NESTING ECOLOGY AND NEST SUCCESS OF THE BLUE GROSBEAK ALONG TWO RIVERS IN NEW MEXICO

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ABSTRACT: From 1997 through 2008, we studied the nesting habits and nest success of the Blue Grosbeak (*Passerina caerulea*) along the middle Gila River (1997–2001) and the middle Rio Grande (2000–2008) in New Mexico. A riparian forest of cottonwoods grows along both rivers, but the forest along the Rio Grande is a much more intensively managed ecosystem, with an understory dominated by saltcedar (*Tamarix* spp.) and other non-native invasive plants, frequent wildfires, and large-scale attempts at remediation of the vegetation. Along the Gila River 100 (95%) of 105 nests were in native shrubs or trees, and the mean height of all nests was 3.4 m. Of 85 nests found along the Rio Grande, 54 (64%) were in saltcedar and 16 (19%) were in other non-native shrubs or trees. Mean nest height was 2.2 m, significantly lower than along the Gila River. Nests were typically found along edges along both rivers but were placed significantly farther from water along the Gila River. In spite of these differences in nest placement, the observed proportion of successful nests along the two rivers did not differ significantly: 28 (47%) of 60 nests along the Rio Grande, 36 (54%) of 67 nests along the Gila River.Overall, differences between the two sites in floristic composition and vegetation structure appeared to affect the placement of Blue Grosbeak nests more than they did nest success.

During the last three decades, much has been published on the ecological role and threatened status of riparian areas in arid and semi-arid southwestern North America (e.g., Johnson et al. 1977, 1987, Hunter et al. 1988, Howe and Knopf 1991, Finch and Yong 2000, Smith et al. 2009a). In particular, southwestern riparian areas are important to birds at lower and middle elevations, where they concentrate key resources such as water, shade, insects and fruits for food, and suitable nest sites (Carothers et al. 1974, Stamp 1978, Ohmart and Anderson 1982, Rosenberg et al. 1982, Hunter et al. 1988, Cartron et al. 2000). In turn, alteration or loss of riparian areas through river regulation, groundwater pumping, woodcutting, overgrazing, and the spread of non-native, invasive plants has reduced riparian bird species and communities (Unitt 1987, Knopf et al. 1988, Ohmart 1994, Cartron et al. 2000, Finch and Stoleson 2000).

In the Southwest, the Blue Grosbeak (*Passerina caerulea*) is one of many birds strongly tied to riparian areas. Range-wide, the species occupies a diversity of habitats (Ingold 1993), but in southwestern North America, it breeds only in riparian areas (Johnson et al. 1987). Like other riparian birds, including the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (e.g., Owen et al. 2005, Sogge et al. 2008), the Blue Grosbeak uses not only native vegetation (e.g., Powell and Steidl 2000) but also areas now dominated by the invasive saltcedar (*Tamarix* spp.) (Hunter et al. 1988, Brown and Trosset 1989, Rosenberg et al. 1991, Ellis 1995). Beyond this finding, however, surprisingly little has been learned about the nesting habits of the Blue Grosbeak in southwestern riparian areas and how these habits may relate to anthropogenic changes in vegetation structure or floristic composition.

Here, we analyze data on Blue Grosbeaks nesting along two main rivers of New Mexico, the Gila River and the Rio Grande. The middle reaches of these two rivers have been altered to different degrees and in different ways, which, in turn, have been addressed by different management strategies. The middle Gila River in the southwestern part of the state is an unregulated river that nonetheless has been seriously degraded in several places by uncontrolled livestock grazing and by phreatophyte control (Boucher et al. 2003). To address local problems of the river deepening its channel, severe bank erosion, and loss of riparian vegetation, livestock grazing was discontinued within much of the riparian zone in the 1990s, followed by excavation and grading of the river banks and by planting of native vegetation. As a result, periodic flooding over the river's bank was restored, and with it, sediment deposition and revegetation along the banks (Boucher et al. 2003).

Compared to that along the middle Gila River, the riparian forest along the middle Rio Grande is a much more intensively managed ecosystem (Crawford et al. 1998, Cartron et al. 2008, Smith et al. 2009a, b). Since the completion of Cochiti Dam in 1973, the river no longer floods over its bank at most locations. Saltcedar and Russian olive (*Elaeagnus angustifolia*), two non-native plants introduced as ornamentals or for erosion control, have spread along the river, replacing most of the original, native understory vegetation. The lack of flooding and the spread of saltcedar and Russian olive have contributed to heavy fuel loads that enabled stand-replacing wildfires during the last decade (Cartron et al. 2008). To reduce the risk of fire, the understory vegetation now has to be removed mechanically at regular intervals, but this practice also promotes the spread of other non-native plants such as kochia (*Kochia scoparis*).

