BIRD SPECIES AND DENSITIES IN RELATION TO FUEL REMOVAL TREATMENTS

Final Report to
Joint Fire Sciences Program
(also submitted to Middle Rio Grande Bosque Initiative, Middle Rio Grande Conservancy District, and other cooperators)

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INTRODUCTION

The objective of the ornithological component of this bosque fuel removal project is to determine the effects of invasive plant removal treatments (i.e., fuel treatments) on species richness and relative abundance of birds. Our twelve study sites are located in mature cottonwood forests along the Middle Rio Grande. Each site initially had high fuel loads comprised of high densities of Tamarisk (*Tamarix ramosissima),* Russian olive (*Elaeagnus angustifolia*), other exotic woody plants, and dead and down wood and debris. Sites with high invasive plant densities were designated as high risk locations for wildfire. We focus on birds, particularly in relation to four nesting guilds, because they are a highly visible and recreational taxonomic group in the Southwest whose local presence and distribution in the bosque may be influenced by retention or clearing of shrubs, small trees and dead wood. From these findings, we will develop recommendations to mitigate the impacts of exotic plant control on bird communities.

Numerous Neotropical migratory bird species are ranked as management priorities by Partners in Flight (PIF), a national consortium of government and private groups that supports bird conservation. New Mexico PIF identifies restoration and protection of riparian habitats as an essential step in conserving Neotropical migrants, several species' populations of which are reported by Breeding Bird Surveys to be declining. Mid-story and canopy-nesting Neotropical migrants that could be affected by habitat disturbances such as catastrophic fire or restoration by removal of mid-story plants include the Yellow-billed Cuckoo (see Appendix for scientific names of bird species), a bird species repeatedly petitioned by environmental groups to be federally-listed as Threatened or Endangered (see *positive finding to list,* 1999 Federal Register). Short-distance migrants such as Spotted Towhee may also respond numerically to treatments that remove midstory or ground layer habitat structure. Some Neotropical migrants that nest in shrubs and small trees could be potentially affected by removal of exotic plants or downed wood. These include such species as Mourning Dove, Black-chinned Hummingbird, Black-headed Grosbeak, Yellow-breasted Chat, Lucy's Warbler, Blue Grosbeak, and the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*).

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Removal of standing snags and mature exotic woody plants could conceivably have either positive or negative effects on canopy-nesting and canopy-foraging migrants such as Summer Tanager and Western Wood Pewee by opening the canopy and removing perch sites. Such treatments may also alter quantity and composition of food supplies (e.g., foliage arthropods, bark beetles), but without research, it is impossible to know whether consequences for birds would be positive or negative. Removal of dead wood, especially standing snags, to reduce fuels may eliminate critical nest sites and foraging substrates for cavity-nesting birds such as woodpeckers, Bewick's Wren, Ash-throated Flycatcher, and Violet-green Swallow. Aerial foraging cavity-nesting species may also benefit, however, from reduced clutter in their foraging space.

METHODS

Breeding Bird Point Counts

At each study site, we established generally eight point count stations along a north to south gradient based on global positioning system (GPS) coordinates. Only two sites do not have the standard number of point count stations; North 3 (7) and South 2 (5). All stations were positioned 150 meters apart and the majority are 75 meters from boundary edges. There is one point count station per 2.5 hectares.

Generally, our point count methods follow Bibby and others (1992). All points are sampled an average of five times per season, with each transect surveyed in a north-south direction, alternating direction each session. A round of counts for all sites were completed before beginning a new session. Point counts were performed every other week during each breeding season (05 May to 25 July, approximately). During each count, the observer at each point recorded all birds seen or heard for 8 minutes. Detection mode (heard, seen), sex, relative age of bird, and distance from point (m) were also recorded. Each transect was surveyed by 3-5 different individuals over the course of each of each season to standardize observer bias (Verner 1985). We used program DISTANCE to convert number of point count detections to density estimates (number of birds per hectare) (Buckland et al. 2001). Because the majority of detections were of singing males, we assume that densities estimated by DISTANCE are an underestimate of the true (unknown) densities but are comparable across time and space.

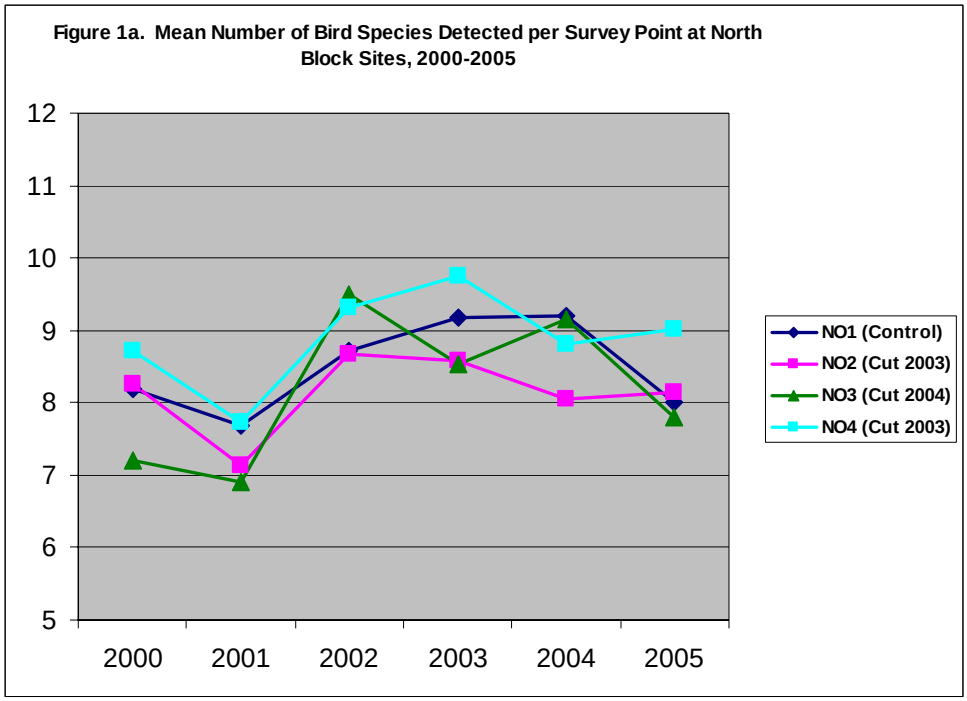
We used General Linear Mixed Model (GLMM) Analysis with Repeated Measures to determine effects and interactions of treatment type ("Trt": control versus treatment) and phase of study ("Period": pre-treatment versus post-treatment phases) on mean number of bird species and number of birds per species or per nesting guild. For the purposes of this report, we pooled sites with different treatments (mechanical removal with garlon herbicide application (MRHA), MRHA followed by fire, and MRHA followed by revegetation) into one category referred to as "treatment". The pre-treatment phase was defined as as a 3-year period consisting of years 2000, 2001, and 2002, and the post-treatment phase was defined as a 2-year period comprised of years 2004 and 2005. Data from 2003 were excluded because treatments were conducted in this year. Some data from the Middle Block of sites were also excluded because of treatments. Because two more years of post-treatment monitoring are planned, we used a $P \leq 0.10$ rather than the traditional $P \leq 0.05$ to detect treatment effects (i.e., interactions of Trt x Period) for individual species.

