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THE EFFECTS OF MESQUITE INVASION ON A SOUTHEASTERN ARIZONA GRASSLAND BIRD COMMUNITY

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ABSTRACT.—We determined which vegetal features influenced the distribution and abundance of grassland birds at the Buenos Aires National Wildlife Refuge, Arizona. The density and distribution of mesquite (*Prosopis velutina*) exerted the strongest influence on the grassland bird community. Abundances of Pyrrhuloxia (*Cardinalis sinuatus*; $r^2 = 0.363$, $P = 0.025$) and Lucy's Warbler (*Vermivora luciae*; $r^2 = 0.348$, $P = 0.04$), and total abundance of birds ($r^2 = 0.358$, $P = 0.04$) were positively correlated with increasing density of mesquite (*Prosopis velutina*), whereas abundance of Cactus Wren (*Campylorhynchus brunneicapillus;* $r^2 = 0.452$, $P = 0.02$) was negatively correlated with increasing mesquite density. Abundance of Loggerhead Shrike (*Lanius ludovicianus*; $r^2 = 0.693$, $P < 0.001$) was positively correlated with an increasing patchiness of mesquite. Shrub-dependent bird species dominated the community, accounting for 12 of the 18 species and 557 of the 815 individuals detected. Species relying on extensive areas of open grassland were largely absent from the study area, perhaps a result of the recent invasion of mesquite into this semi-desert grassland. *Received 15 Aug. 1997, accepted 19 Mar. 1998.*

Grassland birds have declined more rapidly in the past 25 years than any other avian guild (Knopf 1994), and results from the Breeding Bird Survey indicate that less than 30% of grassland species monitored show increasing trends (Sauer et al. 1995). Habitat destruction, primarily the conversion of native grassland to agricultural land, is often implicated in these changes (Sauer et al. 1995). In much of Arizona, overgrazing by livestock is likely the most immediate threat to grassland bird communities. Buenos Aires National Wildlife Refuge, which consists almost entirely of former ranchland, currently is the largest ungrazed grassland in the state and as such represents a potentially important source of habitat for grassland birds. However, the exclusion of fire, the invasion of introduced Lehmann lovegrass (*Eragrostis lehmanniana*), and the encroachment of woody shrub species such as mesquite (*Prosopis velutina*) all have contributed to the degradation of the ecosystem.

Historical records indicate that woody shrubs were largely absent from these grasslands. Brown and Archer (1989) speculated that the introduction of livestock coupled with the exclusion of fire facilitated the lateral spread of mesquite out of riparian areas. Efforts to enhance grass production for cattle also led to the introduction of Lehmann lovegrass in the 1930s, which outcompetes native grasses and forms large, nearly monotypic stands on upland areas at the refuge.

A number of researchers have evaluated the effects of the invasion of Lehmann lovegrass into semi-desert grasslands (e.g., Bock and Bock 1988, 1992), but virtually none has focused on the effects of mesquite invasion. Germano and coworkers (1983) observed more jackrabbits (*Lepus* spp.) and Gambel's quail (*Lophortyx gambelii*) in areas with mesquite than in rangeland that had been cleared of mesquite, but beyond this there have been few quantitative studies of the connection between mesquite and bird communities in southeastern Arizona. In this study, we evaluated the relationship between bird abundance and a number of large-scale vegetation features, including the density and distribution of mesquite. Quantifying these relationships may help in understanding the changes that occur within the bird community as a result of shifts in the physiognomy and species composition of the grassland plant community.

STUDY SITE AND METHODS

This study was conducted on the Buenos Aires National Wildlife Refuge, located in the Altar Valley of

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south central Pima County, Arizona. Elevations on the Refuge range from 912–1460 m. Lehmann lovegrass is the dominant grass species in upland areas with native grasses occurring only in small, scattered patches. Mesquite is essentially the only woody species in upland areas although acacia (*Acacia* spp.), seep willow (*Baccharis* spp.), and palo verde (*Cercidium* spp.) are found occasionally.

The climate of the area is semi-arid, with an average annual rainfall of 40.5 cm. Precipitation follows the pattern typical of the southwestern United States, with 60% falling in July and August and most of the remainder occurring during winter. Temperature extremes on the refuge range from −11° C in the winter to 41° C in the summer, with an average monthly mean of 17° C.

