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Cover Photograph: A view of an observation location in metropolitan Phoenix, Arizona where shoestring acacia trees were found in a street-tree landscape setting. At this location, the landscaping beneath the trees was comprised of cool-season grasses. Photograph © Kristen Hoss, USDA Wildlife Services.

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Avian Use of Exotic Street Treescapes in Metropolitan Areas of Phoenix, Arizona

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Abstract - Urban areas are highly modified environments that are strongly influenced by a variety of anthropogenic factors. Consequently, these areas contain unique wildlife communities typically dominated by species that are generalist in nature or highly adaptable. We examined the use of five species of exotic treescapes by exotic and native birds in metropolitan areas of Phoenix, Arizona. House Sparrows [*Passer domesticus* (37%)], European Starlings [*Sturnus vulagris* (27%)], Mourning Doves [*Zenaida macroura* (11%)], and Great-tailed Grackles [*Quiscalus mexicanus* (7%)] were the most frequently observed species during the study. Approximately two-thirds (67%) of the birds observed during the study were exotic species. Avian community composition and diversity associated with these streetscapes varied among the tree species. Growth habits and other characteristics of the trees themselves, in addition to the landscaping components beneath and adjacent to the street trees, influenced bird use of these habitats in this highly urbanized desert environment. Our findings demonstrate that exotic street treescapes might provide some ecological value to urban birds.

Introduction

As human populations increase, the growth of urban landscapes is occurring at an accelerating rate throughout the world and has created major environmental concerns (Grimm et al. 2008, McKinney 2002). Urbanization of landscapes results in an overall loss of biodiversity, especially notable for avian and insect communities (Chace and Walsh 2006, Czech et al. 2000, McKinney 2002). Within highly urban matrices, birds (and other wildlife) use a variety of semi-natural and man-made habitats, including natural habitat fragments, roadsides, railways, golf courses, parks, green roofs, gardens, and landscaped areas (Fernandez-Juricic and Jokimaki 2001, Hudson and Bird 2009, Meffert and Dziock 2012, Vallego et al. 2009, Washburn et al. 2016). Many of these habitats are small in size (e.g., <1 ha) and contain exotic vegetation planted for aesthetic values (Dunnett and Kingsbury 2004, Green and Baker 2003, Ikin et al. 2013).

Street trees (i.e., trees growing along streets) in suburban environments can influence local populations of wildlife, including both exotic and native species (Fernandez-Juricic 2000, Murgui 2007, White et al. 2005). Streetscapes that include trees and other woody vegetation can serve as a functional, intermediary habitat between urban parks and streetscapes with no vegetation (Fernandez-Juricic 2000, Murgui 2007) and can mitigate the negative effects of anthropogenic noise (e.g., vehicle traffic) on avian communities (Pena et al. 2017). In addition, wooded streetscapes might constitute a functional habitat corridor for some bird species, facilitating their movement through the urban matrix and providing small parcels of habitat (Fischer and Lindenmeyer 2002, Sodhi et al. 1999, White et al. 2005).

Vegetation (e.g., street trees) in highly urbanized areas is especially vulnerable to climate change because many species rely on irrigation and other resource-heavy management

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practices, especially in desert environments (Niinemets and Penuelas 2008, Van der Veken et al. 2008). Consequently, the selection of exotic species is common when urban planners are evaluating what species to use in urban projects (Arizona Municipal Water Users Association 2004, McPherson and Berry 2015, McPherson et al. 2017). However, the value of exotic street trees and other vegetation to wildlife, especially birds, is generally unknown and is in need of evaluation.

We investigated the composition and diversity of avian communities using small groups of exotic street trees (i.e., treescapes) during an entire year at locations in a highly urbanized area within a desert environment. The objectives of this study were to quantify (1) bird use (e.g., abundance), (2) avian diversity, and (3) bird activities and foraging guilds associated with five exotic treescapes commonly used for landscaping in urban environments.

