Monitoring the Effects of Restoration on Riparian Birds: 2017 Field Season Report

A cooperative research project between the Bureau of Land Management, the Dolores River Restoration Partnership, and Bird Conservancy of the Rockies

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Bird Conservancy of the Rockies
Connecting People, Birds and Land

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Bird Conservancy of the Rockies

Connecting people, birds and land

Mission Bird Conservancy of the Rockies conserves birds and their habitats through an integrated approach of science, education, and land stewardship. Our work radiates from the Rockies to the Great Plains, Mexico and beyond.

Vision A world where birds are forever abundant, contributing to healthy landscapes and inspiring human curiosity and love of nature.

Our mission is advanced through sound science, achieved through empowering people, realized through stewardship, and sustained through partnerships. Together, we are improving native bird populations, the land, and the lives of people.

Core Values

- **Science** provides the foundation for effective bird conservation.
- **Education** is critical to the success of bird conservation.
- **Stewardship** of birds and their habitats is a shared responsibility.

Goals

1. Guide conservation action where it is needed most by conducting scientifically rigorous monitoring and research on birds and their habitats within the context of their full annual cycle.
2. Inspire conservation action in people by developing relationships through community outreach and science-based, experiential education programs.
3. Contribute to bird population viability and help sustain working lands by partnering with landowners and managers to enhance wildlife habitat.
4. Promote conservation and inform land management decisions by disseminating scientific knowledge and developing tools and recommendations.

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Executive Summary

Riparian habitat in the arid western U.S. supports a rich diversity of birds and other wildlife. Over the last 50 years an invasive shrub, tamarisk (*Tamarix* sp.), has become prevalent in riparian ecosystems throughout the west, displacing and preventing regeneration of native plant species. Land managers have made large-scale efforts to control tamarisk in the Upper Colorado Basin through mechanical, chemical, and biological means. Previous research indicates that riparian bird communities can utilize tamarisk and that species may respond differently to removal treatments. Monitoring, therefore, is essential to understanding the impact of restoration work on birds within a riparian system.

The Dolores River Restoration Partnership (DRRP), a diverse public-private coalition of agencies, landowners, and non-profit organizations, formed in 2009 to restore native riparian communities along the Dolores River, a tributary of the Colorado River. DRRP has coordinated intensive restoration activities along the river, including removal of tamarisk stands and active revegetation of native plant species in suitable areas. In 2016, Bird Conservancy of the Rockies (Bird Conservancy), in partnership with the Bureau of Land Management (BLM) and DRRP, initiated a project to investigate the effects of restoration projects on riparian birds along the Dolores River. The goal of this project is to aid management by comparing bird response in areas with active revegetation, passive revegetation, and no restoration activity.

This project uses a sampling design and protocol consistent with the Integrated Monitoring in Bird Conservation Regions (IMBCR) program, a large-scale coordinated monitoring effort that allows inferences to avian occurrence and population at local and national levels. IMBCR uses a spatially-balanced sampling design to obtain estimates of avian density, occupancy, and population size at multiple scales. While not integrated into the nested stratification of IMBCR, auxiliary (or “overlay”) projects, such as this one, leverage detection data from the program to address specific management questions.

During 2017, the second year of the project, we conducted 192 point counts along the Dolores River, identifying a total of 1,941 individual birds of 66 different species (10.11 birds/point). From these observations, we generated density and abundance estimates for 63 species across three strata, with robust density estimates for 25 species (CV < 50%). We estimated the proportion of 1 km^2 grids occupied (Psi) for 63 species with robust occupancy estimates for 29 species (CV < 50%).

Although we may not be able to detect trends for several years, we observed initial differences between control and treatment areas for several species. Spotted Towhee and Common Yellowthroat had lower densities in both types of restoration areas in 2016 and 2017. Yellow Warbler, however, had higher densities within treatment areas, particularly areas with passive revegetation. Lazuli Bunting also had higher densities within treatment areas, but had large variation between years in the active revegetation stratum.

In the years following restoration on the Dolores River, we expect to observe a resurgence of native shrub species in areas where tamarisk has been removed and an increase in riparian bird diversity and abundance as habitat conditions improve with time. With a multi-year dataset, we will be able to identify trends within each stratum and observe how various riparian bird species respond following habitat restoration. Supplemental analyses may allow us to pinpoint the drivers behind these trends and quantify the relationships between bird species and tamarisk or native riparian habitat.

Acknowledgements

Many different individuals and organizations were important to the successful completion of this project during the 2017 season. We received funding for implementation and data analysis of the project from the Bureau of Land Management in Colorado in 2017. Dolores River Restoration Partnership provided funding for the study design and stratification as well as the initial implementation. Daniel Oppenheimer assisted with contacting landowners and provided logistical support prior to field work in 2016. Jenny Berven, Sparky Taber, and Rusty Lloyd also helped to contact landowners this year to acquire permission to access private lands. We thank all of the landowners that granted permission for allowing us to access their properties for this project. Most of all, we thank our field technicians, Carla Hanson and Tori Swift, for their hard work conducting surveys this season along the river.

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Introduction

Riparian habitat comprises less than 1% of the landscape western U.S., but is disproportionally important to breeding birds and other wildlife (Knopf et al. 1988). The Bureau of Land Management (BLM) estimated that the number of birds that depend upon riparian habitat in the western U.S. is at least two times higher and possibly up to ten times higher than all other available habitats (BLM 1998). Riparian habitat has been severely impacted in the western U.S. due to exploitation of resources (i.e., water, lumber, forage) by humans (Patten 1998). Channelization, dam building, diversions for agriculture, and other attempts to control water flow regimes have also had a major impact on riparian areas. As a result, human activities have caused a decline in many riparian-dependent species. The introduction of exotic tree and shrub species has also caused dramatic changes to riparian areas. Tamarisk (*Tamarix* sp.), a plant species intentionally introduced to control erosion, has rapidly spread and displaced native species (Glenn and Nagler 2005). Invasion of tamarisk has negatively impacted stream flow, stream sedimentation, soil salinity, fire regimes, livestock forage, and regeneration of native vegetation.

Tamarisk has become well established in areas of the Upper Colorado River basin, including the Dolores River corridor. In 2009, the Dolores River Restoration Partnership (DRRP), a diverse public-private coalition, formed to restore native riparian communities along the Dolores River. DRRP has coordinated intensive restoration activities over the past several years on both public and private land, including removal of tamarisk stands and active revegetation of native plant species in suitable areas (DRRP 2014). Various methods have been employed to remove tamarisk from riparian areas, including mechanical removal, chemical treatment, and biological control, including the release of the non-native Tamarisk Leaf Beetle (*Diorhabda* sp.; Bloodworth et al. 2016, Shafroth 2008).

There has been limited research on the effects of tamarisk invasion and restoration activities in the Upper Colorado River Basin. However, biologist have studied the relationship between birds and tamarisk for several decades in the Lower Colorado River Basin (e.g., Anderson et al. 1977). These studies found that tamarisk usage and avoidance by birds varied among species, river systems, and resident status (Hunter et al. 1988, Ellis 1995, Sogge et al. 2008, van Riper et al. 2008). While pure tamarisk stands can negatively impact avian abundance, van Riper et al. (2008) found abundance peaked with intermediate levels of tamarisk cover mixed with native vegetation. On the Dolores River, tamarisk defoliation had both positive and negative relationships with densities of riparian obligate species (Darrah and van Riper 2017).

Information on bird response to tamarisk removal and habitat enhancement projects is critical to guiding effective management and will require monitoring (Shafroth et al. 2005). Monitoring is an essential component of wildlife management and conservation science (Witmer 2005, Marsh and Trenham 2008). Common goals of population monitoring are to estimate population metrics (i.e. occupancy, abundance, etc.) of target species and to detect changes in populations over time (Thompson et al. 1998, Sauer and Knutson 2008). Effective monitoring programs can provide an understanding of how management actions affect populations (Alexander et al. 2008, Lyons et al. 2008), evaluate population responses to landscape alteration (Lindenmayer and Likens 2009), and provide basic information on species distributions.