During the autumn of 1995, we randomly placed 12 25-ha plots (1000 × 250 m) in areas dominated by the Lehmann lovegrass/mesquite cover type, and then bisected each with a 1 km transect. All transects were at least 200 m from the nearest road to minimize disturbance and any edge effect, and all transects were separated by at least 500 m to maintain independence.

We conducted bird surveys on the transects between 4 April and 17 August 1996 using a line-transect method in which all birds heard or seen within 100 m of the transect were recorded. Surveys began at sunrise and were completed by 10:00 MST. We did not conduct surveys in rain or during periods of high wind.

During the spring and summer of 1996 we sampled vegetation along the 12 transects to determine percent cover of grasses, herbs, and shrubs; density of mesquite trees; and average size of mesquite trees. To measure percent cover, we divided each of the 1 km transects into a series of 20 m segments of which a subset of 6 was randomly selected for sampling. We measured percent cover by species along these segments using the line-intercept method of Canfield (1941). As suggested by Canfield (1941), we measured grass and herbaceous cover basally and shrub cover at the crown-spread intercept.

We sampled mesquite in 10 10-m radius plots on each transect. The plots were established every 100 m at a random distance (≤60 m) perpendicular to each transect. Within each plot, we measured the height and width of all trees that were taller than the surrounding grasses. We found that tree height and width were directly related ($r = 0.949$, $P < .001$), so we arbitrarily chose height as a representative measure of size.

Using simple linear regression, we evaluated the relationship between bird abundance and the following vegetation features: overall grass cover, percent cover of native grasses, percent cover of Lehmann lovegrass, average size of mesquite trees, and density of mesquite trees. Only bird species for which we had at least 20 observations were considered. In addition, we assessed the effect of environmental patchiness by comparing bird abundance with the coefficient of variation of mesquite density, again using simple linear regression. All statistical analyses were performed using SigmaStat version 2.0 (Jandel Scientific), PC version.

RESULTS AND DISCUSSION

The density and distribution of mesquite trees were the only measured features that influenced bird abundance on the study area. Mesquite densities ranged from approximately 111–255 trees/ha, but despite the relatively high densities, mesquite trees tended to be patchily distributed and thus all of the plots retained at least some open grassland.

Total bird abundance was positively correlated with an increasing density of mesquite (Fig. 1a; $r^2 = 0.358$, $P = 0.04$, $n = 12$), probably the result of a number of species showing a positive, yet non-significant, relationship with mesquite density. In a study conducted at the nearby Santa Rita Experimental Range, Maurer (1985) also found total songbird density to be greater in mesquite savannah than in open grassland, although density in the two vegetation types varied throughout the season depending on the nesting phenology of the dominant species in each type.

The abundances of Pyrrhuloxia (*Cardinalis sinuatus;* Fig. 1b, $r^2 = 0.363$, $P = 0.025$, $n = 12$) and Lucy's Warbler (*Vermivora luciae;* Fig. 1c, $r^2 = 0.348$, $P = 0.04$, $n = 12$) were positively correlated with increasing density of mesquite. Maurer (1985) also found both of these species to be more abundant in areas with high densities of mesquite, which fits well with previous descriptions of breeding habitat for these species. Pyrrhuloxia is considered to be a species of shrubby edges, often building their nests in mesquite trees (Bent 1968). Lucy's Warblers are foliage gleaners as well as being one of two North American cavity-nesting warblers and thus are likely to be dependent on mesquite for both foraging and nesting within the study area (Ehrlich et al. 1988). Based on these habitat requirements, it is unlikely that either of these species would have been widespread in these grasslands prior to the invasion of mesquite.

Not all species responded positively to increasing mesquite density. Cactus Wrens (*Campylorhynchus brunneicapillus*; Fig. 1d, $r^2 = 0.452$, $P = 0.02$, $n = 12$) were less abundant in areas of dense mesquite, although the exact nature of this relationship is not clear. McGee (1985) and Farley and Stuart (1994) reported that Cactus Wrens prefer nesting in