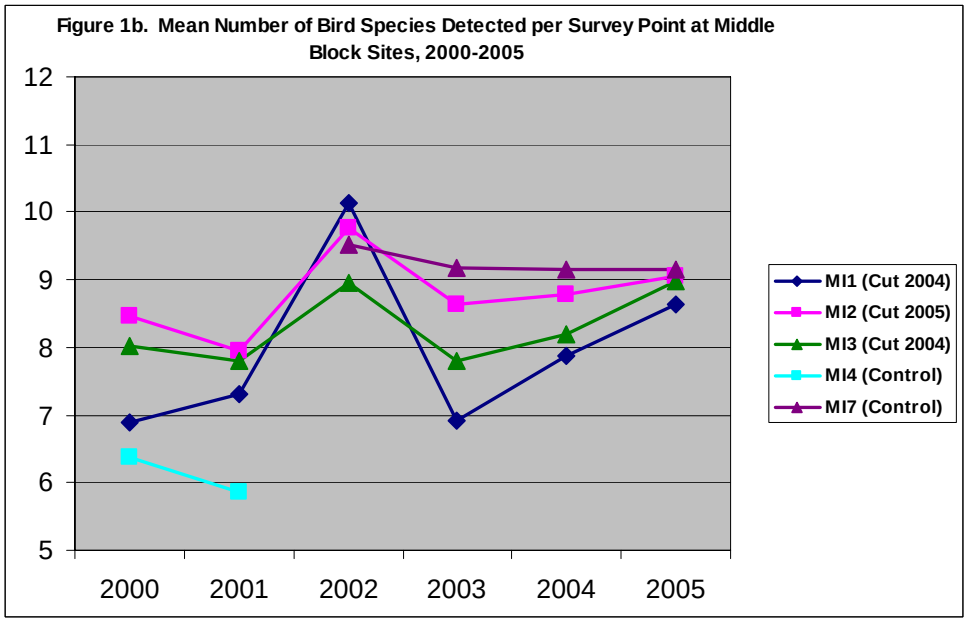
RESULTS

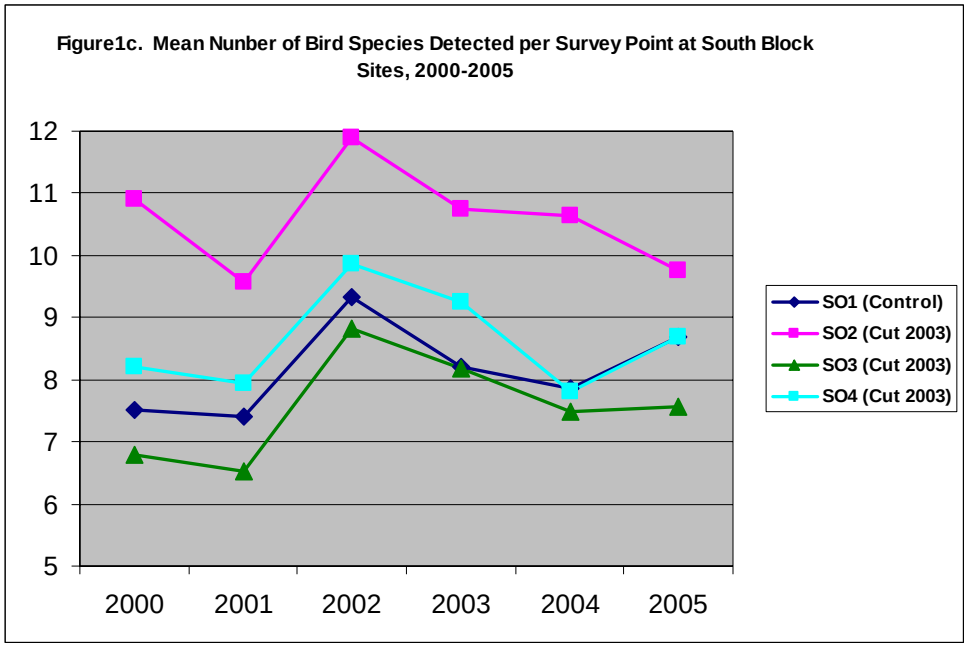
Mean Number of Bird Species

The total number of bird species detected during point counts over the duration of the study was 132. Mean number of bird speces/point (Figure 1a, b, c.) fluctuated between 2001 to 2005. Results of GLMM-Repeated Measures Analysis revealed that number of species/point, when pooled by treatment type (Trt: control versus treatment) and Period (pre- and post-treatment) did not significantly differ between treatment and control sites ($F = 0.55$, $P = 0.4870$) and between pre- and post-treatment periods ($F = 0.73$ and $P = 0.4246$). The interaction between Trt and

Period was also non-significant ($F = 0.08$, $P = 0.7813$), signifying that mean number of species detected at point count stations did not change in response to removal of fuels and invasive plants.







Annual Bird Densities by Guild.

