
Great-blue heron	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Great-tailed grackle	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Green heron	5.5	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mallard	11.1	0.31 (1.09)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	5.6	0.06 (0.23)	11.1	0.22 (0.68)	2.8	0.03 (0.17)
Red-winged blackbird	11.1	0.22 (0.64)	5.6	0.14 (0.59)	8.3	0.14 (0.49)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	8.3	0.08 (0.28)	0.0	0.00 (0.00)
Snowy egret	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Migrants																
Broadtailed hummingbird	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	41.7	0.78 (1.02)	30.6	0.42 (0.69)	16.7	0.25 (0.60)
Cassin's vireo	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cattle egret	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)
Dusky flycatcher	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Great egret	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Hammond's flycatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Lucy's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
MacGillivray's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Phainopepla	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Cleared/overbank area	2011 n=36		2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Townsend's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Wilson's warbler	8.3	0.08 (0.28)	11.1	0.11 (0.32)	8.3	0.11 (0.40)	8.3	0.11 (0.40)	2.8	0.03 (0.17)	5.6	0.06 (0.24)	2.8	0.03 (0.17)	5.6	0.06 (0.23)
Wood duck	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)

Table C-2.—Relative abundance of individual bird species in the Burned area in 2003 and 2004 and 2007 to 2011.

Burned area	2003 n=42		2004 n=47		2007 n=36		2008 n=36		2009 n=36		2010 n=36		2011 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Canopy birds														
Cooper's hawk	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Great-horned owl	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Red-tailed hawk	4.8	0.05 (0.22)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Summer tanager	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	0.0	0.00 (0.00)	5.5	0.06 (0.23)
Turkey vulture	19.0	0.67 (1.72)	8.5	0.36 (1.28)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western tanager	2.4	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western wood pewee	0.0	0.00 (0.00)	2.1	0.02 (0.15)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	5.5	0.06 (0.23)
Cavity birds														
American kestrel	7.1	0.10 (0.37)	2.1	0.02 (0.15)	13.9	0.17 (0.45)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	0.0	0.00 (0.00)
Ash-throated flycatcher	19.0	0.19 (0.40)	6.4	0.06 (0.25)	11.1	0.14 (0.42)	2.8	0.03 (0.17)	8.3	0.08 (0.28)	11.1	0.11 (0.32)	8.3	0.08 0.28
Bewick's wren	4.8	0.05 (0.22)	0.0	0.00 (0.00)	25.0	0.39 (0.80	5.6	0.06 (0.23)	8.3	0.08 (0.28)	13.9	0.17 (0.45)	13.9	0.25 (0.73)
Black-capped chickadee	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Downy woodpecker	0.0	0.00 (0.00)	2.1	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Burned area	2003 n=42		2004 n=47		2007 n=36		2008 n=36		2009 n=36		2010 n=36		2011 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
European starling	2.4	0.02 (0.15)	2.1	0.02 (0.15)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Hairy woodpecker	0.0	0.00 (0.00)	4.3	0.04 (0.20)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Ladder-backed woodpecker	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mountain chickadee	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	11.1	0.14 (0.42)
Northern flicker	19.0	0.21 (0.47)	10.6	0.11 (0.31)	22.2	0.25 (0.50)	5.6	0.06 (0.23)	16.7	0.19 (0.37)	8.3	0.11 (0.40)	0.0	0.00 (0.00)
White-breasted nuthatch	7.1	0.07 (0.26)	17.0	0.17 (0.38)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Dense shrub birds														
Common yellowthroat	19.0	0.19 (0.40)	10.6	0.11 (0.31)	16.7	0.17 (0.38)	13.9	0.14 (0.35)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	13.9	0.17 (0.45)
Yellow warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	5.5	0.06 (0.23)
Edge birds														
Black-chinned hummingbird	45.2	0.57 (0.74)	46.8	0.51 (0.59)	75.0	1.08 (0.81)	44.4	0.44 (0.50)	77.8	1.28 (0.88)	77.8	1.31 (1.09)	83.3	1.00 (0.59)
Common grackle	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Indigo bunting	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Northern mockingbird	2.4	0.05 (0.31)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	5.5	0.06 (0.23)
Say's phoebe	2.4	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western kingbird	11.9	0.19 (0.59)	17.0	0.19 (0.45)	30.6	0.56 (0.91)	5.6	0.06 (0.23)	5.6	0.11 (0.46)	5.6	0.08 (0.37)	0.0	0.00 (0.00)
Ground shrub birds														
Blue grosbeak	33.3	0.40 (0.63)	21.3	0.26 (0.53)	8.3	0.11 (0.40)	11.1	0.11 (0.32)	2.8	0.06 (0.33)	2.8	0.03 (0.17)	19.4	0.25 (0.55)
Gambel's quail	0.0	0.00 (0.00)	2.1	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Burned area	**2003 n=42**		**2004 n=47**		**2007 n=36**		**2008 n=36**		**2009 n=36**		**2010 n=36**		**2011 n=36**	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Killdeer	2.4	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mourning dove	4.8	0.67 (0.90)	61.7	0.96 (0.88)	58.3	1.36 (1.64)	44.4	0.61 (0.80)	38.9	0.64 (0.99)	38.9	0.58 (0.81	55.5	1.03 (1.08)
Orange-crowned warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)
Ring-necked pheasant	4.8	0.05 (0.22)	4.2	0.04 (0.20)	16.7	0.28 (0.78)	13.9	0.14 (0.35)	16.7	0.17 (0.38)	19.4	0.22 (0.48)	5.5	0.06 (0.23)
Midstory birds														
American robin	4.8	0.05 (0.22)	14.9	0.21 (0.59)	8.3	0.08 (0.28)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	5.6	0.08 (0.37)	2.8	0.06 (0.33)
Black-headed grosbeak	69.0	1.00 (0.88)	61.7	0.74 (0.67)	44.4	0.56 (0.81)	58.3	0.83 (0.85)	47.2	0.69 (0.89)	41.7	0.53 (0.70)	36.1	0.47 (0.70)
Blue-gray gnatcatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	5.5	0.06 (0.23)
Brown-headed cowbird	66.7	1.36 (1.43)	36.2	0.66 (1.13)	58.3	0.86 (0.96)	55.6	0.92 (1.34)	36.1	0.64 (0.99)	27.8	0.53 (1.03)	44.4	0.69 (0.92)
Bushtit	0.0	0.00 (0.00)	2.1	0.11 (0.73)	5.6	0.17 (0.85)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	11.1	0.22 (0.68)
Gray catbird	26.2	0.26 (0.45)	48.9	0.53 (0.58)	36.1	0.50 (0.74)	22.2	0.28 (0.57)	50.0	0.77 (0.76)	44.4	0.56 (0.69)	41.7	0.53 (0.70)
House finch	2.4	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	5.5	0.17 (0.70)
Lesser goldfinch	2.4	0.05 (0.31)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	13.9	0.25 (69)
Plumbeous vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Spotted towhee	50.0	0.69 (0.84)	80.8	0.91 (0.54)	61.1	0.94 (0.89)	41.7	0.44 (0.56)	41.7	0.56 (0.73)	44.4	0.58 (0.77)	44.4	0.64 (0.80)
White-winged dove	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Yellow-breasted chat	76.2	1.26 (0.91)	70.2	1.13 (1.03)	38.9	0.47 (0.70)	41.7	0.44 (0.56)	41.7	0.47 (0.61)	30.6	0.33 (0.53)	72.2	1.06 (0.79)
Yellow-rumped warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Open birds														

Burned area	2003 n=42		2004 n=47		2007 n=36		2008 n=36		2009 n=36		2010 n=36		2011 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Barn swallow	2.4	0.02 (0.15)	2.1	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Water birds														
Black phoebe	0.0	0.00 (0.00)	2.1	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-necked stilt	2.4	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Great-blue heron	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Mallard	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.5	0.22 1.05
Red-winged blackbird	9.5	0.12 (0.40)	6.4	0.06 (0.25)	16.7	0.42 (1.16)	11.1	0.69 (2.36)	11.1	0.22 (0.76)	5.5	0.14 (0.68)	11.1	0.28 (0.81)
Snowy egret	0.0	0.00 (0.00)	2.1	0.02 (0.15)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Spotted sandpiper	4.8	0.05 (0.22)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Migrants														
Cassin's vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Dusky flycatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Lazuli bunting	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
MacGillivray's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Wilson's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)

Table C-2(cont'd) .—Relative abundance of individual bird species in the Burned area from 2012 to 2018.

Burned area	**2012 n=36**		**2013 n=36**		**2014 n=36**		**2015 n=36**		**2016 n=36**		**2017 n=36**		**2018 n=36**	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Canopy birds														
Bullock's oriole	0.0	0.00 (0.00)	2.8	0.03 (0.17)	11.1	0.03 (0.17)	11.1	0.14 (0.42)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)
Cooper's hawk	5.6	0.06 (0.23)	8.3	0.11 (0.40)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	5.6	0.11 (0.52)	13.9	0.19 (0.52)	5.6	0.06 (0.23)
Great-horned owl	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Summer tanager	8.3	0.08 (0.28)	8.3	0.11 (0.40)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	11.1	0.14 (0.42)	5.6	0.08 (0.37)	19.4	0.19 (0.40)
Swainson's hawk	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Western tanager	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)
Western wood pewee	2.8	0.03 (0.17)	0.0	0.03 (0.17)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	5.6	0.06 (0.23)	2.8	0.03 (0.17)
Cavity birds														
American kestrel	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Ash-throated flycatcher	22.2	0.25 (0.50)	16.7	0.19 (0.47)	8.3	0.08 (0.28)	5.6	0.06 (0.23)	11.1	0.11 (0.32)	8.3	0.08 (0.28)	8.3	0.08 (0.28)
Bewick's wren	19.4	0.33 (0.76)	11.1	0.11 (0.32)	2.8	0.03 (0.17)	22.2	0.28 (0.57)	25.0	0.25 (0.44)	22.2	0.36 (0.72)	33.3	0.36 (0.54)
Black-capped chickadee	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	16.7	0.28 (0.70)	2.8	0.06 (0.33)
Downy woodpecker	5.6	0.06 (0.23)	8.3	0.14 (0.49)	8.3	0.11 (0.40)	2.8	0.03 (0.17)	0.0	0.03 (0.17)	5.6	0.08 (0.37)	2.8	0.03 (0.17)
Mountain chickadee	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	8.3	0.17 (0.70)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Northern flicker	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Tree swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Western screech-owl	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)

Burned area	2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
White-breasted nuthatch	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Dense shrub birds														
Bell's vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Common yellowthroat	8.3	0.14 (0.49)	0.0	0.00 (0.00)	19.4	0.22 (0.48)	30.6	0.31 (0.47)	16.7	0.17 (0.38)	5.6	0.06 (0.23)	0.0	0.00 (0.00)
Yellow warbler	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Edge birds														
American crow	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Barn owl	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Black-chinned hummingbird	83.3	1.14 (0.76)	91.7	1.47 (0.74)	75.0	1.31 (1.01)	75.0	0.97 (0.70)	39.8	0.64 (0.96)	13.9	0.19 (0.52)	13.9	0.17 (0.45)
Chihuahuan raven	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Common raven	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Indigo bunting	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Loggerhead shrike	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Say's phoebe	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Western kingbird	2.8	0.03 (0.17)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	5.6	0.08 (0.37)	0.0	0.00 (0.00)
Ground shrub birds														
Blue grosbeak	2.8	0.03 (0.17)	22.2	0.25 (0.50)	16.7	0.25 (0.60)	22.2	0.25 (0.50)	16.7	0.28 (0.78)	2.8	0.03 (0.17)	22.2	0.28 (0.57)
Gambel's quail	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mourning dove	72.2	1.00 (0.79)	58.3	0.86 (0.87)	69.4	1.00 (0.86)	36.1	0.44 (0.69)	47.2	0.67 (0.83)	36.1	0.56 (0.91)	58.3	0.86 (0.83)

Burned area	**2012 n=36**		**2013 n=36**		**2014 n=36**		**2015 n=36**		**2016 n=36**		**2017 n=36**		**2018 n=36**	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Orange-crowned warbler	8.3	0.08 (0.28)	16.7	0.19 (0.47)	2.8	0.06 (0.33)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Ring-necked pheasant	16.7	0.17 (0.38)	2.8	0.03 (0.17)	13.9	0.14 (0.35)	5.6	0.06 (0.23)	19.4	0.19 (0.40)	2.8	0.03 (0.17)	2.8	0.03 (0.17)
Midstory birds														
American robin	8.3	0.08 (0.28)	13.9	0.14 (0.35)	0.0	0.00 (0.00)	8.3	0.08 (0.28)	19.4	0.25 (0.55)	11.1	0.14 (0.42)	13.9	0.14 (0.35)
Black-headed grosbeak	55.6	0.75 (0.77)	38.9	0.58 (0.81)	47.2	0.69 (0.82)	30.6	0.42 (0.69)	69.4	1.03 (0.88)	52.8	0.75 (0.81)	50.0	0.75 (0.84)
Blue-gray gnatcatcher	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Brown-headed cowbird	25.0	0.42 (0.77)	27.8	0.64 (1.17)	25.0	0.33 (0.63)	8.3	0.11 (0.40)	8.3	0.08 (0.28)	13.9	0.17 (0.45)	8.3	0.08 (0.28)
Bushtit	5.6	0.08 (0.37)	11.1	0.31 (0.92)	11.1	0.25 (0.81)	11.1	0.25 (0.81)	5.6	0.28 (1.37)	11.1	0.28 (0.85)	16.7	0.22 (0.54)
Gray catbird	47.2	0.67 (0.79)	44.4	0.61 (0.77)	27.8	0.42 (0.73)	52.8	0.61 (0.69)	25.0	0.33 (0.63)	27.8	0.31 (0.52)	16.7	0.17 (0.38)
House finch	2.8	0.06 (0.33)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	11.1	0.11 (0.32)	5.6	0.08 (0.37)	5.6	0.06 (0.23)	11.1	0.14 (0.42)
Lesser goldfinch	5.6	0.08 (0.37)	5.6	0.06 (0.23)	5.6	0.06 (0.23)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)
Plumbeous vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Spotted towhee	55.6	0.78 (0.80)	69.4	0.94 (0.75)	75.0	1.06 (0.79)	47.2	0.61 (0.73)	66.7	1.14 (1.10)	88.9	1.36 (0.72)	77.8	1.03 (0.70)
Warbling vireo	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
White-winged dove	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	16.7	0.17 (0.38)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	5.6	0.06 (0.23)
Yellow-breasted chat	69.4	1.03 (0.81)	80.6	1.36 (0.87)	88.9	1.61 (0.80)	44.4	0.56 (0.69)	44.4	0.64 (0.83)	63.9	0.83 (0.77)	63.9	0.81 (0.71)
Yellow-rumped warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.11 (0.46)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)
Urban birds														
Rock pigeon	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)

Burned area	2012 n=36		2013 n=36		2014 n=36		2015 n=36		2016 n=36		2017 n=36		2018 n=36	
Species	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**	**% Plots**	**Mean (SD)**
Water birds														
Black-crowned night heron	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Black phoebe	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Cliff swallow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)
Canada goose	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Great-blue heron	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Mallard	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.06 (0.33)	2.8	0.06 (0.33)	0.0	0.00 (0.00)
Red-winged blackbird	13.9	0.33 (0.93)	13.9	0.28 (0.74)	8.3	0.14 (0.49)	0.0	0.00 (0.00)	8.3	0.11 (0.40)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Migrants														
Broadtailed hummingbird	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	25.0	0.25 (0.44)	58.3	0.78 (0.80)	88.9	1.53 (0.84)	86.1	1.39 (0.80)
Cattle egret	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Dusky flycatcher	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Lazuli bunting	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.08 (0.37)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
MacGillivray's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Phainopepla	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Townsend's warbler	0.0	0.00 (0.00)	0.0	0.00 (0.00)	5.6	0.06 (0.23)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)
Vesper sparrow	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)
Wilson's warbler	13.9	0.14 (0.34)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	2.8	0.03 (0.17)	0.0	0.00 (0.00)	2.8	0.03 (0.17)	0.0	0.00 (0.00)

APPENDIX D

AVIAN ABUNDANCE BY SPECIES GUILDS

Table D-1.—Total, mean, and standard deviation by species guilds for the Cleared/Overbank Area from 2003 to 2010.

Los Lunas Cleared/overbank area	2003 8 points		2004 8 points		2005 8 points		2006 8 points		2007 12 points		2008 12 points		2009 12 points		2010 12 points	
	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)
# Species	18	1.79 (1.25)	20	2.92 (1.61)	21	3.58 (1.35)	20	3.67 (2.04)	24	3.78 (1.66)	22	3.42 (1.71)	18	2.67 (1.45)	18	2.86 (1.53)
# Birds	22	2.75 (3.08)	37	4.58 (2.92)	77	9.67 (4.47)	70	8.79 (9.14)	79	7.83 (11.21)	66	5.50 (3.26)	40	3.36 (2.09)	48	4.03 (3.08)
# Canopy spp.	1	0.04 (0.20)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Canopy birds	3	0.42 (2.04)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Cavity spp.	1	0.04 (0.20)	2	0.13 (0.45)	2	0.08 (0.28)	1	0.04 (0.20)	1	0.06 (0.23)	2	0.14 (0.49)	0	0.00 (0.00)	2	0.17 (0.45)
# Cavity birds	1	0.04 (0.20)	2	0.17 (0.56)	2	0.08 (0.28)	1	0.04 (0.20)	1	0.06 (0.23)	2	0.14 (0.49)	0	0.00 (0.00)	7	0.19 (0.52)
# Dense shrub spp.	0	0.00 (0.00)	1	0.13 (0.34)	1	0.17 (0.38)	1	0.17 (0.38)	1	0.61 (0.49)	1	0.36 (0.49)	1	0.47 (0.51)	2	0.28 (0.45)
# Dense shrub birds	0	0.00 (0.00)	1	0.13 (0.34)	2	0.21 (0.51)	1	0.17 (0.38)	10	0.81 (0.86)	5	0.42 (0.60)	6	0.50 (0.56)	3	0.28 (0.45)
# Edge spp.	5	0.38 (0.65)	5	0.46 (0.59)	2	0.29 (0.46)	4	1.00 (1.06)	3	0.58 (0.65)	2	0.36 (0.49)	2	0.39 (0.55)	2	0.47 (0.56)
# Edge birds	5	0.54 (1.02)	5	0.50 (0.66)	3	0.33 (0.56)	12	1.50 (1.84)	11	2.19 (8.09)	6	0.50 (0.77)	6	0.47 (0.74)	7	0.56 (0.73)
# Ground shrub spp.	2	0.29 (0.46)	3	0.75 (0.79)	3	0.54 (0.59)	4	1.00 (0.83)	4	1.06 (0.89)	4	0.42 (0.60)	3	0.47 (0.70)	4	0.44 (0.69)
# Ground shrub birds	3	0.42 (0.72)	9	1.13 (1.54)	10	1.25 (1.62)	38	4.71 (7.80)	23	1.94 (2.40)	6	0.53 (0.84)	9	0.75 (1.23)	7	0.58 (1.00)
# Mid-story spp.	3	0.17 (0.38)	4	0.42 (0.78)	3	0.13 (0.45)	2	0.17 (0.48)	7	0.61 (0.73)	5	1.11 (0.95)	7	0.75 (0.73)	6	1.39 (0.99)
# Mid-story birds	3	0.17 (0.38)	5	0.67 (1.20)	3	0.21 (0.83)	2	0.29 (0.81)	12	1.00 (1.37)	23	1.92 (1.92)	11	0.89 (0.95)	24	2.03 (1.93)
# Opening spp.	1	0.04 (0.20)	1	0.17 (0.38)	1	0.08 (0.28)	1	0.21 (0.41)	1	0.03 (0.17)	0	0.00 (0.00)	1	0.03 (0.17)	0	0.00 (0.00)
# Opening birds	2	0.08 (0.41)	1	0.17 (0.38)	1	0.08 (0.28)	5	0.58 (1.32)	2	0.11 (0.67)	0	0.00 (0.00)	1	0.03 (0.17)	0	0.00 (0.00)
# Water spp.	5	0.83 (0.83)	4	0.88 (0.90)	9	2.29 (1.08)	7	1.08 (0.83)	8	0.86 (1.05)	8	1.03 (1.06)	4	0.56 (0.73)	2	0.11 (0.32)
# Water birds	9	1.08 (1.21)	15	1.83 (2.48)	60	7.50 (3.88)	12	1.50 (1.25)	20	1.69 (2.25)	24	2.00 (2.07)	8	0.75 (1.05)	5	0.39 (1.48)

Table D-1 (cont'd).—Total, mean, and standard deviation by species guilds for the Cleared/Overbank Area from 2011 to 2018.