Before monitoring can be used by land managers to guide conservation efforts, sound study designs and analytic methods are necessary to produce unbiased population estimates (Sauer and Knutson 2008). At the most fundamental level, reliable knowledge about the status of avian populations requires accounting for spatial variation and imperfect detection of the target species (Pollock et al. 2002, Rosenstock et al. 2002, Thompson 2002). Addressing spatial variation entails the use of probabilistic sampling designs that allow inferences to be extended over the entire area of interest (Thompson et al. 1998). Accounting for imperfect detection involves the use of appropriate sampling and analytic methods to address the fact that few species are so conspicuous that they are detected with certainty when present during a survey (Pollock et al. 2002, Thompson 2002). Accounting for these two sources of variation and bias ensures observed trends reflect true population changes rather than artifacts of the sampling and observation processes (Pollock et al. 2002, Thompson 2002).

This project utilizes a probabilistic, statistically robust design based on the Integrated Monitoring in Bird Conservation Regions (IMBCR) program, which accounts for imperfect detection and provides estimates of avian population density, abundance, and occupancy at multiple scales (Pavlacky et al. 2017). With a sampling design consistent with the IMBCR program, detection data from the entire program can be leveraged to improve precision and produce population metrics for a greater number of species (White et al. 2016). Using IMBCR methodology, the goals of this project are to:

1. Investigate how the presence of tamarisk impacts avian diversity, occupancy, and abundance along the Colorado portion of the Dolores River;
2. Investigate how tamarisk removal, with and without active revegetation, impacts the diversity, occupancy, and abundance of avian species along the Dolores River within Colorado;
3. Determine how quickly avian and vegetation communities respond following restoration efforts;
4. Guide future riparian management and restoration action along the Dolores River corridor.

Methods

Study Area

The area of inference encompasses the riparian corridor adjacent to the Dolores River, a tributary of the Colorado River, within Mesa, Montrose, and San Miguel counties (Figure 1). The study area starts upstream of Slick Rock, CO (1,800 m elevation) and continues downstream roughly 200 kilometers to the Colorado-Utah border near Gateway, CO (1,350 m elevation). Along this stretch, the riparian zone bordering the Dolores River varies in width from about 50 meters to one kilometer. Sampled locations were mostly in riparian habitat (127 of 192 point counts), with smaller numbers of other habitat types such as desert shrubland, pinyon-juniper woodlands, and sage shrubland. Predominant woody vegetation found at the survey locations included juniper (*Juniperus* spp.), tamarisk (*Tamarix* spp.), Fremont cottonwood (*Populus fremontii*), willow (*Salix* sp.), desert olive (*Forestiera neomexicana*), pinyon pine (*Pinus edulis*), sagebrush (*Artemesia* sp.), greasewood (*Sarcobatus vermiculatus*), rabbitbrush (*Ericameria* sp.), and saltbush (*Atriplex* sp.).

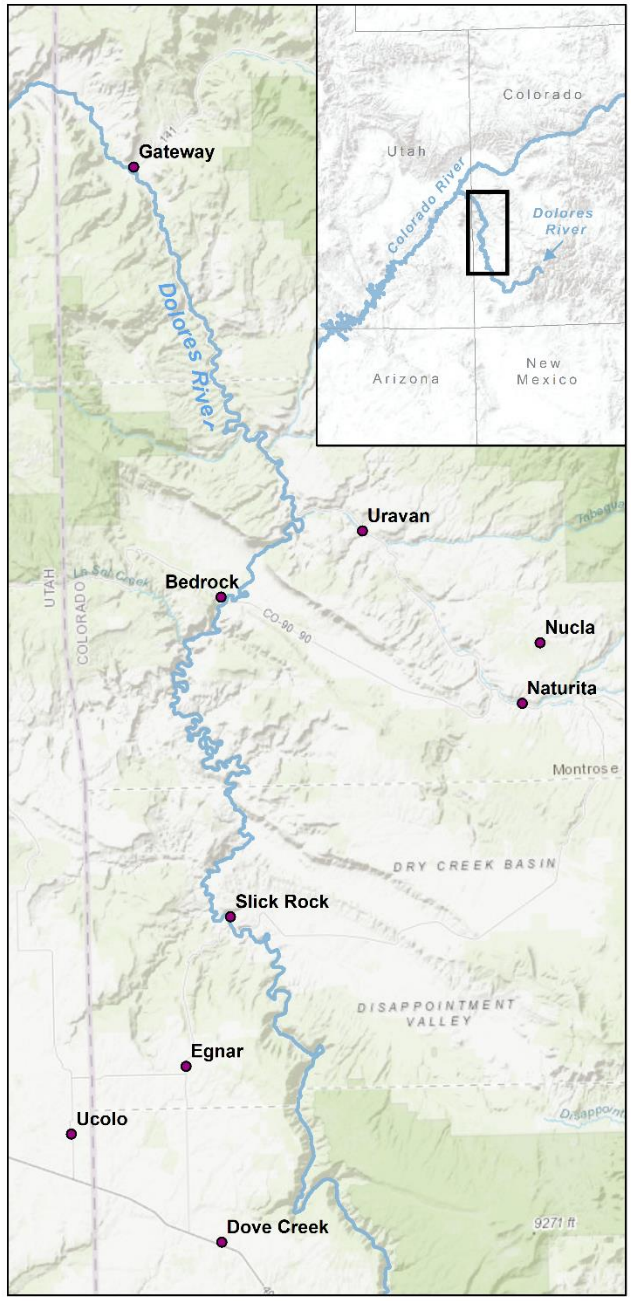

Figure 1. Study area along the Dolores River in Colorado.

Sampling Design

Sampling Frame and Stratification

We used a modified version of the IMBCR sampling design (Pavlacky et al. 2017), intended to better target riparian habitat areas surrounding a linear feature. We designed the stratification scheme to preserve compatibility with the monitoring efforts along the Colorado and Dolores Rivers in Utah (Birek et al. 2014). Using spatial information contained within the Dolores River Restoration Partnership (DRRP) geodatabases, we developed three strata using ArcGIS version 10.X (ESRI 2011):

1) Riparian areas that have been treated for tamarisk removal and are undergoing passive revegetation
2) Riparian areas that have been treated for tamarisk removal and were actively revegetated with native riparian plantings
3) A control stratum for riparian areas that have not undergone habitat enhancement treatments

We used the United States National Grid (FGDC 2001, Cavell 2005), a national grid of 1 km^2 cells, as the basis for the sampling units. We partitioned each 1 km^2 grid cell into four 0.25 km^2 quadrants to create the individual sampling units. Each 0.25 km^2 sampling unit contains four point count stations arranged in a 2 X 2 matrix. The point count stations are spaced 250 m apart from each other and 125 m from the edge of the grid (Figure 2).We generated the sampling frame by selecting grid cells that contained a minimum of two points within the riparian corridor of the Dolores River (i.e. within 25 m of the DRRP Restoration Plan River Corridor spatial layer). Grid cells with at least two points within 25 m of DRRP treatment polygons were included in the treatment strata. We subset these grids by treatment type, selecting grids with at least two points within 25 m of revegetation treatment for the active revegetation stratum and placing all others into the passive revegetation stratum. We classified riparian grids that did not meet these criteria as controls.

Sample Selection

Our site selection process generated 76 available 0.25 km^2 grid cells that met our sampling selection criteria (36 Control, 29 Passive Revegetation, and 11 Active Revegetation). We used Generalized Random-Tessellation Stratified (GRTS), a spatially-balanced sampling algorithm, to select sample units within each stratum (Stevens and Olsen 2004).

Figure 2. Example 0.25 km^2 sampling unit.