Species Classifications by Guild

Removal of invasive plants and woody debris has the potential to change availability of nest substrates and nesting habitat. Bird species that select specific nest substrates may be positively or negatively affected by alteration of specific habitat layers. We classified annual densities of bird species into four general nesting guilds: Ground Shrub, Mid-Story, Canopy, and Cavity (Table 2) and used GLMM Repeated Measures Analysis to detect potential guild responses to treatment. We truncated point count distances at 100 m to exclude species heard or seen off sites (e.g, in adjacent fields) or observed flying over without stopping. Because 2003 was a treatment year, data from this year were not included in analyses. Middle block was still under treatment in 2004, so this block was excluded from 2004 data.

Table 2. Classification of Common Bird Species by Guild.

Ground Shrub	Mid-Story	Canopy	Cavity
Mallard	Mourning Dove	Cooper's Hawk	American Kestrel
Ring-necked Pheasant	Black-chinned Hummingbird	Swainson's Hawk	Ladder-backed Woodpecker
Wild Turkey	Black-billed Magpie	Great Horned Owl	Downy Woodpecker
Gambel's Quail	American Robin	Western Wood-Pewee	Hairy Woodpecker
Killdeer	Phainopepla	Western Kingbird	Northern Flicker

Yellow-billed Cuckoo	Black-headed Grosbeak	American Crow	Ash-throated Flycatcher
Greater Roadrunner	Lesser Goldfinch	Common Raven	Black-capped Chickadee
Verdin		Bushtit	White-breasted Nuthatch
Gray Catbird		Summer Tanager	Bewick's Wren
Yellow-breasted Chat		Bullock's Oriole	European Starling
Spotted Towhee		House Finch	Lucy's Warbler
Blue Grosbeak			
Lazuli Bunting			
Indigo Bunting			

Ground-Shrub Species

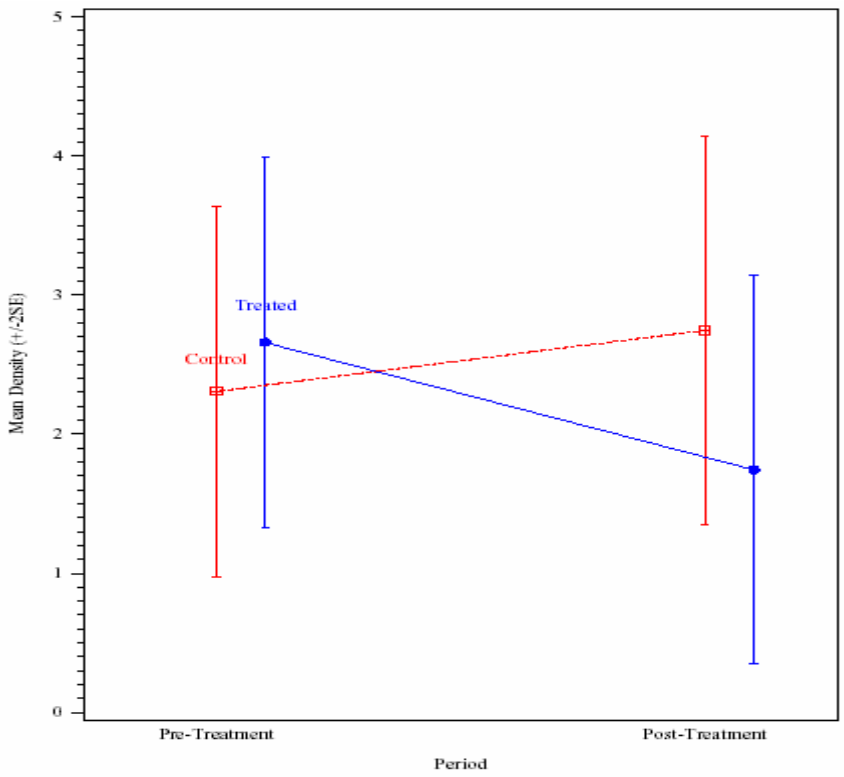
Results of GLMM-Repeated Measures Analysis for ground-shrub nesting species indicate annual bird densities/HA did not significantly differ between treatment and control sites and between pre- and post-treatment periods (Table 4). The interaction between Trt and Period was also non-significant, meaning that abundances of ground-shrub birds did not change over time or between control versus treated sites. This lack of interaction suggests that ground-shrub bird densities were not affected by removal of invasive plants/fuels, at least in the short term (but Figure 1 suggests trends that could become significant if continued into the future). This lack of effect is contrary to what we had predicted (Finch et al. 2005). We had expected populations of ground- and shrub-nesting birds to decrease in response to removal of exotic vegetation and woody debris in the low shrub layer. Over the long term or with additional post-treatment years, effects on population trends for species nesting in this layer may become more visible.

Table 3. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for ground-shrub nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	0.23	0.6502
Period	1	6	0.12	0.7389
Trt*Period	1	6	0.99	0.3591

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	2.7464	0.6968	6	3.94	0.0076
Trt*Period	Control	Pre-Trt	2.3073	0.6648	6	3.47	0.0133
Trt*Period	Treated	Post-Trt	1.7448	0.6968	6	2.50	0.0463
Trt*Period	Treated	Pre-Trt	2.6602	0.6648	6	4.00	0.0071

Figure 1. Breeding densities (#birds/HA) of ground-shrub nesters at pooled control and treatment sites during pre- and post-treatment periods.