Methods

This study was conducted in Maricopa County and the City of Phoenix, which is located in south central Arizona, USA (33° 27' N, 112° 03' W). Phoenix is located in the Sonoran Desert and historically the natural vegetation of the area was a combination of Lower and Upland Sonoran plant communities as well as vegetation associated with riparian corridors (Brown, 1994). The study area has a hot and dry climate and an average annual precipitation of 204 mm. Air temperatures in the study area average 30.8°C during summer and 11.3°C during winter months (Arizona State Climate Office 2018). Approximately one-half of the annual precipitation that falls in the Phoenix metropolitan area occurs during the summer months as monsoons, often resulting in flash flooding along waterways and drainage areas.

Exotic Tree Species

We located sites within the Phoenix metropolitan area where the candidate tree species were currently growing in a street-tree setting. From a larger pool of candidate study sites (i.e., streetscapes), we selected a total of 20 similar observation locations (4 replicates of each of 5 exotic street tree species) that were located in business areas, along major roadways (i.e., 4-lane roads) and contained only one of the exotic street trees. The five exotic tree species included in this study were: Shoestring Acacia (*Acacia stenophylia* A. Cunn ex Benth), Evergreen Elm (*Ulmus parvifolia* Jacquin), Mulga (*Acacia aneura* F. Muell. ex Benth), the Sissoo tree (*Dahlbergia sissoo* Roxb. ex DC), and Thornless Mesquite (*Prosopis hybrid* 'Phoenix' Linnaeus). These trees are commonly used in urban landscaping in hot, dry climates due to their drought tolerance and floristic characteristics (McPherson and Berry 2015, McPherson et al. 2017).

The Shoestring Acacia is a fast-growing, slender upright tree that has evergreen leaves and is native to Australia (Arizona Municipal Water Users Association 2004). This tree thrives under conditions of intense desert heat and drought, is characterized by a low amount of litter fall, and provides filtered shade. Evergreen Elms (or Chinese Elms) are fast-growing, umbrella-like trees that have semi-evergreen foliage and are native to eastern Asia, including China, India, Taiwan, Japan, North Korea, and Vietnam (Perry 1992). Mature Evergreen Elms have long, arching branches that provide dense summer shade. The Mulga is a thornless, slow-growing large erect shrub (or small-size tree) that has evergreen leaves (Arizona Municipal Water Users Association 2004). Native to the deserts of Australia, during extreme dry periods, the Mulga drops much of its foliage to the ground, which provides a layer of mulch and allows for nutrient recycling. Sissoo trees are deciduous and grow to be large trees with dense, leathery leaves that produce heavy shade. Sissoo (also known as North Indian Rosewood) is native to India and tolerates the Phoenix summer heat very well (Perry 1992).

Thornless Mesquite trees are slower-growing, umbrella-like trees that have evergreen foliage. Although some Mesquite species are native to North America, Thornless Mesquites are native to Chile and Argentina (Arizona Municipal Water Users Association 2004).

Bird Observations

During the study, we conducted 98 bird survey days (i.e., series of avian fixed area counts) centered on the 20 observation sites (Bibby et al. 2000, Ralph et al. 1995). Observations were conducted on one randomly chosen day per week (Monday through Friday) for a one-year period (8 April 2005–27 March 2006) at each location. We conducted these observations so that, during each survey day, one series of observations (survey) was made during the morning (06:00 to 12:00 h) and one series of observations was made during the afternoon and evening (13:00 to 19:00 h). Each survey consisted of a series of 5-minute fixed area counts at four pre-determined observation locations (replicates) that contained five individual trees of the same species (Fig. 1). During each individual 5-minute fixed area count, an observer walked very slowly through the survey area and recorded the presence, number, and behavior of all birds observed on or in the street trees, on the ground within 5 m of, or flying within 25 m of the group of five trees. Birds observed during the fixed area count were placed into one of several activity categories, including: (1) flying (locally), (2) on the ground, (3) feeding on the ground, (4) perched in a study tree, (5) vocalizing in a study tree, (6) feeding in a study tree, or (7) nesting in a study tree.