The GRTS design has several appealing properties with respect to long-term monitoring of birds at large spatial scales:

- Spatially balanced sampling is generally more efficient than simple random sampling of natural resources (Stevens and Olsen 2004). Incorporating information about spatial autocorrelation in the data can increase precision in density estimates;

- All sample units in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially well-balanced sample (Stevens and Olsen 2004). In the case of fluctuating budgets, partners can adjust the sampling effort among years within each stratum while still preserving a random, spatially balanced sampling design.

This design is well suited for estimating avian density and abundance using distance sampling (Thomas et al. 2010), as well as avian occupancy of sample grids and point count locations (Pavlacky et al. 2012). It is useful for determining temporal trends in bird populations, and the comparison of the treatment and control strata allows an evaluation of bird responses to riparian restoration. A spatially-balanced design ensures a representative sample of bird assemblages and riparian conditions along the Dolores River, allowing for the opportunity to model multi-scale habitat relationships in the future (Pavlacky et al. 2017).

As an additional criterion, we only surveyed grids that contained a minimum of two accessible points within 50 meters of riparian vegetation to ensure our effort was focused on riparian areas. Point count stations lying outside of riparian habitat were still surveyed to account for bird movement and changes in habitat that occur from restoration efforts within the dry terraces of the historic flood zone.

Sampling Methods

Field technicians with excellent aural and visual bird-identification skills conducted field work in 2017. Prior to conducting surveys, technicians completed an intensive training program to ensure full understanding of the field protocol, review bird and plant identification, and practice distance estimation in a variety of habitats.

Technicians conducted point counts (Buckland et al. 2001) following protocols established by IMBCR partners (Hanni et al. 2016) in the morning, beginning one-half hour before sunrise and concluding no later than five hours after sunrise. For every bird detected during the six-minute survey period, observers recorded species; sex; horizontal distance from the observer; minute; type of detection (e.g., call, song, visual); whether the bird was thought to be a migrant; and whether or not the observer was able to visually identify each record.

Observers measured distances to each bird using laser rangefinders, when possible. When it was not possible to measure the distance to a bird, observers estimated the distance by measuring to some object near the bird. In addition to recording all bird species detected in the area during point counts, observers recorded birds flying over but not using the immediate surrounding landscape. During travel between points within a sampling unit, technicians recorded the presence of any species not recorded during a point count. The opportunistic detections of these species are used for distribution mapping purposes only.

Technicians considered all non-independent detections of birds (i.e., flocks or pairs of conspecific birds together in close proximity) as part of a “cluster” rather than as independent observations. Observers recorded the number of birds detected within each cluster along with a letter code to distinguish between multiple clusters.

At the start and end of each survey, observers recorded time, ambient temperature, cloud cover, precipitation, and wind speed. Technicians navigated to each point using hand-held Global Positioning System units. Before each six-minute count, surveyors recorded vegetation data (within a 50 m radius of the point). Vegetation data included the dominant habitat type and relative abundance; percent cover and mean height of trees and shrubs by species; as well as grass height and ground cover types. Technicians recorded vegetation data quietly to allow birds time to return to their normal levels of activity prior to beginning each count.

Data Analysis

Distance Analysis

Distance sampling theory was developed to account for the decreasing probability of detecting an object of interest (e.g., a bird) with increasing distance from the observer to the object (Buckland et al. 2001). The detection probability is used to adjust the count of birds to account for birds that were present but undetected. Application of distance theory requires that five critical assumptions be met: 1) all birds at and near the sampling location (distance = 0) are detected; 2) distances to birds are measured accurately; 3) birds do not move in response to the observer's presence (Buckland et al. 2001, Thomas et al. 2010); 4) cluster sizes are recorded without error; and 5) the sampling units are representative of the entire survey region (Buckland et al. 2008).

Analysis of distance data includes fitting a detection function to the distribution of recorded distances (Buckland et al. 2001). The distribution of distances can be a function of characteristics of the object (e.g., for birds, size and color, movement, volume of song or call and frequency of call), the surrounding environment (e.g., density of vegetation), and observer ability. Because detectability varies among species, we analyzed these data separately for each species. The development of robust density estimates typically requires 80 or more independent detections ($n \geq 80$) within the entire sampling area (Buckland et al. 2001). We excluded from analyses birds flying over and not using the immediate surrounding landscape, birds detected while migrating (not breeding), juvenile birds, and birds detected between points.

We estimated density for each species using a sequential framework where 1) year specific detection functions were applied to species with greater than or equal to 80 detections per year ($n \geq 80$), 2) global detection functions were applied to species with less than 80 detections per year ($n < 80$) and greater than or equal to 80 detections over the life of the project ($n \geq 80$), and 3) remedial measures were used for species with moderate departures from the assumptions of distance sampling (Buckland et al. 2001).

Beginning in 2015, we streamlined the analysis by fitting models with no series expansions to all species using the recommended 10% truncation for point transects. For the year specific detection functions, we fit Conventional Distance Sampling models using the half-normal and hazard-rate key functions with no series expansions (Thomas et al. 2010). For the global detection functions, in addition to the above models, we fit Multiple-Covariate Distance Sampling models using half-normal and hazard-rate key function models with a categorical year covariate and no series expansions (Thomas et al. 2010). We selected the most parsimonious detection function for each species using Akaike's Information Criterion adjusted for small sample size (AIC_c); Burnham & Anderson 2002; Thomas et al. 2010), and considered the most parsimonious model as the estimation model. We estimated abundance (N) for each stratum as $N = D*A$, where D was the estimated population density and A was the number of 1 km² sampling units in each stratum. We calculated Satterthwaite 90% Confidence Intervals (CI) for the estimates of density and population size for each stratum (Buckland et al. 2001). In addition, we combined the stratum-level density estimates at various spatial scales, such as management entity, State and BCR, using an area-weighted mean. For the combined density estimates, we calculated the variance for detection and cluster size using the delta method (Powell 2007, Thomas et al. 2010) and the variance for the encounter rate using the design-based estimator of Fewster et al. (2009).

We reviewed the highest ranking detection function for each species to check the shape criteria, evaluate the fit of the model and identify species with moderate departure from the assumptions of distance sampling (Buckland et al. 2001). First, we checked the shape criteria of the histogram to make sure the detection data exhibited a "shoulder" that fell away at increasing distances from the point. Second, we evaluated the fit of the model using the Kolmogorov-Smirnov goodness-of-fit test. Finally, we visually inspected the detection histograms to identify species that demonstrated evasive movement and/ or measurement errors. We looked for a type of measurement error involving the clumping of detections at certain distances that occurs when observers round detection distances. We also looked for histograms with detections that were highly skewed to the right, which may indicate a pattern of evasive movement (Buckland et al. 2001).

For species with moderate departures from the assumptions and shape criteria, we used two sequential remedial measures. First, we truncated the data to the distance where detection probability was approximately 0.1 [g(w) ~ 0.1] and included key functions with second order cosine series-expansion terms in the candidate set of models (Buckland et al. 2001). We did not include detection function models with a single cosine expansion term because the half-normal and hazard-rate models require the order of the terms are > 1 (Buckland et al. 2001). Second, when the goodness-of-fit test and/ or inspection of the detection histogram continued to suggest evasive movement and/or measurement errors, we grouped the distance data into four to eight bins, and applied custom truncation and second order expansion terms. These remedial measures can ameliorate problems associated with moderate levels of evasive movement and/ or distance measurement errors (Buckland et al. 2001).

Occupancy Analysis

Occupancy estimation is most commonly used to quantify the proportion of sample units (i.e., 1 km^2 cells) occupied by a target species (MacKenzie et al. 2002). The application of occupancy modeling requires multiple surveys of the sample unit in space or time to estimate a detection probability (MacKenzie et al. 2006). The detection probability adjusts the proportion of sites occupied to account for species that were present but undetected (MacKenzie et al. 2002). We used a removal design (MacKenzie et al. 2006), to estimate a detection probability for each species, in which we binned minutes one and two, minutes three and four and minutes five and six to meet the assumption of a monotonic decline in the detection rates through time. After the target species was detected at a point, we set all subsequent sampling intervals at that point to “missing data” (MacKenzie et al. 2006).