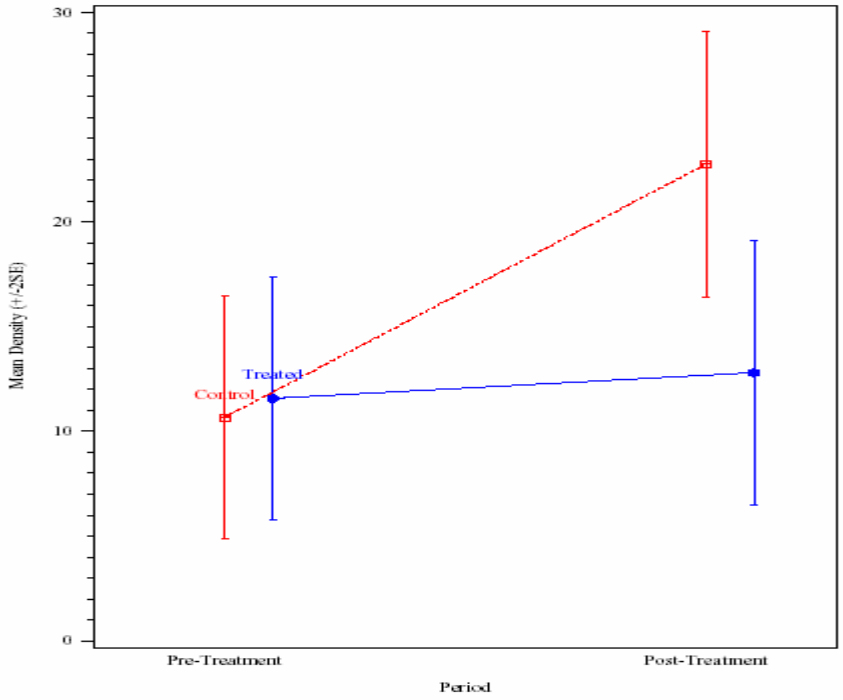
Results of GLMM-Repeated Measures Analysis for mid-story species indicate annual bird densities differed between treatment and control sites (i.e., significant Trt effect) and between pre- and post-treatment phases (i.e., significant Period effect) (Table 3a). The interaction between Trt and Period was also significant, meaning that mid-story bird abundance changed over time but the extent or direction of this change was different at control versus treated sites (Table 3b). This interaction indicates that mid-story bird densities were affected by removal of invasive plants/fuels. Annual densities of mid-story birds on control sites increased substantially in 2004-2005 but this increasing trend was suppressed on treated sites during this post-treatment period (Figure 2). Thus, our analyses suggest that removal of exotic trees and woody fuels suppressed the local abundances of mid-story species.

Tables 4. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for the mid-story nest guild comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	8.74	0.0254
Period	1	6	16.90	0.0063
Trt*Period	1	6	11.65	0.0143

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	22.7619	3.1703	6	7.18	0.0004
Trt*Period	Control	Pre-Trt	10.6636	2.8902	6	3.69	0.0102
Trt*Period	Treated	Post-Trt	12.7992	3.1703	6	4.04	0.0068
Trt*Period	Treated	Pre-Trt	11.5759	2.8902	6	4.01	0.0071

Figure 2. Breeding bird densities (# birds/HA) of mid-story species at pooled control and treatment sites during pre- and post-treatment periods.



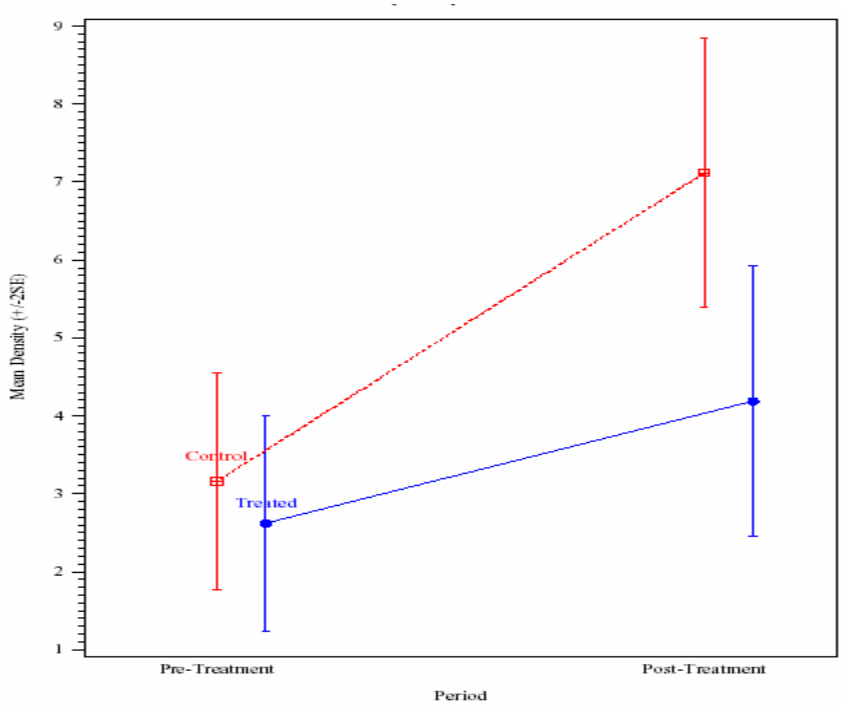
Results of GLMM-Repeated Measures Analysis for cavity-nesting species indicate annual bird densities were almost significantly different between treatment and control sites (i.e., Trt Effect: $0.10 < P > 0.05$) and were significantly different between pre- and post-treatment phases (i.e., significant Period effect) (Table 5). The interaction between Trt and Period, however, was not significant, meaning that densities of cavity nesters changed over time but the extent and direction of this change was similar at control versus treated sites. This lack of interaction suggests that densities of cavity nesters were not immediately affected by removal of invasive plants in the understory. Annual densities of cavity-nesters on both control and treated sites increased substantially from the 2000-2002 period to the 2004-2005 period (Figure 3). Thus, our analyses suggest that overall densities of the cavity-nesting group increased over the duration of the study, but this increase was probably not in response to the removal of exotic trees and fuel loads. In other words, cavity-nesters were not noticeably benefited by exotic tree removal at least in the short term. Also, the exotic woody species present on our study sites have stems with diameters too small for cavities, and therefore, nest site availability for cavity-nesters may not be detrimentally reduced by exotic tree removal. In the long term, cavity nesters may benefit from exotic tree removal if competition between exotics and native cavity trees is reduced such that that cavity trees are preserved and sustained.

Table 5. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for cavity nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	5.03	0.0662
Period	1	6	12.09	0.0132
Trt*Period	1	6	2.26	0.1837

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	7.1156	0.8648	6	8.23	0.0002
Trt*Period	Control	Pre-Trt	3.1599	0.6947	6	4.55	0.0039
Trt*Period	Treated	Post-Trt	4.1864	0.8648	6	4.84	0.0029
Trt*Period	Treated	Pre-Trt	2.6176	0.6947	6	3.77	0.0093

Figure 3. Breeding densities (# birds/HA) of cavity-nesters at pooled control and treatment sites during pre- and post-treatment periods.



