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Characterization of riparian bird communities in a Mojave Desert watershed

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Urbanization, dry-land and irrigated agriculture, and invasion of non-native plants are greatly affecting riparian zones, modifying the structure and composition of natural vegetation throughout the arid western United States. Along the Muddy River in the Mojave Desert (Clark County, Nevada), introduced saltcedar (*Tamarix ramosissima*) has displaced native tree species including cottonwood (*Populus fremontii*), willow (*Salix exigua, S. gooddingii*), and mesquite (*Prosopis pubescens, P. glandulosa*). There, an aggressive campaign to remove saltcedar has succeeded in eradicating thousands of individual trees along several kilometers of stream course, but the areas have been left devoid of overstory vegetation and virtually free of understory shrubs, forbs, and grasses. In such areas, saltcedar has provided virtually the only vegetational overstory; many species of native birds, including the endangered and federally protected Southwestern Willow Flycatcher (*Empidonax traillii extimus*), are able to exploit saltcedar for shelter and nesting, especially when some native trees remain. Unless native riparian vegetation can be restored in the near term, removal of saltcedar will have little short-term benefit to native animals that require a mature vegetational community, and eradication efforts may threaten the local persistence of some of these species.

Determining whether non-native riparian vegetation supports elements of native biodiversity therefore can help to predict the effects of land management strategies in the Muddy River basin and other watersheds in the Mojave Desert. Here we present the early results from an ongoing study that has been designed to test how bird communities in the region respond to differences in vegetation composition and structure. Summary tables are provided in this article; the full appendix referred to in this article is available at the Great Basin Bird Observatory website (<http://www.gbbo.org>). We found that broad differences in vegetation complexity affect species richness and abundance of resident birds, but not evenness (the extent to which individuals are equally partitioned among species). Many species of conservation interest were recorded during our studies, including all eight species of birds granted coverage under the Clark County (Nevada) Multiple Species Habitat Conservation Plan. We also recorded multiple breeding pairs of locally uncommon species such as Cassin's Kingbird (*Tyrannus vociferans*) and Brown-crested Flycatcher (*Myiarchus tyrannulus*), and regional rarities such as Red-eyed Vireo (*Vireo olivaceus*). Further field studies will be necessary to increase understanding of relationships among native and non-native species of plants and animals, thus to contribute to regional conservation and restoration efforts.

METHODS

We established 33 study sites along the Muddy River drainage. Study sites were grouped into four distinct clusters—California Wash, Dairy Ditch, Lewis Ranch, and Warm Springs—on the basis of geographic location. The California Wash cluster included 4 sites, Dairy Ditch included 16 sites, Warm Springs included 8 sites, and Lewis Ranch included 5 sites. Although vegetation structure and composition were somewhat heterogeneous within each cluster, qualitative differences among clusters could be distinguished. Much of California Wash had a high water table, and riparian areas were dominated by saltcedar. Current human activity in the vicinity was minimal. Dairy Ditch had some mesquite, with a narrow linear corridor of saltcedar along much of the Muddy River, but otherwise was fairly open and dominated by halophytic plants such as quailbush (*Atriplex*) and, to a lesser extent, salt grass (*Distichlis*). Lewis Ranch included lush, wide stands of saltcedar interspersed with coyote willow (*Salix exigua*) along the Muddy River, large stands of reeds (Phragmites) and quailbush, and some agricultural activity. Warm Springs had the greatest diversity of vegetation types, including mesquite, cottonwood stands of varying density, and areas dominated by grasses and forbs. Livestock grazed portions of Warm Springs in previous years but not during our study period.

Birds were sampled using one or two fixed-radius point counts per sample day in each site. At Warm Springs, the points had a radius of ~125 m. The radius of all other points was ~100 m. Each site was visited ≥ 7 times between 2 May and 29 June 2001. During each visit, we recorded all birds seen or heard during 30 minutes in each point. Bird species were categorized as either locally breeding (including both year-round residents and migratory species) or non-breeding and as either riparian obligates (species that rely upon riparian areas for at least some of their critical resources, such as food or nesting sites) or non-riparian obligates. Categorizations were inferred on the basis of the species' known breeding ranges and life history.