Nesting Observations

During each 5–minute fixed area count, we noted any nesting activity by birds. After the observer completed the observations (at the end of each count) all bird nests were examined for activity using binoculars and/or a mirror on a telescoping pole to determine the status of the nest. The status (e.g., active or inactive), the species of bird using each nest, and the number of eggs or chicks (if present) were recorded for each nest observed during each survey.

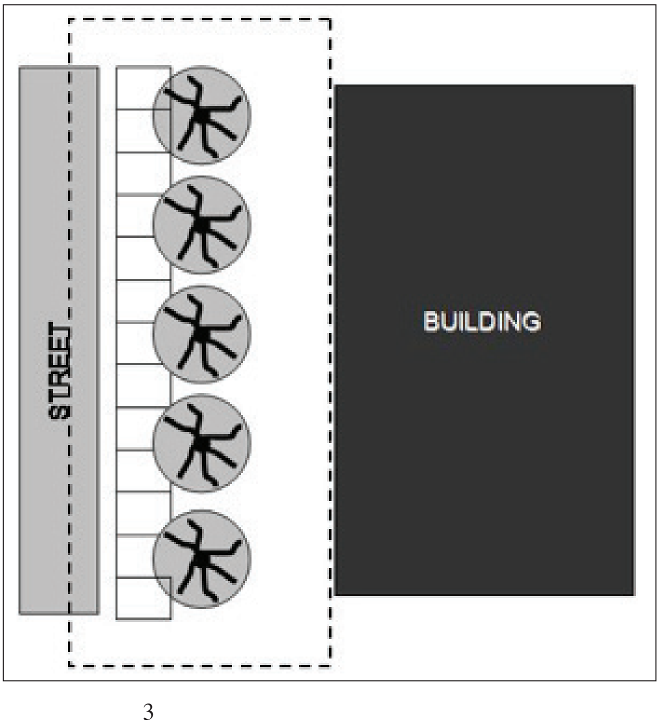

Figure 1. Hypothetical example of a 5-minute fixed area count associated with a study of five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006. Five individual exotic street trees of the same species were contained within the sampling area. All birds within the sampling area, here displayed as the dashed-line box, were counted and their activities recorded.

Data Analyses

We compared the bird use (e.g., abundance) among the five exotic tree streetscapes (as a fixed effect) for each individual bird species and for all species combined, using repeated measures analysis of variance (survey day was the repeated factor) and Fisher's Protected LSD tests (Neter et al. 1990, Zar 1996). Prior to conducting these analyses, we used Shapiro-Wilk tests (to ensure normality) and Levene's tests (to ensure equality of variances) for dependent variables (Neter et al. 1990). We considered differences significant at $P \leq 0.05$ and conducted all analyses using SAS statistical software version 9.1 (SAS Institute, Cary, NC). Data are presented as mean ±1 standard error (SE).

Bird species were divided into two groups, exotic and native. The exotic birds group consisted of House Sparrow (*Passer domesticus* Linnaeus), European Starling (*Sturnus vulgaris* Linnaeus), and Rock Pigeon (*Columba livia* Gmelin). The native birds group consisted of all birds that are native to the Phoenix area. Although Inca Doves (*Columbina inca* Lesson) and Great-tailed Grackles (*Quiscalus mexicanus* Gmelin) arrived in the Phoenix area around 1885 and in the 1940s, respectively, we considered them to be native species as they came to the area through natural range expansions (Emlen 1974, Phillips 1950). We evaluated bird use patterns among exotic tree streetscapes for exotic and native species (individually) to determine if differences existed.

We calculated bird species richness (S) associated with each of the five street trees. Comparison of avian species diversity was conducted by calculating the Shannon's diversity index (H'), the Simpson's diversity index (1/D), and the Berger–Parker dominance index (BP) for each of the five tree species (Gotelli and Entsminger 2001, Magurran 2004, Morris et al. 2014).

We examined bird activities and compared the proportion of birds (all species combined) flying, using the trees, and on the ground among the five tree species using *G*-tests for independence (Sokal and Rohlf 2011, Zar 1996). In addition, we assigned all birds observed into foraging guilds using a standard classification (DeGraff et al. 1985). We compared the proportion of birds within avian foraging guilds among the five tree species using *G*-tests for independence (Sokal and Rohlf 2011, Zar 1996).