Los Lunas Cleared/overbank area	2011 12 points		2012 12 points		2013 12 points		2014 12 points		2015 12 points		2016 12 points		2017 12 points		2018 12 points	
	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)
# Species	34	4.86 (1.05)	26	5.89 (1.04)	27	5.92 (1.00)	31	5.44 (1.42)	36	5.33 (0.99)	36	5.17 (1.67)	28	4.89 (1.35)	28	5.50 (1.44)
# Birds	83	6.94 (2.33)	109	9.08 (2.20)	106	8.81 (1.89)	100	8.33 (2.93)	89	7.39 (2.07)	87	7.25 (2.51)	85	7.06 (3.08)	97	8.11 (2.75)
# Canopy spp.	2	0.06 (0.23)	1	0.03 (0.17)	3	0.08 (0.28)	4	0.19 (0.47)	3	0.25 (0.44)	5	0.28 (0.51)	3	0.14 (0.35)	1	0.06 (0.23)
# Canopy birds	2	0.06 (0.23)	1	0.03 (0.17)	3	0.08 (0.28)	4	0.19 (0.47)	3	0.25 (0.44)	5	0.28 (0.51)	3	0.14 (0.35)	1	0.06 (0.23)
# Cavity spp.	4	0.31 (0.52)	4	0.28 (0.45)	4	0.19 (0.47)	4	0.25 (0.44)	5	0.25 (0.44)	5	0.47 (0.70)	4	0.31 (0.47)	4	0.14 (0.35)
# Cavity birds	4	0.36 (0.64)	5	0.39 (0.69)	4	0.22 (0.54)	4	0.31 (0.58)	5	0.28 (0.51)	7	0.56 (0.88)	5	0.39 (0.77)	2	0.17 (0.45)
# Dense shrub spp.	2	0.53 (0.51)	2	0.47 (0.56)	2	0.14 (0.35)	2	0.25 (0.50)	2	0.56 (0.61)	1	0.19 (0.40)	2	0.42 (0.50)	2	0.25 (0.44)
# Dense shrub birds	7	0.61 (0.64)	10	0.81 (0.82)	2	0.14 (0.35)	4	0.31 (0.67)	8	0.67 (0.83)	3	0.28 (0.62)	6	0.53 (0.70)	4	0.28 (0.51)
# Edge spp.	4	0.50 (0.56)	2	0.58 (0.50)	2	0.72 (0.51)	3	0.78 (0.48)	4	0.61 (0.55)	4	0.61 (0.55)	2	0.33 (0.54)	2	0.56 (0.56)
# Edge birds	7	0.64 (0.76)	10	0.86 (0.83)	12	1.03 (0.84)	16	1.33 (1.10)	10	0.83 (0.88)	7	0.58 (0.81)	4	0.36 (0.64)	9	0.78 (0.83)
# Ground shrub spp.	4	0.78 (0.64)	5	1.14 (0.76)	5	1.31 (0.79)	5	1.08 (0.69)	5	0.72(0.66)	4	0.92 (0.73)	4	0.89 (0.79)	5	0.92 (0.87)
# Ground shrub birds	13	1.06 (1.09)	19	1.56 (1.08)	22	1.86 (1.22)	17	1.44 (1.03)	11	0.89 (0.89)	15	1.28 (1.19)	14	1.14 (1.13)	12	1.03 (1.06)
# Mid-story spp.	12	2.33 (0.93)	9	3.25 (0.87)	9	3.36 (0.90)	10	2.75 (1.05)	10	2.36 (0.90)	12	2.67 (1.41)	9	2.56 (1.16)	10	3.28 (0.94)
# Mid-story birds	42	3.50 (1.76)	64	5.36 (1.97)	63	5.22 (1.99)	52	4.36 (2.22)	37	3.11 (1.39)	49	4.10 (2.18)	50	4.14 (2.83)	63	5.22 (2.32)
# Opening spp.	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	1	0.39 (0.49)	1	0.03 (0.17)	0	0.00 (0.00)	1	0.08 (0.28)
# Opening birds	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	10	1.14 (1.79)	1	0.06 (0.33)	0	0.00 (0.00)	2	0.14 (0.49)
# Water spp.	6	0.36 (0.64)	3	0.14 (0.35)	2	0.11 (0.32)	3	0.14 (0.42)	6	0.33 (0.59)	4	0.14 (0.35)	4	0.25 (0.60)	2	0.19 (0.40)
# Water birds	9	0.72 (1.58)	3	0.25 (0.69)	3	0.25 (0.81)	5	0.39 (1.18)	7	0.56 (1.03)	4	0.14 (0.35)	4	0.36 (0.90)	5	0.42 (1.00)

Table D-2.—Total, mean, and standard deviation by species guilds for the Burned Area from 2003 to 2004 and 2007 to 2011.

Los Lunas Burned area	2003 17 points		2004 17 points		2007 12 points		2008 12 points		2009 12 points		2010 12 points		2011 12 points	
	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)
# Species	30	5.71 (1.66)	27	5.47 (1.40)	24	5.81 (2.23)	17	3.83 (1.54)	24	4.42 (1.44)	18	3.89 (1.53)	30	5.44 (0.81)
# Birds	146	8.45 (3.23)	118	7.34 (2.55)	107	8.89 (3.77)	65	5.42 (3.55)	75	6.28 (2.35)	66	5.50 (2.81)	96	8.03 (2.08)
# Canopy spp.	3	0.26 (0.50)	2	0.11 (0.31)	2	0.14 (0.35)	0	0.00 (0.00)	4	0.22 (0.42)	0	0.00 (0.00)	2	0.11 (0.32)
# Canopy birds	11	0.74 (1.80)	6	0.38 (1.28)	2	0.14 (0.35)	0	0.00 (0.00)	3	0.22 (0.42)	0	0.00 (0.00)	2	0.11 (0.32)
# Cavity spp.	6	0.60 (0.70)	7	0.45 (0.69)	6	0.83 (0.97)	3	0.14 (0.35)	4	0.36 (0.59)	4	0.39 (0.55)	3	0.33 (0.53)
# Cavity birds	12	0.62 (0.76)	7	0.45 (0.69)	13	1.08 (1.38)	3	0.14 (0.35)	5	0.39 (0.64)	6	0.47 (0.70)	5	0.47 (0.91)
# Dense shrub spp.	1	0.19 (1.40)	1	0.11 (0.31)	1	0.17 (0.38)	1	0.14 (0.35)	2	0.06 (0.23)	1	0.03 (0.17)	2	0.19 (0.40)
# Dense shrub birds	3	0.19 (1.40)	2	0.11 (0.31)	2	0.17 (0.38)	2	0.14 (0.35)	2	0.06 (0.23)	1	0.03 (0.17)	3	0.22 (0.48)
# Edge spp.	4	0.62 (0.58)	2	0.64 (0.61)	3	1.08 (0.65)	3	0.53 (0.70)	3	0.86 (0.42)	2	0.83 (0.51)	3	0.92 (0.44)
# Edge birds	15	0.83 (0.93)	12	0.70 (0.69)	20	1.69 (1.21)	6	0.53 (0.70)	17	1.42 (0.87)	17	1.39 (1.13)	13	1.08 (0.60)
# Ground shrub spp.	4	0.88 (0.80)	4	0.89 (0.70)	3	0.83 (0.61)	3	0.69 (0.71)	3	0.58 (0.60)	3	0.61 (0.65)	4	0.83 (0.61)
# Ground shrub birds	18	1.14 (1.26)	20	1.28 (1.04)	21	1.75 (1.73)	10	0.86 (1.05)	10	0.86 (1.13)	10	0.83 (0.94)	17	1.39 (1.23)
# Mid-story spp.	8	2.98 (1.18)	7	3.15 (0.98)	8	2.58 (1.18)	6	2.22 (1.10)	7	2.22 (1.35)	7	1.97 (1.08)	12	2.83 (1.06)
# Mid-story birds	83	4.69 (2.28)	69	4.30 (1.94)	44	3.64 (1.96)	37	3.06 (1.82)	37	3.11 (2.14)	32	2.64 (1.89)	50	4.19 (1.83)
# Opening spp.	1	0.02 (0.15)	1	0.02 (0.15)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Opening birds	1	0.02 (0.15)	1	0.02 (0.15)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Water spp.	3	0.17 (0.38)	3	0.11 (0.31)	1	0.17 (0.38)	1	0.11 (0.32)	1	0.11 (0.32)	1	0.06 (0.23)	4	0.22 (0.48)
# Water birds	4	0.19 (0.45)	3	0.11 (0.31)	5	0.42 (1.16)	8	0.69 (2.36)	3	0.22 (0.76)	2	0.14 (0.68)	7	0.56 (1.52)

Table D-2 (cont'd).—Total, mean, and standard deviation by species guilds for the Burned Area from 2012 to 2018.

Los Lunas Burned area	2012 12 points		2013 12 points		2014 12 points		2015 12 points		2016 12 points		2017 12 points		2018 12 points	
	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)
# Species	30	5.72 (0.74)	23	5.61 (0.87)	28	5.50 (1.21)	32	4,97 (1.11)	38	5.14 (1.73)	32	4.50 (1.52)	28	4.58 (1.36)
# Birds	96	7.97 (1.73)	102	8.53 (2.08)	100	8.31 (2.27)	73	6.06 (1.96)	91	7.58 (1.13)	76	6.36 (2.46)	69	5.78 (2.08)
# Canopy spp.	3	0.17 (0.38)	3	0.19 (0.47)	5	0.25 (0.50)	4	0.25 (0.50)	4	0.22 (0.42)	5	0.31 (0.58)	4	0.31 (0.52)
# Canopy birds	2	0.17 (0.38)	3	0.25 (0.65)	5	0.28 (0.57)	4	0.28 (0.57)	4	0.31 (0.67)	5	0.44 (0.94)	4	0.31 (0.52)
# Cavity spp.	6	0.58 (0.60)	4	0.39 (0.55)	4	0.22 (0.48)	7	0.44 (0.69)	7	0.58 (0.60)	6	0.58 (0.69)	5	0.50 (0.65)
# Cavity birds	9	0.78 (0.90)	6	0.47 (0.70)	4	0.25 (0.55)	7	0.53 (0.88)	10	0.86 (1.25)	10	0.86 (1.02)	7	0.56 (0.81)
# Dense shrub spp.	2	0.14 (0.35)	0	0.00 (0.00)	2	0.22 (0.42)	1	0.31 (0.47)	2	0.17 (0.38)	3	0.08 (0.28)	1	0.03 (0.17)
# Dense shrub birds	2	0.19 (0.52)	0	0.00 (0.00)	3	0.25 (0.50)	4	0.31 (0.47)	2	0.17 (0.38)	3	0.08 (0.28)	1	0.03 (0.17)
# Edge spp.	4	0.92 (0.50)	2	0.94 (0.33)	1	0.75 (0.44)	4	0.89 (0.52)	4	0.47 (0.51)	2	0.22 (0.49)	2	0.19 (0.40)
# Edge birds	15	1.25 (1.00)	18	1.53 (0.84)	16	1.31 (1.01)	13	1.11 (0.78)	9	0.72 (0.94)	3	0.31 (0.71)	2	0.22 (0.48)
# Ground shrub spp.	4	1.00 (0.72)	4	1.00 (0.72)	5	1.06 (0.75)	5	0.72 (0.78)	7	0.94 (0.92)	4	0.44 (0.56)	3	0.83 (0.56)
# Ground shrub birds	14	1.19 (0.89)	16	1.33 (1.10)	18	1.47 (1.23)	10	0.86 (0.93)	16	1.28 (1.23)	8	0.64 (0.93)	14	1.17 (0.88)
# Mid-story spp.	10	2.78 (1.05)	9	2.94 (0.98)	9	2.89 (0.98)	10	2.33 (1.24)	11	2.56 (1.38)	9	2.78 (1.17)	12	2.72 (1.06)
# Mid-story birds	48	3.97 (1.76)	56	4.67 (2.01)	55	4.58 (1.79)	35	2.94 (2.11)	48	3.97 (2.57)	47	3.92 (2.00)	42	3.47 (1.44)
# Opening spp.	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Opening birds	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)
# Water spp.	1	0.14 (0.35)	1	0.14 (0.35)	2	0.11 (0.40)	1	0.03 (0.17)	4	0.17 (0.45)	3	0.08 (0.28)	0	0.00 (0.00)
# Water birds	4	0.33 (0.93)	3	0.28 (0.74)	2	0.17 (0.61)	1	0.03 (0.17)	4	0.25 (0.69)	3	0.11 (0.40)	0	0.00 (0.00)

APPENDIX E

SOUTHWESTERN WILLOW FLYCATCHER AND WESTERN YELLOW-BILLED CUCKOO SURVEY FORMS AND MAPS 2018

Willow Flycatcher (WIFL) Survey and Detection Form (revised April, 2010)

Site Name:	**BL-25**	State:	**New Mexico**	County:	**Valencia**
USGS Quad Name:	**Tome, Los Lunas**			Elevation:	**1,469** (meters)
Creek, River, or Lake Name:	**Rio Grande**				

Is copy of USGS map marked with survey area and WIFL sightings attached (as required)? ***Yes*** **X** ***No***

Survey Coordinates:		E		N				
	Start:	E	**341,191**	N	**3,848,584**	UTM	Datum: **NAD83**	(See instructions)
	Stop:	E	**340,201**	N	**3,845,501**	UTM	Zone: **13**	

If survey coordinates changed between visits, enter coordinates for each survey in comments section on back of this page.

*****Fill in additional site information on back of this page*****

Survey # Observer(s) (Full Name)	Date (m/d/y) Survey Time	Number of Adult WIFLs	Estimated Number of Pairs	Estimated Number of Territories	Nest(s) Found? Y or N / If Yes, number of nests	Comments (e.g., bird behavior; evidence of pairs or breeding; potential threats [livestock, cowbirds, *Diorhabda* spp.]). If *Diorhabda* found, contact USFWS and State WIFL coordinator.	# Birds	Sex	UTM E	UTM N
Survey # 1	Date: 5/21/2018	3	0	3	N	All detections in coyote willow or mixed coyote willow and salt cedar with Russian olive/ cottonwood overstory, along river. Site dry. Evidence of recent livestock activity.	1	M	340,882	3,847,676
Observer(s): K. Barnhart	Start: 5:30						1	M	340,780	3,847,499
	Stop: 11:00						1	M	340,839	3,847,598
	Total hrs: 5.5									
Survey # 2	Date: 6/5/2018	2	0	2	N	Limted habitat in southern end of site. Potentially suitable habitat throughout rest of site, with dense understory and overstory vegetation. Vegetation comprised predominately of salt cedar, young coyote willow, and cottonwood.	1	M	340,830	3,847,875
Observer(s): B. Kakert	Start: 6:00						1	M	340,839	3,847,598
	Stop: 10:30									
	Total hrs: 4.5									
Survey # 3	Date: 6/29/2018	0	0	0	N	Abundant native overstory with moderately dense mixed native and exotic understory vegetation. Site dry. Cowbirds present.				
Observer(s): M. Curtis	Start: 5:45									
	Stop: 10:45									
	Total hrs: 5.0									
Survey # 4	Date:									
Observer(s):	Start:									
	Stop:									
	Total hrs:									
Survey # 5	Date:									
Observer(s):	Start:									
	Stop:									
	Total hrs:									

Overall Site Summary	Total Adult Residents	Total Pairs	Total Territories	Total Nests	
Totals do not equal the sum of each column. Include only resident adults. Do not include migrants, nestlings, and fledglings. Be careful not to double count individuals.	0	0	0	0	Were any WIFLs color-banded? Yes ___ No **X**
Total survey hrs: 15.0					If yes, report color combination(s) in the comments section on back of form and report to USFWS.

Reporting Individual:	**Darrell Ahlers**	Date Report Completed:	**9/4/2018**
US Fish & Wildlife Service Permit #:	**TE819475-7**	State Wildlife Agency Permit #:	**N/A**

<u>Submit</u> form to USFWS and State Wildlife Agency by September 1st. Retain a copy for your records.

Fill in the following information completely. Submit form by September 1st. Retain a copy for your records.

Reporting Individual **Darrell Ahlers** Phone # **(303) 445-2233**

Affiliation **Bureau of Reclamation** E-mail dahlers@usbr.gov

Site Name **BL-25** Date report Completed **9/4/2018**

Was this site surveyed in a previous year? Yes__X__ No____ Unknown____

Did you verify that this site name is consistent with that used in previous yrs? Yes **X** No ____ Not Applicable ____

If name is different, what name(s) was used in the past? **N/A**

If site was surveyed last year, did you survey the same general area this year? Yes **X** No ____ If no, summarize below.

Did you survey the same general area during each visit to this site this year? Yes **X** No ____ If no, summarize below.

Management Authority for Survey Area: Federal ____ Municipal/County ____ State ____ Tribal ____ Private **X**

Name of Management Entity or Owner (e.g., Tonto National Forest) **MRGCD**

Length of area surveyed: **3.3** (km)

Vegetation Characteristics: Check (only one) category that best describes the predominant tree/shrub foliar layer at this site:

____ Native broadleaf plants (entirely or almost entirely, > 90% native)

X Mixed native and exotic plants (mostly native, 50 - 90% native)

____ Mixed native and exotic plants (mostly exotic, 50 - 90% exotic)

____ Exotic/introduced plants (entirely or almost entirely, > 90% exotic)

Identify the 2-3 predominant tree/shrub species in order of dominance. Use scientific name.

Salix exigua, Eleagnus angustifolia, Populus sp.

Average height of canopy (Do not include a range): **15** (meters)

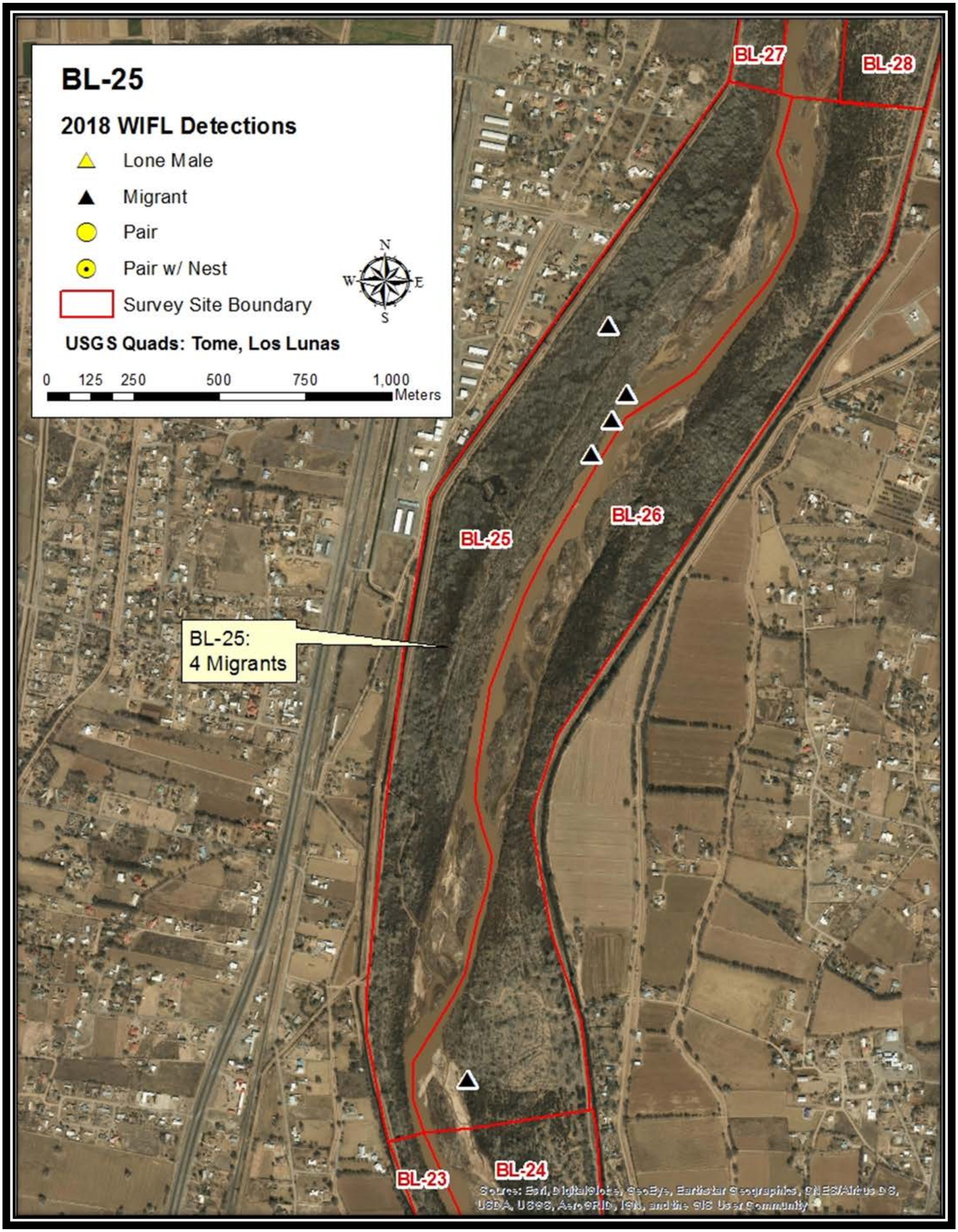
Attach the following: 1) copy of USGS quad/topographical map (REQUIRED) of survey area, outlining survey site and location of WIFL detections;
2) sketch or aerial photo showing site location, patch shape, survey route, location of any detected WIFLs or their nests;
3) photos of the interior of the patch, exterior of the patch, and overall site. Describe any unique habitat features in Comments.

Comments (such as start and end coordinates of survey area if changed among surveys, supplemental visits to sites, unique habitat features. Attach additional sheets if necessary.

Territory Summary Table. Provide the following information for each verified territory at your site.

Territory Number	All Dates Detected	UTM E	UTM N	Pair Confirmed? Y or N	Nest Found? Y or N	Description of How You Confirmed Territory and Breeding Status (e.g., vocalization type, pair interactions, nesting attempts, behavior)

Attach additional sheets if necessary


BL-25
2018 WIFL Detections
Lone Male
Migrant
Pair
Pair w/ Nest
Survey Site Boundary
USGS Quads: Tome, Los Lunas
0 125 250 500 750 1,000
Meters
N
W
E
S
BL-27
BL-28
BL-26
BL-25
BL-25:
4 Migrants
BL-23
BL-24
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Yellow-billed Cuckoo Survey Form

Site Name:	BL-25	County: Socorro	State: New Mexico
USGS Quad Name:	Tome		Elevation: 1,469m
Creek, River, Wetland, or Lake Name	Rio Grande		
Site Coordinates:	Start: E 341,191	N 3,848,584	UTM Zone: 13
	Stop: E 340,201	N 3,845,501	Datum: NAD83
Ownership:	Private		
Was site surveyed in previous year?	Yes	If yes, what site name was used?	BL-25

Survey # Observer(s) (Last Name, First Initial)	Date (m/d/y) Time, Total Hours	Total Number of YBCUs detected.	Time Detected (AM):	Detect Type: I=Incidental P=Playback A=aural V=visual B=both	Voc. Type: CN=Contact CO=coo AL=alarm OT=other (describe)	Playback #: Number of times 'Kowlp' call played prior to response	Behavior code	Surveyor Detection Coordinates UTM E	Surveyor Detection Coordinates UTM N	Distance (m)	Bearing	Cuckoo#	Corrected Coordinates UTM E	Corrected Coordinates UTM N
Survey Period #1	Date: 6/29/2018													
Observer(s): Curtis	Start: 5:45 AM													
	Stop: 10:45 AM													
	Total hrs: 5.00	Total: 0												
Survey Period #2	Date: 7/12/2018													
Observer(s): Lambeau	Start: 5:45 AM													
	Stop: 10:15 AM													
	Total hrs: 4.50	Total: 0												
Survey Period #3	Date: 7/31/2018													
Observer(s): Baughman	Start: 6:00 AM													
	Stop: 10:30 AM													
	Total hrs: 4.50	Total: 0												
Survey Period #4	Date: 8/14/2018													
Observer(s): Fetherston	Start: 6:15 AM													
	Stop: 10:30 AM													
	Total hrs: 4.25	Total: 0												
Survey Period #5	Date:													
Observer(s):	Start:													
	Stop:													
	Total hrs:	Total:												

Survey Summary: Total YBCUs*	# Det	#PO	#PR	#CO	#Nests found	Total Survey Hours:
	0	0	0	0	0	18.25

Notes (refer to Cuckoo # associated with individual detections)

Cottonwood overstory and semi-dense mixed native and exotic understory.
Understory a mix of coyote willow, salt cedar, and Russian olive. Areas of sparse canopy throughout.
Young coyote willow throughout site, mature cottonwood along road.