Here we focus primarily on a comparison of the Blue Grosbeak's nesting habits and nest success along the Rio Grande and the Gila River.

MATERIALS AND METHODS

Study Areas

Our study along the middle Gila River extended from 1997 to 2001, that along the middle Rio Grande from 2000 to 2008 (Figure 1). The Gila River study area is located in the Cliff–Gila Valley of Grant County, at elevations ranging from 1335 to 1420 m. It consisted of two disjunct sites (33° 1′ N, 108° 35′ W and 32° 46′ N, 108° 34′ W), of 50 ha and 25 ha both supporting a mosaic of brushy floodplain vegetation, narrow (width 10–200 m) patches of riparian forest, and fields along the Gila River and associated earthen irrigation ditches. Most patches of forest included in the study area consisted of stands of mature Fremont cottonwood (*Populus fremontii*) with a canopy >25 m (reaching 40 m in places). The canopy or mid-story veg-

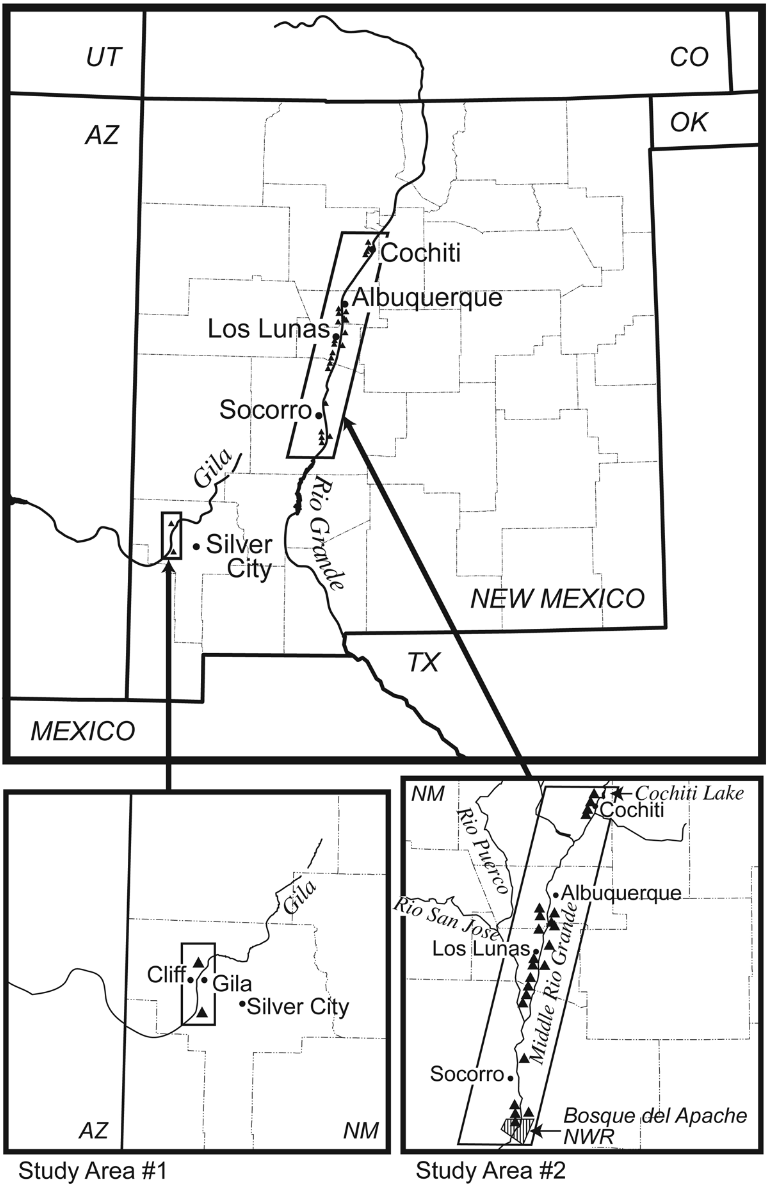

Figure 1. Locations of study areas along the middle Gila River (1997–2001) and middle Rio Grande (2000–2008) in New Mexico. Black triangles represent sites of field work.