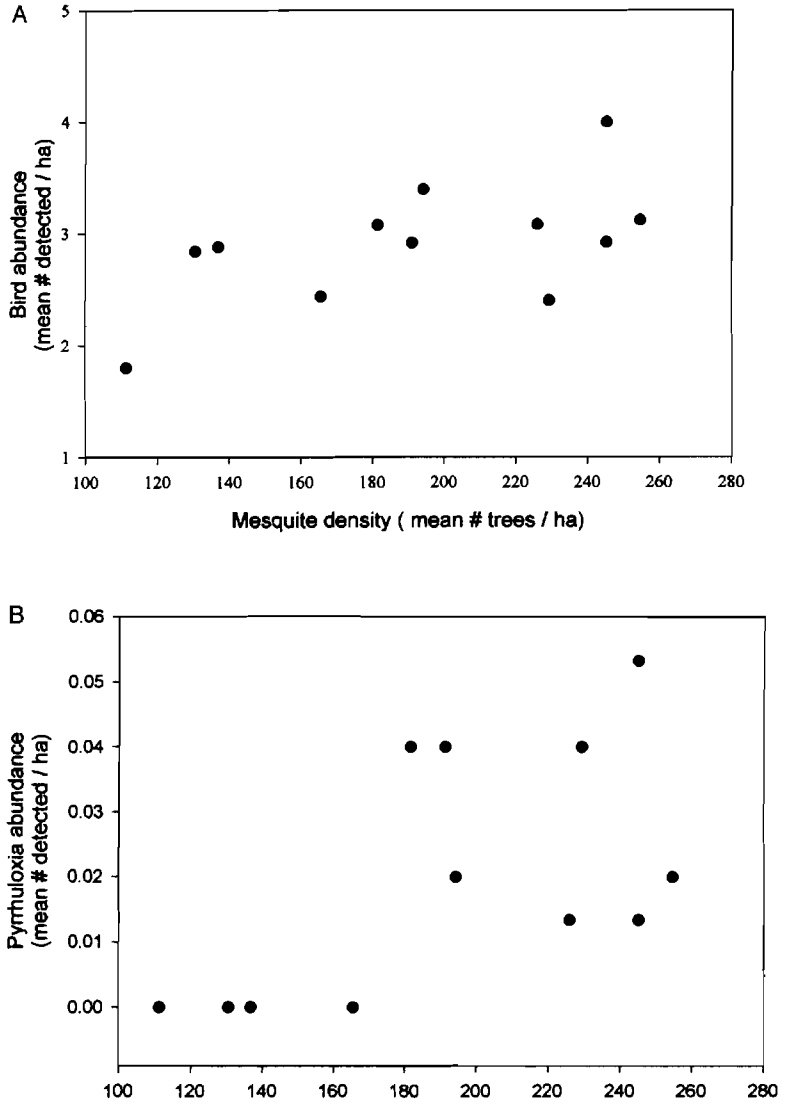

FIG. 1. Relationship between mesquite density and bird abundance on 12 study plots at Buenos Aires National Wildlife Refuge, Arizona. A. All species combined, B. Pyrrhuloxia, C. Lucy's Warbler, D. Cactus Wren.

cholla cacti (*Opuntia* sp.), which we observed to be absent from areas with a high density of mesquite. Thus, Cactus Wrens may be responding to the absence of their preferred nesting substrate rather than to changes in mesquite density. Nonetheless, a similar relationship was reported by Maurer (1985) in which Cactus Wrens were found occupying grassland sites at much greater densities than in mesquite savannah sites.

Although they did not respond directly to mesquite density, the abundance of Loggerhead Shrikes (*Lanius ludovicianus*) was positively correlated with an increasingly patchy distribution of mesquite ($r^2 = 0.693$, $P < 0.001$, $n = 12$). Again, this result is not surprising given the ecological requirements of the species. Loggerhead shrikes rely upon elevated perches in open areas from which to hunt their prey, and thus would benefit from