Results of GLMM-Repeated Measures Analysis for canopy-nesting species indicate annual bird densities did not significantly differ between treatment and control sites and between pre- and

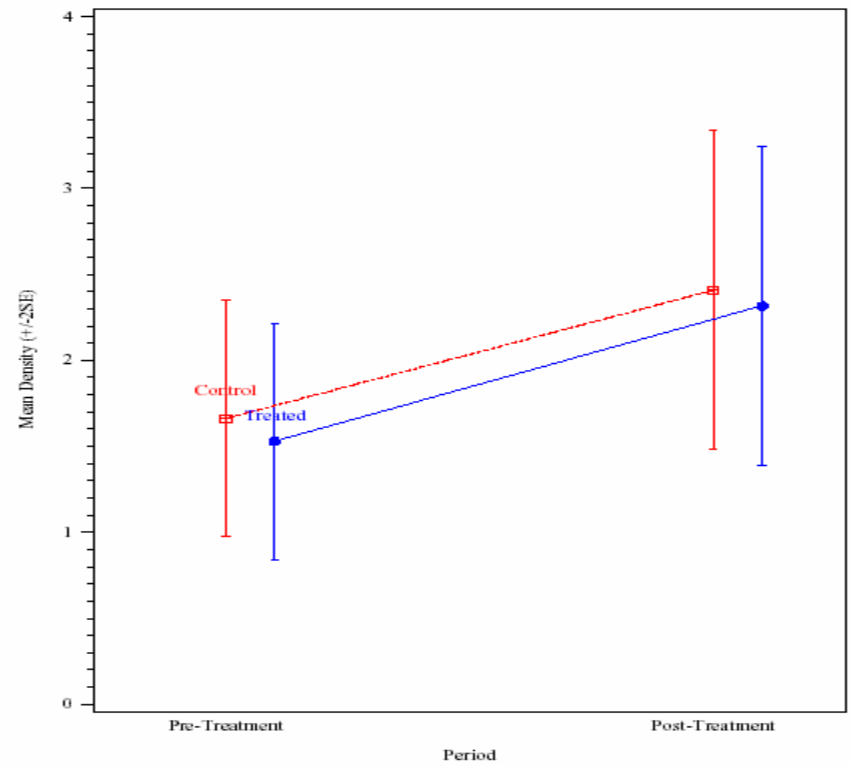
post-treatment periods (Table 6). The interaction between Trt and Period was also non-significant, meaning that overall abundances of canopy birds did not greatly change over time or between control versus treated sites. This lack of interaction indicates that canopy bird densities were not apparently affected by removal of invasive plants/fuels, at least in the short term. This lack of effect is contrary to what we had predicted (Finch et al. 2005). We had expected populations of canopy-nesting birds to respond positively (e.g., like bat activity) to reductions in "clutter" from removal of exotic vegetation and woody debris. There was a tendency toward increasing populations over time (Figure 4), and over the long term, interactions between effects of time and treatment may become more apparent for this guild.

Table 6. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for canopy nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	0.08	0.7912
Period	1	6	3.51	0.1100
Trt*Period	1	6	0.00	0.9616

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	2.4083	0.4636	6	5.19	0.0020
Trt*Period	Control	Pre-Trt	1.6617	0.3437	6	4.83	0.0029
Trt*Period	Treated	Post-Trt	2.3162	0.4636	6	5.00	0.0025
Trt*Period	Treated	Pre-Trt	1.5285	0.3437	6	4.45	0.0043

Figure 4. Breeding densities (# birds/HA) of canopy-nesters at pooled control and treatment sites during pre- and post-treatment periods.



Variation in Pooled Densities of Individual Species

Black-chinned Hummingbird was consistently the most abundant species observed each year. Other common species detected each year during point count surveys are listed in Table 7. A full list of all species detected over the duration of the study is provided in the Appendix.

We selected 13 species to conduct in-depth analyses of density estimates over time (pre- and post-treatment), space (block), and treatment type (Trt: Control, Treated). To convert point count detections to density estimates using Program DISTANCE, we first pooled count data across sites and years to produce densities by block, treatment type and period (Table 7). We refer to these estimates as "pooled densities" to distinguish them from later analyses of "annual densities". We were able to evaluate more species using pooled densities than annual densities because sample sizes did not constrain tests. With the exception of Spotted Towhee,

Table 7. Density estimates (birds/HA) ±SE of 13 bird species at control and treated sites in North, Middle, and South blocks during the pre- and post-treatment periods.

Key: DENS. = Density. SE= Standard Error. *=sample size too small for analysis.**