etation also included Goodding's willow (*Salix gooddingii*), boxelder (*Acer negundo*), velvet ash (*Fraxinus velutinus*), Arizona walnut (*Juglans major*), Arizona sycamore (*Platanus wrightii*), Arizona alder (*Alnus oblongifolia*), and Russian olive. In the understory were shrubs such as three-leaf sumac (*Rhus trilobata*), false indigo (*Amorpha fruticosa*), and New Mexico olive (*Forestiera neomexicana*), and forbs and grasses. Along the river, flooding over the banks promotes an early stage of open vegetation consisting of coyote willow (*Salix exigua*), bluestem willow (*S. irrorata*), seepwillow (*Baccharis salicifolia*), and cottonwood saplings. Most of the Gila River study area was on private land (the U Bar Ranch), where the riparian zone is flanked by dry and irrigated pastures used for livestock grazing and hay farming. Also included in the study area were lands managed by The Nature Conservancy and the Gila National Forest.

The second study area was located along the middle Rio Grande from Cochiti Lake (35° 37′ N, 106° 19′ W, elevation 1608 m) in Sandoval County south approximately 235 km to the Bosque del Apache National Wildlife Refuge (33° 48′ N, 106° 54′ W, elevation 1372 m) in Socorro County (Figure 1). It consisted of 23 scattered sites representing a total of 454 ha along the river. Most of the 23 sites were narrow (width 50–250 m) patches of riparian vegetation, although the width of some of the sites in the south reached 400 m or more (maximum 600 m). The 23 study sites along the middle Rio Grande consisted of a mix of untreated cottonwood forest with a canopy of Rio Grande cottonwoods (*Populus deltoides* ssp. *wislizenii*) and understory typically dominated by saltcedar and Russian olive, burned areas with little or no forest canopy, and patches of vegetation from which the understory was cleared sometime during the study. Within two years, burned sites were colonized or re-colonized by non-native plants including not only saltcedar and Russian olive but also kochia, Siberian elm (*Ulmus pumila*), and tree of heaven (*Ailanthus altissima*) forming a dense shrub layer. Our study sites were variously under the administrative oversight of the Middle Rio Grande Conservancy District, the U.S. Bureau of Reclamation, the Bosque del Apache National Wildlife Refuge, and the city of Albuquerque's Open Space Division. Land use adjacent to the riparian zone was mostly agricultural (pastures and crop fields).

Field Methods

Along both the Gila River and the Rio Grande, searches for Blue Grosbeak nests were part of a larger effort to study entire riparian bird communities, habitat associations, and responses to disturbance or management. We actively searched for nests from the second week of May through the middle of August. Along the Rio Grande, stands of mature cottonwood and their edges were thoroughly searched, as were the more open river banks. In some areas the river-edge vegetation consisted of tall, nearly impenetrable thickets of willow and/or Russian olive. Although searches for nests were limited to the edges of those thickets, Blue Grosbeaks appeared to largely avoid the thickets' interior, unlike other species such as the Spotted Towhee (*Pipilo maculatus*). Along both rivers, we recorded nest height (m), nest substrate, nest-substrate height (m), distance between the nest and the trunk or main stem of the nest plant (m), diameter at breast height of the nest plant (cm), and distance to the nearest body of water (either the river or a riverside drain; m). Along the Gila River, we also measured the distance to the nearest edge.

Nests were monitored every 3–5 days with use of binoculars, pole-mounted mirrors or video cameras, or 15× spotting scopes. Nests that were abandoned or destroyed were examined for evidence (e.g., cowbird eggs, mammal hairs) of the cause of nest failure. We considered a nest successful if (1) the parents were observed feeding one or more fledged young Blue Grosbeaks; (2) the parents behaved as if dependent young were nearby in the vicinity of a now-empty nest that had not been parasitized; or (3) Blue Grosbeak nestlings were in the nest within one or two days of the estimated date of fledging. We considered a nest to have failed if (1) the nest's contents disappeared before fledging of young was possible (depredation), assuming the young require 9–10 days for fledging (Stabler 1959), (2) the nest contained no grosbeak young but contained cowbird eggs or chicks, (3) the nest was deserted after eggs had been laid (desertion), or (4) the nest was abandoned prior to egg laying (abandonment).