The 4 points in each sampling unit served as spatial replicates for estimating the proportion of points occupied within the sampled sampling units. We used a multi-scale occupancy model to estimate 1) the probability of detecting a species given presence (*p*), 2) the proportion of points occupied by a species given presence within sampled sampling units (Theta) and 3) the proportion of sampling units occupied by a species (Psi). Theta can be considered an availability parameter or the probability a species was present and available for sampling at the points (Nichols et al. 2008, Pavlacky et al. 2012).

We truncated the data, using only detections less than 125 m from the sample points. Truncating the data at less than 125 m allowed us to use bird detections over a consistent plot size and ensured that the points were independent (points were spread 250 m apart), which in turn allowed us to estimate Theta (Pavlacky et al. 2012)

We expected that regional differences in the behavior, habitat use, and local abundance of species would correspond to regional variation in detection and the proportion of occupied points. Therefore, we estimated the proportion of sampling units occupied (Psi) for each stratum by evaluating four models with different structure for detection (*p*) and the proportion of points occupied (Theta). Within these models, p and Theta were held constant across the BCRs and/or allowed to vary by BCR. Models are defined as follows:

Model 1: Held *p* and Theta constant;

Model 2: Held *p* constant, but allowed Theta to vary across BCRs;

Model 3: Allowed p to vary across BCRs, but held Theta constant;

Model 4: Allowed both p and Theta to vary across BCRs.

We ran model 1 for species with less than 10 point detections in each BCR or less than 10 point detections in all but one BCR. We ran models 1 through 4 for species with greater than 10 point detections in more than one BCR. For the purpose of estimating regional variation in detection (p) and availability (Theta), we pooled data for BCRs with fewer than 10 point detections into adjacent BCRs with sufficient numbers of detections. We used model selection and AIC corrected for small sample size (AIC_c) to weight models from which estimates of Psi were derived for each species (Burnham and Anderson 2002). We model averaged the estimates of Psi from models 1 through 4 and calculated unconditional standard errors and 90% CIs (Burnham and Anderson 2002). We combined stratum-level estimates of Psi using an area-weighted mean. The variances and standard errors for the combined estimates of Psi were estimated using the delta method (Powell 2007).

Our application of the multi-scale model was analogous to a within-season robust design (Pollock 1982) where the two-minute intervals at each point were the secondary samples for estimating p and the points were the primary samples for estimating Theta (Nichols et al. 2008, Pavlacky et al. 2012). We considered both p and Theta to be nuisance variables that were important for generating unbiased estimates of Psi but not of interest for this particular study.

Automated Analysis

We estimated population density using point transect distance sampling and site occupancy using the multi-scale occupancy model within a modified version of the RIMBCR package (R Core Team 2017; Paul Lukacs, University of Montana, Missoula). The RIMBCR package streamlines the analyses by calling the raw data from the IMBCR Structured Query Language (SQL) server database and incorporating the R code created in previous years. We allowed the input of all data collected in a manner consistent with the IMBCR design to increase the number of detections available for estimating global detection rates for population density and site occupancy. The RIMBCR package uses package mrds (Thomas et al. 2010, R Core Team 2017) to fit the point transect distance sampling model, and program MARK (White and Burnham 1999) and package RMark (Laake 2013, R Core Team 2017) to fit the multi-scale occupancy model. The RIMBCR package provides an automated framework for combining strata-level estimates of population density and site occupancy at multiple spatial scales, as well as calculating the standard errors and CIs for the combined estimates.

Results

Summary of Results

In 2017, Bird Conservancy conducted 59 out of 60 planned surveys (98%) along the Dolores River from June 1st through June 22nd, 2017 (26 in control areas, 22 in passive revegetation areas, and 11 in active revegetation treatment areas (Figure 3). We did not complete one survey in the passive revegetation stratum due to lack of private landowner permission. No backup surveys in any stratum were accessible at that time to replace this missed survey.

In total, field technicians recorded and identified 1,941 individual birds during 192 6-minute point counts (10.11 birds/point) representing 66 species. These included five Tier 2 Species of Greatest Conservation Need as listed in the Colorado State Wildlife Action Plan (CPW 2015): Brewer's Sparrow (n=2), Gray Vireo (n=17), Lazuli Bunting (n=90), Pinyon Jay (n=2), and Virginia's Warbler (n=8).

Tables 1 and 2 provide density estimates and occupancy estimates, respectively, for all avian species detected in 2017. Estimates are only included if there were sufficient detections within a particular stratum. Active revegetation areas are labeled as "Active", passive revegetation areas are labeled as "Passive", and areas with no restoration activity are labeled as "Control".

Results for both 2016 and 2017 are also available on the Rocky Mountain Avian Data Center (ADC). To view a map of survey locations, density and occupancy results, and species counts for this project, follow the link below and hit the "Run Query" button highlighted in red located near the top of the page (precise survey locations require a password from Bird Conservancy). If you want to limit results to 2017, select "Year" from the Filter drop down box on the top left of the screen. Hit the "Add" button, select "2017", hit "Add Filter", then "Run Query". Strata codes on the ADC are "CO-DOTAM-CO" for control areas, "CO-DOTAM-TN" for passive revegetation areas, and "CO-DOTAM-TV" for active revegetation areas.

Dolores River Monitoring Results

Raw counts of individual species can also be found in the Appendix, listed by both stratum and totals throughout the study area.

Site Visit Summaries by Stratum

Control Areas

Field technicians completed 26 of 20 planned surveys (130%) in the control stratum in 2016. We surveyed six additional grid cells within the control stratum because we were unable to obtain the desired number of surveys in the treatment strata. Field staff conducted 71 individual point counts within the 26 surveyed grids and detected 792 individual birds (11.15 birds/point count) of 46 species.

Bird Conservancy estimated densities and population sizes for 44 species, 4 of which are priority species. The data yielded robust density estimates (CV < 50%) for 18 of these species (Table 1).

Bird Conservancy estimated the proportion of 1 km^2 grid cells occupied (Psi) throughout this stratum for 45 species, 4 of which are priority species. The data yielded robust occupancy estimates (CV < 50%) for 20 of these species (Table 2).

Tamarisk Removal with Passive Revegetation

Field technicians completed 22 of 29 planned surveys (76%) in the passive revegetation stratum in 2017. Seven surveys were not completed due to lack of permission from private landowners. In future years, we may be able to reach additional sites if we can secure landowner permission. Technicians conducted

79 individual point counts within the 22 surveyed grids and detected 805 individual birds (10.19 birds/point count) of 51 species.

Bird Conservancy estimated densities and population sizes for 47 species, 3 of which are priority species. The data yielded robust density estimates (CV < 50%) for 17 of these species (Table 1).

Bird Conservancy estimated the proportion of 1 km^2 grid cells occupied (Psi) throughout this stratum for 48 species, 3 of which are priority species. The data yielded robust occupancy estimates (CV < 50%) for 20 of these species (Table 2).

Tamarisk Removal with Active Revegetation

Field technicians completed 11 of 11 planned surveys (100%) in the active revegetation stratum in 2017. Field staff conducted 42 individual point counts within the 11 surveyed grids and detected 344 individual birds (8.19 birds/point count) of 35 species.

Bird Conservancy estimated densities and population sizes for 32 species, 4 of which are priority species. The data yielded robust density estimates (CV < 50%) for 10 of these species (Table 1).

Bird Conservancy estimated the proportion of 1 km^2 grid cells occupied (Psi) throughout this stratum for 30 species, 3 of which are priority species. The data yielded robust occupancy estimates (CV < 50%) for 13 of these species (Table 2).