Species	Trt	North Pre DENS.	SE	North Post DENS.	SE	Middle Pre DENS.	SE	Middle Post DENS.	SE	South Pre DENS.	SE	South Post DENS.	SE
Spotted Towhee	**Treated**	1.778	0.203	0.725	0.075	1.133	0.101	0.340	0.071	1.770	0.170	0.871	0.103
	Control	1.050	0.134	1.169	0.209	1.349	0.188	1.529	0.189	0.996	0.175	0.454	0.095
Yellow-Breasted Chat	**Treated**	0.228	0.039	0.103	0.037	0.207	0.033	0.098	0.021	0.650	0.090	0.428	0.078
	Control	0.131	0.030	0.246	0.057	0.043	0.016	0.121	0.052	0.283	0.050	0.132	0.049
Bewick's Wren	**Treated**	1.095	0.070	0.801	0.090	0.506	0.058	0.191	0.024	1.170	0.145	1.041	0.123
	Control	1.541	0.342	2.625	0.402	1.386	0.204	1.405	0.304	0.697	0.144	0.708	0.125
Blue Grosbeak	**Treated**	0.357	0.074	0.212	0.037	0.403	0.056	0.466	0.087	0.475	0.050	0.679	0.084
	Control	0.315	0.072	0.379	0.104	0.468	0.189	1.159	0.472	1.109	0.124	0.969	0.169
Black-Headed Grosbeak	**Treated**	1.332	0.066	1.446	0.167	1.041	0.077	0.547	0.070	0.706	0.066	0.605	0.078
	Control	0.852	0.106	1.341	0.163	1.228	0.131	2.140	0.447	1.719	0.148	0.986	0.135
Black-Chinned Hummingbird	**Treated**	15.079	0.796	14.349	0.912	12.978	0.754	11.868	1.152	3.733	0.634	6.577	1.407
	Control	11.510	1.119	28.888	3.285	17.433	1.307	19.034	1.941	6.396	0.502	9.590	1.620
Ash-throated Flycatcher	**Treated**	0.305	0.047	0.599	0.074	0.934	0.172	1.480	0.172	0.974	0.104	1.612	0.137
	Control	0.335	0.270	0.657	0.421	1.557	0.348	2.617	0.617	1.770	0.270	2.293	0.421
Black-capped Chickadee	**Treated**	0.450	0.095	0.602	0.132	0.741	0.099	0.234	0.065	***	***	***	***
	Control	1.076	0.224	1.269	0.290	0.507	0.148	0.525	0.174	***	***	***	***
Brown-Headed Cowbird	**Treated**	0.409	0.062	0.287	0.042	0.653	0.071	0.711	0.131	1.244	0.150	0.561	0.083
	Control	0.325	0.079	0.352	0.085	0.891	0.196	1.268	0.272	1.711	0.257	1.364	0.264
Mourning Dove	**Treated**	0.315	0.039	0.401	0.067	0.330	0.039	0.434	0.064	0.514	0.044	0.613	0.041
	Control	0.212	0.057	0.168	0.053	0.862	0.124	1.240	0.261	0.544	0.100	2.073	0.385
Summer Tanager	**Treated**	0.480	0.051	0.963	0.129	0.449	0.053	0.651	0.095	0.796	0.087	1.117	0.195
	Control	0.417	0.086	0.905	0.177	0.884	0.196	1.498	0.358	0.624	0.106	0.489	0.092
White-breasted Nuthatch	**Treated**	0.330	0.056	0.636	0.058	0.348	0.063	0.431	0.061	0.143	0.045	0.297	0.056
	Control	0.770	0.199	1.541	0.401	0.512	0.080	0.886	0.188	0.096	0.026	0.263	0.083
Western Wood-Pewee	**Treated**	0.310	0.055	0.612	0.089	0.136	0.039	0.311	0.065	0.172	0.035	0.070	0.013
	Control	0.145	0.039	0.121	0.042	0.145	0.054	***	***	0.583	0.136	0.143	0.049

truncating detection distances did not result in substantial changes in analytical results of individual species so we used all observations to estimate pooled densities.

Pooled densities of only one species, Ash-throated Flycatcher, differed between treatment and control sites ($P < 0.0213$) and between pre- and post-treatment periods ($P < 0.0199$) but Trt x Period interactions were not significant. Pooled flycatcher densities demonstrated parallel increases on treatments over time, suggesting that they responded positively to unidentified factors (e.g., food supply, winter habitat quality) which varied similarly over time, either at both control and treated sites or perhaps at wintering sites.

At $P < .10$, pooled densities of Spotted Towhee differed between pre- and post-treatment periods ($P < 0.0586$), and significant interactions between Trt and Period ($P < 0.0988$) suggested that towhees decreased after treatment on treated sites but increased on control sites during the same period. These effects were more marked (Trt x Period: $P < 0.025$) when truncated count distances were used to estimate towhee densities. These results suggest that towhee densities were negatively affected by removal of invasives and fuel loads. Density increases at control sites suggest that towhees may have emigrated from treated areas (not just our sites) in 2004-2005 in search of denser, uncleared understories.

Pooled Brown-headed Cowbird and White-breasted Nuthatch densities showed Period effects (at $P < 0.10$), but interactions with Trt were absent, suggesting that removal of invasive trees did not explain temporal density changes in the short term. Species exhibiting Trt effects (at $P < 0.10$) were Black-chinned Hummingbird, White-breasted Nuthatch, and Blue Grosbeak, but interactions with Period were not significant. This means that pooled densities of these species differed at control and treatment sites in the pre-treatment period as well as in the post-treatment period and were likely not influenced by clearing of invasive fuels in either period (but see tests of annual hummingbird densities).

Variation in Annual Densities of Individual Species

We selected a subset of six species with sufficient detections in each year (2000, 2001, 2002, 2004, 2005) of each block to conduct GLMM Repeated Measures Analysis of "annual densities" sorting by Trt, Block, Period, and Year. Comparing annual densities may reveal trends that were masked by pooling densities. Data from 2003 were excluded because this was a treatment year and data from middle block 2004 were excluded because of differences in site within block treatment times. These common species were Black-chinned Hummingbird, Mourning Dove, Ash-throated Flycatcher, Bewick's Wren, Black-headed Grosbeak, and Spotted Towhee. Individuals of these species were usually detected within 100 m of the count station rather than flying overhead or heard or seen off the site, and therefore we did not deem it necessary to truncate detection distances when converting count data to densities.

We used $P \leq 0.10$ to detect effects of treatments, time, and interactions between time and treatments on bird abundances. A generous Type I error level was applied with the intent to reduce the likelihood of failing to detect differences in annual densities. We believe this is wise

at this stage, given that three years of post-treatment data are not yet available for use in detecting differences and therefore, we consider our analyses preliminary.

Results of GLMM-Repeated Measures Analysis indicate annual bird densities differed between treatment and control sites (i.e., significant Trt effect) for only 1 of the 6 tested species, Black-headed Grosbeak (Table 8). Annual bird densities varied between pre- and post-treatment phases (i.e., significant Period effect) for 3 species, Ash-throated Flycatcher, Mourning Dove, and Black-chinned Hummingbird. The interaction between Trt and Period was significant for annual densities of 4 of 6 species, Mourning Dove, Black-chinned Hummingbird, Spotted Towhee, and Black-headed Grosbeak, meaning that bird yearly abundances changed between pre- and post-treatment periods but the extent or direction of this change was different at control versus treated sites. Three of the species, Black-chinned Hummingbird, Mourning Dove, and Black-headed Grosbeak, are mid-story nesters, and the fourth species, Spotted Towhee, is a ground-shrub nester. These interaction effects suggest that densities of species that typically use the lower two-thirds of the vertical habitat space were affected by removal of invasive plants/fuels. This is consistent with results of GLMM analysis of mid-story guild densities. Annual densities of all four species on control sites increased substantially from the pre-treatment period to the post-treatment period but this trend was dampened or reversed on treated sites. Thus, our analyses suggest that removal of exotic trees and woody fuels suppressed the local abundances of selected species.