*Include justification for these designations.

Behavior Codes: AN = at nest, BI = brooding or incubating, CF = adult carrying food, CN = carrying nest material, COP = copulation, CP = catches prey, DD = distraction displays/defense of nesting area, EF = eats food, FL = recently fledged young of species incapable of flight, FLY = flying, FO = foraging, FS = adult carrying a fecal sac, FY = adults feeding nestlings, JUV = juvenile, NB = nest building, NE = active nest with unbroken eggs in it, NY = nest with young seen or heard in it, ON = occupied nest, PR = preening, SI = sitting, US = used, inactive nest with blue-green eggshells.

Yellow-Billed Cuckoo Survey Site Description Form for Electronic Submission

This form is intended to provide a general descrition of the habitat surveyed at a site. More detailed vegetation analysis requires precise measurements, and is outside the scope of this survey protocol. Please check your permit for additional requirements.

Fill in the following information completely	**Date Report completed:** 9/14/18	
Site Name: BL-25	State: New Mexico	County: Socorro
Name of Reporting Individual Darrell Ahlers	Affiliation Bureau of Reclamation	
Phone # (303) 445-2233	Email: dahlers@usbr.gov	
USFWS Permit # TE819475-7	State Permit # N/A	

Site Coordinates:	Start: E 341,191	N 3,848,584	UTM Zone: 13
	Stop: E 340,201	N 3,845,501	NAD: NAD 83
USGS Quad Name(s): Tome		Length of area surveyed (in kilometers) 3.3	Elevation: 1,469
Name of nearest Creek, River, Wetland, or Lake: Rio Grande			
Ownership: Private			
Was site surveyed in previous year? ☑ Yes ☐ No ☐ Unknown		If yes, what site name was used? BL-25	
Did you survey the same general area during each visit this year? ☑ Yes ☐ No		If no, summarize in comments below	
If "Yes", was the same general area surveyed this year? ☑ Yes ☐ No		If no, summarize in comments below	

Native/Exotic: The species in tree/shrub layer at this site are comprised predominantly of (check one):

Native broadleaf plants (>75% native) ☐	Mixed native and exotic plants (mostly native 51%-75%) ☑
Exotic/introduced plants (>75% exotic) ☐	Mixed native and exotic plants (mostly exotic 51%-75%) ☐

List up to 5 species of overstory vegetation and percent canopy cover of each species. Use scientific names. For percent cover, please use <1%; 10%, 25%, 50%, 75%, 90%, 100%.

1. *Populus deltoides*	% cover: 80	2. *Tamarix sp.*	% cover: 10	3. *Morus sp.*	% cover: 10
4.	% cover:	5.	% cover:		
Average height of overstory (m)(do not include a range)	15		Estimated Overall Canopy Cover (percent)	50%	

List up to 5 species of understory/shrub vegetation (not all sites will have a separate understory) and estimate percent understory cover of each species. Use scientific names. For percent cover, please use <1%; 10%, 25%, 50%, 75%, 90%, 100%.

1. *Salix gooddingii*	% cover: 1	2. *Salix exigua*	% cover: 40	3. *Eleagnus angustifolia*	% cover: 50
4. *Tamarix sp.*	% cover: 4	5. *Morus sp.*	% cover: 5		
Average height of understory (m)(do not include a range)	3		Estimated Overall Cover (percent)	80%	

Describe adjacent habitat (e.g. upland vegetation; desert scrub; urban/residential; agriculture/orchard; oak woodland)

Adjacent habitat within 500 meters east of the site is composed of agricultural and riparian vegetation, the habitat west is primarily residential areas.

List up to five categories of adjacent habitat, and estimate percent cover. Use <1%; 10%, 25%, 50%, 75%, 90%, 100%.

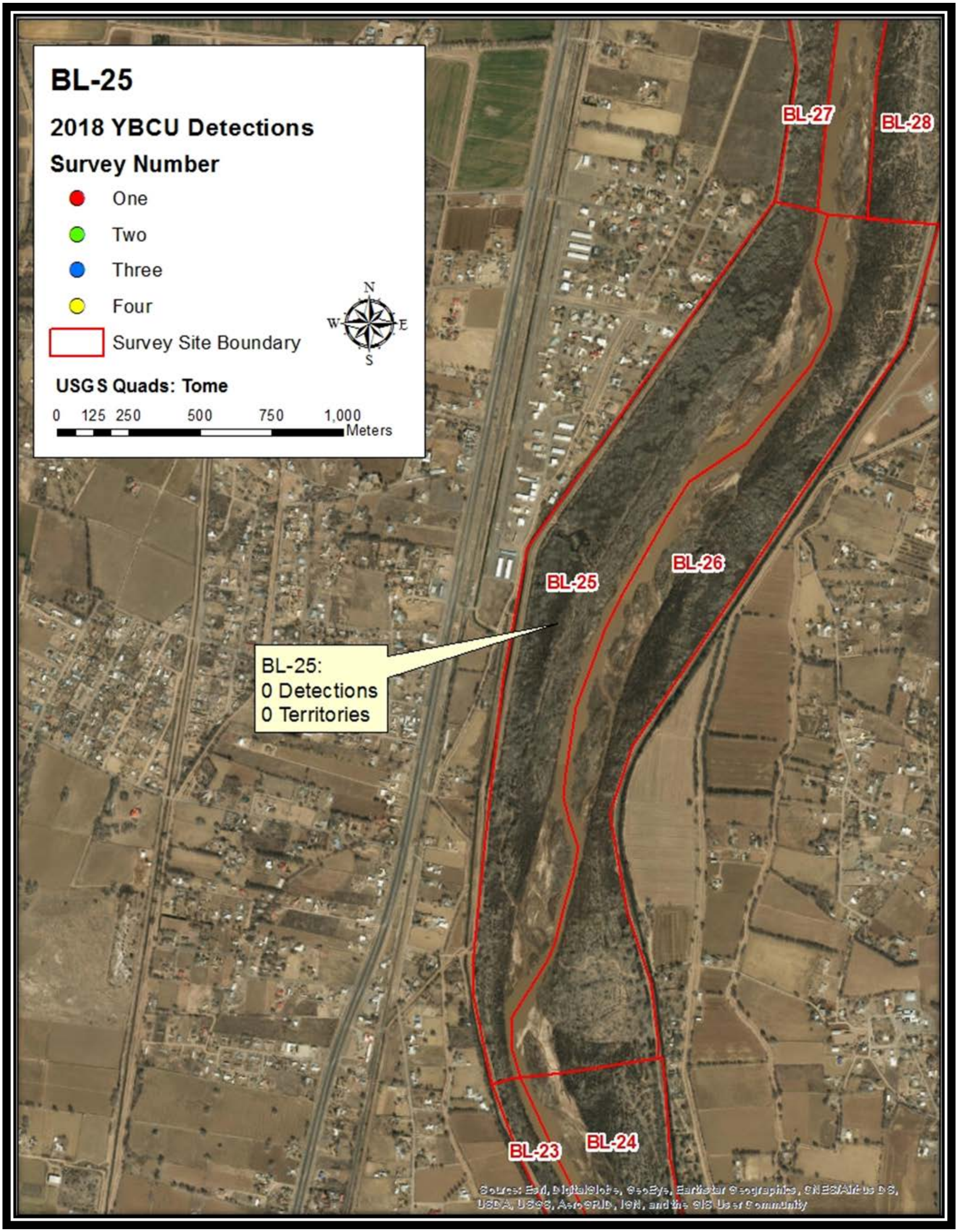
1. Residential	% cover: 50	2. Riparian	% cover: 45	3. Agricultural	% cover: 5
4.	% cover:	5.	% cover:		

Was surface water or saturated soil present at or adjacent to site within 300 meters?	☑ Yes ☐ No
Was surface water or saturated soil present at or adjacent to all patches surveyed?	☑ Yes ☐ No

Comments. Please provide comments regarding differences between the survey patches within the site. For example, if the average canopy for this site is 30% cover, but within one patch it is 60% cover - please note. Also, please note significant differences between dominant overstory and understory vegetation among the patches. Document these differences with photographs whenever possible. Make sure to reference comments to photo number whenever available.

Canopy cover and vegetation patches vary throughout the site. Generally, there are more open areas and tamarisk dominated patches on the eastern side and more canopy cover and density on the western side near the river.

*See survey site map below



BL-25
2018 YBCU Detections
Survey Number
One
Two
Three
Four
Survey Site Boundary
USGS Quads: Tome
0 125 250 500 750 1,000
Meters
N
W
E
S
BL-27
BL-28
BL-25
BL-26
BL-25:
0 Detections
0 Territories
BL-23
BL-24
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

APPENDIX F

PLANT SPECIES LIST

TOTAL PERCENT COVER OF PLANTS DETECTED IN THE UNDERSTORY LAYER BY INDIVIDUAL SPECIES, LIFE-FORM, AND COVER TYPE

TOTAL PERCENT COVER, HEIGHT, AND FREQUENCY OF PLANTS DETECTED IN THE OVERSTORY LAYER BY INDIVIDUAL SPECIES

Table F-1.— List of plant species detected from 2003 to 2018.

	Code	Scientific name	Common name	Lifeform*
Trees/shrubs	BASA	*Baccharis salicifolia*	Seep willow	NS
	ELAN	*Eleagnus angustifolia*	Russian olive	IT
	MOSP	*Morus* sp	Mulberry	IT
	POAN	*Populus angustifolia*	Narrowleaf cottonwood	NT
	PODE	*Populus deltoides*	Rio Grande cottonwood	NT
	SAEX	*Salix exigua*	Coyote willow	NT/S
	SAGO	*Salix gooddingii*	Gooddings willow	NT
	TARA	*Tamarix ramosissima*	Saltcedar	IT/S
	ULPU	*Ulmus pumila*	Siberian elm	IT
Grasses/grass-like	AGGI	*Agrostis gigantea*	Redtop	IG
	BOBA	*Bothriochloa barbinodis*	Cane bluestem	NG
	BRIN	*Bromus inermis*	Smooth brome	IG
	BRJA	*Bromus japonicus*	Japonese brome	IG
	CAEM	*Carex* emoryi	Emory's sedge	NG
	COSE	*Cortaderia selloana*	Pampas grass	IG
	CYOD	*Cyperus odoratus*	Fragrant flatsedge	NG
	DISP	*Distichlis spicata*	Saltgrass	NG
	ECCR	*Echinochloa crus-galli*	Barnyard grass	IG
	ELPA	*Eleocharis palustris*	Common spikerush	NG
	ELCA	*Elymus canadensis*	Canada wildrye	NG
	ELTR	*Elymus trachycaulus*	Slender wheatgrass	NG
	ERHY	*Eragrostis hypnoides*	Teal lovegrass	NG
	HOJU	*Hordeum jubatum*	Barley foxtail	NG
	JUBA	*Juncus balticus*	Baltic rush	NG
	JUEN	*Juncus ensifolius*	Sword-leaved rush	NG
	LEOR	*Leersia oryzoides*	Rice cutgrass	NG
	LEFU	*Leptochloa fusca*	Mexican sprangletop	NG
	MUAS	*Muhlenbergia asperifolia*	Scratchgrass	NG
	MURA	*Muhlenbergia racemosa*	Muhly	NG
	PACA	*Panicum capillare*	Witchgrass	NG
	PAOB	*Panicum obtusum*	Vine mesquite	NG
	PHAU	*Phragmites australis*	Common reed	NG
	POPA	*Poa pratensis*	Kentucky bluegrass	NG
	POMO	*Polypogon monspeliensis*	Rabbitfoot grass	IG
	SCPR	*Schedonorus pratensis*	Meadow fescue	IG
	SCAC	*Schoenplectus acutis*	Hardstem bulrush	NG
	SCAM	*Schoenplectus americanus*	American threesquare	NG
	SOHA	*Sorghum halepense*	Johnson grass	IG
	SPAI	*Sporobolus airoides*	Alkali sacaton	NG
	SPCR	*Sporobolus cryptandrus*	Sand dropseed	NG

Forbs	AGPA	*Agastache pallidiflora ssp neomexicana*	New Mexico giant hyssop	NF
	AMBL	*Amaranthus blitoides*	Prostrate amaranth	IF
	AMPS	*Ambrosia psilostachya*	Western ragweed	NF
	APCA	*Apocynum cannabinum*	Clasping-leaf dogbane	NF
	ARAB	*Artemisia absinthium*	Wormwood	IF
	ARAN	*Argentina anserina*	Silverweed cinquefoil	NF
	ASSU	*Asclepias subverticillata*	Horsetail milkweed	NF
	ASSP	*Astragalus* sp.	Milkvetch	NF
	BIFR	*Bidens frondosa*	Beggarstick	NF
	CHAL	*Chenopodium album*	Lambsquarters	IF
	CHSE	*Chamaesyce serpyllifolia*	Thymeleaf spurge	NF
	CLLI	*Clematis ligusticifolia*	Virgin's bower	NF
	COAR	*Convolvulus arvensis*	Field bindweed	IF
	COCA	*Conyza canadensis*	Horseweed	NF
	CUSP	*Cuscuta* sp.	Dodder	NF
	DALE	*Dalea leporina*	Foxtail dalea	NF
	DEIL	*Desmanthus illinoensis*	Bundleflower	NF
	EQLA	*Equisetum laevigatum*	Smooth scouringrush	NF
	EUOC	*Euthamia occidentalis*	Western goldentop	NF
	GAPA	*Gaura parviflora*	Small-flowered gaura	NF
	GRSQ	*Grindelia squarrosa*	Curlycup gumweed	NF
	HEAN	*Helianthus annuus*	Common sunflower	NF
	KOSC	*Kochia scoparia*	Kochia	IF
	LASP	*Lactuca serriola*	Prickly lettuce	IF
	LELA	*Lepidium latifolium*	Perrenial pepperweed	IF
	MEAL	*Melilotus albus*	White sweetclover	IF
	OEEL	*Oenothera elata*	Hooker's evening primrose	NF
	PESP	*Penstemon* sp.	Penstemon	NF
	PLLA	*Plantago lanceolata*	Narrowleaf plantain	IF
	PLMA	*Plantago major*	Common plantain	IF
	POLA	*Polygonum lapathifolium*	Pale smartweed	NF
	PSST	*Pseudognaphalium stramineum*	Cottonbatting cudweed	NF
	PYPA	*Pyrrhopappus pauciflorus*	Smallflower desert-chicory	NF
	RATA	*Ratibida tagetes*	Short-rayed coneflower	NF
	RUCR	*Rumex crispis*	Curly dock	IF
	SAIB	*Salsola iberica*	Russian thistle	IF
	SOAR	*Sonchus arvensis*	Field sowthistle	IF
	SOCA	*Solidago canadensis*	Golden rod	NF
	SYER	*Symphyotrichum ericoides*	White heath aster	NF
	TAOF	*Taraxacum officinale*	Dandelion	IF
	TRTE	*Tribulus terrestris*	Goats head	IF
	XAST	*Xanthium strumarium*	Common cocklebur	NF

*N=NATIVE, I=INTRODUCED, T=TREE, S=SHRUB, G=GRASS, F=FORB

Table F-2.— Total percent cover by individual species, life-form and cover type in the understory layer.

Understory layer	Total Percent Cover															
	2003	**2004**	**2005**	**2006**	**2007***	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Coyote willow	0.6	1.0	1.9	4.7	0.5	1.0	1.3	1.1	2.2	0.8	3.4	1.9	0.9	1.1	1.0	1.2
Cottonwood	0	0.4	1.3	7.1	0.3	0.5	0.3	0.1	0.4	0.3	0.5	0.1	0	0	0.3	0.3
Gooddings willow	0	0	0	0.1	0.1	0	0.1	0	0.1	0	0	0	0	0	0.1	0
Baccharis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Total native shrubs	0.6	1.4	3.2	11.9	0.9	1.5	1.7	1.2	2.7	1.1	3.9	2.0	0.9	1.1	1.4	1.8
Saltcedar	0.4	0.8	2.8	5.0	1.0	0.8	0.8	1.1	1.3	0.7	1.1	1.1	0.6	0.8	0.5	0.3
Russian olive	0	0	0	0.2	0	0.1	0	0	0	0	0	0.1	0	0	0	0
Siberian elm	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0	0
Total introduced shrubs	0.4	0.8	2.8	5.2	1.0	0.9	0.8	1.1	1.3	0.7	1.1	1.2	0.8	1.0	0.5	0.3
Fragrant flatsedge	1.7	3.5	8.4	0.5	2.1	4.4	1.0	0.1	0	0	0	0	0	0	0.1	0
Baltic rush	1.3	0	0	0	0	0	1.1	0.7	0.3	0.2	0	0.1	0.3	0.1	0	0
Muhly	1.3	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Witchgrass	1.1	5.2	4.4	0.8	0.4	1.7	0.4	0.4	0.3	0	0.3	0	0.2	0	0	0
Vine mesquite	0.4	0.4	1.6	4.7	7.6	12.2	16.9	15.7	9.2	4.5	6.7	6.7	9.2	5.7	7.7	6.1
Common spikerush	0	0.2	0	0	0.2	0.4	0.5	0.4	0	0	0	0	0	0	0.3	0
Saltgrass	0	0.1	0	0	0	0	0.2	0	0	0	1.0	0	0.3	1.4	1.7	0.8
Kentucky bluegrass	0	0.2	0.6	0.3	0.1	0	0	0.4	0	0.1	0	0.4	0.4	0	0.4	0.2
Emory's sedge	0	0.1	0	0	0.1	0.6	0.1	0.7	0.6	0.8	0.5	0.3	1.6	1.8	3.2	2.6
Mexican sprangletop	2.2	6.7	1.1	2.5	0.1	0.7	0.4	0.2	0	0	0.1	0	0	0	0	0
Teal lovegrass	0	0	2.6	0	0.3	0.2	0.2	0	0	0	0.1	0	0	0	0	0
Barley foxtail	0	0	0	2.8	5.3	7.4	2.6	4.2	0.4	0.3	0.1	0.4	0.3	1.5	0.9	2.7
Common reed	0	0	0	0	0.8	0.4	0.6	0.7	0.7	1.0	0.5	0.3	0.4	0.3	0.1	0.1
Sword-leaved rush	0	0	0	0	0	0.2	0	0.2	0	0	0	0	0	0	0	0
Rice cutgrass	0	0	0	0	0	0.2	0.5	0.2	0	0	0	0	0	0	0	0
Hardstem bulrush	0	0	0	0	0	0.4	0.2	0	0	0	0	0	0	0.3	0.8	0
American threesquare	0	0	0	0	0	0	0.7	0.2	0.1	0	0	0	0	0	0	0
Scratchgrass	0	0	0	0	0	0	0	0.4	0.4	0.9	1.8	0.3	1.0	1.8	2.3	2.1
Sand dropseed	0	0	0	0	0	0	0	0	0	0.1	0.7	0.5	0.3	1.0	0	0
Slender wheatgrass	0	0	0	0	0	0	0	0.4	0.4	0.2	0	0	0	0.3	0	0
Cane bluestem	0	0	0	0	0	0	0	0	0	0	0.2	0.1	0.3	0	0	0
Alkali sacaton	0	0	0	0	0	0	0	0	0	0	0.4	0.3	0.4	0.4	0.1	0
Canada wildrye	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0

Understory layer	Total Percent Cover															
	2003	2004	2005	2006	2007*	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total native grasses	8.0	19.1	18.7	11.6	17.0	28.8	25.4	24.7	12.4	8.1	12.4	9.4	14.7	14.7	17.6	14.6
Barnyard grass	1.3	4.3	6.0	2.8	1.0	1.1	0.4	0.1	0	0	0	0	0	0	0	0
Rabbitfoot grass	1.6	4.5	2.8	0.1	2.0	3.2	0.2	0	0	0	0	0	0	0	0.2	0
Smooth brome	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0
Meadow fescue	0	0	0	0	0	0.1	0.3	0.1	0.5	0.6	0.4	0.4	0.4	0.7	0.2	0.3
Johnson grass	0	0	0	0	0	0.0	0.1	0.3	0.1	0	0	0	0	0	0	0.3
Japanese brome	0	0	0	0	0	0	0	0.4	0	0.5	0.3	0.2	0	1.2	0	0.3
Pampas grass	0	0	0	0	0	0	0	0.4	0	0.2	0.2	0	0.3	0.1	0.2	0.3
Redtop	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.3	0
Total introduced grasses	2.9	8.8	8.8	2.9	3.0	5.7	1.0	1.3	0.6	1.3	0.9	0.8	0.7	2.4	1.0	1.2
Horseweed	0.2	0	0	4.3	7.7	0	0	0.7	0.3	0.6	0.4	4.1	0.2	0	0	1.7
Common sunflower	7.9	13.9	0.3	3.9	1.1	1.9	0	1.0	0	0.8	0.2	0.3	0	0	0	0.1
Pale smartweed	0.8	1.2	0.2	5.9	1.0	0.2	0.1	0.1	0	0	0	0	0	0	0	0
Common cocklebur	0.3	3.3	17.9	8.1	10.3	19.4	11.8	3.8	0.1	0.2	1.2	1.2	1.1	0.6	0.7	0
Beggarstick	0	0.9	3.4	0.5	0.1	0.2	0.2	0	0	0	0	0	0.1	0	0.1	0
Western goldentop	0	0.3	0.8	1.7	2.9	11.9	9.2	7.3	3.4	2.8	2.3	2.6	3.9	3.9	6.2	6.2
Clasping-leaf dogbane	0	0	0.3	0.2	0.9	1.5	1.5	1.4	1.5	1.3	1.3	1.5	1.0	3.3	2.3	2.4
Milkvetch	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Cottonbatting cudweed	0	0	0	1.2	0.6	0	0.2	0.1	0.3	0	0	0	0	0	0	0
Hooker's evening primrose	0	0	0	1.2	0	0.2	0.1	0.7	0.4	0	0.1	0.2	0.3	0.1	0	0
Dodder	0	0	0	0.1	0	0	0.4	0	0	0	0	0	0	0	0	0
Bundleflower	0	0	0	0	0.5	0.2	0.7	1.3	0.2	0	0	0	0	0	0	0
Western ragweed	0	0	0	0.2	0.4	0.8	1.3	2.0	2.5	2.7	2.5	2.3	3.8	3.9	0.9	1.5
Silverweed cinquefoil	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0
Penstemon	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Smooth scouringrush	0	0	0	0	0	0.1	0.2	0.8	0.7	1.0	0.4	0.4	0.2	1.4	2.5	2.8
New Mexico giant hyssop	0	0	0	0	0	0	0.4	0.2	0.1	0.1	0	0	0	0	0	0
Curlycup gumweed	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
Thymeleaf spurge	0	0	0	0	0	0	0	0.2	0	0.1	0.8	0	0.3	0.3	0.2	0
Small-flowered gaura	0	0	0	0	0	0	0	0.3	0	0	0	0.3	0	0	0	0.8
Foxtail dalea	0	0	0	0	0	0	0	0	0.3	0.1	0.3	0	0	0	0	0
Golden rod	0	0	0	0	0	0	0	0	0	0.1	0.1	0.2	0	0	0	0
Short-rayed coneflower	0	0	0	0	0	0	0	0	0	0.2	0	0.1	0.3	0	0	0