As the study progressed, we observed that the landscaping below the exotic street trees might be an important influence on bird use. Although 16 of the 20 observation locations had gravel landscaping, four of the locations (3 Shoestring Acacia and 1 Evergreen Elm) had manicured cool-season grass landscaping. We compared the bird use among the Evergreen Elm and Shoestring Acacia streetscapes with grass landscaping and gravel landscaping (tree species and landscaping type were fixed effects) and tested for interactions between these factors for all species combined and for individual bird species, using repeated measures analysis of variance (survey day was the repeated factor) and Fisher's Protected LSD tests (Neter et al. 1990, Zar 1996).

Results

During 196 avian fixed area count surveys, we observed at total of 6,305 birds, representing 23 different species. House Sparrows (37%), European Starlings (27%), Mourning Doves (*Zenaida macroura* Linnaeus [11%]), and Great-tailed Grackles (7%) were the most frequently observed species during the study. Approximately two-thirds (67%) of the birds observed during the study were exotic species, whereas the other one-third were native.

Overall, bird use (abundance) varied ($F_{4,1900} = 6.38$, $P = 0.0004$) among the five street treescapes. The lowest number of birds were observed in Mulga streetscapes, whereas the most birds were found in Shoestring Acacia streetscapes; bird use of Evergreen Elm trees, Sissoo trees, and Thornless Mesquite streetscapes was intermediate relative to Mulga and Shoestring Acacia (Table 1).

Exotic Bird Species

House Sparrows were very common and were observed flying in the vicinity of all tree species studied (Table 1). House Sparrows were present on or in Evergreen Elm, Sissoo, and Thornless Mesquite trees more ($F_{4,1900} = 13.31$, $P < 0.0001$) than in Mulga and Thornless Mesquite streetscapes.

The number of European Starlings varied ($F_{4,1900} = 16.74$, $P < 0.0001$) among the tree streetscapes (Table 1). European Starlings used Shoestring Acacia streetscapes exclusively; these birds typically fed in the grassy areas beneath these trees and used the acacias as a refuge when startled. Although European Starlings were commonly observed flying in the vicinity of Mulga trees, they did not use these trees or the ground beneath them.

Rock Pigeons were typically observed flying and only rarely observed feeding or resting under trees. Pigeons used Mulga, Sissoo, and Thornless Mesquite streetscapes more ($F_{4,1900} = 4.45$, $P = 0.004$) than Shoestring Acacia streetscapes (Table 1).

Native Birds

Doves were commonly observed during the study (Table 1). Mourning Doves used all five exotic tree streetscapes relatively equally ($F_{4,1900} = 1.29$, $P = 0.29$). Inca Doves were observed almost exclusively ($F_{4,1900} = 20.18$, $P < 0.0001$) in association with Thornless Mesquite streetscapes, using these trees and the ground beneath (Table 1). White-winged Doves (*Zenaida asiatica* Linnaeus) were commonly observed flying within all of the streetscapes we studied, but they used only Shoestring Acacias.

Other birds, such as native songbirds and raptors, were occasionally observed flying, beneath, or in the street trees being studied. Verdins (*Auriparus flaviceps* Sunduvail) ($F_{4,1900} = 1.69$, $P = 0.17$) and raptors ($F_{4,1900} = 1.87$, $P = 0.13$) used all five streetscapes relatively equally. In contrast, Northern Mockingbirds (*Mimus polyglottos* Linnaeus) were more abundant ($F_{4,1900} = 6.38$, $P = 0.0004$) on or in Evergreen Elms compared to the other street trees. Great-tailed Grackle use varied ($F_{4,1900} = 10.63$, $P < 0.0001$) among the streetscapes (Table 1). Great-tailed Grackles used the ground beneath the Shoestring Acacia trees for resting and foraging. In addition, our observations suggest Great-tailed Grackles also use Evergreen Elm and Thornless Mesquite trees themselves.