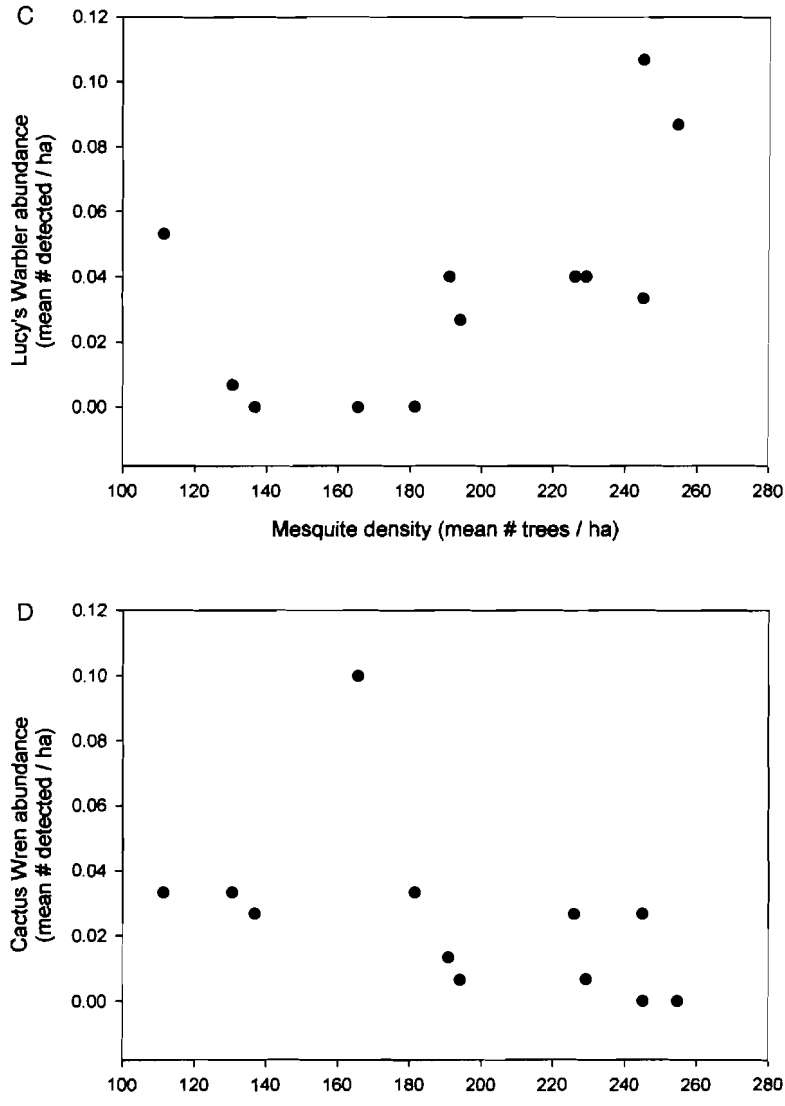

FIG. 1. Continued.

a mix of open grassland and scattered mesquite (Porter et al. 1975, Johnsgard 1986).

In addition to affecting the abundance of individual species, the spread of mesquite appears to have altered the overall bird species composition of grassland areas at the refuge. Of the 18 species for which we had at least 10 observations and which were known to breed on the refuge, 12 are species dependent on the presence of a shrub component (Table 1). This is reflected in the greater bird species richness found on plots with higher mesquite densities (r^2 = 0.491, P = 0.01, n =12). In addition to accounting for most of the species richness in this community, shrub-dependent species make up roughly 70% of the individuals present on the study area (Table 1). Maurer (1985) reported similar patterns, with shrub-dependent species accounting for roughly 60% of overall songbird density. This pattern of dominance by shrub-dependent species has likely come about only recently. Based on the records of early settlers these grasslands historically would not have provid-

TABLE 1. Total bird detections on transects at the Buenos Aires National Wildlife Refuge, Arizona, April to August 1996.

Species	Total number detected	Shrub-dependent?[a]
Black-throated Sparrow (*Amphispiza bilineata*)	251	Y
Eastern Meadowlark (*Sturnella magna*)	101	N
Lucy's Warbler (*Vermivora luciae*)	65	Y
Cassin's Sparrow (*Aimophila cassinii*)	57	N
Cactus Wren (*Campylorhynchus brunneicapillus*)	46	N
Ash-throated Flycatcher (*Myiarchus cinerascens*)	46	Y
Northern Mockingbird (*Mimus polyglottos*)	45	Y
Pyrrhuloxia (*Cardinalis sinuatus*)	36	Y
Loggerhead Shrike (*Lanius ludovicianus*)	33	Y
Mourning Dove (*Zenaida macroura*)	23	N
Blue Grosbeak (*Guiraca caerulea*)	21	Y
Botteri's Sparrow (*Aimophila botterii*)	17	N
Western Kingbird (*Tyrannus verticalis*)	14	Y
Brown-headed Cowbird (*Molothrus ater*)	14	Y
Horned Lark (*Eremophila alpestris*)	14	N
Bullock's Oriole (*Icterus bullocki*)	11	Y
Canyon Towhee (*Pipilio fuscus*)	11	Y
Verdin (*Auriparus flaviceps*)	10	Y

[a] Based on Bent 1968, Whitmore 1981, Ehrlich et al. 1988, Webb and Bock 1990, Farley and Stuart 1994.

ed suitable habitat for species requiring extensive shrub coverage (W. Kuvlesky, pers. comm.).