Understory layer	Total Percent Cover															
	2003	**2004**	**2005**	**2006**	**2007***	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Horsetail milkweed	0	0	0	0	0	0	0	0	0	0	0.5	0	0.3	0.9	0.3	0.3
Vigin's bower	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0.1	0	0.2
White heath aster	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Smallflower desert-chicory	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0
Total native forbs	9.2	19.6	22.9	27.5	25.5	37.0	26.1	19.7	9.8	10.0	10.3	13.7	11.5	14.8	13.2	16.0
Lambsquarters	6.2	5.2	0.3	0.1	0	0.1	0.1	0	0	0	0	0	0	0	0	0
Kochia	0.5	3.6	3.8	4.2	2.8	2.7	2.7	3.3	0	3.0	2.1	1.8	2.2	1.0	2.8	1.0
Prickly lettuce	0.1	0.8	0	6.0	2.3	0.9	0	0.2	0.1	0.6	0.1	0.2	0	0.1	0	0.1
White sweetclover	4.2	7.1	0.4	6.8	4.7	1.7	1.5	1.2	4.4	2.7	3.5	7.3	1.8	0.5	0	4.9
Russian thistle	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perrenial pepperweed	0	0.2	0	0	0	0	0.1	2.3	0.3	1.0	0.3	0.1	0	0.1	0	0.1
Wormwood	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curly dock	0	0	0.1	0.5	1.6	0.1	0.0	0.1	0.3	0	0.1	0	0	0	0.2	0
Prostrate amaranth	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Goats head	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Field bindweed	0	0	0	0	0	0.2	0	0	0	0	0.5	0.3	0.2	0.1	0.5	0.3
Narrowleaf plantain	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Dandelion	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
Common plantain	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Field sowthistle	0	0	0	0	0	0	0	0	0	0	0	0.3	0.1	0.1	0	0.2
Total Introduced forbs	11.0	17.8	4.8	17.8	11.4	5.7	4.4	7.0	5.3	7.3	6.7	10.0	4.3	1.9	3.5	6.6
Total understory vegetation	32.1	67.5	61.2	76.9	58.8	79.6	59.4	55.0	32.1	28.5	35.3	37.1	32.9	35.9	37.2	40.5
Litter	4.4	5.2	7.3	5.5	23.4	12.7	30.5	42.6	60.1	67.8	55.3	59.3	65.7	57.2	50.7	54.4
Bare soil	63.5	27.3	31.5	17.6	17.8	7.7	10.2	2.4	7.9	3.7	9.4	3.7	1.4	7.0	12.3	5.3
Total cover	100.0	100.0	100.0	100.0	100.0	100.0	100.1	100.0	100.1	100.0	100.0	100.1	100.0	100.1	100.2	100.2

Table F-3.— Total percent cover by individual species in the overstory layer.

Overstory plant species	2007			2008			2009			2010			2011			2012		
	Tot % cover	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**
Coyote willow	14.9	1.6	92	23.9	2.1	92	35.8	2.4	100	25.4	2.3	100	25.7	2.2	100	14.2	2.3	100
Goodding willow	0.7	1.6	25	0.9	2.4	25	1.5	2.9	58	1.0	3.3	50	1.0	3.4	42	0.2	2.4	17
Rio Grande Cottonwood	15.0	2.3	100	27.7	3.1	92	43.4	4.6	100	41.5	4.9	100	53.9	5.1	100	45.4	6.4	100
Narrowleaf cottonwood	0.0		0	0.0		0	0.0		0	0.0		0	0.3	5.3	8	0.3	3.3	8
Baccharis spp	0.0		0	0.0		0	0.0		0	0.0		0	0.0		0	0.2	1.9	8
Total native woody spp	**30.6**			**52.5**			**80.7**			**67.9**			**80.9**			**60.3**		
Saltcedar	8.5	2.3	92	5.8	2.2	83	9.7	2.8	100	8.9	2.8	100	6.5	2.6	100	5.7	2.7	92
Russian olive	1.1	2.9	17	1.1	3.4	25	1.6	3.9	33	1.9	5.2	42	2.5	4.7	50	3.5	4.9	50
Siberian elm	0.0		0	0.0		0	0.0		0	0.0		0	0.0		0	0.2	2.8	17
Total introduced woody spp	**4.9**			**6.9**			**11.3**			**10.8**			**9.0**			**9.4**		
Total transect cover (accounting for overlap)	**25.9**			**51.1**			**70.0**			**62.7**			**68.3**			**60.8**		

Overstory plant species	2013			2014			2015			2016			2017			2018		
	Tot % cover	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**	**Tot % cover**	**Avg ht (m)**	**Freq (%)**
Coyote willow	22.2	2.4	92	23.1	2.4	100	32.0	2.5	100	30.2	2.3	100	34.1	2.5	100	23.8	2.7	100
Goodding willow	0.5	2.7	33	1.1	3.0	33	1.4	4.2	25.0	0.8	3.6	25.0	0.8	4.2	17	0.4	3.9	25
Rio Grande Cottonwood	49.9	6.4	100	53.8	7.1	100	55.1	7.8	100	64.8	8.9	100	67.5	9.8	100	66.2	10.2	100
Baccharis spp	0.0		0	0.0		0	0.1	1.8	8	0.7	2.3	8	0.2	1.0	8	0.2	2.1	8
Virgin's bower (vine)	0.0		0	0.2	2.5	8	0.0		0	0.0		0	0.0		0	0.0		0
Total native woody spp	**72.6**			**78.2**			**88.6**			**96.5**			**102.6**			**90.6**		
Saltcedar	9.2	3.3	92	9.6	3.0	100	6.8	3.0	83	8.6	3.2	92.0	8.4	2.9	100	8.5	3.2	100
Russian olive	5.5	4.8	58	9.1	4.9	75	13.6	5.5	92	14.7	6.5	100	16.3	5.7	100	21.5	6.2	100
Siberian elm	0.2	2.9	8	0.3	3.7	8	0.1	1.6	8	1.2	2.9	42	2.0	4.6	8	1.9	5.3	17
Total introduced woody spp	**14.9**			**19.0**			**20.5**			**24.5**			**26.7**			**31.9**		
Total transect cover (accounting for overlap)	**72.6**			**76.5**			**84.1**			**88.6**			**90.4**			**86.3**		

APPENDIX G

GROUNDWATER MONITORING WELLS MONTHLY DATA
JUNE 2003 – OCTOBER 2010

Table G-1.—Depth (in inches) below the ground surface to water at each well for each monthly reading from June 2004 to October 2010.

	Well number (depth of well)										
Date	**N1 (62)**	**N2 (62)**	**N3 (60.5)**	**N4 (64)**	**M1 (59)**	**M2 (61)**	**M3 (59)**	**M4 (61)**	**S1 (56)**	**S2 (61.5)**	**S3 (69)**
06/04/03	44.0	41.0	29.0	No well	30.0	29.0	28.0	No well	34.0	49.0	No well
09/04/03	dry	dry	dry	No well	dry	dry	dry	No well	dry	dry	No well
10/30/03	45.0	41.0	31.0	No well	32.0	32.5	36.5	No well	40.0	dry	No well
11/27/03	36.0	41.0	37.0	No well	20.0	19.0	22.5	No well	28.5	51.0	No well
12/21/03	37.0	33.0	25.0	No well	20.0	20.0	21.5	No well	30.5	53.0	No well
01/24/04	38.0	33.0	23.0	No well	20.5	19.5	20.5	No well	31.0	53.0	No well
03/11/04	38.5	33.5	23.5	No well	21.5	20.5	20.5	No well	32.0	54.0	No well
04/01/04	32.0	27.5	18.5	No well	15.5	15.5	18.0	No well	27.5	50.5	No well
04/30/04	42.0	37.0	26.0	No well	26.5	25.5	25.5	No well	37.5	60.0	No well
05/30/04	35.5	33.0	24.0	No well	19.5	20.5	21.5	No well	31.5	55.5	No well
06/29/04	53.5	47.5	35.0	No well	39.5	37.0	36.5	No well	48.5	dry	No well
08/05/04	57.0	53.0	46.0	42.0	31.0	41.0	41.5	dry	39.5	dry	65.0
09/02/04	dry	dry	dry	58.0	dry	dry	dry	dry	56.0	dry	66.0
10/05/04	54.0	49.0	37.0	39.5	41.5	42.0	46.5	dry	50.5	dry	64.0
11/05/04	42.0	37.0	26.0	31.0	28.0	No well	29.5	41.0	35.5	58.0	49.0
12/04/04	36.5	30.0	19.0	23.5	20.0	No well	17.5	28.0	27.5	48.5	41.0
01/07/05	36.5	32.0	23.5	30.0	19.0	20.0	21.0	36.5	29.5	51.0	45.0
02/04/05	36.5	32.0	23.0	29.5	19.0	16.0	20.0	34.5	29.5	51.0	44.0
03/03/05	30.0	27.0	19.0	27.5	13.0	11.0	16.0	33.0	23.0	45.5	39.5
04/02/05	26.5	24.0	16.0	26.0	10.0	8.5	13.0	32.0	19.0	42.0	37.0
05/06/05	0.0	14.5	8.5	19.0	0.0	0.0	5.5	25.5	11.0	36.0	32.5
06/06/05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
07/31/05	dry	57.5	43.0	40.5	47.0	39.5	42.0	49.5	52.0	dry	61.5
08/30/05	dry	59.0	40.0	34.0	48.0	40.0	37.5	52.0	52.5	dry	63.0
09/30/05	56.0	47.0	34.0	35.5	26.0	26.0	34.5	47.0	39.5	dry	56.0
10/31/05	52.0	43.5	31.0	34.0	28.0	24.5	29.0	43.5	34.5	56.5	48.5
11/29/05	45.5	38.0	27.0	32.0	22.5	20.0	25.0	40.0	30.0	52.0	45.5
12/30/05	42.5	35.0	23.5	28.0	21.0	17.0	21.5	33.0	29.0	50.0	43.5
01/31/06	46.5	39.0	27.5	32.5	24.0	21.0	25.0	38.0	34.0	54.5	46.5
02/28/06	48.0	40.0	28.5	32.5	26.5	22.5	25.0	38.5	36.5	56.5	49.0
03/31/06	59.5	49.5	35.0	36.0	39.5	32.5	34.5	44.5	46.0	dry	55.5
04/28/06	57.5	48.5	36.0	37.0	38.0	32.0	35.5	47.0	43.0	dry	54.5
05/29/06	53.5	46.5	36.0	38.0	32.0	29.0	34.5	47.5	39.0	dry	53.0
06/30/06	54.0	45.0	32.0	33.5	37.0	31.0	33.0	42.5	40.5	60.0	50.0
07/26/06	dry	55.0	39.5	36.0	52.0	43.5	43.5	49.0	55.5	dry	60.5
08/28/06	55.5	46.5	33.0	33.5	39.0	32.5	33.5	43.0	42.0	dry	52.5
09/21/06	dry	53.5	38.5	38.0	48.0	40.0	41.5	50.0	52.0	dry	60.5
10/31/06	42.0	35.0	36.0	29.5	19.0	17.0	22.5	36.5	26.5	49.5	43.0
11/30/06	41.5	36.0	29.5	24.5	15.0	13.0	17.5	33.0	23.5	46.5	40.5
01/27/06	43.5	36.5	26.0	31.5	21.5	18.5	22.0	36.5	31.5	53.0	45.5
02/26/07	43.0	36.0	25.5	31.0	21.0	18.0	21.5	36.0	31.0	52.5	45.0
03/28/07	29.0	24.0	15.0	22.5	9.5	7.5	12.0	28.0	20.0	42.0	36.0
04/29/07	46.5	37.5	25.5	28.5	29.5	24.0	26.0	37.5	36.0	56.5	47.0
05/31/07	27.5	21.5	17.5	25.0	10.5	9.5	14.5	32.5	20.0	56.5	38.0
06/29/07	50.0	41.5	28.0	29.0	37.5	32.5	34.5	43.0	42.5	dry	51.5
07/31/07	51.5	44.0	31.5	33.0	36.5	32.0	35.5	46.0	41.5	dry	53.5
08/31/07	56.0	47.0	33.0	31.0	42.0	36.0	38.5	45.5	47.0	dry	54.0
09/28/07	57.5	47.0	34.5	35.0	42.5	36.5	38.5	47.5	47.5	dry	56.5
10/30/07	51.0	44.0	31.0	34.5	34.0	33.0	39.5	50.0	43.0	dry	54.5
11/30/07	46.5	40.5	29.0	33.5	30.5	30.5	33.5	46.5	38.5	58.0	51.5

	Well number (depth of well)										
Date	**N1 (62)**	**N2 (62)**	**N3 (60.5)**	**N4 (64)**	**M1 (59)**	**M2 (61)**	**M3 (59)**	**M4 (61)**	**S1 (56)**	**S2 (61.5)**	**S3 (69)**
12/28/07	40.0	34.0	25.0	30.5	22.5	19.0	22.5	37.5	31.5	53.0	46.0
01/29/08	37.5	32.5	23.0	29.5	19.5	17.5	22.0	37.5	29.5	51.5	44.5
02/29/08	29.0	26.0	18.0	26.0	11.0	10.0	16.0	33.0	20.5	43.0	38.0
03/31/08	17.0	14.0	6.0	15.0	1.0	0.0	6.5	22.0	9.5	33.0	28.0
04/28/08	14.0	10.5	3.5	14.0	-4.0	-2.5	5.0	21.5	6.5	30.5	26.0
05/28/08	12.0	12.0	2.0	13.5	-5.0	-3.5	4.5	21.5	5.5	32.0	26.5
06/30/08	35.0	30.0	19.0	22.0	24.0	18.5	10.0	31.5	28.5	50.5	40.5
07/28/08	49.0	41.5	28.0	28.5	36.0	29.5	32.0	38.5	40.0	dry	51.5
08/27/08	59.0	49.0	34.0	35.0	42.0	36.0	37.5	46.0	45.5	dry	55.0
09/27/08	58.0	48.0	32.5	32.0	41.0	34.5	36.5	44.0	45.5	dry	56.0
10/31/09	52.5	44.0	30.0	32.5	33.5	28.5	32.0	42.5	39.5	dry	51.5
11/29/08	43.0	36.5	25.5	30.0	28.0	23.5	26.5	39.0	34.5	56.5	48.0
12/30/08	43.0	36.0	25.0	29.5	25.5	22.0	25.5	38.0	33.5	55.5	47.5
01/31/09	43.5	36.0	25.0	29.5	26.0	22.0	25.0	38.0	33.5	55.0	47.0
02/28/09	38.0	31.0	19.0	22.5	23.0	18.5	22.5	34.0	31.0	52.0	44.5
03/30/09	35.0	28.5	17.0	21.0	19.5	16.0	21.0	33.0	28.0	50.0	42.0
04/27/09	19.0	17.5	10.0	17.5	1.5	2.0	10.5	25.5	9.5	35.5	29.5
05/25/09	6.5	17.0	8.0	17.0	-0.5	0.5	6.5	23.5	9.0	34.5	30.0
07/02/09	36.0	32.0	19.5	24.5	24.0	20.5	25.0	37.0	35.1	50.5	42.0
09/07/09	dry	dry	36.0	34.5	45.5	38.0	39.5	47.5	44.5	dry	52.5
10/09/09	dry	dry	37.0	36.0	46.5	38.5	40.0	47.5	45.5	dry	54.0
11/02/09	55.5	45.0	31.5	32.5	35.0	29.0	32.0	41.5	37.5	58.5	49.0
12/02/09	50.5	42.0	30.0	33.5	27.5	23.0	26.5	39.5	31.5	53.5	44.5
01/04/10	48.5	40.5	29.5	33.5	26.5	22.5	26.0	40.0	32.0	53.0	44.0
02/08/10	45.0	38.0	27.0	31.5	25.0	21.5	25.0	39.0	32.0	52.5	44.0
03/05/10	46.5	38.0	27.0	30.5	26.0	22.0	24.5	38.0	32.0	52.0	43.0
04/05/10	38.5	31.0	20.5	24.5	22.5	18.5	22.0	33.0	30.0	50.0	41.5
05/03/10	27.0	22.5	17.5	22.5	10.0	10.5	13.5	29.5	20.5	42.0	36.0
05/30/10	24.5	19.0	13.5	18.5	10.0	9.0	13.5	32.0	17.5	42.0	35.5
06/30/10	56.0	46.0	32.5	32.0	41.5	36.0	38.5	46.5	41.0	dry	51.0
07/31/10	49.0	41.5	30.0	31.0	33.0	29.0	33.5	44.0	35.0	58.0	47.5
08/30/10	dry	dry	41.0	dry	54.5	45.0	45.5	48.0	dry	dry	62.0
9/22/2010	dry	dry	50.0	43.0	dry	60.0	57.5	58.0	dry	dry	dry

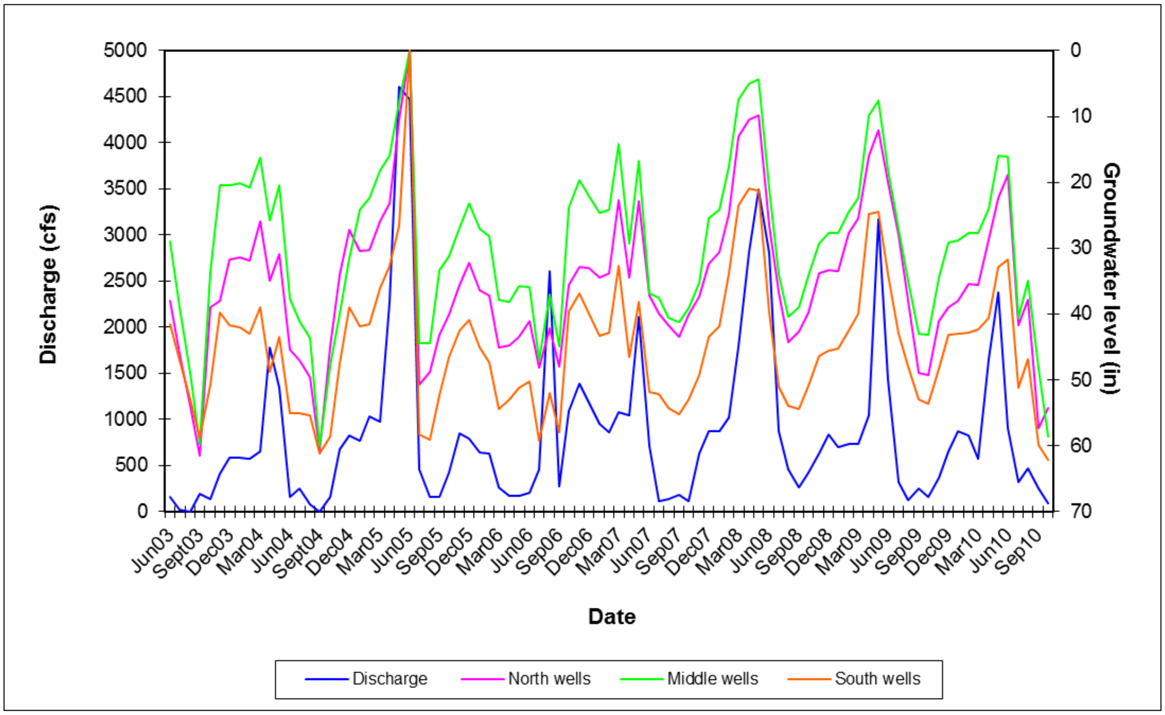


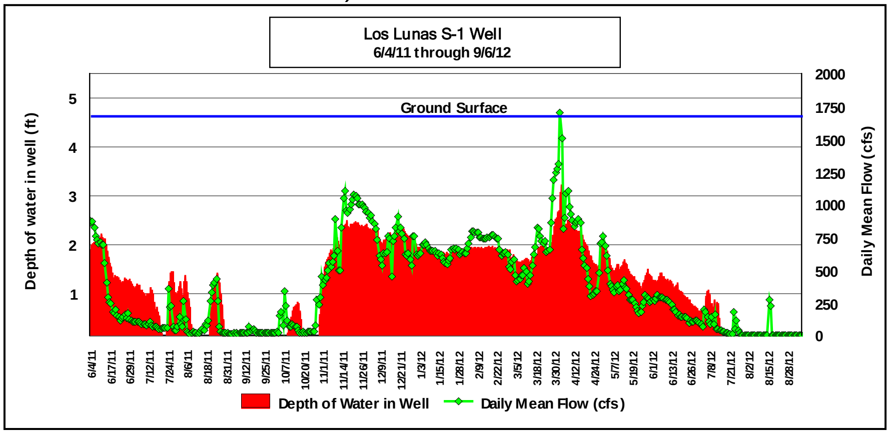
Figure G-1. Discharge (cfs) of the Rio Grande at San Acacia, New Mexico, and average ground water levels (inches from the surface) in wells along the South, Middle, and North transects at the LLRS, June 2003 to Oct. 2010.