Bird Community Diversity

Avian diversity varied among the five exotic tree streetscapes (Table 2). Overall, the avian community associated with Mulga streetscapes had the highest levels of diversity (a consistent finding across all four diversity measures). In contrast, the diversity of avian communities was lowest within streetscapes comprised of Evergreen Elms (Table 2). Shoestring Acacia, Sissoo, and Thornless Mesquite streetscapes had avian communities with intermediate diversity relative to Mulga and Evergreen Elm habitats.

Bird Activities

The proportion of birds (all species combined) flying near ($G_4 = 699.7$, $P < 0.0001$), using the street trees ($G_4 = 1499.9$, $P < 0.0001$), and on the ground under or near study trees ($G_4 = 1083.9$, $P < 0.0001$) varied among the five tree streetscapes. The highest amount of local flying occurred near Mulga trees, whereas the ground under Shoestring Acacias was

Table 1. Mean (± SE) no. of birds observed per 5-minute fixed area count of individual species and guilds of birds associated with five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006.

Species or Guild	Evergreen Elm	Mulga	Shoestring Acacia	Sissoo	Thornless Mesquite
House Sparrow (*Passer domesticus*)	2.21 ± 0.23 ^{a*}	0.24 ± 0.08 ^{b}	0.12 ± 0.04 ^{b}	1.58 ± 0.14 ^{a}	1.87 ± 0.15 ^{a}
Mourning Dove (*Zenaida macroura*)	0.13 ± 0.02 ^{a}	0.47 ± 0.08 ^{a}	1.05 ± 0.38 ^{a}	0.32 ± 0.04 ^{a}	0.31 ± 0.04 ^{a}
European Starling (*Sturnus vulgaris*)	0.04 ± 0.02 ^{a}	0.20 ± 0.06 ^{a}	3.53 ± 0.55 ^{b}	0 ^{a}	0.02 ± 0.01 ^{a}
Great-tailed Grackle (*Quiscalus mexicanus*)	0.14 ± 0.04 ^{a}	0.04 ± 0.01 ^{a}	0.76 ± 0.10 ^{b}	0.03 ± 0.01 ^{a}	0.21 ± 0.05 ^{a}
House Finch (*Haemorhous mexicanus*)	0.14 ± 0.03 ^{ab}	0.07 ± 0.02 ^{a}	0.16 ± 0.04 ^{ab}	0.30 ± 0.04 ^{c}	0.26 ± 0.04 ^{bc}
Inca Dove (*Columbina inca*)	< 0.01 ± < 0.01 ^{a}	0.08 ± 0.02 ^{b}	0.01 ± 0.01 ^{a}	0.02 ± 0.01 ^{a}	0.42 ± 0.05 ^{c}
Verdin (*Auriparus flaviceps*)	0.07 ± 0.01 ^{a}	0.08 ± 0.02 ^{a}	0.03 ± 0.01 ^{a}	0.08 ± 0.02 ^{a}	0.07 ± 0.01 ^{a}
Rock Pigeon (*Columba livia*)	0.03 ± 0.01 ^{ab}	0.10 ± 0.04 ^{bc}	0 ^{a}	0.12 ± 0.03 ^{c}	0.08 ± 0.02 ^{bc}
Northern Mockingbird (*Mimus polyglottos*)	0.09 ± 0.04 ^{a}	0.04 ± 0.02 ^{b}	0.03 ± 0.01 ^{b}	0.01 ± 0.01 ^{b}	0.02 ± 0.01 ^{b}
Anna's Hummingbird (*Calypte anna*)	< 0.01 ± < 0.01 ^{a}	< 0.01 ± < 0.01 ^{a}	0.02 ± 0.01 ^{a}	0 ^{a}	0 ^{a}
Songbirds**	0.01 ± 0.01 ^{a}	0.09 ± 0.02 ^{bc}	0.10 ± 0.03 ^{bc}	0.05 ± 0.01 ^{ab}	0.12 ± 0.02 ^{c}
Raptors***	0 ^{a}	0.01 ± 0.01 ^{a}	0.01 ± 0.01 ^{a}	0 ^{a}	< 0.01 ± < 0.01 ^{a}
All Species Combined	2.89 ± 0.27 ^{a}	1.46 ± 0.14 ^{b}	5.84 ± 0.68 ^{c}	2.54 ± 0.16 ^{a}	3.35 ± 0.19 ^{a}

*Means within the same row with the same letter are not significantly different ($p > 0.05$).