Table 1. Estimated densities (*D*) per km^2 by stratum, coefficient of variation of estimates (CV), lower and upper confidence limits on *D* (LCL and UCL, respectively), and number of independent detections used in analysis (*n*) for avian species in along the Dolores River in 2017. Active revegetation areas are labeled as “Active”, passive revegetation areas are labeled as “Passive”, and areas with no restoration activity are labeled as “Control”. Priority species from the Colorado State Wildlife Action Plan are highlighted in bold.

Common Name	Stratum	D	LCL	UCL	CV (%)	n
American Goldfinch	Passive	2.73	1.08	6.89	58	4
	Active	5.13	2.51	10.46	41	4
American Kestrel	Control	0.75	0.30	1.89	58	4
	Passive	0.17	0.04	0.71	100	1
American Robin	Control	0.45	0.11	1.90	101	1
	Passive	6.09	2.11	17.59	68	15
Ash-throated Flycatcher	Control	5.03	2.94	8.62	32	12
	Passive	7.54	5.11	11.11	23	20
	Active	8.51	4.73	15.31	33	12
Barn Swallow	Active	3.33	0.74	15.08	101	1
Belted Kingfisher	Active	0.40	0.09	1.81	100	1
Bewick's Wren	Control	2.81	1.04	7.58	63	5
Black-billed Magpie	Control	2.23	1.19	4.20	38	20
Black-chinned Hummingbird	Passive	19.72	4.64	83.77	102	1
	Active	37.09	8.14	168.96	102	1
Black-headed Grosbeak	Control	1.54	0.57	4.19	64	5
	Passive	5.81	3.47	9.73	31	21
	Active	1.04	0.35	3.12	67	2
Black-throated Gray Warbler	Control	0.80	0.19	3.36	101	1
	Passive	4.31	1.95	9.51	49	6

Common Name	Stratum	D	LCL	UCL	CV (%)	n
Black-throated Sparrow	Control	0.87	0.21	3.55	98	2
	Passive	2.35	0.96	5.71	55	6
	Active	2.94	1.44	5.99	41	4
Blue Grosbeak	Control	0.50	0.18	1.41	67	2
	Passive	2.46	1.22	4.98	43	11
	Active	2.53	0.96	6.67	58	6
Blue-gray Gnatcatcher	Control	52.70	37.96	73.17	19	28
	Passive	67.67	50.76	90.20	17	40
	Active	47.73	34.57	65.89	18	15
Brewer's Sparrow	Control	1.39	0.49	3.93	67	2
Brown-headed Cowbird	Control	13.74	7.87	23.99	34	20
	Passive	0.56	0.13	2.37	101	1
Bullock's Oriole	Passive	2.99	1.31	6.84	51	6
Canada Goose	Passive	0.72	0.17	3.00	100	1
Canyon Wren	Control	0.92	0.46	1.82	42	7
	Passive	1.06	0.45	2.47	52	9
	Active	0.66	0.27	1.63	53	3
Chipping Sparrow	Control	12.76	6.60	24.66	40	10
Cliff Swallow	Control	1.86	0.44	7.82	102	1
Common Raven	Control	1.35	0.85	2.14	28	31
	Passive	1.13	0.59	2.17	39	24
	Active	1.40	0.90	2.18	25	19
Common Yellowthroat	Control	11.19	7.19	17.41	26	24
	Passive	6.70	4.16	10.81	29	16
	Active	3.15	0.92	10.76	77	4
Eurasian Collared-Dove	Control	2.24	0.90	5.57	58	5
	Passive	2.42	0.58	10.15	100	4
European Starling	Control	17.85	4.37	72.95	99	5
	Passive	3.21	0.77	13.42	100	1
Gray Catbird	Passive	2.68	0.85	8.39	75	3
Gray Vireo	Control	1.37	0.55	3.39	57	3
	Passive	3.68	1.44	9.46	59	9
	Active	3.08	1.18	8.01	57	4
Great Blue Heron	Active	0.20	0.04	0.90	100	1
Hairy Woodpecker	Passive	0.71	0.17	2.97	100	1
House Finch	Control	8.66	4.62	16.21	38	9
	Passive	19.10	10.20	35.73	38	22
	Active	14.63	5.98	35.82	53	9
House Sparrow	Passive	4.87	1.16	20.44	101	2
House Wren	Active	1.19	0.26	5.37	100	1
Indigo Bunting	Control	0.52	0.13	2.16	100	1

Common Name	Stratum	D	LCL	UCL	CV (%)	n
Lark Sparrow	Control	9.62	5.62	16.47	32	16
	Passive	5.95	2.74	12.91	47	11
	Active	13.22	7.97	21.92	29	13
Lazuli Bunting	Control	10.77	6.09	19.05	34	18
	Passive	20.96	12.88	34.12	29	39
	Active	13.14	5.47	31.58	51	13
Lesser Goldfinch	Control	2.80	0.69	11.45	99	1
	Passive	3.78	1.23	11.61	73	3
Mountain Bluebird	Passive	0.48	0.11	1.99	100	1
Mourning Dove	Control	1.73	1.02	2.92	32	10
	Passive	1.40	0.85	2.31	30	9
	Active	0.58	0.20	1.75	66	2
Northern Flicker	Control	1.60	0.61	4.20	62	7
	Passive	0.41	0.10	1.71	100	1
	Active	0.39	0.09	1.74	100	1
Northern Mockingbird	Active	0.29	0.06	1.29	100	1
Pinyon Jay	Active	0.69	0.15	3.16	102	2
Plumbeous Vireo	Control	2.00	0.73	5.50	65	5
	Passive	1.44	0.57	3.63	58	4
Red-winged Blackbird	Control	1.88	0.65	5.42	69	5
	Passive	1.69	0.40	7.05	100	5
Ring-necked Pheasant	Control	1.88	1.20	2.95	27	36
	Passive	0.28	0.07	1.17	100	6
Rock Wren	Control	1.38	0.55	3.42	57	8
	Passive	1.08	0.58	2.00	37	7
	Active	0.29	0.06	1.31	100	1
Savannah Sparrow	Control	15.38	4.71	50.30	79	20
Say's Phoebe	Control	0.19	0.05	0.79	98	1
	Passive	1.05	0.59	1.87	35	6
	Active	1.32	0.61	2.82	44	4
Song Sparrow	Control	4.20	1.59	11.13	62	8
	Passive	0.47	0.11	1.97	100	1
Spotted Sandpiper	Control	0.54	0.13	2.26	102	1
	Passive	0.48	0.11	2.02	100	1
	Active	4.53	1.47	13.95	69	5
Spotted Towhee	Control	58.65	46.36	74.19	14	104
	Passive	33.96	25.31	45.55	17	67
	Active	12.39	7.13	21.55	31	13
Vesper Sparrow	Control	0.53	0.18	1.55	69	2
Virginia's Warbler	Control	0.96	0.23	3.99	100	1
	Passive	0.87	0.20	3.67	101	1
	Active	4.88	1.53	15.57	71	3
Warbling Vireo	Active	2.16	0.48	9.73	100	2

Common Name	Stratum	D	LCL	UCL	CV (%)	n
Western Kingbird	Control	2.59	1.21	5.56	47	5
	Passive	1.86	0.73	4.76	59	4
	Active	6.13	2.23	16.84	61	7
Western Meadowlark	Control	7.13	4.42	11.52	29	50
	Passive	1.67	0.62	4.46	62	13
Western Tanager	Passive	1.05	0.43	2.58	56	3
Western Wood-Pewee	Passive	0.29	0.07	1.24	101	1
White-throated Swift	Control	27.11	11.39	64.50	56	13
	Passive	10.08	3.44	29.51	71	7
Willow Flycatcher	Passive	6.80	3.05	15.17	50	7
Wilson's Snipe	Control	0.32	0.08	1.34	102	2
Woodhouse's Scrub-Jay	Passive	0.28	0.07	1.17	100	1
	Active	1.05	0.23	4.74	100	2
Yellow Warbler	Control	23.08	13.06	40.79	34	34
	Passive	43.31	34.74	53.99	13	70
	Active	33.27	22.21	49.84	23	29
Yellow-breasted Chat	Control	37.29	27.54	50.48	18	99
	Passive	40.62	31.47	52.43	15	120
	Active	43.30	32.98	56.84	16	68

Table 2. Estimated proportion of sample units occupied by stratum (Psi), standard error on Psi (SE), coefficient of variation of Psi (CV), and number of grid cells with one or more detections (nTran) for avian species along the Dolores River in 2017. Active revegetation areas are labeled as “Active”, passive revegetation areas are labeled as “Passive”, and areas with no restoration activity are labeled as “Control”. Priority species from the Colorado State Wildlife Action Plan are highlighted in bold.