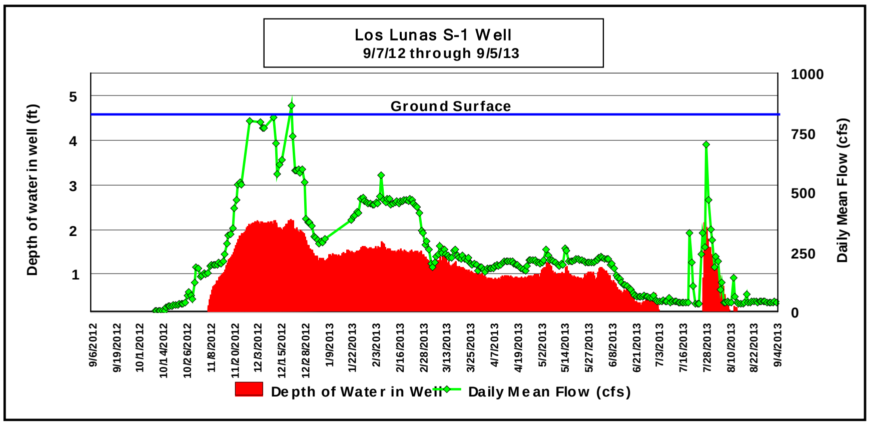
APPENDIX H

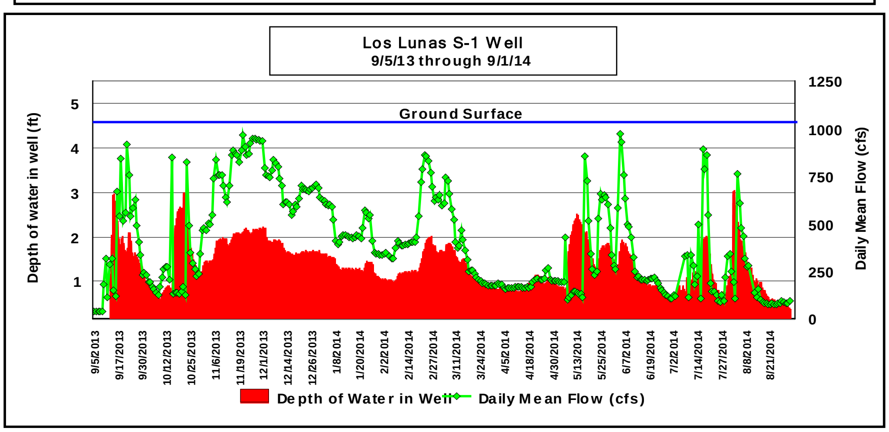
GROUNDWATER MONITORING WELLS HOBO WATER LEVEL LOGGER DATA JUNE 2011 – SEPTEMBER 2018

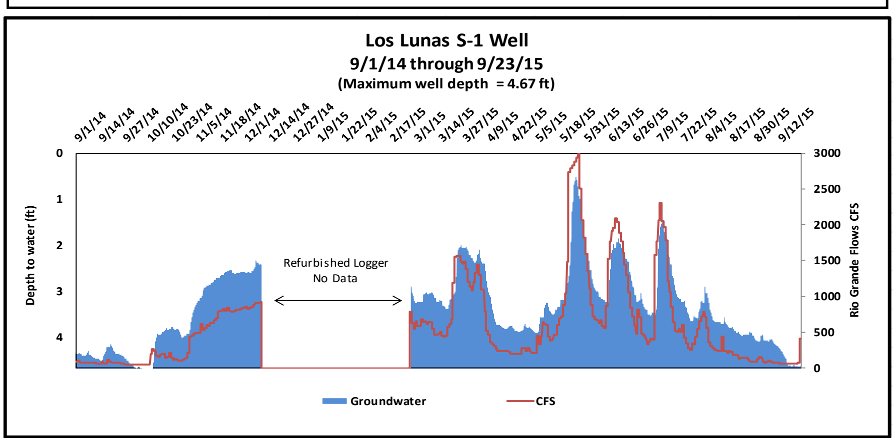
South Transect

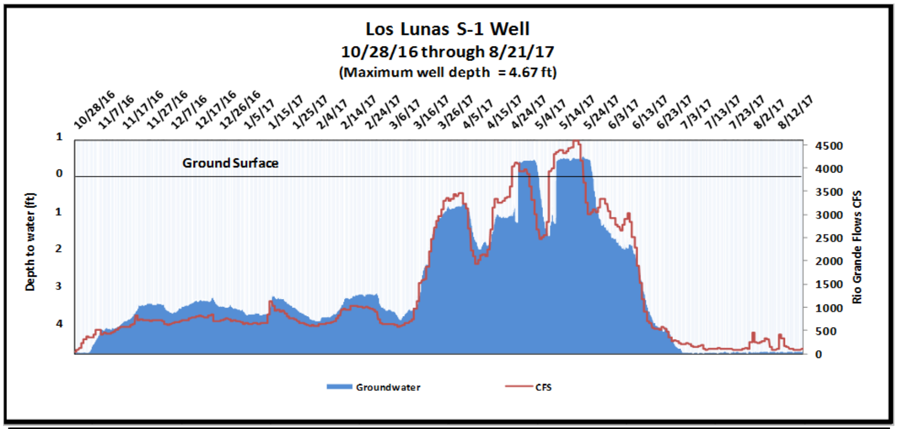
Well S1 (Missing logger - no data from 9/15 to 10/16)



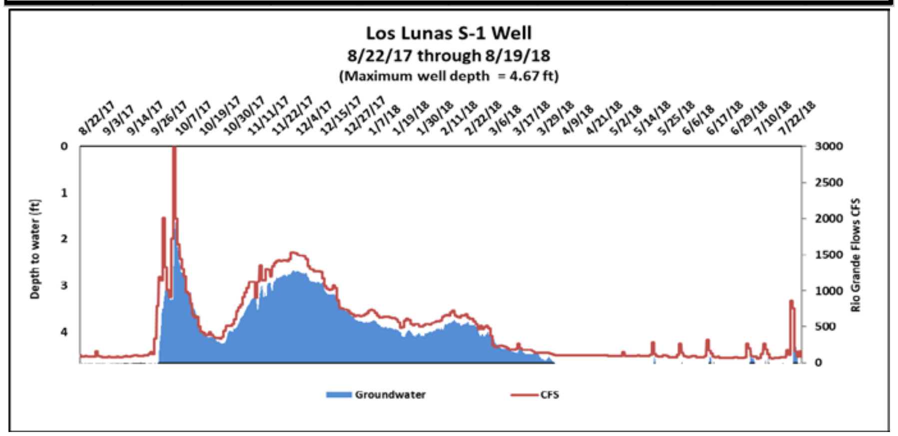






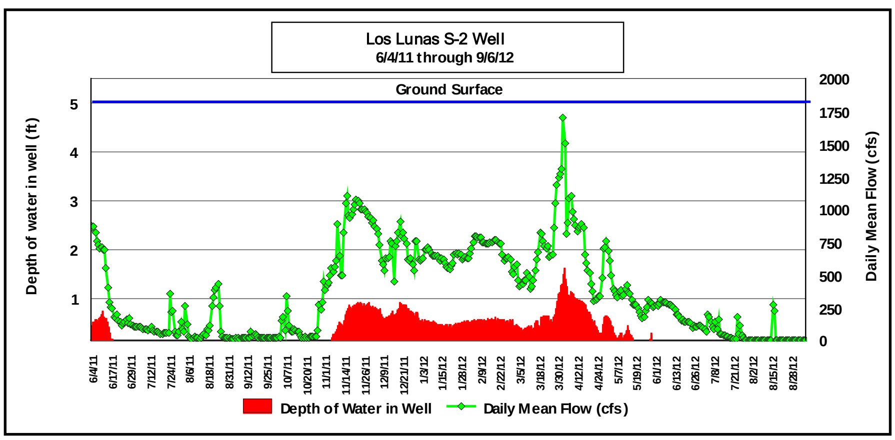


Los Lunas S-1 Well
10/28/16 through 8/21/17
(Maximum well depth = 4.67 ft)
10/28/16 11/7/16 11/17/16 11/27/16 12/7/16 12/17/16 12/26/16 1/5/17 1/15/17 1/25/17 2/4/17 2/14/17 2/24/17 3/6/17 3/16/17 3/26/17 4/5/17 4/15/17 4/24/17 5/4/17 5/14/17 5/24/17 6/3/17 6/13/17 6/23/17 7/3/17 7/13/17 7/23/17 8/2/17 8/12/17
Ground Surface
Depth to water (ft)
1 0 1 2 3 4
Rio Grande Flows CFS
4500 4000 3500 3000 2500 2000 1500 1000 500 0
Groundwater
CFS

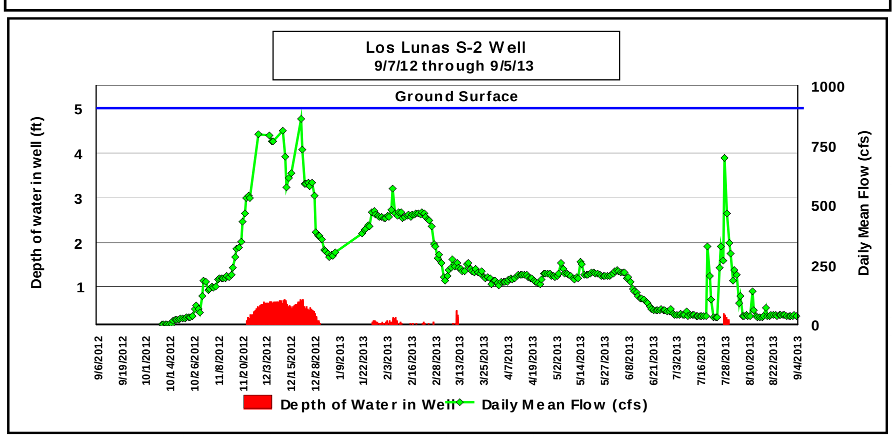


Los Lunas S-1 Well
8/22/17 through 8/19/18
(Maximum well depth = 4.67 ft)
8/22/17 9/3/17 9/14/17 9/26/17 10/7/17 10/19/17 10/30/17 11/11/17 11/22/17 12/4/17 12/15/17 12/27/17 1/7/18 1/19/18 1/30/18 2/11/18 2/22/18 3/6/18 3/17/18 3/29/18 4/9/18 4/21/18 5/2/18 5/14/18 5/25/18 6/6/18 6/17/18 6/29/18 7/10/18 7/22/18
Depth to water (ft)
0 1 2 3 4
Rio Grande Flows CFS
3000 2500 2000 1500 1000 500 0
Groundwater
CFS

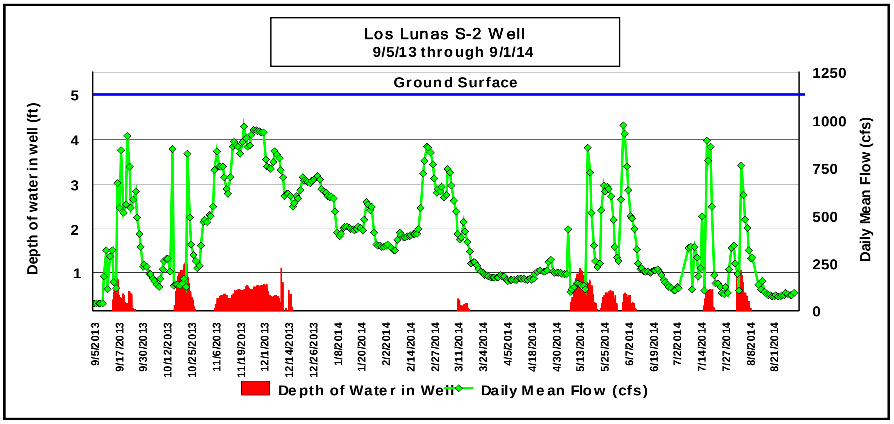
Well S2

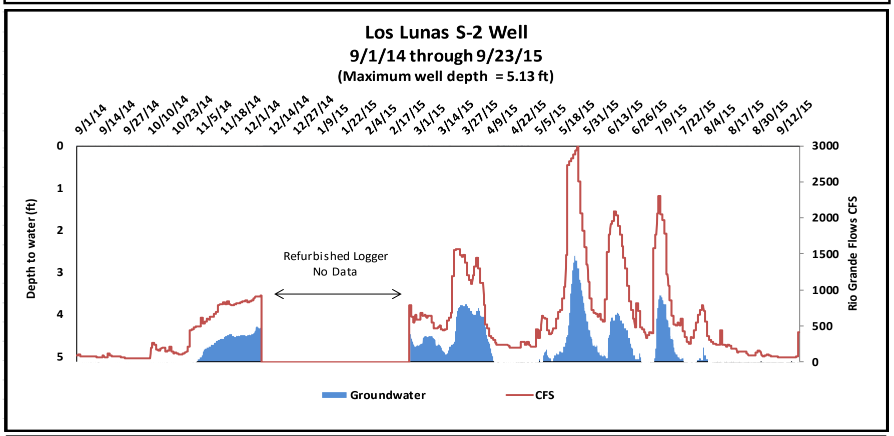


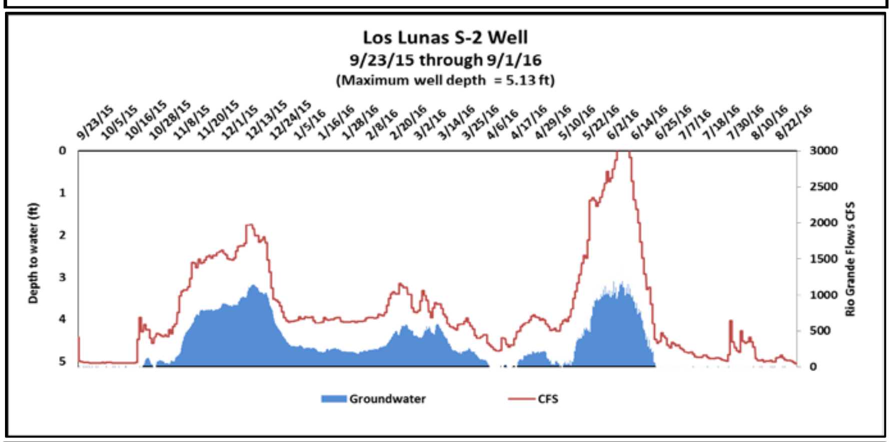
Los Lunas S-2 Well
6/4/11 through 9/6/12
Ground Surface
Depth of water in well (ft)
5 4 3 2 1
Daily Mean Flow (cfs)
2000 1750 1500 1250 1000 750 500 250 0
6/4/11 6/17/11 6/29/11 7/12/11 7/24/11 8/6/11 8/18/11 8/31/11 9/12/11 9/25/11 10/7/11 10/20/11 11/1/11 11/14/11 11/26/11 12/9/11 12/21/11 1/3/12 1/15/12 1/28/12 2/9/12 2/22/12 3/5/12 3/18/12 3/30/12 4/12/12 4/24/12 5/7/12 5/19/12 6/1/12 6/13/12 6/26/12 7/8/12 7/21/12 8/2/12 8/15/12 8/28/12
Depth of Water in Well
Daily Mean Flow (cfs)

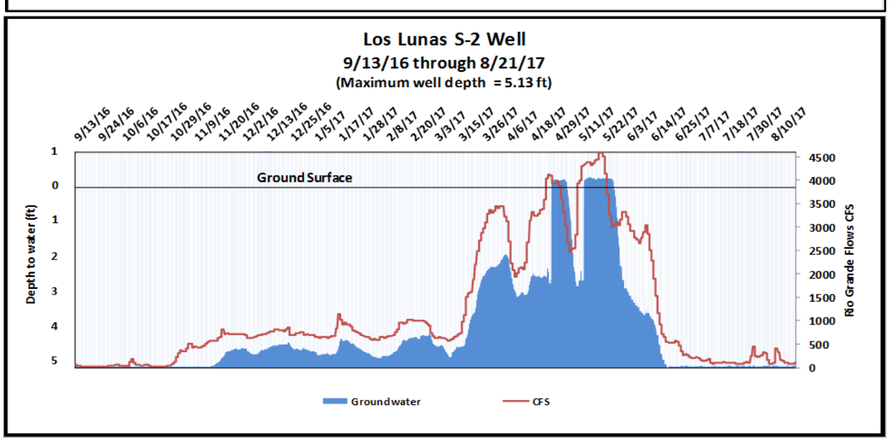


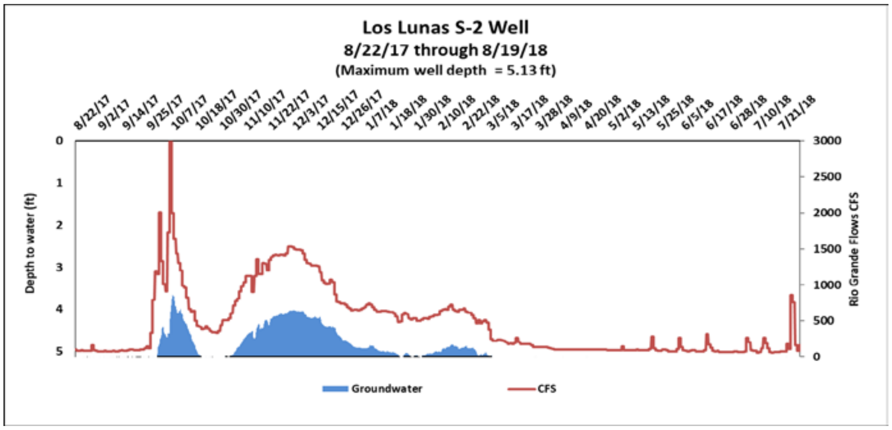
Los Lunas S-2 Well
9/7/12 through 9/5/13
Ground Surface
Depth of water in well (ft)
5 4 3 2 1
Daily Mean Flow (cfs)
1000 750 500 250 0
9/6/2012 9/19/2012 10/1/2012 10/14/2012 10/26/2012 11/8/2012 11/20/2012 12/3/2012 12/15/2012 12/28/2012 1/9/2013 1/22/2013 2/3/2013 2/16/2013 2/28/2013 3/13/2013 3/25/2013 4/7/2013 4/19/2013 5/2/2013 5/14/2013 5/27/2013 6/8/2013 6/21/2013 7/3/2013 7/16/2013 7/28/2013 8/10/2013 8/22/2013 9/4/2013
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas S-2 Well
9/5/13 through 9/1/14
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)

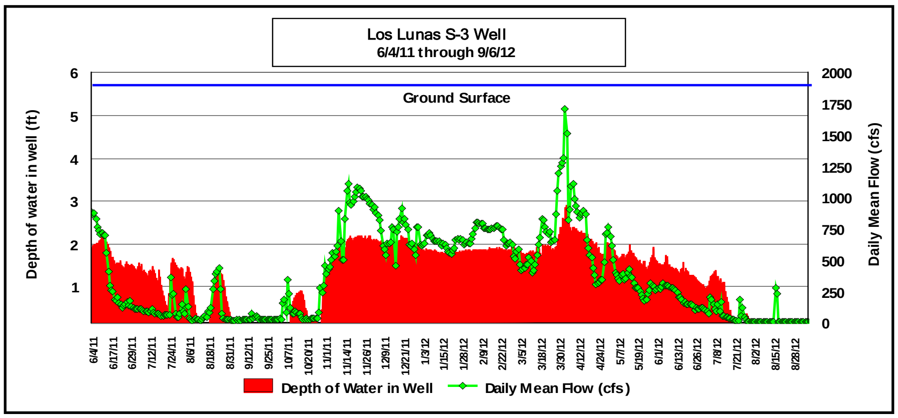

Los Lunas S-2 Well
9/1/14 through 9/23/15
(Maximum well depth = 5.13 ft)
Depth to water (ft)
Rio Grande Flows CFS
Refurbished Logger
No Data
Groundwater
CFS

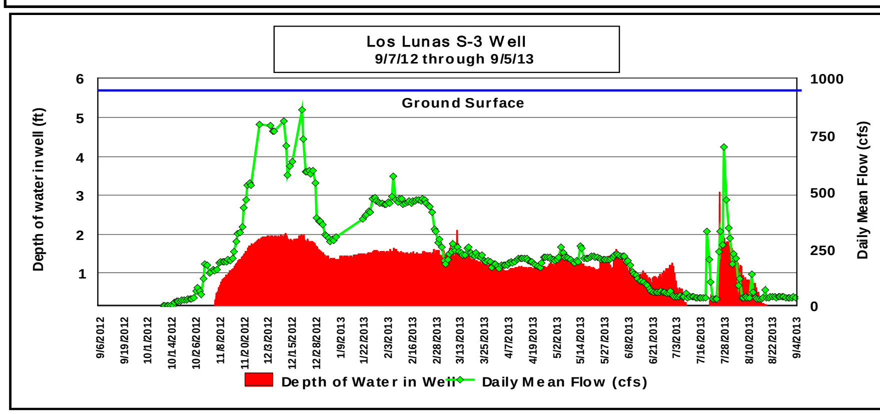

Los Lunas S-2 Well
9/23/15 through 9/1/16
(Maximum well depth = 5.13 ft)
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

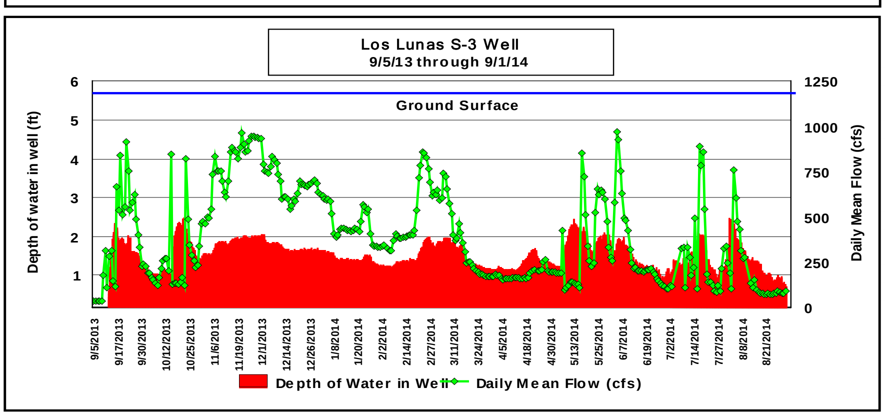

Los Lunas S-2 Well
9/13/16 through 8/21/17
(Maximum well depth = 5.13 ft)
Ground Surface
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