We were most interested in testing whether there were differences in bird communities among clusters that could be related to qualitative differences in vegetation structure and composition. Because sampling effort (number of visits per site) was not equal among clusters ($F_{3,32} = 205.19$, $P < 0.001$), we used analysis of covariance to test whether species richness (number of bird species per site) differed significantly among clusters if sampling effort was kept constant. Our data met the assumption of analysis of covariance that the relationship between dependent and independent variables (in this case, species richness and sampling effort) was approximately linear ($F_{1,32} = 108.96$, $P < 0.001$, $r^2 = 0.78$). We used analysis of variance to test whether abundance (mean number of individual birds per site per visit) and species evenness, the extent to which birds in each site were equally partitioned among species (Magurran 1988, Hayek and Buzas 1997), differed significantly among clusters. When there was a significant experiment-wise effect, we used Tukey-Kramer HSD tests ($\lambda = 0.05$) to compare all pairs of clusters. To quantify evenness, we used the diversity index E (Hayek and Buzas, 1997). E is calculated as $E = e^H/S$. $H = -\Sigma p_i \ln(p_i)$, where p_i is the proportion of individuals found in the *i*th species, and S is the number of species in the site (Magurran 1988, Hayek and Buzas 1997). E ranges from 0 to 1, approaching 1 when individuals are partitioned equally among species. Analyses of species richness, abundance, and evenness were calculated separately for all species and for breeding species.

We used analysis of variance to test whether breeding bird community similarity of sites within clusters varied by cluster. We measured similarity within each cluster with the Jaccard index, $C_J = j/(a+b-j)$, where *j* is the number of species found in all sites and *a* and *b* are the number of species in sites A and B, respectively. C_J approaches 1.0 when species composition is identical among sites and 0.0 when sites have no species in common (Magurran 1988).

RESULTS

We recorded a total of 125 species of birds from our 33 study sites (Appendix on GBBO website: http://www.gbbo.org). On the basis of their known breeding ranges and our observations of nesting birds, 76 of the species breed in the Muddy River drainage. Of the breeding species, 33 were categorized as riparian obligates (i.e., probably could not maintain viable populations in the absence of a functional riparian area) (see Appendix). Thirty-one species (13 breeding, 6 of which were riparian obligates) were recorded only from Warm Springs, 11 species (6 breeding, 3 riparian obligate) were recorded only from California Wash, and 8 species (2 breeding) were recorded only from Dairy Ditch. No species was recorded only from Lewis Ranch.

All eight species of birds protected by the Clark County Multiple Species Habitat Conservation Plan were recorded during our surveys: Peregrine Falcon

(*Falco peregrinus*), Yellow-billed Cuckoo (*Coccyzus americanus*), Willow Flycatcher (*Empidonax traillii*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Bell's Vireo (*Vireo bellii*), Phainopepla (*Phainopepla nitens*), Blue Grosbeak (*Guiraca caerulea*), and Summer Tanager (*Piranga rubra*).

We also recorded several additional species of particular interest. For example, we documented breeding by species that are typically found at low densities in the Mojave Desert, such as Anna's Hummingbird (*Calypte anna*), Brown-crested Flycatcher (*Myiarchus tyrannulus*), Cassin's Kingbird (*Tyrannus vociferans*), and Hooded Oriole (*Icterus cucullatus*). Further, we documented the occurrence of a number of species rarely found in the region, including Green Heron (*Ardea herodia*), Red-eyed Vireo (*Vireo olivaceus*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*), and Indigo Bunting (*Passerina cyanea*). An accidental Mississippi Kite (*Ictinia mississippiensis*) also was recorded.

Summary data values (means and standard errors) are presented in Table 1; experiment-wise F-statistics and significance values are presented in Table 2. Cluster had a significant effect on species richness when sampling effort was kept constant. Clusters decreased in species richness from Warm Springs to California Wash, Dairy Ditch, and Lewis Ranch.

We recorded a total of 3627 birds. Abundance differed significantly among clusters, but evenness did not differ among clusters. Mean community similarity at the site level was significantly different among clusters ($F_{3,163} = 37.71$, $P < 0.001$). Mean community similarity was significantly greater within Warm Springs than within California Wash or Dairy Ditch, and Lewis Ranch had greater community similarity than Dairy Ditch.