Common Name	Stratum	Psi	SE	CV (%)	nTran
American Goldfinch	Passive	0.498	0.297	60	3
	Active	1	0	0	4
American Kestrel	Control	0.689	0.442	64	2
	Passive	0.329	0.365	111	1
American Robin	Control	0.054	0.053	98	1
	Passive	0.168	0.09	54	3
Ash-throated Flycatcher	Control	0.647	0.174	27	9
	Passive	0.78	0.165	21	11
	Active	0.922	0.211	23	7
Barn Swallow	Active	0.599	0.348	58	2
Belted Kingfisher	Active	0.964	1.056	109	1
Bewick's Wren	Control	0.194	0.105	54	3
Black-billed Magpie	Control	0.287	0.199	70	2
Black-chinned Hummingbird	Passive	0.118	0.117	99	1
	Active	0.224	0.216	96	1
Black-headed Grosbeak	Control	0.256	0.141	55	3
	Passive	0.728	0.195	27	9
	Active	0.159	0.153	96	1

Common Name	Stratum	Psi	SE	CV (%)	nTran
Black-throated Gray Warbler	Control	0.05	0.049	98	1
	Passive	0.269	0.106	39	5
Black-throated Sparrow	Control	0.104	0.07	68	2
	Passive	0.212	0.096	45	4
	Active	0.42	0.168	40	4
Blue Grosbeak	Control	0.235	0.166	71	2
	Passive	0.552	0.241	44	5
	Active	0.609	0.322	53	3
Blue-gray Gnatcatcher	Control	0.878	0.143	16	15
	Passive	1	0	0	18
	Active	1	0	0	10
Brewer's Blackbird	Control	0.09	0.089	98	1
Brewer's Sparrow	Control	0.119	0.081	68	2
Broad-tailed Hummingbird	Passive	0.07	0.069	98	1
Brown-headed Cowbird	Control	1	0	0	9
	Passive	0.213	0.145	68	2
Bullock's Oriole	Passive	0.558	0.366	66	4
Canada Goose	Passive	0.344	0.372	108	1
Canyon Wren	Control	1	0	0	5
	Passive	0.746	0.427	57	3
	Active	0.466	0.454	97	1
Chipping Sparrow	Control	0.415	0.148	36	6
Cliff Swallow	Control	0.094	0.093	99	1
Common Raven	Control	1	0	0	7
	Passive	1	0	0	8
	Active	1	0.047	5	3
Common Yellowthroat	Control	1	0.005	0	14
	Passive	0.903	0.215	24	11
	Active	0.322	0.209	65	2
Eurasian Collared-Dove	Control	0.316	0.153	48	4
	Passive	0.075	0.074	99	1
European Starling	Control	0.077	0.077	100	1
	Passive	0.075	0.075	99	1
Gray Catbird	Passive	0.229	0.164	72	2
Gray Vireo	Control	0.272	0.125	46	4
	Passive	0.28	0.127	45	4
	Active	0.394	0.195	49	3
Hairy Woodpecker	Passive	0.149	0.146	98	1
House Finch	Control	0.499	0.161	32	7
	Passive	0.763	0.163	21	11
	Active	0.398	0.196	49	3
House Sparrow	Passive	0.103	0.11	106	1
House Wren	Active	0.113	0.107	95	1

Common Name	Stratum	Psi	SE	CV (%)	nTran
Indigo Bunting	Control	0.108	0.107	99	1
Lark Sparrow	Control	0.517	0.168	33	7
	Passive	0.268	0.122	45	4
	Active	0.94	0.215	23	7
Lazuli Bunting	Control	0.473	0.154	32	7
	Passive	0.86	0.152	18	13
	Active	0.626	0.208	33	5
Lesser Goldfinch	Control	0.08	0.079	99	1
	Passive	0.234	0.127	54	3
Mountain Bluebird	Passive	0.092	0.09	98	1
Mourning Dove	Control	0.239	0.13	54	3
	Passive	0.619	0.175	28	8
	Active	0.145	0.139	95	1
Northern Flicker	Control	0.374	0.203	54	3
	Passive	0.231	0.156	68	2
Northern Mockingbird	Active	0.168	0.162	96	1
Plumbeous Vireo	Control	0.346	0.16	46	4
	Passive	0.346	0.157	46	4
Red-winged Blackbird	Control	0.107	0.106	99	1
	Passive	0.101	0.099	99	1
Ring-necked Pheasant	Control	0.344	0.169	49	4
	Passive	0.081	0.08	99	1
Rock Wren	Control	0.247	0.134	54	3
	Passive	0.415	0.163	39	5
	Active	0.156	0.149	95	1
Savannah Sparrow	Control	0.47	0.302	64	3
Say's Phoebe	Passive	0.467	0.218	47	4
	Active	0.647	0.327	51	3
Song Sparrow	Control	0.409	0.232	57	3
	Passive	0.13	0.129	99	1
Spotted Sandpiper	Control	0.178	0.182	102	1
	Passive	0.168	0.171	102	1
	Active	0.927	0.316	34	3
Spotted Towhee	Control	1	0	0	23
	Passive	0.856	0.098	11	17
	Active	0.803	0.148	18	8
Vesper Sparrow	Control	0.115	0.078	68	2
Virginia's Warbler	Control	0.068	0.067	98	1
	Passive	0.135	0.091	67	2
	Active	0.262	0.167	64	2
Warbling Vireo	Passive	0.057	0.056	98	1
	Active	0.11	0.105	95	1

Common Name	Stratum	Psi	SE	CV (%)	nTran
Western Kingbird	Control	0.446	0.217	49	4
	Passive	0.301	0.167	56	3
	Active	0.579	0.297	51	3
Western Meadowlark	Control	0.348	0.125	36	6
	Passive	0.172	0.092	54	3
Western Tanager	Passive	0.112	0.076	67	2
	Active	0.108	0.103	95	1
Western Wood-Pewee	Passive	0.063	0.061	98	1
White-throated Swift	Control	0.59	0.197	33	7
	Passive	0.511	0.183	36	6
Willow Flycatcher	Passive	0.543	0.334	62	4
Wilson's Snipe	Control	0.102	0.101	99	1
Woodhouse's Scrub-Jay	Control	0.182	0.124	68	2
	Active	0.342	0.221	64	2
Yellow Warbler	Control	0.976	0.15	15	16
	Passive	1	0	0	21
	Active	1	0	0	10
Yellow-breasted Chat	Control	0.889	0.074	8	22
	Passive	0.937	0.064	7	20
	Active	0.937	0.09	10	10