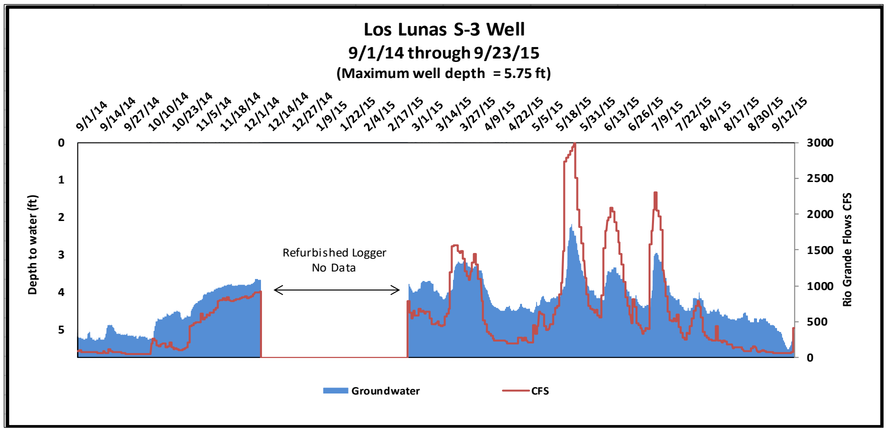

Los Lunas S-2 Well
8/22/17 through 8/19/18
(Maximum well depth = 5.13 ft)
8/22/17 9/2/17 9/14/17 9/25/17 10/7/17 10/18/17 10/30/17 11/10/17 11/22/17 12/3/17 12/15/17 12/26/17 1/7/18 1/18/18 1/30/18 2/10/18 2/22/18 3/5/18 3/17/18 3/28/18 4/9/18 4/20/18 5/2/18 5/13/18 5/25/18 6/5/18 6/17/18 6/28/18 7/10/18 7/21/18
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

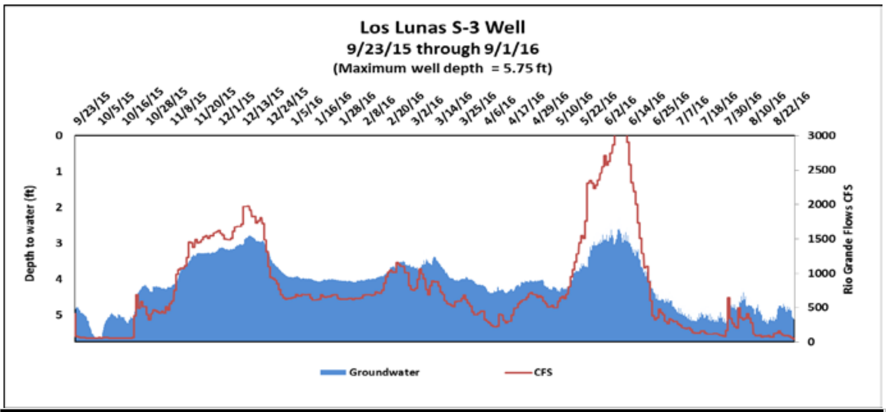
Well S3

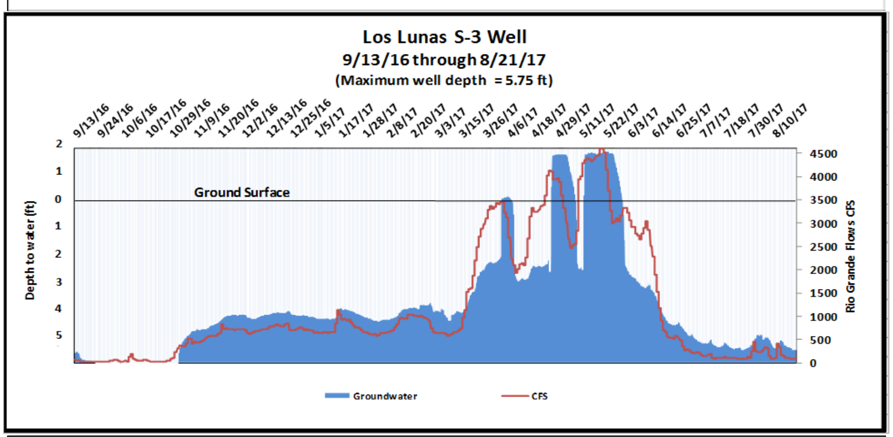

Los Lunas S-3 Well
6/4/11 through 9/6/12
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)

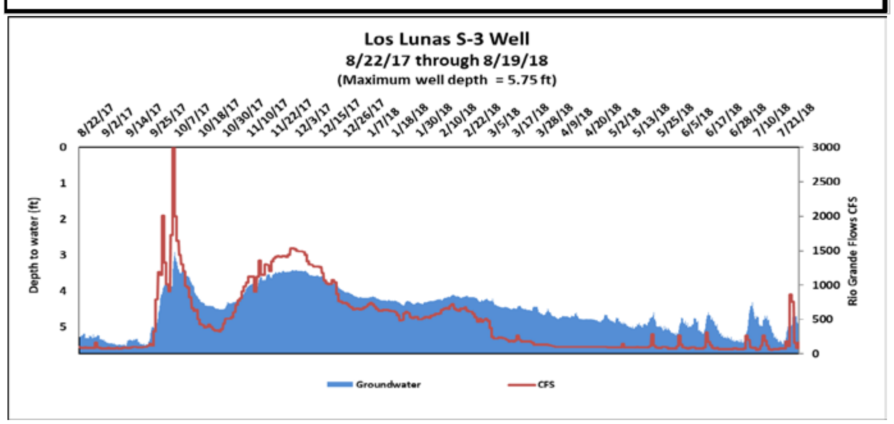

Los Lunas S-3 Well
9/7/12 through 9/5/13
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas S-3 Well
9/5/13 through 9/1/14
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas S-3 Well
9/1/14 through 9/23/15
(Maximum well depth = 5.75 ft)
9/1/14 9/14/14 9/27/14 10/10/14 10/23/14 11/5/14 11/18/14 12/1/14 12/14/14 12/27/14 1/9/15 1/22/15 2/4/15 2/17/15 3/1/15 3/14/15 3/27/15 4/9/15 4/22/15 5/5/15 5/18/15 5/31/15 6/13/15 6/26/15 7/9/15 7/22/15 8/4/15 8/17/15 8/30/15 9/12/15
Depth to water (ft)
Rio Grande Flows CFS
Refurbished Logger
No Data
Groundwater
CFS

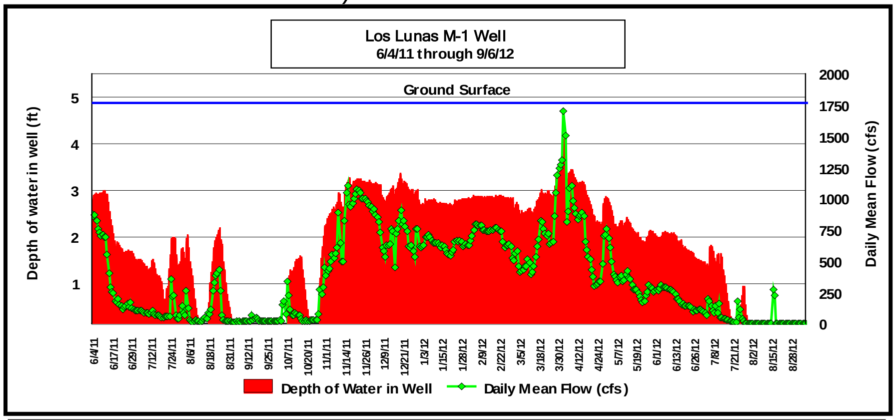

Los Lunas S-3 Well
9/23/15 through 9/1/16
(Maximum well depth = 5.75 ft)
9/23/15 10/5/15 10/16/15 10/28/15 11/8/15 11/20/15 12/1/15 12/13/15 12/24/15 1/5/16 1/16/16 1/28/16 2/8/16 2/20/16 3/2/16 3/14/16 3/25/16 4/6/16 4/17/16 4/29/16 5/10/16 5/22/16 6/2/16 6/14/16 6/25/16 7/7/16 7/18/16 7/30/16 8/10/16 8/22/16
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

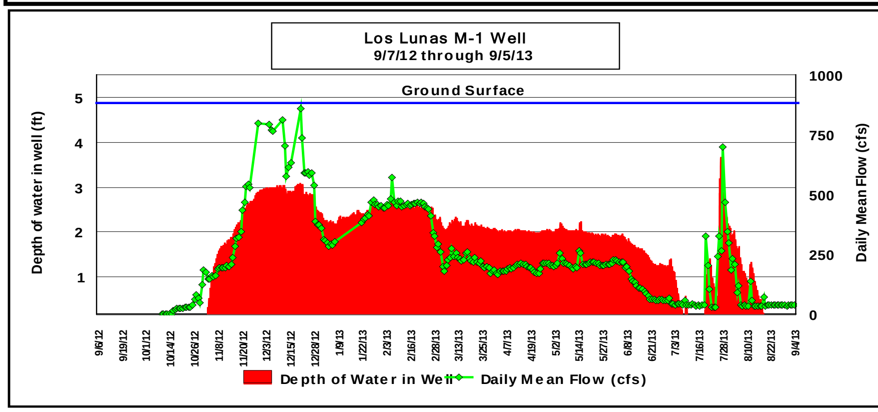

Los Lunas S-3 Well
9/13/16 through 8/21/17
(Maximum well depth = 5.75 ft)
9/13/16 9/24/16 10/6/16 10/17/16 10/29/16 11/9/16 11/20/16 12/2/16 12/13/16 12/25/16 1/5/17 1/17/17 1/28/17 2/8/17 2/20/17 3/3/17 3/15/17 3/26/17 4/6/17 4/18/17 4/29/17 5/11/17 5/22/17 6/3/17 6/14/17 6/25/17 7/7/17 7/18/17 7/30/17 8/10/17
Ground Surface
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

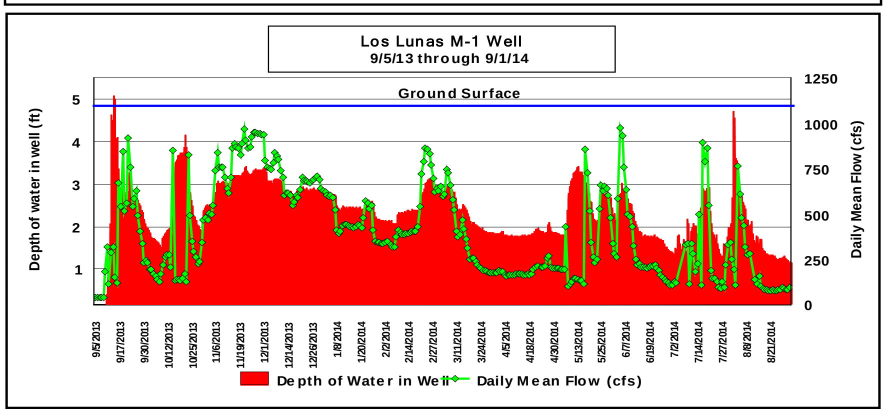

Los Lunas S-3 Well
8/22/17 through 8/19/18
(Maximum well depth = 5.75 ft)
8/22/17 9/2/17 9/14/17 9/25/17 10/7/17 10/18/17 10/30/17 11/10/17 11/22/17 12/3/17 12/15/17 12/26/17 1/7/18 1/18/18 1/30/18 2/10/18 2/22/18 3/5/18 3/17/18 3/28/18 4/9/18 4/20/18 5/2/18 5/13/18 5/25/18 6/5/18 6/17/18 6/28/18 7/10/18 7/21/18
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

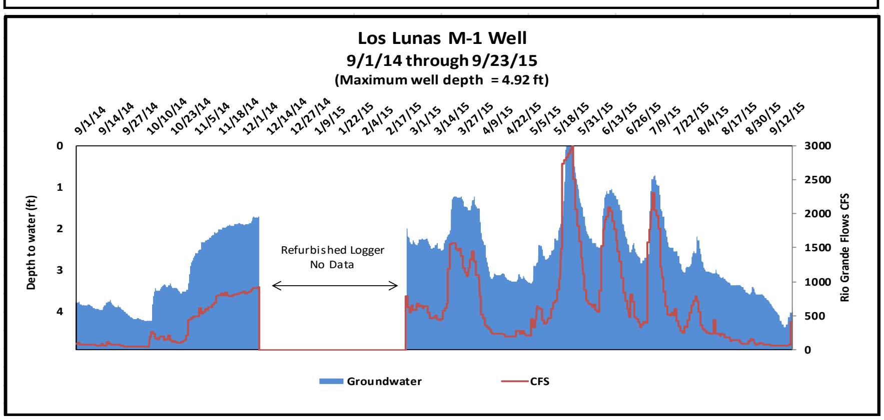
Middle Transect

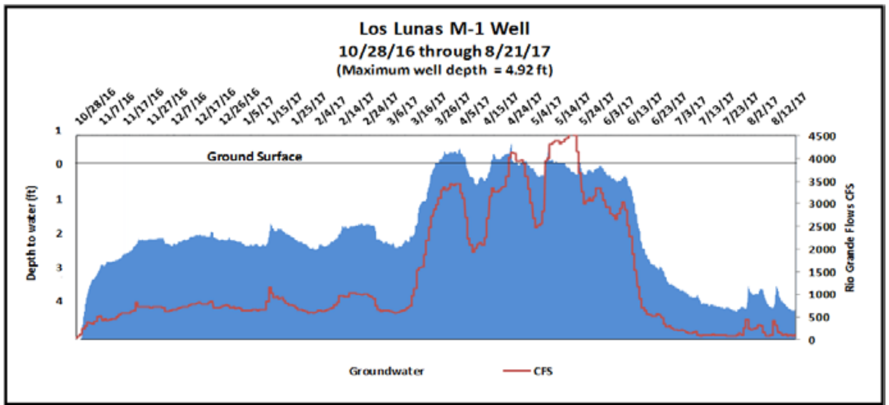
Well M1 (Missing logger – no data from 9/15 to 9/16)

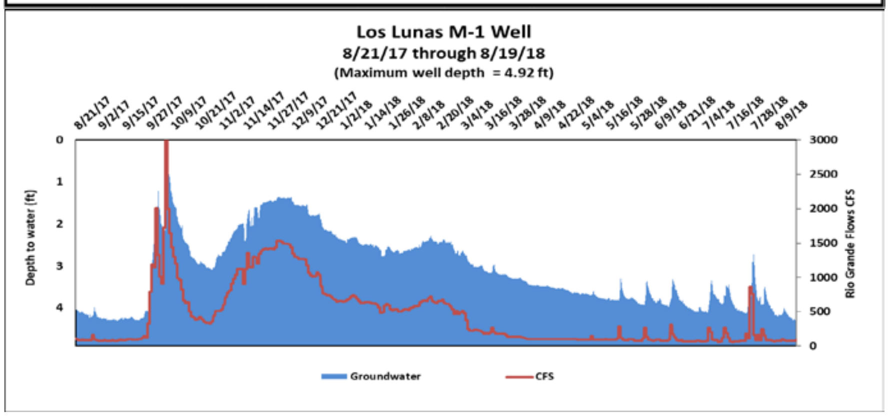




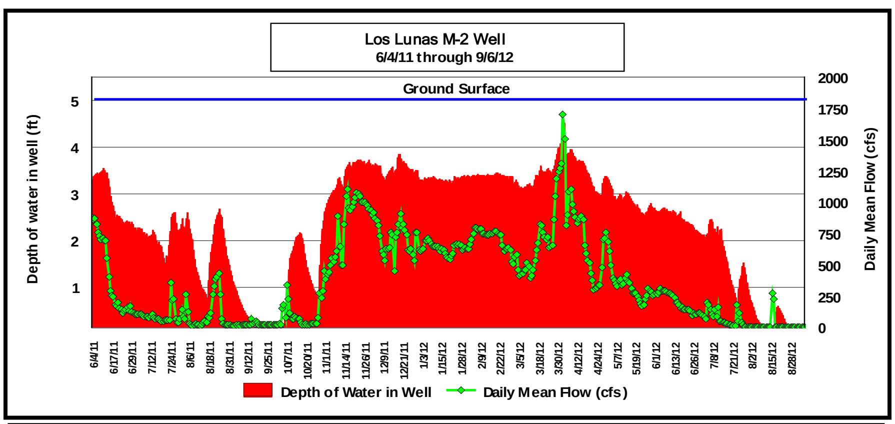


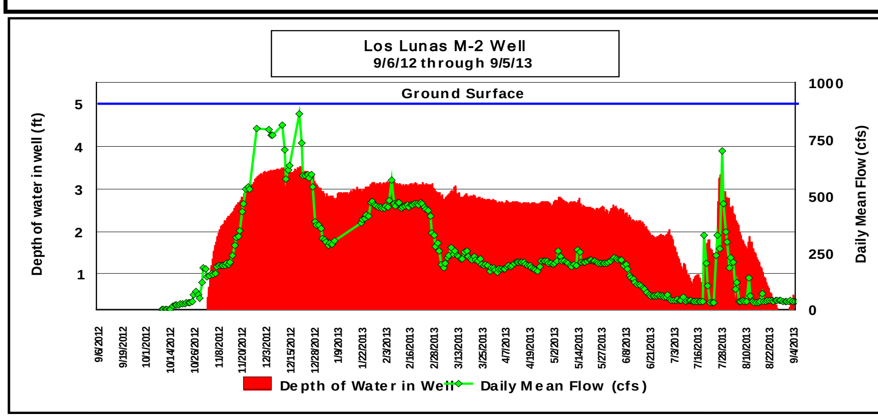


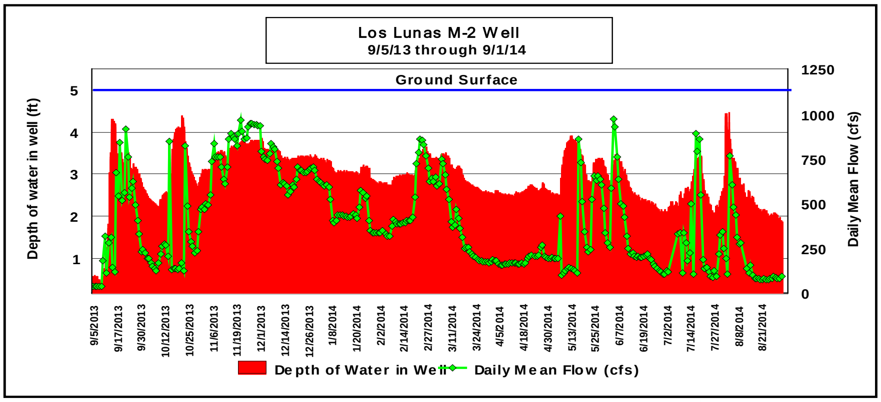

Los Lunas M-1 Well
10/28/16 through 8/21/17
(Maximum well depth = 4.92 ft)
Ground Surface
Depth to water (ft)
1
0
1
2
3
4
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Rio Grande Flows CFS
Groundwater
CFS

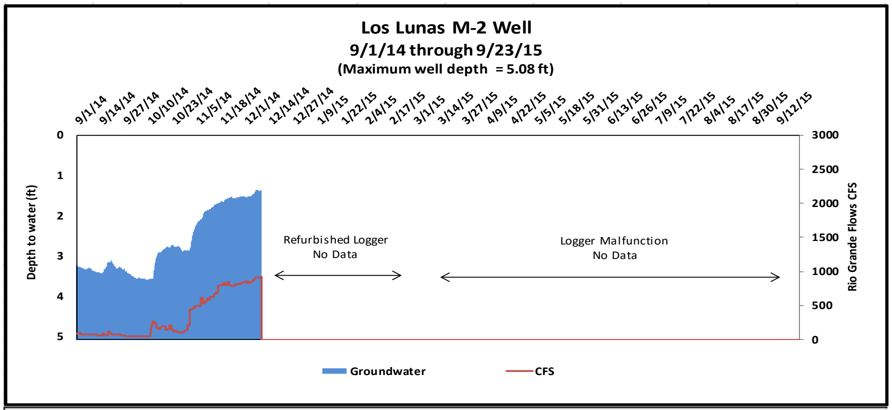

Los Lunas M-1 Well
8/21/17 through 8/19/18
(Maximum well depth = 4.92 ft)
Depth to water (ft)
0
1
2
3
4
3000
2500
2000
1500
1000
500
0
Rio Grande Flows CFS
Groundwater
CFS

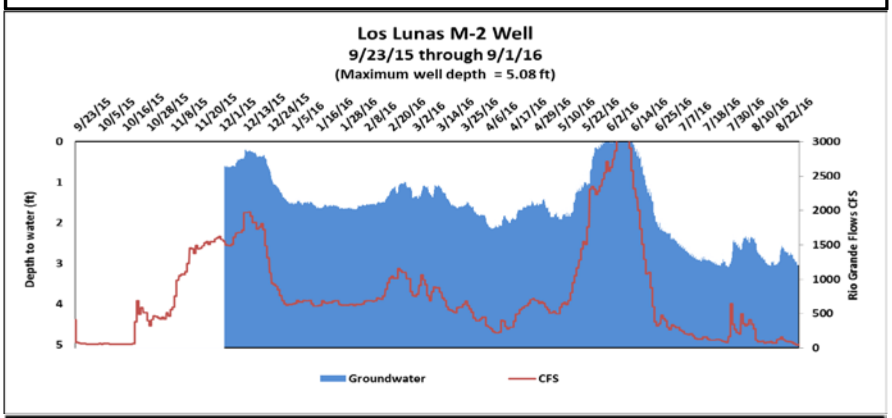
Well M2

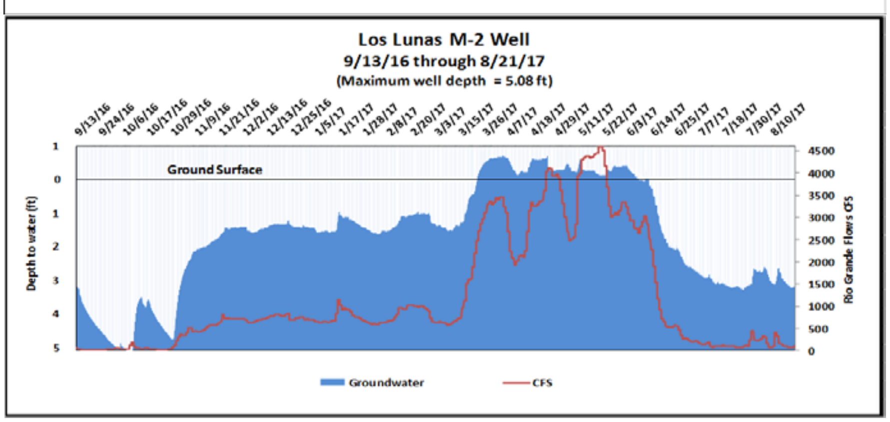

Los Lunas M-2 Well
6/4/11 through 9/6/12
Ground Surface
Depth of water in well (ft)
5
4
3
2
1
2000
1750
1500
1250
1000
750
500
250
0
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)