Statistical Analyses

For all analyses we used the statistical software Centurion XV.II (Statgraphics). We used *t* tests to identify significant differences between the Gila River and Rio Grande datasets in nest height, nest plant height, diameter at breast height of the nest plant, distance between nest and trunk or main stem, and distance between nest and nearest body of water. We assessed differences in proportions of successful and unsuccessful nests with chi-squared tests.

RESULTS

We found a total of 190 Blue Grosbeak nests during our study, 105 (55%) along the Gila River and 85 (45%) along the Rio Grande. In both areas, some pairs initiated nesting in late May, eggs were typically recorded from early June through mid-August, and young fledged through at least the end of August. The peak of the nesting season appeared to be in July, when 61 (72%) of the 85 Rio Grande nests and 73 (70%) of the 105 Gila River nests were active. One nest along the Gila River and one nest along the Rio Grande were found after mid-August and the end of our active nest searches. The late nest along the Rio Grande was discovered on 5 September 2003. It contained two Blue Grosbeak eggs and two cowbird eggs and was deserted.

Nest Substrate and Nest Materials

Along the Gila River, Blue Grosbeaks built their nests in plants of at least 20 species (Table 1). Most (70%) nests were found in four native species of shrub or tree, primarily boxelder, followed in order of decreasing frequency by seepwillow, Goodding's willow, and netleaf hackberry (*Celtis reticulata*). Only five nests were found in exotic vegetation, Russian olive or saltcedar. Atypical were nests built in plants such as stinging nettles (*Urtica dioica*), common sunflower (*Helianthus annuus*), and canyon grape (*Vitis arizonica*). Along the Gila River we recorded the nest materials in only a few

Table 1 Substrates and Heights of Blue Grosbeak Nests along the Middle Gila River (1997–2001) and Middle Rio Grande (2000–2008) in New Mexico

		Nest height (m)		
Plant species[a]	No. (%) nests	Mean	SD	Range
Middle Gila River				
Boxelder	29 (28)	6.73	3.88	0.3–15.0
Seepwillow	17 (16)	1.65	0.54	1.1–3.1
Goodding's willow	16 (15)	2.04	0.85	0.9–4.3
Netleaf hackberry	12 (11)	2.46	1.23	1.3–5.2
Fremont cottonwood	6 (6)	2.13	0.39	1.8–2.8
New Mexico locust	4 (4)	1.47	0.67	0.7–2.3
Russian olive	4 (4)	1.66	0.87	0.6–2.7
Arizona sycamore	2 (2)	8.1	1.98	6.7–9.5
Arizona alder	2 (2)	3.15	1.06	2.4–3.9
Velvet mesquite	2 (2)	1.45	0.49	1.1–1.8
Bluestem willow	2 (2)	2.65	0.64	2.2–3.1
Saltcedar	1 (1)	2.4	—	—
Wingleaf soapberry	1 (1)	0.5	—	—
Velvet ash	1 (1)	0.8	—	—
Canyon grape	1 (1)	2.0	—	—
Stinging nettles	1 (1)	1.3	—	—
Catclaw mimosa	1 (1)	1.7	—	—
Common sunflower	1 (1)	0.9	—	—
Wild rose (*Rosa* sp.)	1 (1)	1.0	—	—
Acacia (*Acacia* sp.)	1 (1)	0.9	—	—
Total	105 (100)	3.36	3.12	0.3–15.0
Middle Rio Grande				
Saltcedar	54 (64)	2.12	1.22	0.2–8.7
Russian olive	11 (13)	1.21	0.64	0.4–2.5
Rio Grande cottonwood	7 (9)	6.64	5.27	1.4–15
Coyote willow	6 (7)	1.36	0.85	0.5–2.5
Kochia	2 (2)	1.05	0.21	0.9–1.2
Tree of heaven	1 (1)	1.03	—	—
White mulberry	1 (1)	0.50	—	—
Siberian elm	1 (1)	1.20	—	—
Desert olive	1 (1)	1.80	—	—
Goodding's willow	1 (1)	0.96	—	—
Total	83(100)	2.24	2.24	0.2–15

[a] See text for the scientific names of nest plants; names of introduced species are in bold type.

nests; these consisted of dried grasses, leaves, and, occasionally, also snake skin, used plastic flagging, and hair.

