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Effects of land use on riparian birds in a semiarid region

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A B S T R A C T

We investigated the influence of landscape characteristics on avian species occupancy in riparian forests embedded in a matrix of urban and agricultural land use in a semiarid region of the Southwestern US. We conducted bird and vegetation (local-scale characteristics) surveys within 196 50-m radius sample points in 10 riparian forests in southern California. We quantified landscape composition within a 500 m-radius surrounding each point. For each species we developed 8 single-season occupancy models using principal components summarizing local- and landscape-scale characteristics and a spatial autocovariate as covariates. Of 21 species analyzed, occupancy by 11 was associated with landscape characteristics, by 6 with local vegetation characteristics, by 3 with both local and landscape characteristics, and by 1 with none. Five species positively responded to surrounding urban development (2 negative), whereas 4 negatively responded to agricultural land (1 positive). The amount of riparian forests had a strong positive effect on the occurrence of riparian obligates. Our results emphasize the importance of landscape characteristics on species occupancy patterns in riparian systems although relationships were also species-specific. Our results imply a positive effect of urbanization compared to agricultural land uses in this region, most likely due to enhanced vegetation development.

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1. Introduction

Riparian forests occupy less than 2% of the total land surface in the American Southwest but are often the most biologically productive and ecologically important lands in this semiarid and arid region (Debano and Baker, 1999). In particular, avian and plant species diversity are greater in riparian forests, and habitat structure is more complex compared to vegetation types in adjacent uplands (Ohmart, 1994; Knopf and Samson, 1994). While the conservation values of riparian forests have been well recognized in less disturbed landscapes, less attention has been paid to the riparian forests in human-altered landscapes, especially urbanizing ones (Rottenborn, 1999; Hennings and Edge, 2003; Oneal and Rotenberry, 2009; Trammell et al., 2011).

Urban development is considered one of major threats to biodiversity (Czech et al., 2000) and the American Southwest has undergone extensive urbanization in recent decades. In the US streamside development is restricted by the Clean Water Act. While riparian forests often appear intact, those riparian forests are susceptible to fluxes of energy, materials, and organisms from adjacent urban and agricultural lands that can increase surface runoff, erosion, and nutrient loading, lower water tables, facilitate spread of non-native vegetation, and attract avian brood parasites and predators (e.g., Saab, 1999; NRC, 2002; Allan, 2004; Smith and Wachob, 2006). However, it has also been reported that urban development in semiarid and arid regions may have positive effects on riparian systems. Urban development can increase water availability via enhanced runoff and, hence, the quantity of riparian vegetation in a system (White and Greer, 2006). Several studies have found greater bird species richness in riparian forests within a city (Trammell et al., 2011) and noted positive responses of some riparian bird species to surrounding urbanization (Oneal and Rotenberry, 2009).

Most avian studies conducted along an urban-rural gradient have focused primarily on urbanization itself. In some regions of the Southwest, urban development has replaced agricultural lands that were dominant in the past, and riparian forests may now be surrounded by both urban development and agricultural land. Although avian species in natural habitats embedded in an agricultural matrix may show positive or negative responses similar to those embedded in an urban matrix, it has been argued that a less

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intensive agricultural land use can be a more favorable matrix than urban development (Dunford and Freemark, 2004).

Understanding species-habitat relationships in human-altered landscapes requires a multi-scale approach because the extent to which the nature of the surrounding matrix influences avian species distributions largely depends on species' sensitivity to variations in habitat characteristics at different spatial scales (e.g., Bolger et al., 1997; Fahrig, 2003). Some birds in riparian forests may respond more to vegetation changes within a riparian forest (i.e., local characteristics) than development patterns in the surrounding landscape (Martin et al., 2006; Oneal and Rotenberry, 2009) Others may be strongly affected by the amount of riparian forest and other natural habitats within a landscape (i.e., landscape characteristics; Saab, 1999; Miller et al., 2003). Thus, to assess which habitat characteristics appear important to species distributions it is necessary to determine the relative influences of both local and landscape characteristics (Rodewald and Bakermans, 2006; Pennington et al., 2008).

Our principal objective was to examine the effects of surrounding land use on bird species' occupancy in riparian areas in semiarid southern California, in a region consisting of a mixture of agriculture, urban areas, and remnant native habitats. Our aims were two-fold: (1) to investigate the relationship between site occupancy by avian species in riparian forests at two spatial scales (local-scale structural features of the vegetation and landscape-scale composition); and (2) in particular, to assess the implications of agricultural development compared to urbanization for this avifauna. Although we expected responses to local and landscape characteristics would be species-specific, we also expected that more species would be influenced by landscape characteristics given the relatively strong explanatory power of landscape variables found in human-altered landscapes (e.g., Donovan et al., 1997; Saab, 1999; Miller et al., 2003). For those species that did show a response to landscape attributes, we expected positive relationships with the amount of riparian forest in the surrounding matrix (particular for riparian obligate species primarily restricted to nesting in riparian forest), and for more positive and fewer negative responses to agriculture compared to urbanization (e.g., Dunford and Freemark, 2004).