**The songbirds category in this study includes Abert's Towhee (*Pipilo alberti*), Brown-crested Flycatcher (*Myiaarchus tyrannulus*), Brown-headed Cowbird (*Molothrus atar*), Black Phoebe (*Sayornis nigricans*), Curve-billed Thrasher (*Toxostoma curvirostre*), Cliff Swallow (*Hirundo pyrrhonota*), Common Raven (*Corvus corax*), Gila Woodpecker (*Melanerpes uropygialis*), Say's Phoebe (*Sayornis saya*), White-winged Dove (*Zenaida asiatica*), and Yellow-rumped Warbler (*Dendroica coronate*).

***Raptors include American Kestrel (*Falco sparverius*) and Harris' Hawk (*Parabuteo unicinctus*).

the most used by birds (Fig. 2). Bird use of the trees themselves was highest for Evergreen Elm, Sissoo, and Thornless Mesquite trees (Fig. 2).

A total of 31 bird nests was observed and monitored during our study (Table 3). Seventy-seven percent (24 of 31 nests) of all bird nests were located in Sissoo trees; 16% (5 of 31) were located in Thornless Mesquite trees; and 7% (2 of 31) were located in Evergreen Elms. We found no bird nests in either the Mulga trees or the Shoestring Acacia trees. Doves (i.e., Mourning Doves and Inca Doves) accounted for two-thirds of the nests, whereas native species (overall) accounted for 92% of the bird nests identified to species during the study (Table 3).

Foraging Guilds

We found significant variation in the proportion of avian foraging guilds for omnivorous ground foragers ($G_4 = 4210.2$, $P < 0.0001$), granivorous ground gleaners ($G_4 = 831.3$, $P < 0.0001$), insectivorous air salliers ($G_4 = 51.6$, $P < 0.0001$), tree focused foragers ($G_4 = 12.1$, $P = 0.02$), and other guilds ($G_4 = 27.4$, $P < 0.0001$) when comparing across tree streetscapes. Although omnivorous ground foragers was the dominant avian foraging guild observed within Shoestring Acacia streetscapes, granivorous ground gleaners was the most frequently observed avian foraging guild at streetscapes comprised of the other four exotic tree species (Fig. 3). The highest proportion of insectivorous air salliers, tree focused foragers, and other guilds were found in association with Mulga streetscapes, whereas the composition of avian foraging guilds were very similar among Evergreen Elm, Sisso, and Thornless Mesquite streetscapes (Fig. 3).

Landscaping

We found that, for all birds combined, exotic tree streetscapes with grass landscaping (7.61 ± 0.51 birds per 5-minute count) had higher ($F_{1,194} = 79{,}29$, $P < 0.0001$) bird use than

Table 2. Avian diversity indices associated with five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006.

Diversity Index	Evergreen Elm	Mulga	Shoestring Acacia	Sissoo	Thornless Mesquite
Species richness	13	20	16	10	14
Shannon's diversity (H')	0.977	2.123	1.076	1.257	1.533
Simpson's diversity (1/D)	1.656	5.682	1.927	2.315	2.874
Berger–Parker dominance (BP)	0.772	0.339	0.702	0.631	0.560

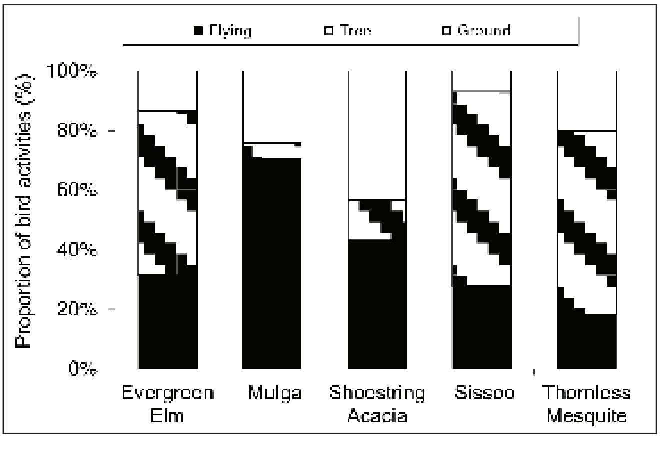

Figure 2. Proportion of bird activities associated with five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006.