Table 8. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for selected species comparing fixed effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site). Detection distances were not truncated. P < 0.10 are highlighted in red.

Species	Trt		Period		Trt x Period	
	F value	*P*	*F value*	*P*	*F value*	*P*
Ash-throated Flycatcher	2.44	0.169	19.61	0.004	0.53	0.495
Bewick's Wren	2.19	0.190	0.37	0.567	1.80	0.228
Mourning Dove	2.34	0.180	3.79	0.099	3.91	0.095
Black-chinned Hummingbird	2.03	0.204	4.90	0.069	4.49	0.078
Spotted Towhee	0.04	0.576	1.02	0.352	5.32	0.061
Black-headed Grosbeak	7.21	0.036	1.84	0.224	4.37	0.082

CONCLUSION

Mean number of bird species per point did not appear to change in response to removal of invasives and fuels, suggesting that the contribution of bird species richness to the biological diversity of this system was not substantially altered by treatment. However, bird densities of the mid-story nest guild showed declining trends. Bird densities of the ground-shrub, cavity and canopy guilds were not affected by treatments. In evaluations of individual bird species, we found that annual densities of three mid-story species, Mourning Dove, Black-chinned Hummingbird and Black-headed Grosbeak, and one ground-shrub species, Spotted Towhee were reduced in response to treatment effects. Tamarisk and Russian olive are small trees that

dominate the mid-story biomass of our study sites. Removal of these two invasive plant species reduces the availability of nesting and foraging substrates for bird species that use the mid-story layer of habitat. Therefore, effects on bird species using this layer are predictable. Based on the mid-story guild response, we speculate that populations of rarer mid-story species such as Yellow-billed Cuckoo and Southwestern Willow Flycatcher will respond similarly and negatively to removal of invasive woody plants in riparian woodlands of the Southwest.

Overall bird densities of the cavity-nesting guild increased over time at both control and treated sites. A cavity-nesting species, Ash-throated Flycatcher, substantially increased in the period following treatments. While the flycatcher increase was not directly explained by removal of invasives, it can also be said that this treatment was not harmful to this species. Reduced vegetation clutter in the mid-story and canopy layers following treatment may actually improve foraging navigability for this flycatcher species.

We regard these results as preliminary. Two more years of post-treatment sampling are scheduled. We view the data from these additional sampling years as essential for determining treatment effects. For the purposes of this final report, however, we suggest a few recommendations.

1. To retain the full diversity of a wide range of bird species and to reduce effects on sensitive and endangered species, we recommend replanting of native woody plants at treated sites after removal of woody species such as Tamarisk and Russian olive.
2. We do not recommend removal of invasives at sites occupied by sensitive or endangered bird species except as identified in recovery plans.
3. Where removal of invasives is necessitated to reduce fire risk, we suggest that treatments be staged over a period of years and in small patches to allow birds to adapt to habitat changes over time.
4. Treatments should be scheduled during the non-breeding season of birds whenever possible. Birds are disturbed by noise and can vacate nests and territories in response to disturbance during the breeding season.
5. Prior to treatments, surveys should be conducted for threatened and endangered bird species, and decisions to treat sites should be adjusted according to survey results.
6. If sites are at risk of wildfire, select and restore sites with high fuel loads and in close proximity to urban areas first.

Our results and recommendations apply to sites with cottonwood overstories and are not intended to guide decision-making for sites having monotypic stands of invasives.

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APPENDIX

Birds Detected on Point Count Surveys, 2000-2005

Common Name	Scientific Name
Waterfowl	**Anatidae**
Canada Goose	Branta canadensis
Wood Duck	Aix sponsa
Gadwall	Anas strepera
Mallard	Anas platyrhynchos
Northern Shoveler	Anas clypeata
Northern Pintail	Anas acuta
Green-winged Teal	Anas crecca
Pheasant and Turkey	**Phasianidae**
Ring-necked Pheasant	Phasianus colchicus
Wild Turkey	Meleagris gallopavo
Quail	**Odontophoridae**
Gambel's Quail	Callipepla gambelii
Grebes	**Podicipedidae**
Pied-billed Grebe	Podilymbus podiceps
Pelicans	**Pelecanidae**
American White Pelican	Pelecanus erythrorhynchos
Cormorants	**Phalacrocoracidae**
Neotropic Cormorant	Phalacrocorax brasilianus
Double-crested Cormorant	Phalacrocorax auritus
Herons and Egrets	**Ardeidae**
Great Blue Heron	Ardea herodias

Great Egret	Ardea alba
Snowy Egret	Egretta thula
Cattle Egret	Bubulcus ibis
Green Heron	Butorides virescens
Black-crowned Night-Heron	Nycticorax nycticorax
Ibises	**Threskiornithidae**
White-faced Ibis	Plegadis chihi
Vultures	**Cathartidae**
Turkey Vulture	Cathartes aura
Osprey, Kites and Hawks	**Accipitridae**
Osprey	Pandion haliaetus
Mississippi Kite	Ictinia mississippiensis
Cooper's Hawk	Accipiter cooperii
Swainson's Hawk	Buteo swainsonii
Red-tailed Hawk	Buteo jamaicensis
Ferruginous Hawk	Buteo regalis
Falcons	**Falconidae**
American Kestrel	Falco sparverius
Rails and Coots	**Rallidae**
Common Moorhen	Gallinula chloropus
American Coot	Fulica americana
Virginia Rail	Rallus limicola
Plovers	**Charadriidae**
Killdeer	Charadrius vociferus
Stilt and Avocet	**Recurvirostridae**
Black-necked Stilt	Himantopus mexicanus
American Avocet	Recurvirostra americana
Sandpipers	**Scolopacidae**
Greater Yellowlegs	Tringa melanoleuca
Spotted Sandpiper	Actitis macularius
Long-billed Curlew	Numenius americanus
Wilson's Snipe	Gallinago delicata
Gulls	**Laridae**
Ring-billed Gull	Larus delawarensis
Pigeons and Doves	**Columbidae**
Rock Pigeon	Columba livia
White-winged Dove	Zenaida asiatica
Mourning Dove	Zenaida macroura
Cuckoos and Roadrunner	**Cuculidae**
Yellow-billed Cuckoo	Coccyzus americanus
Greater Roadrunner	Geococcyx californicus
Typical Owls	**Strigidae**
Western Screech-Owl	Megascops kennicotti
Great Horned Owl	Bubo virginianus
Nightjars	**Caprimulgidae**
Lesser Nighthawk	Chordeiles acutipennis
Common Nighthawk	Chordeiles minor
Hummingbirds	**Trochilidae**
Black-chinned Hummingbird	Archilochus alexandrinus
Broad-tailed Hummingbird	Selasphorus platycercus
Rufous Hummingbird	Selasphorus rufus
Kingfishers	**Alcedinidae**
Belted Kingfisher	Ceryle alcyon
Woodpeckers	**Picidae**
Lewis's Woodpecker	Melanerpes lewis
Ladder-backed Woodpecker	Picoides scalaris

Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus
Northern Flicker	Colaptes auratus
Flycatchers	**Tyrannidae**
Olive-sided Flycatcher	Contopus cooperi
Western Wood-Pewee	Contopus sordidulus
Willow Flycatcher	Empidonax traillii
Dusky Flycatcher	Empidonax oberholseri
Cordilleran Flycatcher	Empidonax occidentalis
Black Phoebe	Sayornis nigricans
Say's Phoebe	Sayornis saya
Ash-throated Flycatcher	Myiarchus cinerascens
Western Kingbird	Tyrannus verticalis
Vireos	**Vireonidae**
White-eyed Vireo	Vireo griseus
Plumbeous Vireo	Vireo plumbeus
Cassin's Vireo	Vireo cassinii
Warbling Vireo	Vireo gilvus
Red-eyed Vireo	Vireo olivaceus
Jays, Magpies, Crows and Ravens	**Corvidae**
Western Scrub-Jay	Aphelocoma californica
Pinyon Jay	Gymnorhinus cyanocephalus
Black-billed Magpie	Pica hudsonia
American Crow	Corvus brachyrhynchos
Chihuahuan Raven	Corvus cryptoleucus
Common Raven	Corvus corax
Swallows	**Hirundinidae**
Violet-green Swallow	Tachycineta thalassina
Northern Rough-winged Swallow	Stelgidopteryx serripennis
Bank Swallow	Riparia riparia
Cliff Swallow	Petrochelidon pyrrhonota
Barn Swallow	Hirundo rustica
Chickadees	**Paridae**
Black-capped Chickadee	Poecile atricapillus
Mountain Chickadee	Poecile gambeli
Verdin	**Remizidae**
Verdin	Auriparus flaviceps
Bushtit	**Aegithalidae**
Bushtit	Psaltriparus minimus
Nuthatches	**Sittidae**
White-breasted Nuthatch	Sitta carolinensis
Creeper	**Certhiidae**
Brown Creeper	Certhia americana
Wrens	**Troglodytidae**
Bewick's Wren	Thryomanes bewickii
House Wren	Troglodytes aedon
Marsh Wren	Cistothorus palustris
Kinglets	**Regulidae**
Ruby-crowned Kinglet	Regulus calendula
Gnatcatchers	**Sylviidae**
Blue-gray Gnatcatcher	Polioptila caerulea
Bluebirds, Thrushes and Robins	**Turdidae**
Eastern Bluebird	Sialia sialis
Swainson's Thrush	Catharus ustulatus
Hermit Thrush	Catharus guttatus
American Robin	Turdus migratorius

Thrashers	**Mimidae**
Gray Catbird	Dumetella carolinensis
Northern Mockingbird	Mimus polyglottos
Starling	**Sturnidae**
European Starling	Sturnus vulgaris
Waxwings	**Bombycillidae**
Cedar Waxwing	Bombycilla cedrorum
Silky-flycatcher	**Ptilogonatidae**
Phainopepla	Phainopepla nitens
Warblers	**Parulidae**
Orange-crowned Warbler	Vermivora celata
Virginia's Warbler	Vermivora virginiae
Lucy's Warbler	Vermivora luciae
Yellow Warbler	Dendroica petechia
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Black-and-white Warbler	Mniotilta varia
American Redstart	Setophaga ruticilla
Prothonotary Warbler	Protonotaria citrea
Ovenbird	Seiurus auricapilla
Northern Waterthrush	Seiurus noveboracensis
Kentucky Warbler	Oporornis formosus
MacGillivray's Warbler	Oporornis tolmei
Common Yellowthroat	Geothlypis trichas
Hooded Warbler	Wilsonia citrina
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Tanagers	**Thraupidae**
Summer Tanager	Piranga rubra
Western Tanager	Piranga ludoviciana
Towhees and Sparrows	**Emberizidae**
Spotted Towhee	Pipilo maculatus
Chipping Sparrow	Spizella passerina
Lark Sparrow	Chondestes grammacus
White-crowned Sparrow	Zonotrichia leucophrys
Cardinals, Grosbeaks and Buntings	**Cardinalidae**
Northern Cardinal	Cardinalis cardinalis
Rose-breasted Grosbeak	Pheucticus ludovicianus
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Lazuli Bunting	Passerina amoena
Indigo Bunting	Passerina cyanea
Blackbirds, Meadowlarks and Orioles	**Icteridae**
Red-winged Blackbird	Agelaius phoeniceus
Eastern Meadowlark	Sturnella magna
Western Meadowlark	Sturnella neglecta
Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Brewer's Blackbird	Euphagus cyanocephalus
Common Grackle	Quiscalus quiscula
Great-tailed Grackle	Quiscalus mexicanus
Brown-headed Cowbird	Molothrus ater
Bullock's Oriole	Icterus bullockii
Finches	**Fringillidae**
House Finch	Carpodacus mexicanus
Pine Siskin	Carduelis pinus
Lesser Goldfinch	Carduelis psaltria

American Goldfinch	Carduelis tristis
Evening Grosbeak	Coccothraustes vespertinus
Weaver Finches	**Passeridae**
House Sparrow	Passer domesticus