Along the Middle Rio Grande, nests were found in 10 species of plants (Table 1). Most (82%) nests were built in non-native shrubs or trees, primarily saltcedar and Russian olive (e.g., Figure 2). Only 15 (18%) nests were found in native plants, mainly Rio Grande cottonwood and coyote willow. Nest materials included leaves and twigs of saltcedar, leaves, shredded bark, cotton, seed pods, and twigs from cottonwood trees, grass, forb stems, horse

Figure 2. Nest of the Blue Grosbeak in a Russian olive along the middle Rio Grande, New Mexico.

Photo by June Galloway, Rocky Mountain Research Station

hair, snake skin, candy-bar wrappers, pieces of plastic bag, paper, and old flagging tape.

Measurements of Nests' Characteristics

We pooled measurements of nests and nest plants for all years to maximize sample sizes and because there were no detectable annual differences in the five variables we measured (consensus t test, $P > 0.5$). Along the Gila River, observed nest height varied from 0.3 to 15 m, with a median of 2.1 m. Most (69%) nests were found at heights of ≤3 m, but nest height varied considerably by substrate (Table 1). Nests in boxelder were significantly higher than nests in the other three main substrates combined ($t = 7.87$, df $= 1$, $P < 0.001$). Nests also found at heights substantially higher than the mean included those in Arizona sycamore (Table 1). Along the middle Rio Grande, nest height varied from 0.16 m (one nest in a saltcedar) to 15 m (one nest in a cottonwood), with a median of 1.7 m. Most (86%) nests were placed at heights of ≤3 m. With the exception of those in cottonwoods, Blue Grosbeak nests were placed at mean heights of ≤2.5 m in every species of nest plant observed (Table 1).

Nests were placed significantly lower along the Rio Grande than along the Gila River (Table 2). Additionally, nest plants were significantly shorter along the Rio Grande than along the Gila River, as they were in diameter at breast height. But the placement of the nest relative to the trunk or main stem did not differ. The mean distance of nests to water (either the river or a drain) was significantly smaller along the Rio Grande than along the Gila River. Of the 104 nests along the Gila River whose distance to the nearest

Table 2 Characteristics of Blue Grosbeak Nests and Nest Plants along the Middle Gila River (1997–2001) and the Middle Rio Grande (2000–2008) in New Mexico

	Middle Gila River		Middle Rio Grande		
Nest and nest-plant attributes	Mean ± SD	No. (%) nests	Mean ± SD	No. (%) nests	Result of *t* test (*P*)[a]
Nest height (m)	3.4 ± 3.12	105 (100)	2.2 ± 2.2	83 (98)	0.006**
Nest-plant height (m)	7.2 ± 5.8	104 (99)	5.2 ± 3.3	77 (91)	0.006**
Diameter of nest plant at breast height (cm)	22.5 ± 38.9	104 (99)	8.5 ± 13.5	77 (91)	< 0.001**
Distance from trunk or main stem (m)	0.9 ± 1.5	85 (81)	0.8 ± 2.2	73 (86)	0.9
Distance from water (m)	113.9 ± 177.8	93 (89)	67.1 ± 57.4	80 (94)	0.025*
Distance from edge (m)	4.7 ± 8.3	104 (99)	—	—	—

[a]Levels of significance: *$P < 0.05$; **$P < 0.01$.

edge was recorded, 83 (80%) were placed ≤5 m from the nearest edge; 48 (46%) were ≤1 m from the nearest edge (Table 2). Although distance to the nearest edge was not quantified during field work along the Rio Grande, nests placed along edges were also common, if not typical, in that study area.

Nest Success

We were able to determine the outcome of 60 nests along the Rio Grande and 67 nests along the Gila River (Table 3). The observed proportion of successful nests along the two rivers did not differ significantly ($\chi^2 = 0.38$, df = 1, $P = 0.427$). The cause of nest failure remained unknown in many cases, especially along the Rio Grande (Table 3). Along the Gila River, however, more than half of all failures were caused by predation. Less frequently, nest failure was caused by weather or the nest failed to produce any Blue Grosbeak fledglings but instead fledged cowbirds. Along the Rio Grande, cowbird parasitism, predation, and weather were all responsible for some of the failures.

Along the Rio Grande, we were able to determine the outcome of 42 (78%) of the 54 nests in saltcedar, and of those 17 (45%) were successful, a proportion that was not significantly ($\chi^2 = 0.15$, df = 1, $P = 0.694$) different from that of nests in substrates other than saltcedar.