those with gravel streetscapes (1.42 ± 0.51). European Starlings ($F_{1,194} = 21.62$, $P < 0.0001$) and Great-tailed Grackles ($F_{1,194} = 10.60$, $P = 0.001$) used Shoestring Acacia streetscapes landscaped with grass more than Shoestring Acacia streetscapes with gravel landscaping and Evergreen Elm streetscapes. Conversely, House Sparrows ($F_{1,194} = 62.98$, $P < 0.0001$), Rock Pigeons ($F_{1,194} = 5.67$, $P = 0.02$), Northern Mockingbirds ($F_{1,194} = 12.26$, $P = 0.006$), and Verdin ($F_{1,194} = 5.26$, $P = 0.02$) all used the Evergreen Elm streetscape landscaped with grass more than Shoestring Acacia streetscapes with grass or gravel landscaping and the gravel landscaped Evergreen Elm streetscapes. For all other bird species, there was no significant difference (all $F_{1,194} < 2.29$, $P > 0.13$) in their use of the grass and gravel landscaped Shoestring Acacia and Evergreen Elm streetscapes.

Table 3. Nests found in the street trees during the study of five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006

Bird Species	Number of Nests	Number of Active Nests
Mourning Dove	10	2
Inca Dove	6	1
Verdin	3	2
House Finch	2	1
House Sparrow	2	2
Northern Mockingbird	1	0
Unknown bird species	7	1

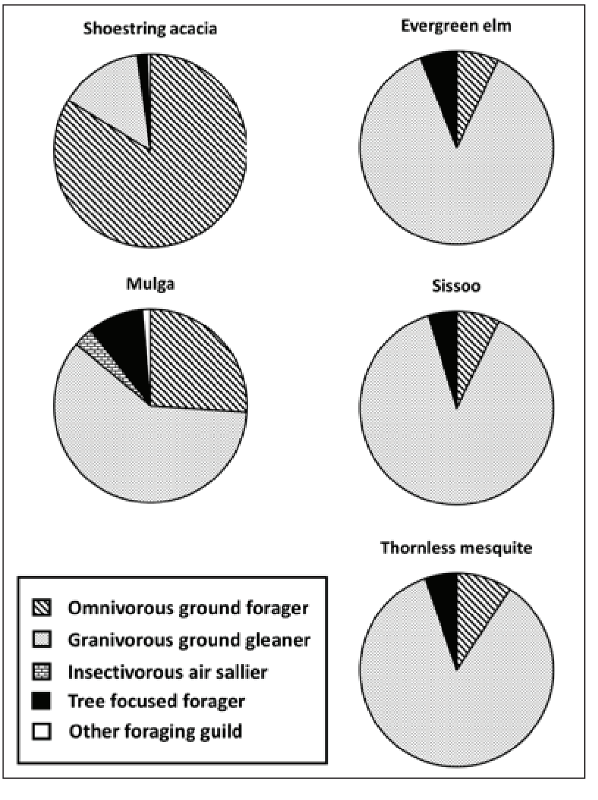

Figure 3. Proportion of avian foraging guilds associated with five exotic tree streetscapes in metropolitan areas of Phoenix, AZ, April 2005 through March 2006.

Discussion

The five exotic tree streetscapes varied in their use by birds of different species and foraging guild associations. Several bird species appeared to exhibit clear preferences for one or more of these streetscapes, whereas other species used all of the streetscapes relatively equally. These findings are consistent with studies of streetscapes in cities located on other continents, including Europe (Fernandez-Juricic 2000, Murgui 2007) and Australia (Ikin et al. 2013, White et al. 2005, Young et al. 2007).