Although mesquite invasion has probably enhanced bird species richness in these semidesert grasslands, it may have diminished their suitability for grassland obligate species. For example, Grasshopper Sparrows (*Ammodramus savannarum*) were absent from the study area during the breeding season, although they did breed in nearby areas and were present on the study area during the winter. Grasshopper Sparrows rely on open grasslands and are thought to be sensitive to the encroachment of woody shrubs (Whitmore 1981), thus it may be reasonable to assume that the invasion of mesquite has resulted in a loss of habitat for this species.

Although most of the recent research on bird communities in the semidesert grasslands of southeastern Arizona has focused on the consequences of exotic grass invasion, our findings indicate that the spread of mesquite likely has had strong effects on the grassland avifauna as well. In fact, based on our knowledge of past conditions and on the habitat requirements of the species found within the study area, it is likely that much of the refuge now supports a very different bird community than was historically present, primarily as a result of shrub encroachment. Thus, ecosystem restoration efforts, which have until now been focused mainly on eliminating exotic grasses, should also include steps to reduce the density and extent of mesquite within traditionally open grasslands.

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LITERATURE CITED

BENT, A. C. 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows and allies. Bull. U.S. Nat. Mus. 237(1): 1–602.

BOCK, C. E. AND J. H. BOCK. 1988. Grassland birds in southeastern Arizona: impacts of fire, grazing, and alien vegetation. Pp. 43–58 *in* Ecology and conservation of grassland birds (P. D. Goriup, Ed.). International Council for Bird Preservation, Cambridge, U.K.

BOCK, C. E. AND J. H. BOCK. 1992. Response of birds to wildfire in native vs. exotic Arizona grassland. Southwest. Nat. 37:73–81.

BROWN, J. R. AND S. ARCHER. 1989. Woody plant invasion of grasslands: establishment of honey mesquite (*Prosopis glandulosa* var. *glandulosa*) on sites differing in herbaceous biomass and grazing history. Oecologia 80:19–26.

CANFIELD, R. H. 1941. Application of the line inter-

ception method in sampling range vegetation. J. For. 39:388–394.

EHRLICH, P. R., D. S. DOBKIN, AND D. WHEYE. 1988. The birder's handbook. Simon and Schuster, New York.

FARLEY, G. H. AND J. N. STUART. 1994. Atypical nesting sites of the cactus wren. Tex. J. Sci. 46:193–195.

GERMANO, D. J., R. HUNGERFORD, AND S. C. MARTIN. 1983. Responses of selected wildlife species to the removal of mesquite from desert grassland. J. Range Manage. 36:309–311.

JOHNSGARD, P. A. 1986. Birds of the Rocky Mountains. Univ. of Nebraska Press, Lincoln.

KNOPF, F. L. 1994. Avian assemblages on altered grasslands. Stud. Avian Biol. 15:247–257.

MAURER, B.A. 1985. Avian community dynamics in desert grasslands: observational scale and hierarchical structure. Ecol. Monogr. 55:295–312.

MCGEE, M. 1985. Interspecific nest interference: the influence of Cactus Wrens (*Campylorhynchus brunneicapillus*) on Verdin (*Auriparus flaviceps*) nest site selection. M. S. thesis, Univ. of Arizona, Tucson.

PORTER, D. K., M. S. STRONG, J. B. GIEZENTANNER, AND R. A. RYDER. 1975. Nest ecology, productivity and growth of the loggerhead shrike on the short-grass prairie. Southwest. Nat. 19:429–436.

SAUER, J. R., B. G. PETERJOHN, S. SCHWARTZ, AND J. E. HINES. 1995. The grassland bird home page. Version 95.0. Patuxent Wildlife Research Center, Laurel, MD. URL = http://www.mbr-pwrc.usgs.gov/bbs/grass/graslist.htm.

WEBB, E. A. AND C. E. BOCK. 1990. Relationship of the Botteri's Sparrow to sacaton grassland in southeastern Arizona. Pp. 199–209 *in* Managing wildlife in the southwest (P. R. Krausman and N. S. Smith, Eds.). Arizona Chapter of the Wildlife Society, Phoenix.

WHITMORE, R. C. 1981. Structural characteristics of Grasshopper Sparrow habitat. J. Wildl. Manage. 45:811–814.