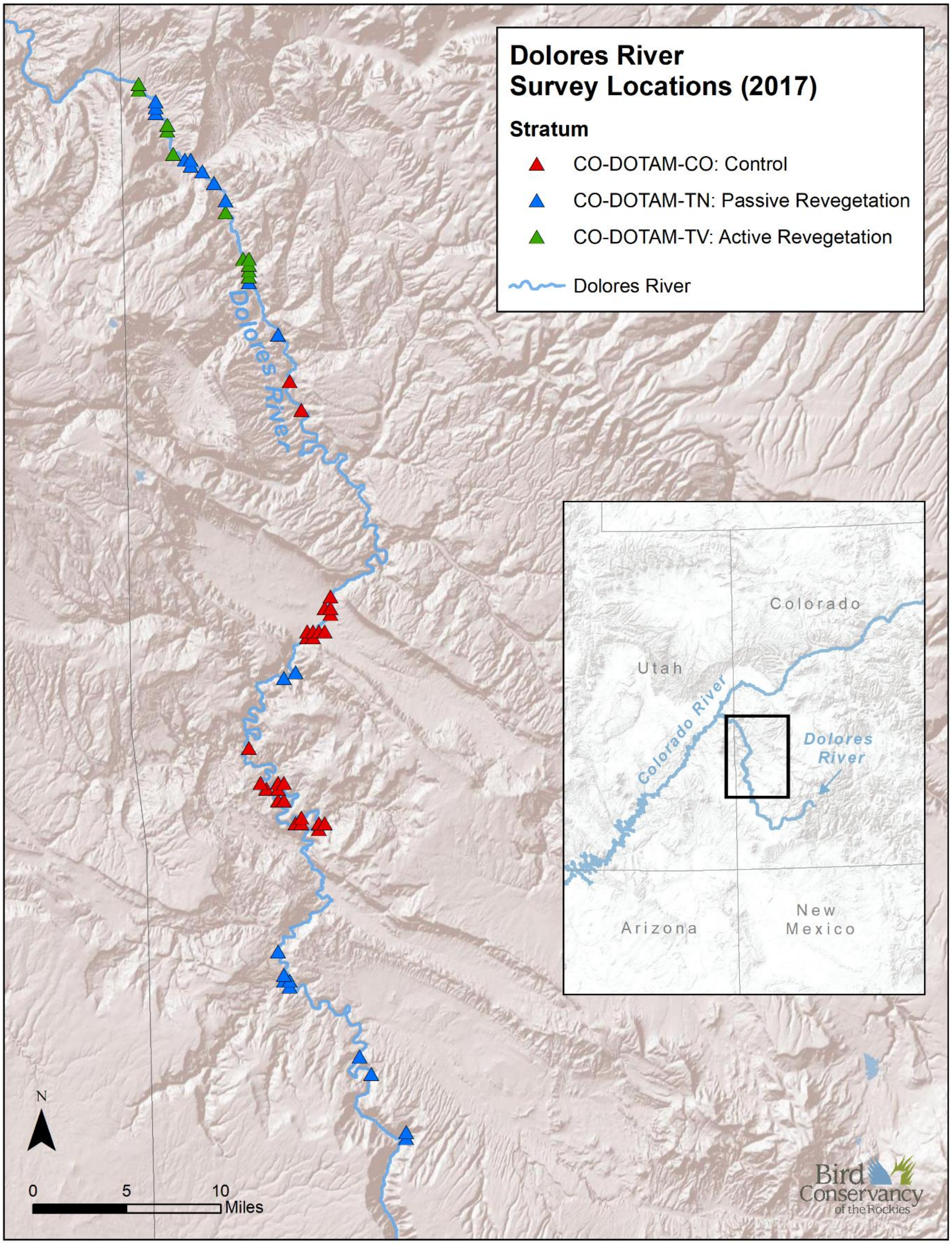

Figure 3. Surveyed sampling unit locations in three strata along the Dolores River in 2017.

Discussion

The objective of this project is to determine the effects of restoration projects on riparian bird species along the Dolores River corridor, which will require a long-term monitoring effort. Among all species, including riparian and upland birds, there was a noticeable decrease in bird density and number of species compared to 2016, when technicians recorded 91 unique species and averaged 13.63 birds/point across all strata. Several confounding factors may have led to this decrease: 1) later seasonal timing of our surveys in 2017, resulting in fewer migrant birds (not included in analysis) and possibly lower bird activity due to higher daily temperatures, 2) stream noise from large water releases on particular days in June 2017, which could have impacted detection, 3) typical year-to-year variation in abundance and species richness within this system.

While we may not be able to detect species trends for several years, we found some differences in the first two years of monitoring for a few species for which we have relatively precise estimates within all three strata (Figure 4). Densities of four species differed between years and between active restoration and control areas. In the Control stratum, Lazuli Bunting, Common Yellowthroat, and Yellow Warbler densities decreased between 2016 and 2017 while Spotted Towhee densities increased. These background changes can be compared to changes within vegetation treatments. Yellow Warbler and Spotted Towhee densities in the two treatments changed in the same direction as their densities in the control – i.e., warbler densities decreased while towhee densities increased. In contrast, Common Yellowthroat densities increased between years in the passive revegetation treatment while Lazuli Bunting densities dramatically decreased in the active revegetation treatment.

We found consistent patterns for Spotted Towhee, Common Yellowthroat, and Yellow Warbler between treatment and control strata across both years indicating an initial response to restoration activities. Spotted Towhee, a generalist species that prefers dense shrub cover, had significantly lower densities in both treatment strata. Common Yellowthroat, a riparian specialist that also prefers dense vegetation, showed similar lower densities within restoration areas, although the effect was less evident in the active revegetation stratum in 2017. These results indicate that there may be temporary negative impacts on these species following restoration. On the other hand, another riparian species, Yellow Warbler, showed higher densities within the passive revegetation stratum versus the control and a weaker positive effect in active revegetation areas. Yellow Warbler is an adaptable species that is known to inhabit more open or disturbed areas (Lowther et al. 1999). However, Yellow Warblers prefer mature willow and cottonwood species in Colorado (Wickersham 2016), which may not be present in areas dominated by tamarisk.

With just two years of data, we cannot be certain of the reasons for annual or among-treatment differences; fluctuations may be due to natural annual variation in numbers. In addition, because restoration sites were prioritized partially on the presence of native vegetation (DRRP 2010), there may be some initial differences between habitat quality among strata. Our results suggest that certain species may respond differently to tamarisk removal, as several studies have shown (Sogge et al. 2008; van Riper et al. 2008, Darrah and Van Riper 2017). These may be due to ecological differences between riparian and non-riparian species, habitat preference, and species adaptability. Additional analyses that include habitat covariates may provide some insight into differences among species, years, and treatments. As native shrub cover regenerates, we expect to see increases in the abundance of shrub-dwelling species, such as Spotted Towhee and Common Yellowthroat, in areas where tamarisk removal has occurred. It will take several years of monitoring, however, to truly determine the effects of restoration in the Dolores River system and show meaningful differences between active and passive revegetation areas.