With the exception of House Sparrows, few birds used the Evergreen Elm trees themselves. House Sparrows used the Evergreen Elms for perching and vocalizing. In addition, House Sparrows (granivorous ground gleaner) comprised the vast majority of birds that rested and foraged under the Evergreen Elm trees.

Thornless Mesquite is the only street tree that was frequently used by Inca Doves. Five nests were found in Thornless Mesquite trees, almost all of which were made by Inca Doves or Mourning Doves. We suspect the umbrella-like growth form of this tree provides thermal and protective cover (i.e., shade) to both birds using the trees (e.g., for nesting) and for birds using the ground below. Moreover, birds in this region are adapted to desert environments and consequently to desert trees (Green and Baker 2003, Hostetler and Knowles-Yanez 2003, Litteral and Wu 2012), such as the Velvet Mesquite (*Prosopis velutina* Wooten) and Screwbean Mesquite (*Prosopis pubescens* Benth.), which are native tree species closely related to the Thornless Mesquite.

Growth habits and other characteristics of the trees themselves, in addition to the landscaping components beneath and adjacent to the street trees, influenced the bird use of these exotic tree streetscapes in this highly urbanized desert environment. Although the use of Shoestring Acacia trees by birds was moderate, European Starlings (omnivorous ground forager), Great-tailed Grackles (omnivorous ground forager), Mourning Doves (granivorous ground gleaner), and White-winged Doves (granivorous ground gleaner) frequently used the ground beneath most of the Shoestring Acacia trees. The areas under three of the four Shoestring Acacia tree streetscapes studied were landscaped with thick stands of cool-season grasses (e.g., perennial ryegrass [*Lolium perenne* Linnaeus]) which the birds foraged on. In contrast, the Shoestring Acacia trees that were landscaped with gravel (only one of the studied streetscapes) were used infrequently by birds. Thus, we suspect much of the attractiveness of the Shoestring Acacia streetscapes to birds from a foraging perspective is likely due to the grass landscaping rather than the trees themselves.

House Sparrows and Mourning Doves used the Sissoo trees for perching, vocalizing, nesting, and other activities. Most of the nests observed and monitored during our study (e.g., those of Mourning Doves, Inca Doves, House Sparrows, and House Finches (*Haemorhous mexicanus* Muller) were located in Sissoo trees. Tweit and Tweit (1986) found that Inca Doves only nest in exotic vegetation and not in native plants in urban areas within a desert environment. The dense foliage of Sissoo trees likely provides good thermal and protective cover, thus making these trees attractive to birds for nesting and other activities. Interestingly, in their native range Sissoo trees are used by a variety of birds, including Columbids and Passerines (Kaur and Kumar 2018).

Of the five exotic tree streetscapes studied, Mulga streetscapes were used the least by birds (in regard to abundance) but these streetscapes had the highest avian diversity. This finding is consistent with studies from Australia (where the Mulga is native) where high levels of avian diversity are associated with Mulga forests and plantings (Cody 1994, Recher and Davis 1997). The sparse foliage and upright growth form of this tree appears to provide little thermal or protective cover, thus making it unattractive to birds. No birds were observed feeding from the flowers or the seeds produced by the Mulga trees. Most observations of birds associated with Mulga trees were Mourning Doves and Great-tailed Grackles forging on sparse amounts of seed-producing grasses beneath the Mulga trees.

Urban bird use of exotic tree streetscapes is influenced by the species of street trees present as reflected in the composition and diversity of the avian communities observed. Avian communities found in these streetscapes were comprised of both exotic and native species. The growth habits and other characteristics of these exotic street trees, in addition to the landscaping components related to them, influenced the bird use of these streetscapes in this highly urbanized desert environment. Developers, city planners, biologists, and landscape architects who are interested in providing suitable habitat for birds, either native species or all species (including exotic species) while simultaneous providing a functional, aesthetic streetscape environment in cities (Savard et al. 2000) located within arid desert environments could select exotic tree species using the findings from our study.

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