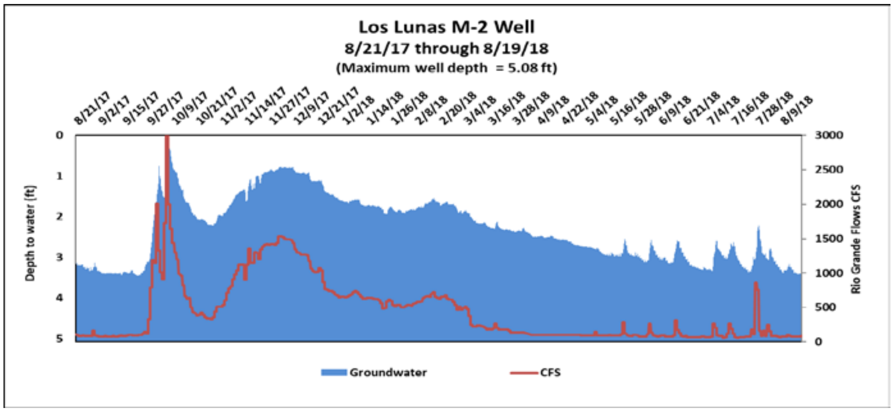

Los Lunas M-2 Well
9/6/12 through 9/5/13
Ground Surface
Depth of water in well (ft)
5
4
3
2
1
1000
750
500
250
0
Daily Mean Flow (cfs)
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas M-2 Well
9/5/13 through 9/1/14
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
5
4
3
2
1
1250
1000
750
500
250
0
9/5/2013
9/17/2013
9/30/2013
10/12/2013
10/25/2013
11/6/2013
11/19/2013
12/1/2013
12/14/2013
12/26/2013
1/8/2014
1/20/2014
2/2/2014
2/14/2014
2/27/2014
3/11/2014
3/24/2014
4/5/2014
4/18/2014
4/30/2014
5/13/2014
5/25/2014
6/7/2014
6/19/2014
7/2/2014
7/14/2014
7/27/2014
8/8/2014
8/21/2014
Depth of Water in Well
Daily Mean Flow (cfs)

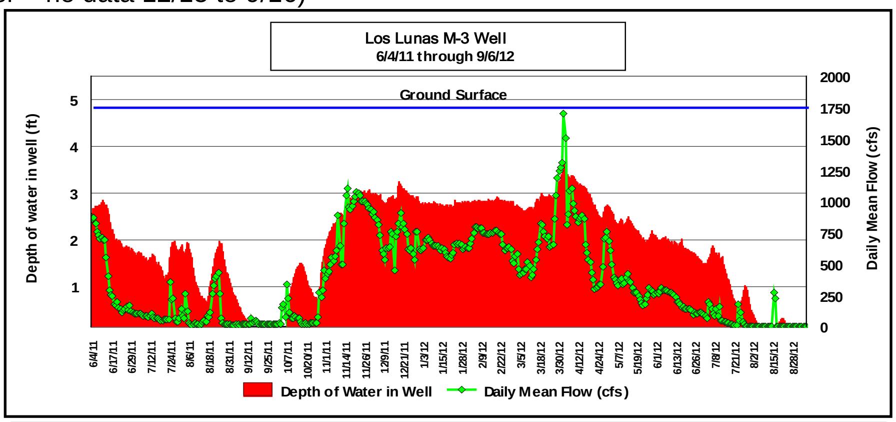

Los Lunas M-2 Well
9/1/14 through 9/23/15
(Maximum well depth = 5.08 ft)
9/1/14
9/14/14
9/27/14
10/10/14
10/23/14
11/5/14
11/18/14
12/1/14
12/14/14
12/27/14
1/9/15
1/22/15
2/4/15
2/17/15
3/1/15
3/14/15
3/27/15
4/9/15
4/22/15
5/5/15
5/18/15
5/31/15
6/13/15
6/26/15
7/9/15
7/22/15
8/4/15
8/17/15
8/30/15
9/12/15
Depth to water (ft)
Rio Grande Flows CFS
0
1
2
3
4
5
3000
2500
2000
1500
1000
500
0
Refurbished Logger
No Data
Logger Malfunction
No Data
Groundwater
CFS

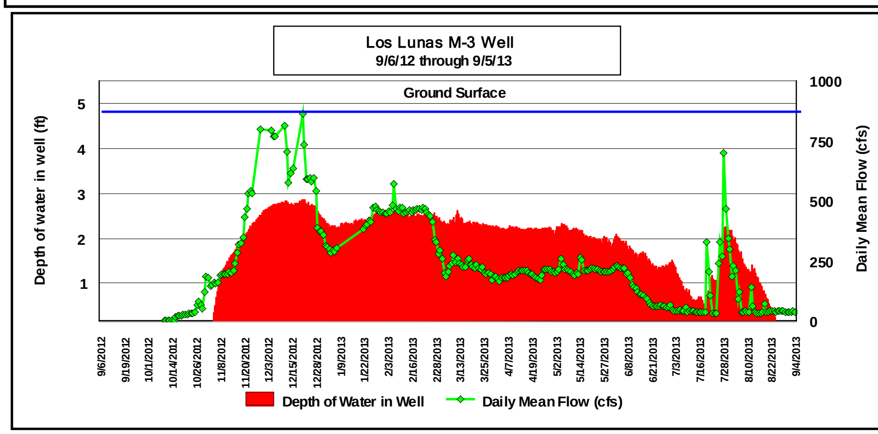

Los Lunas M-2 Well
9/23/15 through 9/1/16
(Maximum well depth = 5.08 ft)
9/23/15
10/5/15
10/16/15
10/28/15
11/8/15
11/20/15
12/1/15
12/13/15
12/24/15
1/5/16
1/16/16
1/28/16
2/8/16
2/20/16
3/2/16
3/14/16
3/25/16
4/6/16
4/17/16
4/29/16
5/10/16
5/22/16
6/2/16
6/14/16
6/25/16
7/7/16
7/18/16
7/30/16
8/10/16
8/22/16
Depth to water (ft)
Rio Grande Flows CFS
0
1
2
3
4
5
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

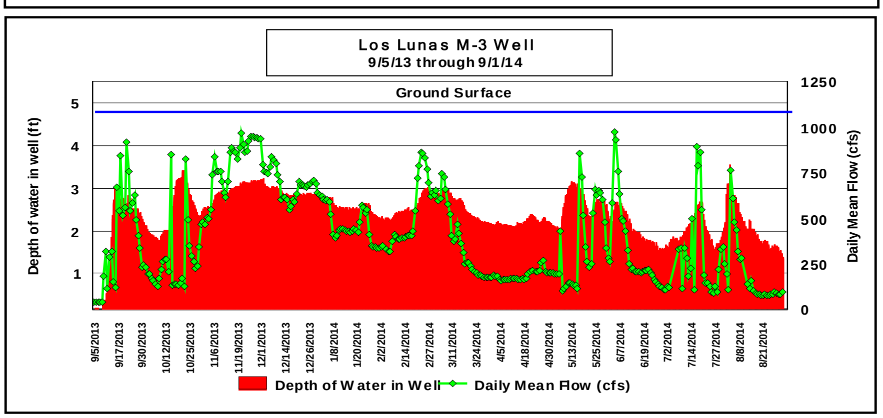

Los Lunas M-2 Well
9/13/16 through 8/21/17
(Maximum well depth = 5.08 ft)
9/13/16
9/24/16
10/6/16
10/17/16
10/29/16
11/9/16
11/21/16
12/2/16
12/13/16
12/25/16
1/5/17
1/17/17
1/28/17
2/8/17
2/20/17
3/3/17
3/15/17
3/26/17
4/7/17
4/18/17
4/29/17
5/11/17
5/22/17
6/3/17
6/14/17
6/25/17
7/7/17
7/18/17
7/30/17
8/10/17
Ground Surface
Depth to water (ft)
Rio Grande Flows CFS
1
0
1
2
3
4
5
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

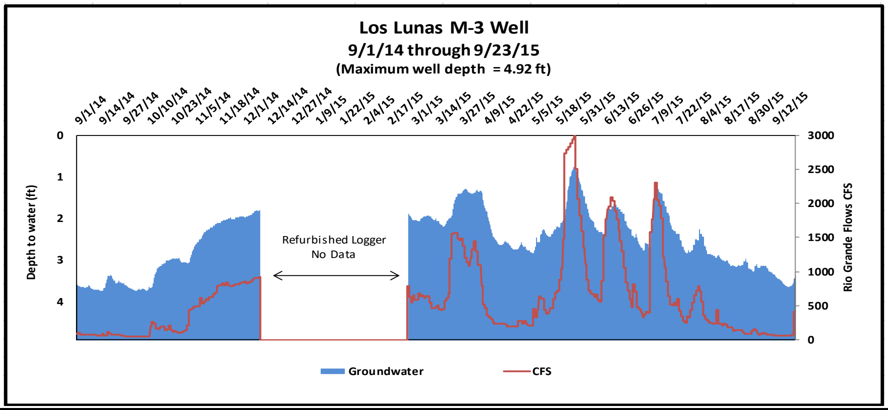


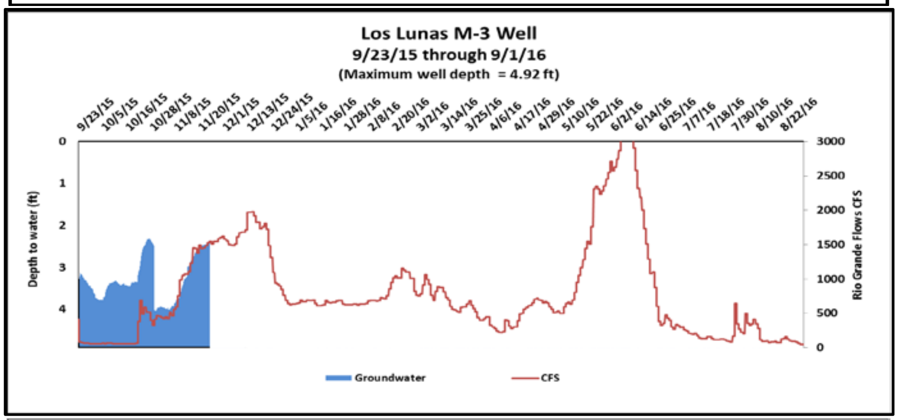
Well M3 (Missing logger – no data 12/15 to 9/16)

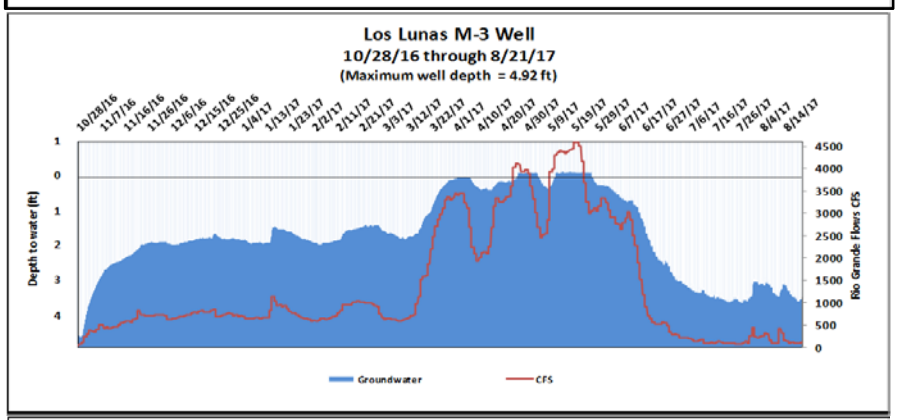


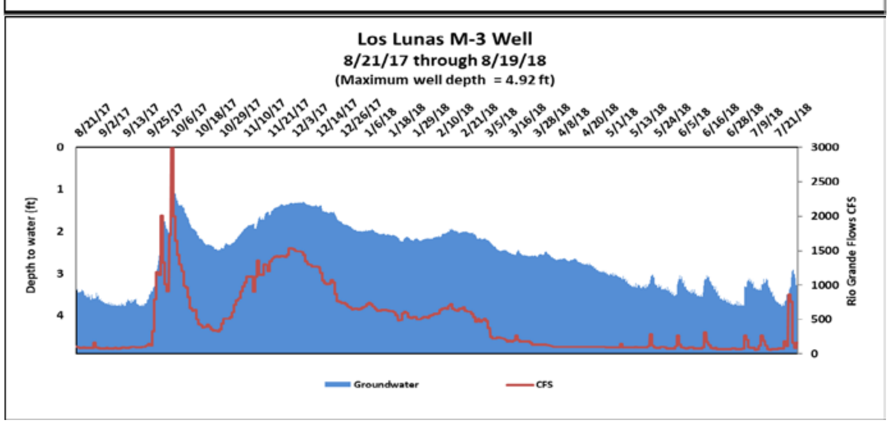





Los Lunas M-3 Well
9/1/14 through 9/23/15
(Maximum well depth = 4.92 ft)
9/1/14 9/14/14 9/27/14 10/10/14 10/23/14 11/5/14 11/18/14 12/1/14 12/14/14 12/27/14 1/9/15 1/22/15 2/4/15 2/17/15 3/1/15 3/14/15 3/27/15 4/9/15 4/22/15 5/5/15 5/18/15 5/31/15 6/13/15 6/26/15 7/9/15 7/22/15 8/4/15 8/17/15 8/30/15 9/12/15
Depth to water (ft)
Rio Grande Flows CFS
Refurbished Logger
No Data
Groundwater
CFS

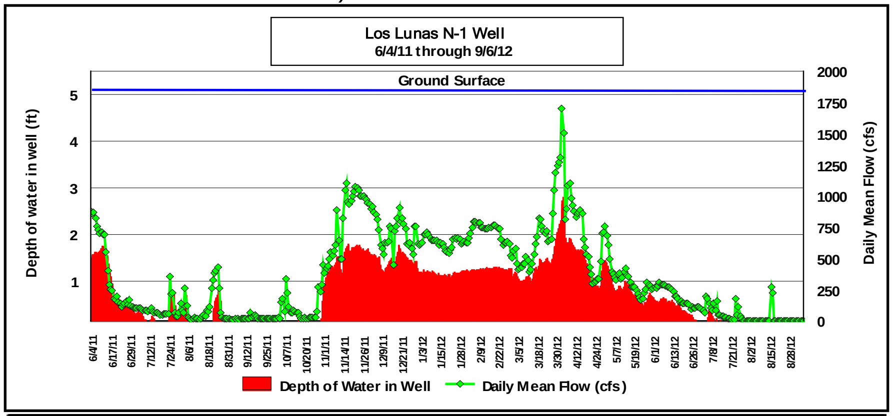

Los Lunas M-3 Well
9/23/15 through 9/1/16
(Maximum well depth = 4.92 ft)
9/23/15 10/5/15 10/16/15 10/28/15 11/8/15 11/20/15 12/1/15 12/13/15 12/24/15 1/5/16 1/16/16 1/28/16 2/8/16 2/20/16 3/2/16 3/14/16 3/25/16 4/6/16 4/17/16 4/29/16 5/10/16 5/22/16 6/2/16 6/14/16 6/25/16 7/7/16 7/18/16 7/30/16 8/10/16 8/22/16
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

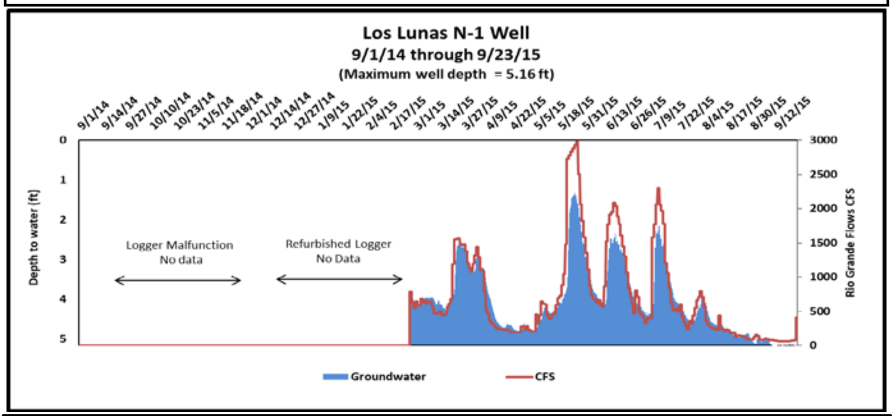

Los Lunas M-3 Well
10/28/16 through 8/21/17
(Maximum well depth = 4.92 ft)
10/28/16 11/7/16 11/16/16 11/26/16 12/6/16 12/15/16 12/25/16 1/4/17 1/13/17 1/23/17 2/2/17 2/11/17 2/21/17 3/3/17 3/12/17 3/22/17 4/1/17 4/10/17 4/20/17 4/30/17 5/9/17 5/19/17 5/29/17 6/7/17 6/17/17 6/27/17 7/6/17 7/16/17 7/26/17 8/4/17 8/14/17
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

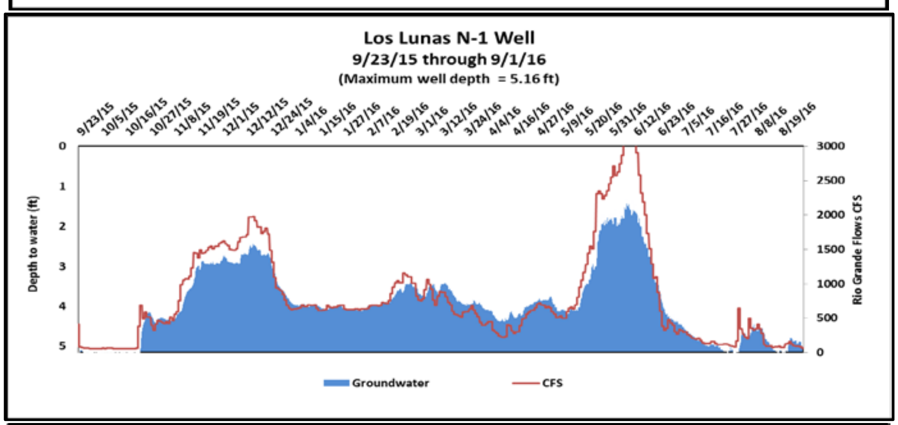

Los Lunas M-3 Well
8/21/17 through 8/19/18
(Maximum well depth = 4.92 ft)
8/21/17 9/2/17 9/13/17 9/25/17 10/6/17 10/18/17 10/29/17 11/10/17 11/21/17 12/3/17 12/14/17 12/26/17 1/6/18 1/18/18 1/29/18 2/10/18 2/21/18 3/5/18 3/16/18 3/28/18 4/8/18 4/20/18 5/1/18 5/13/18 5/24/18 6/5/18 6/16/18 6/28/18 7/9/18 7/21/18
Depth to water (ft)
Rio Grande Flows CFS
Groundwater
CFS

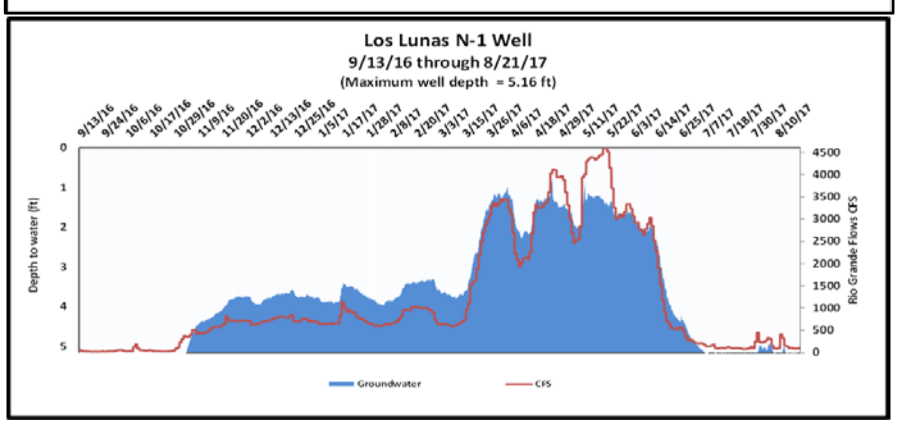
North Transect

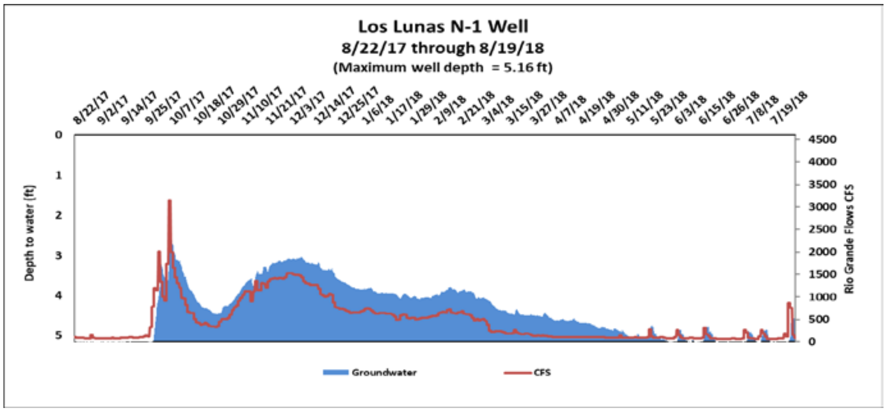
Well N1 (Missing logger – no data from 9/12 to 9/14)