2. Methods

2.1. Study sites and survey points

The study was conducted in 10 riparian forest study sites in a landscape containing a gradient of natural vegetation covers as well as land uses in western Riverside County, California (Figs. 1 and 2). This region exhibits a Mediterranean-type climate characterized by a long, hot, dry summer and a short, cool, highly variably wet winter; mean annual precipitation is ~25 cm. Numerous agricultural lands have been converted to urban and suburban uses beginning in the 1970s (Hornor, 1972–1996).

Riparian vegetation is dominated by willows (*Salix* spp.), Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*), and *Baccharis* spp., with non-native giant reed (*Arudo donax*) and salt-cedar (*Tamarisk* spp.) abundant in some areas. The natural vegetation of upland areas consists of coastal sage scrub dominated by California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), and California brittle-bush (*Encelia californica*). Exotic annual grasses (*Bromus* spp., *Avena barbata*) and wild mustards (*Hirschfeldia incana*) dominate the herbaceous understory of riparian forests as well as upland areas.

Historically, many of the streams were ephemeral or intermittent, but some, particularly those near high density urban or irrigated agricultural areas, now have year-round water due to runoff. The width of riparian forests, except a small portion of Santa Ana River (SARI; Fig. 1), is narrow, ranging from 30 m to 70 m. Within each riparian forest, survey points were spaced at 200-m intervals alongside the stream, with the number varying from 4 to 32 depending on riparian forest length and accessibility. A total of 275 survey points was established across 10 study sites.

2.2. Bird sampling

Bird surveys were conducted at each sampling point twice between April and early July in 2004, using fixed-radius point counts (Ralph et al., 1993). At each point, an observer recorded species seen or heard within a 50-m radius of the sampling point for a 10-min duration. Three observers conducted surveys and they were rotated among sites to randomize any observer effects. We also alternated surveys to minimize the effect of time-of-day. Surveys were performed between dawn to 1030 PDT. We did not conduct surveys during periods of rain or high wind.

We classified each bird species within 3 guilds based on a review of the literature (Appendix A; Ohmart and Anderson, 1982; Ehrlich et al., 1988; Miller et al., 2003; Oneal and Rotenberry, 2009): riparian dependency (riparian dependent species including riparian obligates vs. riparian independent species including facultative users and other species), migratory behavior (migrant vs. resident), and nest placement (tree/shrub, cavity, or ground).

2.3. Local variables-vegetation sampling

We conducted vegetation sampling in June and July after bird surveys were completed using the Point Reyes Bird Observatory "Veggie" (relevé) protocol (PRBO, 2002). We focused on estimating structural attributes (i.e., percent vegetation cover at different layer) due to the importance of vegetation structure to avian distributions (e.g., Karr and Roth, 1971; Robinson and Holmes, 1982). Within a 50-m radius surrounding a sampling point, we visually estimated the percentage of riparian vegetation cover and percentage of any other vegetation types. Within riparian vegetation, we estimated the percent cover of each of three vegetation layers: tree (5 > m), shrub (0.5–5 m), and herb (<0.5 m). Relevé methods such as this have been shown to efficiently capture relevant attributes of avian habitat (Wood et al., 2010). Vegetation sampling was done by a team of two biologists who were trained together to reduce bias in estimating percent cover of vegetation.

2.4. Landscape variables

We generated landscape variables using a land cover map prepared in 2005 for the Western Riverside County Multiple Species Habitat Conservation Plan. The map was created by both field surveys and the interpretation of aerial photography (a resolution of 1–2 m), considering unique vegetation characteristics in western Riverside County (Evens and Klein, 2006). Although the accuracy of the map was high, the scale of resolution (minimum mapping unit was 0.4 ha, about 60 m × 60 m) was not precise in depicting the spatial extent of several parts of the riparian forests we surveyed. However, this was limited to <5% of the total number of points surveyed, and these points also represented relatively low percent cover of riparian vegetation. Thus, we assume that this imprecision had no substantive effect on our analyses. We condensed 14 land cover types in the 2005 map into 4 types: urban development (developed/disturbed lands), agriculture, shrubland (mainly Riversidean coastal sage scrub), and riparian areas. We calculated percent cover of each of the 4 land cover types within a 500-m radius area surrounding a sampling point. We also calculated 2

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