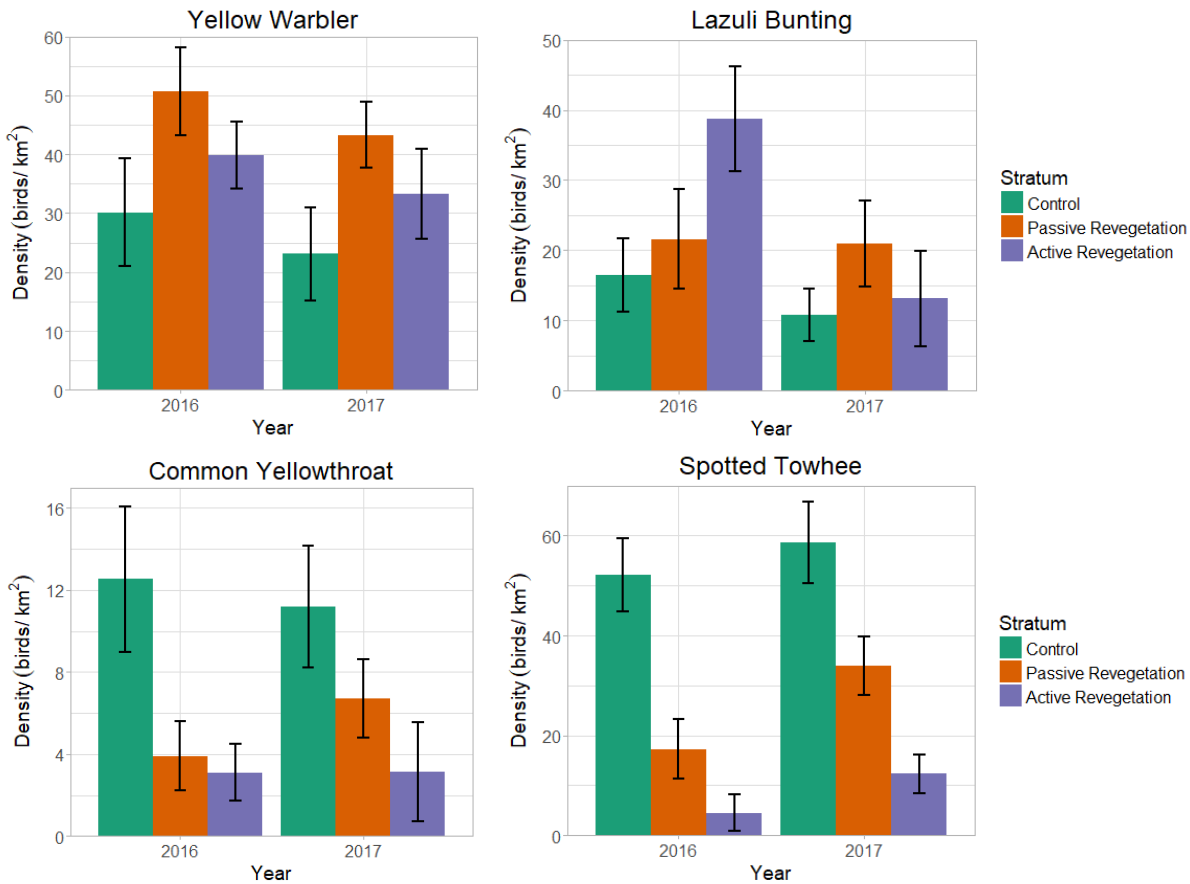

Figure 4. Density (birds/km², ± SE) of four frequently detected species in three strata along the Dolores River from 2016-2017.

Advantages of Collaboration with the IMBCR Program

Auxiliary, or "overlay", projects are a growing component of the IMBCR program that improve efficiency and can be tailored to address specific management questions. These projects utilize the IMBCR sampling design and field methods but are not integrated into the nested stratification of the IMBCR program. These projects benefit from the IMBCR program by incorporating detection data from relevant IMBCR surveys in their analyses. Leveraging IMBCR data in analyses improves the number of species for which results can be obtained and the precision of the resulting estimates. If this were a stand-alone project, we would have only been able to estimate densities for 12 species rather than 63, since at least 80 detections are generally needed to perform distance analysis. Utilizing the IMBCR design also allows the resulting population estimates to be placed in a regional context. In this way, the collaborative efficiency of the IMBCR program is extended to auxiliary projects by improving the accuracy and precision of population estimates for infrequently detected species as well as allowing those estimates to be compared to larger, geographic regions. In a similar fashion, data collected as part of auxiliary projects contribute to the efficiency of the IMBCR program by increasing the overall size of the bird detection data set.

Future Opportunities and Recommendations

One of the strengths of the IMBCR program is that local stratum-level estimates can be compared to state and regional estimates to determine whether local populations are above or below estimates for the region. Although IMBCR does not employ habitat stratification, the regional monitoring data can be post-stratified for riparian habitats to estimate riparian-specific bird population density and occupancy rates and compared to the estimates obtained in this study. In addition, adding habitat covariates, such as the percentage tamarisk or native shrub cover, to model bird-habitat relationships among treatment strata would strengthen our understanding of the occupancy and density patterns that we see. This would allow the DRRP to adjust their treatment options to achieve desired management outcomes.

Continued monitoring of bird populations in the Dolores River corridor will enable us to better understand bird responses to treatments as these areas change over time. First, several years of monitoring are necessary to obtain trends in density and occupancy. Secondly, using IMBCR protocols and analyses techniques, annual estimates of density and occupancy can be compared over time to determine if population changes are a result of population change and/or range expansion or contraction. For example, if population densities of a species declined over time, but the occupancy rates remained constant, then the population change was driven by declines in local abundance. In contrast, if both density and occupancy rates of a species declined, then population change was the result of range contraction or shift. DRRP can use these comparisons to help determine whether changes are due to local management actions or larger regional trends.

It is critical that we continue to monitor restoration areas with ongoing spot treatment and maintenance actions to preserve the integrity of this project in future years. We hope to continue to provide the Dolores River Restoration Partnership with a statistically robust, long-term avian dataset to help fulfill the monitoring needs of the partnership and inform further management efforts on the Dolores River.

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Appendix: Raw Species Counts

Table 3. The number of individuals detected by species within three strata along the Dolores River in 2017. Active revegetation areas are labeled as "Active", passive revegetation areas are labeled as "Passive", and areas with no restoration activity are labeled as "Control". Priority species from the Colorado State Wildlife Action Plan are highlighted in bold.

Common Name	Control	Passive	Active	Total
American Goldfinch	0	7	4	11
American Kestrel	5	1	0	6
American Robin	1	16	0	17
Ash-throated Flycatcher	17	25	19	61
Barn Swallow	0	0	2	2
Belted Kingfisher	0	0	1	1
Bewick's Wren	7	1	0	8
Black-billed Magpie	25	0	0	25
Black-chinned Hummingbird	0	1	1	2
Black-headed Grosbeak	6	27	5	38
Black-throated Gray Warbler	1	9	1	11
Black-throated Sparrow	6	6	5	17
Blue Grosbeak	3	11	7	21
Blue-gray Gnatcatcher	40	50	18	108
Brewer's Blackbird	1	0	0	1
Brewer's Sparrow	2	0	0	2
Broad-tailed Hummingbird	0	1	0	1
Brown-headed Cowbird	25	2	0	27
Bullock's Oriole	0	9	0	9
Canada Goose	0	20	0	20
Canyon Wren	9	9	3	21
Chipping Sparrow	14	0	0	14
Cliff Swallow	1	0	0	1
Common Raven	40	34	20	94
Common Yellowthroat	25	19	5	49
Eurasian Collared-Dove	9	7	0	16
European Starling	25	12	0	37
Gray Catbird	0	3	0	3
Gray Flycatcher	0	1	0	1
Gray Vireo	4	9	4	17
Great Blue Heron	0	0	1	1
Hairy Woodpecker	0	1	0	1
House Finch	13	32	18	63
House Sparrow	0	3	0	3
House Wren	0	0	1	1
Indigo Bunting	2	0	0	2
Lark Sparrow	24	14	13	51
Lazuli Bunting	21	46	23	90
Lesser Goldfinch	3	6	0	9
Mountain Bluebird	0	1	0	1

Common Name	Control	Passive	Active	Total
Mourning Dove	11	10	2	23
Northern Flicker	9	3	3	15
Northern Mockingbird	0	0	1	1
Pinyon Jay	0	0	2	2
Plumbeous Vireo	6	6	0	12
Red-winged Blackbird	8	6	0	14
Ring-necked Pheasant	39	6	0	45
Rock Wren	8	8	1	17
Savannah Sparrow	20	0	0	20
Say's Phoebe	2	9	5	16
Song Sparrow	8	2	1	11
Spotted Sandpiper	1	1	7	9
Spotted Towhee	111	77	18	206
Vesper Sparrow	2	0	0	2
Virginia's Warbler	2	2	4	8
Warbling Vireo	0	1	2	3
Western Kingbird	5	6	9	20
Western Meadowlark	54	18	0	72
Western Tanager	0	5	1	6
Western Wood-Pewee	0	2	0	2
White-throated Swift	29	19	0	48
Willow Flycatcher	0	8	0	8
Wilson's Snipe	2	0	0	2
Woodhouse's Scrub-Jay	3	3	3	9
Yellow Warbler	39	82	34	155
Yellow-breasted Chat	104	148	100	352