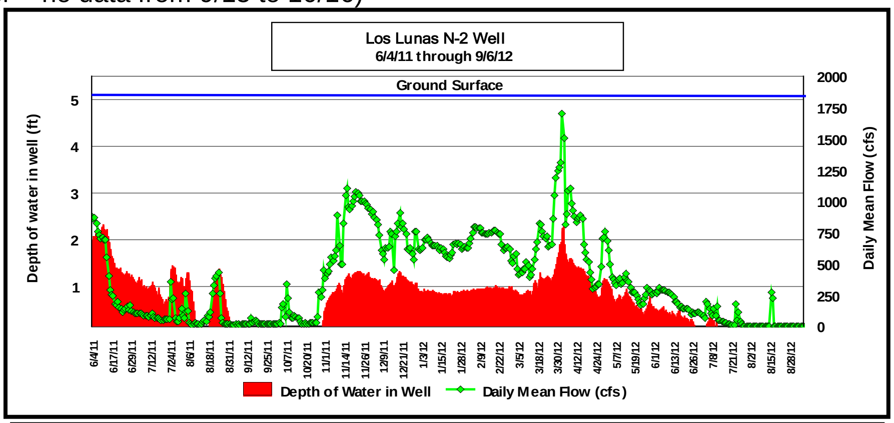


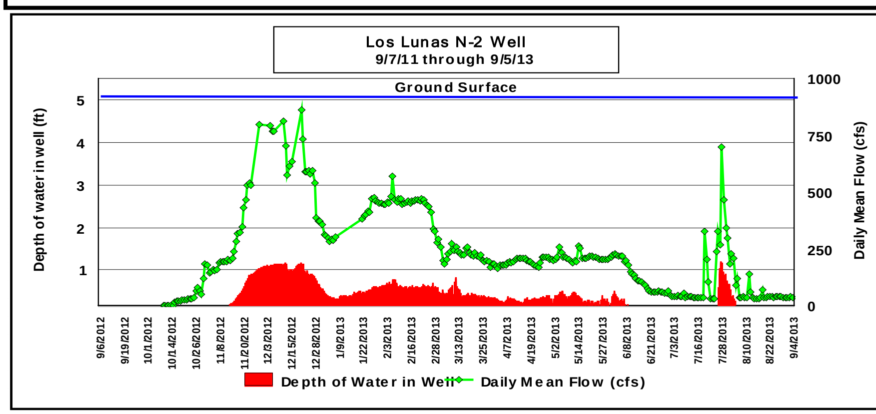


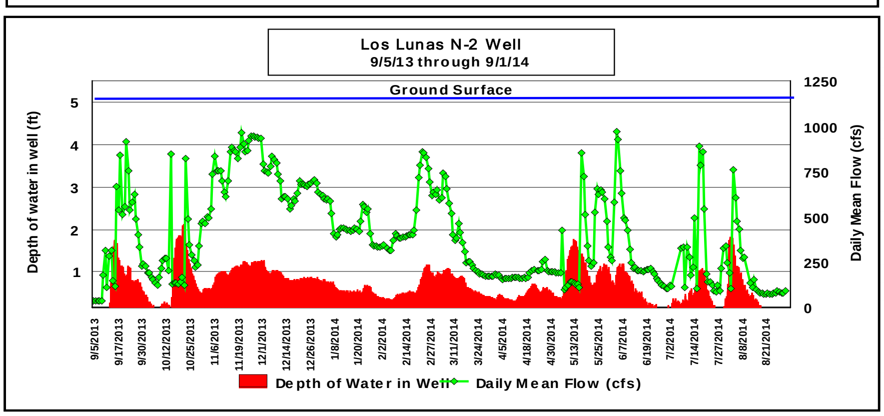


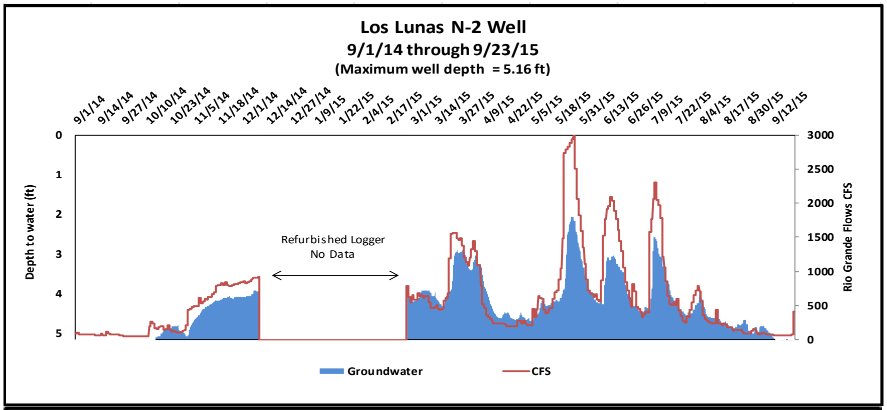


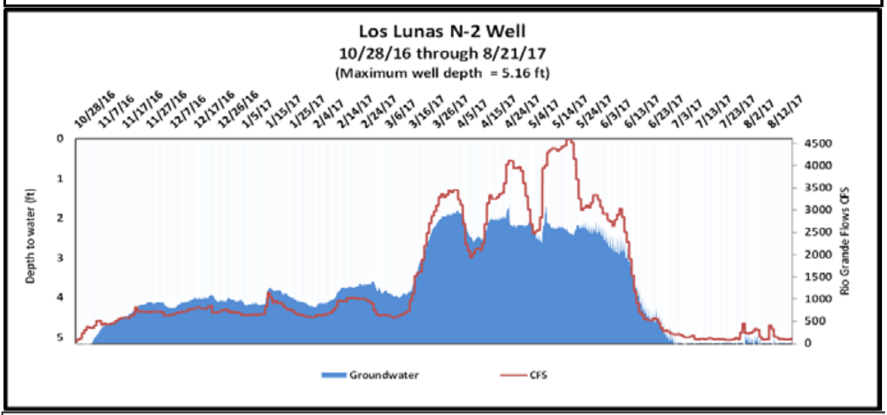
Well N2 (Missing logger – no data from 9/15 to 10/16)

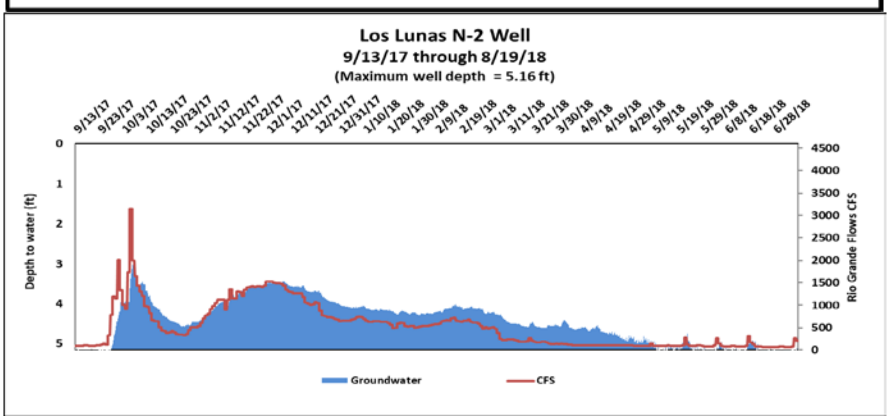




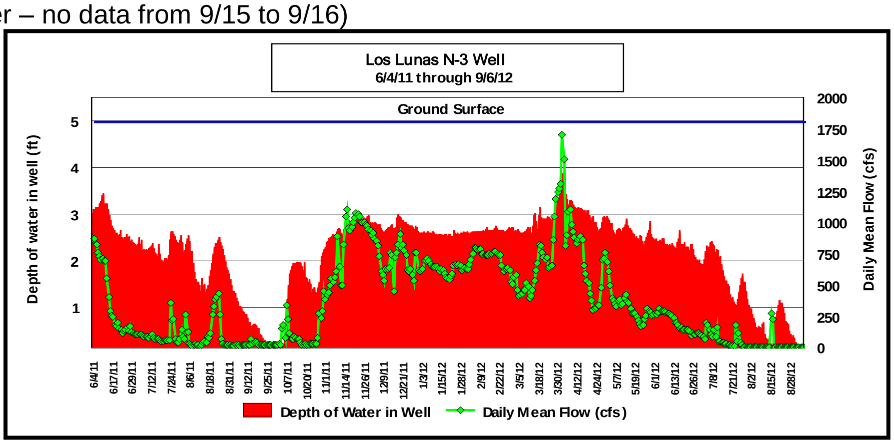


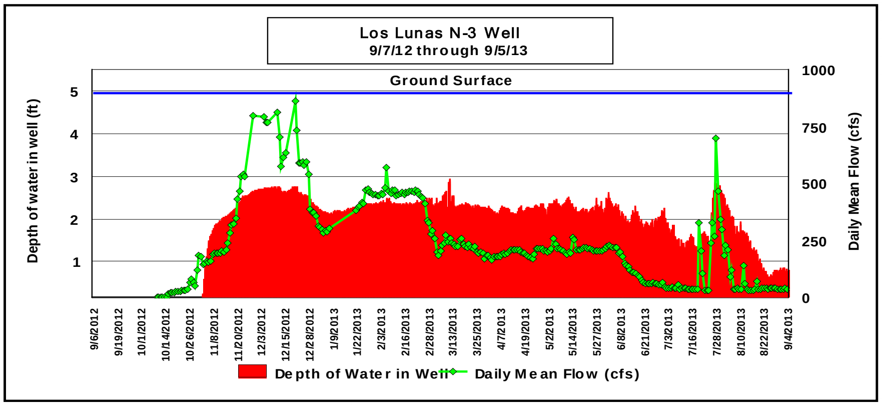


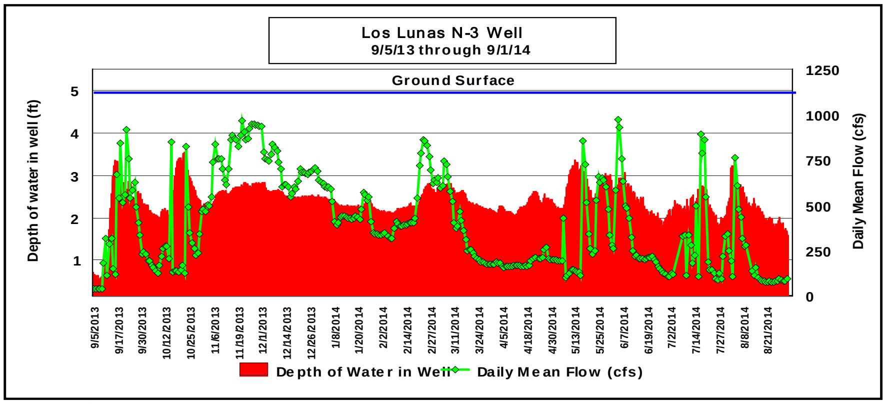


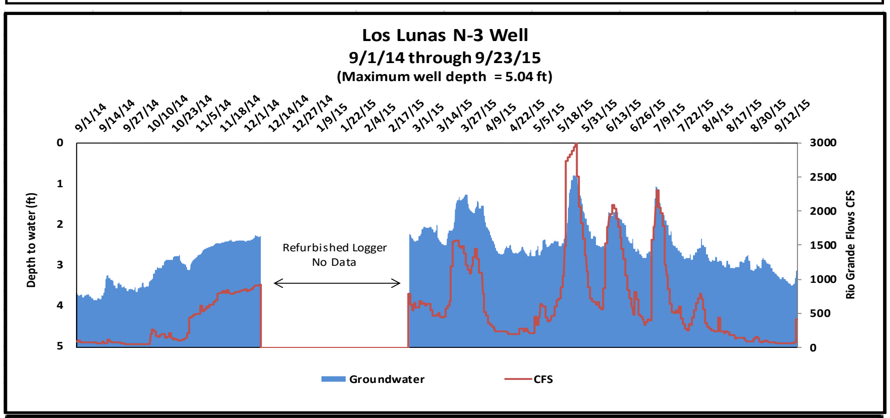


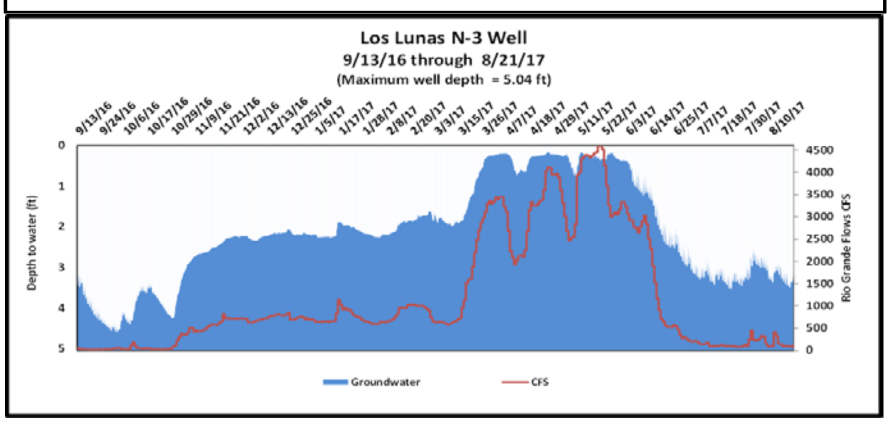
Well N3 (Missing logger – no data from 9/15 to 9/16)

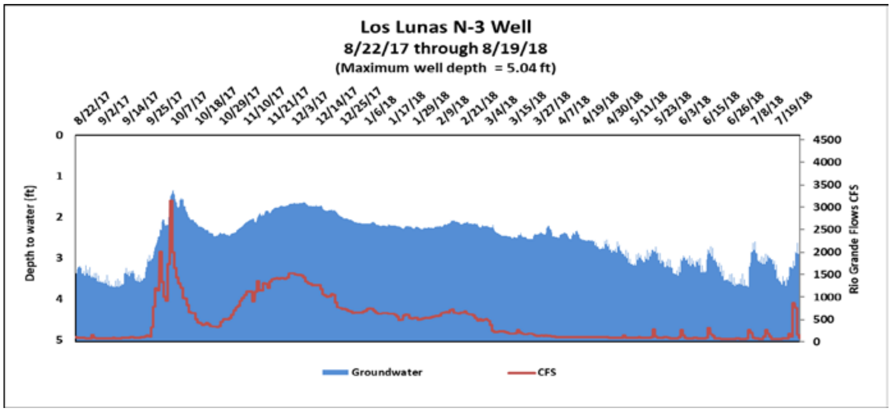



Los Lunas N-3 Well
9/7/12 through 9/5/13
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
5
4
3
2
1
1000
750
500
250
0
9/6/2012
9/19/2012
10/1/2012
10/14/2012
10/26/2012
11/8/2012
11/20/2012
12/3/2012
12/15/2012
12/28/2012
1/9/2013
1/22/2013
2/3/2013
2/16/2013
2/28/2013
3/13/2013
3/25/2013
4/7/2013
4/19/2013
5/2/2013
5/14/2013
5/27/2013
6/8/2013
6/21/2013
7/3/2013
7/16/2013
7/28/2013
8/10/2013
8/22/2013
9/4/2013
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas N-3 Well
9/5/13 through 9/1/14
Ground Surface
Depth of water in well (ft)
Daily Mean Flow (cfs)
5
4
3
2
1
1250
1000
750
500
250
0
9/5/2013
9/17/2013
9/30/2013
10/12/2013
10/25/2013
11/6/2013
11/19/2013
12/1/2013
12/14/2013
12/26/2013
1/8/2014
1/20/2014
2/2/2014
2/14/2014
2/27/2014
3/11/2014
3/24/2014
4/5/2014
4/18/2014
4/30/2014
5/13/2014
5/25/2014
6/7/2014
6/19/2014
7/2/2014
7/14/2014
7/27/2014
8/8/2014
8/21/2014
Depth of Water in Well
Daily Mean Flow (cfs)


Los Lunas N-3 Well
9/1/14 through 9/23/15
(Maximum well depth = 5.04 ft)
9/1/14
9/14/14
9/27/14
10/10/14
10/23/14
11/5/14
11/18/14
12/1/14
12/14/14
12/27/14
1/9/15
1/22/15
2/4/15
2/17/15
3/1/15
3/14/15
3/27/15
4/9/15
4/22/15
5/5/15
5/18/15
5/31/15
6/13/15
6/26/15
7/9/15
7/22/15
8/4/15
8/17/15
8/30/15
9/12/15
Depth to water (ft)
0
1
2
3
4
5
Rio Grande Flows CFS
3000
2500
2000
1500
1000
500
0
Refurbished Logger
No Data
Groundwater
CFS


Los Lunas N-3 Well
9/13/16 through 8/21/17
(Maximum well depth = 5.04 ft)
9/13/16
9/24/16
10/6/16
10/17/16
10/29/16
11/9/16
11/21/16
12/2/16
12/13/16
12/25/16
1/5/17
1/17/17
1/28/17
2/8/17
2/20/17
3/3/17
3/15/17
3/26/17
4/7/17
4/18/17
4/29/17
5/11/17
5/22/17
6/3/17
6/14/17
6/25/17
7/7/17
7/18/17
7/30/17
8/10/17
Depth to water (ft)
0
1
2
3
4
5
Rio Grande Flows CFS
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Groundwater
CFS


Los Lunas N-3 Well
8/22/17 through 8/19/18
(Maximum well depth = 5.04 ft)
8/22/17
9/2/17
9/14/17
9/25/17
10/7/17
10/18/17
10/29/17
11/10/17
11/21/17
12/3/17
12/14/17
12/25/17
1/6/18
1/17/18
1/29/18
2/9/18
2/21/18
3/4/18
3/15/18
3/27/18
4/7/18
4/19/18
4/30/18
5/11/18
5/23/18
6/3/18
6/15/18
6/26/18
7/8/18
7/19/18
Depth to water (ft)
0
1
2
3
4
5
Rio Grande Flows CFS
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

APPENDIX I

PHOTO STATIONS

Photo Station 1 - Facing North


2003


2004


2005


2006


2007


2008


2009


2010


2011


2012


2013


2014


2015


2016


2017


2018

Photo Station 1 – Facing River

2003

No photo available

2004

2005

2006

2007

2008

2009

2010

2011

2012

2013

2014

2015

2016

2017

2018

Photo Station 1 – Facing South

2003

2004

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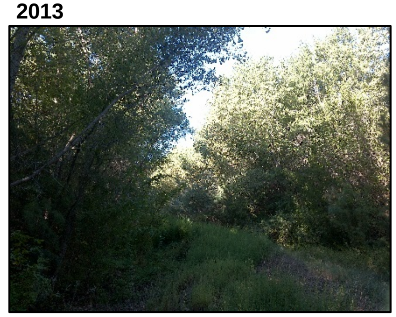
2015

2016



2017

2018

Photo Station 2 – Facing North


2003


2004


2005


2006


2007


2008


2009


2010


2011


2012


2013


2014


2015


2016


2017


2018

Photo Station 2 – Facing River


2003

No photo available
2004


2005


2006


2007


2008


2009


2010


2011


2012


2013


2014


2015


2016


2017


2018

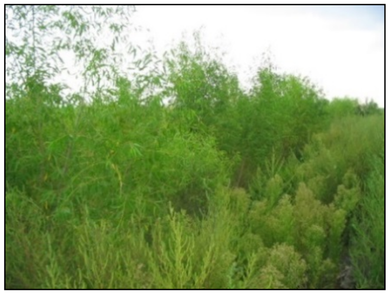
Photo Station 2 – Facing South


2003


2004


2005


2006


2007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2012


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2017


2018

Photo Station 3 – Facing North


2003


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2011


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2015


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2017


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Photo Station 3 - Facing South


2003


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2006


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Photo Station 4 – Facing North


2003


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2013


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2015


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2017


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Photo Station 4 – Facing South


2003


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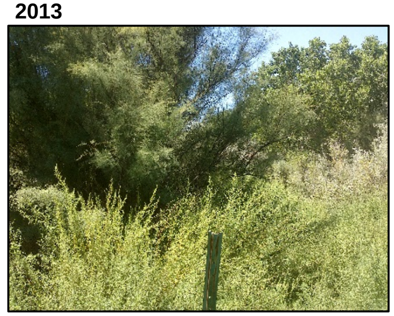
2015


2016


2017


2018

Photo Station 5 – Facing North


2003


2004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2014


2015


2016


2017


2018

Photo Station 5 – Facing South


2003


2004


2005


2006


2007


2008


2009


2010


2011


2012


2013


2014


2015


2016


2017


2018

Photo Station 6 – Facing North

No photo available

2003

2004

2005

2006

2007

2008

2009

2010

2011

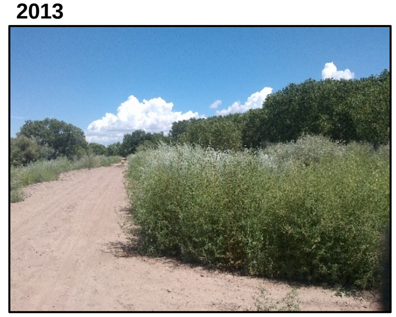
2012

2013

2014

2015

2016



2017

2018

Photo Station 6 – Facing South


2003


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Photo Station 7 – Facing North


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2018

Photo Station 8 – Pond

2003

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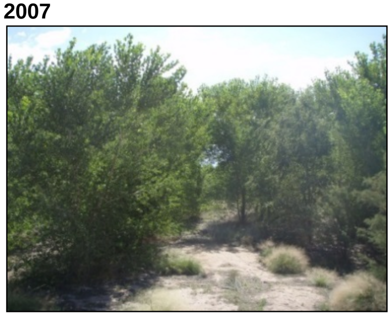
2009

2010



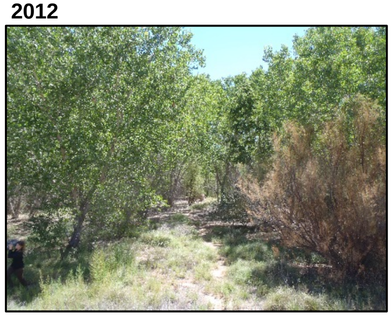
2011

2012

2013

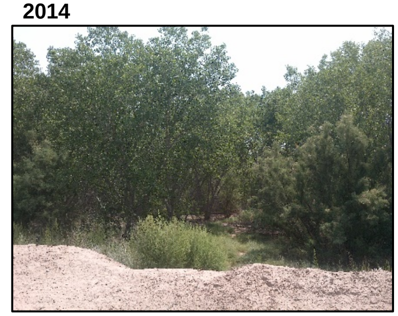
2014

2015



2016

2017



2018

Photo Station 9 – Facing South


2003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2018

Photo Station 10 – Facing North

2003

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2017

2018

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Los Lunas Habitat Restoration Monitoring WOID OA635

Document 2018 Report for the Los Lunas Habitat Restoration Project; 16 Years of Monitoring

Document Date May 2019

Team Leader Dave Moore

Document Author(s)/Preparer(s) Rebecca Siegle, Darrell Ahlers

Peer Reviewer Dave Moore

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain ______

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s):	Reviewer:
Entire document subject to review	Dave Moore

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Dave Moore Review Date: February 2019 Signature: [signature]

I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Leader: Dave Moore Date: May 6, 2018 Signature: [signature]