DISCUSSION

Although we would prefer to restore degraded ecosystems to prior conditions, there are few conceptual guidelines for determining the extent to which native species can be reestablished and few operational frameworks for implementation. Ideally, we would like to replace saltcedar along drainages in the Mojave Desert with a vegetational community that is richer in terms of native species composition and structural complexity. The feasibility of reestablishing a full complement of native trees, shrubs, forbs, and grasses, however, is ecologically questionable and undeniably expensive. Moreover, many plants and animals survive in the face of some degree of habitat modification. Therefore, it is important to examine whether native species can exploit human-modified landscapes. Our results suggest that while the species richness and abundance of resident birds is positively correlated with the complexity of native vegetation, saltcedar is not categorically detrimental. In areas with little understory and few other tree species, saltcedar provides an element of structural diversity that is important to the regional persistence of many species of birds.

Our work also helps elucidate a more general ecological question of continued interest to researchers — how bird communities in different ecoregions respond to variation in vegetation structure and composition (MacArthur and MacArthur 1961, Robinson and Holmes 1984, Rotenberry 1985, Mac Nally 1990, Mills et al. 1991). This enhanced ecological knowledge will assist us in effectively conserving native biological diversity, setting realistic objectives for restoration, and balancing demands for competing land uses.

Further, the studies introduced in this paper highlight the regional importance of the Muddy River drainage, an ecological system that received scant attention until recent years. The Muddy River drainage supports unusually high densities of bird species of conservation concern (Sullivan and Titus 2000), and it has become a focal area for studies and surveys of landscapes in southern Nevada (Tomlinson 2000).

During the period of time in which we conducted bird surveys along the Muddy River drainage, we found geographic differences in species richness, abundance, and community similarity of birds that appeared to be related to broad differences in vegetation structure and composition. Locations with the greatest diversity of plant taxa and growth forms supported the richest communities of breeding birds. Even locations dominated by non-native saltcedar, however, provided habitat for more species of birds than did locations with relatively little structural complexity. Some studies of biodiversity patterns in riparian areas have found that faunal evenness was significantly lower in sites with relatively homogenous vegetation than in sites with greater vegetational heterogeneity (Fleishman et al. 1999). We, however, did not find that individuals were partitioned more equally among species in locations with less diverse structure and composition. We are in the process of collecting quantitative vegetational data that will allow us to analyze bird community patterns in greater detail. While non-native riparian vegetation cannot substitute for comparatively undisturbed riparian areas, it does appear to help support diversity of native birds in the Muddy River basin.

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Table 1. Summary data values. Means and standard errors (in parentheses). CW, California Wash; DD, Dairy Ditch; LR, Lewis Ranch; WS, Warm Springs.

	Cluster			
	CW	DD	LR	WS
Number of site visits	13.0 (0)	11.6 (0.54)	6.8 (0.20)	26 (0)
Species richness				
all species	42.0 (2.1)	27.0 (1.7)	23.6 (4.1)	50.8 (5.7)
breeding species	34.0 (1.7)	23.1 (1.4)	22.0 (3.2)	40.1 (4.4)
Total abundance				
all species	31.8 (4.2)	20.9 (2.9)	23.0 (3.9)	32.8 (2.4)
breeding species	30.5 (4.3)	19.9 (2.9)	22.2 (3.4)	31.4 (2.3)
Evenness				
all species	0.67 (0.06)	0.70 (0.03)	0.76 (0.03)	0.69 (0.03)
breeding species	0.67 (0.07)	0.69 (0.03)	0.77 (0.03)	0.73 (0.03)
Community similarity	0.53 (0.02)	0.48 (0.01)	0.61 (0.03)	0.70 (0.01)

Table 2. Effect of geographic cluster on bird community measurements. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

	F-statistics
Species richness (sampling effort kept constant)	
all species	11.27***
breeding species	10.41***
Total abundance	
all species	3.11*
breeding species	3.04*
Evenness	
all species	0.72
breeding species	0.97