DISCUSSION

Several studies (Hunter et al. 1988, Brown and Trosset 1989, Rosenberg et al. 1991, Ellis 1995) have shown the Blue Grosbeak to readily occupy, and nest in, saltcedar-dominated riparian habitats. Our study was not designed

Table 3 Observed Total Number of Blue Grosbeak Nests, Successful Nests, and Nests that Failed by Cause along the Middle Gila River (1997–2001) and the Middle Rio Grande (2000–2008), New Mexico

	Gila River		Rio Grande	
Observed number of nests	105	(100)	85	(100)
Number (%) of nests with known outcome	67	(64)	60	(71)
Observed number (%) of nests that succeeded	36	(54)	28	(47)
Observed number (%) of nests that failed	31	(46)	32	(53)
Observed number (%) of nests that failed because of predation	17	(55)	3	(9)
Observed number (%) of nests that failed because of cowbird parasitism	6	(19)	9	(28)
Observed number (%) of nests that failed because of weather	2	(6)	0	(0)
Observed number (%) of nests that failed from an undetermined cause	6	(19)	20	(62)

to assess use of nest plants relative to their availability, but nesting Blue Grosbeaks did not seem to avoid saltcedar at any of the Rio Grande sites where it was dominant. Along the Rio Grande, we found the grosbeaks to nest not only in saltcedar-dominated vegetation but also to use saltcedar as the most frequent nest-supporting plant.

In riparian areas, Blue Grosbeak nests are typically found close to the ground (Bent 1968, Rosenberg et al. 1991, Averill 1996). Powell and Steidl (2000), however, showed that nests can also be built high in trees where the understory vegetation is sparse. Along both the Rio Grande and the Gila River, most nests were constructed at heights of ≤3 m above ground, many of them at heights of only 1 m or less. We also detected nests in trees, however, and as Powell and Steidl (2000) reported, they tended to be found where little to no understory vegetation was present. Along the Rio Grande, we found seven nests in cottonwoods. Of those, only four were at heights of ≥2 m, and these were at sites where the shrub layer had been cleared. Tree nests were particularly common along the Gila River, in boxelders and Arizona sycamores. As the main nesting substrate, boxelder substantially raised the mean height of Blue Grosbeak nests along the Gila River. If nests in boxelder are excluded, the mean heights of nests along the Rio Grande (2.24 m) and along the Gila River (2.07 m) were similar. Boxelder tends to cast considerable shade, and along the Gila River we found it in stands with few shrubs growing underneath its foliage. Paralleling our finding that Blue Grosbeak nests were significantly higher along the Gila River than along the Rio Grande, Stoleson and Finch (2003) reported that along the Gila River Southwestern Willow Flycatchers nested primarily in boxelder and at heights greater than reported for other populations of that bird.

Throughout much of its distribution, the Blue Grosbeak often nests along woodland edges adjacent to open areas (Ingold 1993), and an association between nests and wooded riparian edges has been noted in Arizona (e.g., LaRue 2005) and in California (Gaines 1974, Riparian Habitat Joint Venture 2004). That association was also evident in both of our study areas. Along the Gila River, where we measured distances between nests and the nearest edges, that association was particularly pronounced. In contrast, close proximity to water did not characterize many of the nests along either the Gila River or the Rio Grande. This finding is congruent with that of other studies (e.g., Pequegnat 1951) showing that Blue Grosbeaks can nest in the absence of nearby water. We found the mean distance to water to be significantly higher along the Gila River, where the riparian zone tended to extend farther from the river channel and where most Blue Grosbeak nests were along the edges between the riparian forest and fields rather than along the edges between the riparian forest and river bank (Stoleson pers. obs.).

The differences between the Rio Grande and the Gila River we noted in the placement of Blue Grosbeak nests—in nest height, nest substrate, and distance from water—did not visibly translate into differences in nest success. Nest success was not significantly lower along the Rio Grande than along the Gila River despite the much greater representation of non-native plants in general and saltcedar in particular. Nesting in saltcedar was not associated with reproductive success lower than in other nests along the Rio Grande. Our study thus did not detect any direct harmful effect of saltcedar per se on the Blue Grosbeak's nest success along the Rio Grande. This finding seems congruent with the fact that in terms of habitat quality, saltcedar cannot simply be dismissed as poor or unsuitable habitat. The quality of saltcedar as habitat for birds varies geographically; it is also better for some riparian species than for others (Sogge et al. 2008).

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