SONGBIRD COMMUNITY COMPOSITION AND NESTING SUCCESS IN GRAZED AND UNGRAZED PINYON–JUNIPER WOODLANDS

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Abstract: Livestock grazing is a dominant land use of pinyon–juniper habitats in the western United States, yet the effects of grazing on breeding bird communities in this habitat have been poorly studied. We compared habitat structure, songbird abundance, and nesting productivity within pinyon–juniper woodlands on an actively grazed site and a site experiencing long-term relief from livestock grazing in northeastern New Mexico. From 1992 to 1995, we performed vegetation sampling, conducted songbird point counts, and located and monitored nests on 8 35-ha study plots. Four of these plots experienced moderate cattle grazing and 4 were ungrazed since 1973. We found no differences in habitat or vegetation features between grazed and ungrazed plots. Bird communities were similar, with only 1 of the 11 species we tested more abundant on the ungrazed treatment (western scrub-jay; *Aphelocoma californicus*). We detected no differences in nesting success or cause-specific rates of nest failure for 7 common bird species ($P < 0.05$), and we detected no differences in brown-headed cowbird (*Molothrus ater*) parasitism rates for the major hosts between grazed and ungrazed areas. Greater than 75% of the nests of the solitary vireo (*Vireo solitarius*), western tanager (*Piranga ludoviciana*), and blue-gray gnatcatcher (*Polioptila caerulea*) were parasitized on both treatments. These high parasitism rates may be the result of high densities of local cowbirds because of abundant feeding sites (i.e., livestock), the high mobility of cowbirds, and the close proximity of ungrazed plots to grazed areas (all <4 km). Our results suggest that 20 years of relief from grazing had little influence on the habitat structure or bird species composition of the pinyon–juniper woodlands on our study site. However, livestock grazing has indirectly affected the nesting success of some songbird species via the influence of grazing on cowbird abundance. Our findings highlight the need for studies that incorporate nest monitoring and landscape-scale approaches to better understand the relation between cowbirds, livestock, and songbirds, and the time required for recovery from grazing effects.

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Livestock grazing is a dominant land use in the western United States, with over 85 million ha grazed regularly on federal lands alone (Sabadell 1982). Among the least studied of the grazed forest types in the West is pinyon–juniper. Pinyon–juniper habitat occupies over 24 million ha (Tidwell 1987), with livestock grazing as its primary land use (Buckman and Wolters 1987). Neotropical migrant songbirds commonly constitute 30–50% of the breeding bird species in pinyon–juniper woodlands (Balda and Masters 1980). At present, however, the breeding bird communities of this habitat have been poorly studied, and virtually nothing is known about the influence of grazing on birds within pinyon–juniper systems (Bock et al. 1993).

Numerous studies have shown that livestock grazing can alter avian species' composition (Ryder 1980, Bock et al. 1993), and a few studies have shown effects on nesting success (Weller et al. 1958, Kirsch and Higgins 1976, Barker et al. 1990). In general, grazing influences plant communities by modifying plant biomass, structural components such as vegetation height and cover, and plant species composition (Holechek et al. 1989). These vegetation changes, in turn, may affect availability of avian foraging sites, food resources such as seeds, mast, and insects (Ryder 1980, Putnam et al. 1989), and nesting sites and cover (Koerth et al. 1983, Bowen and Kruse 1993). Additionally, the presence of livestock may influence nesting success of ground-nesting species through direct trampling of nests (Koerth et al. 1983).

For songbirds, nest losses due to brood parasitism by the brown-headed cowbird (hereafter, cowbird) also could be an important indirect effect of livestock. The cowbird is an open-habitat species that commonly associates with

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livestock because of the foraging opportunities livestock provide (Mayfield 1965). In the western United States, expansion of livestock grazing into forested areas appears to have facilitated cowbird population increases and range expansion (Rothstein et al. 1984). Given that brood parasitism generally reduces host nesting productivity (Mayfield 1965), increases in cowbird abundance could affect the breeding success of songbird populations.

We sought to evaluate the direct effects of long-term livestock removal on songbird abundance and breeding productivity in pinyon–juniper woodlands in a predominantly grazed region. We tested the hypotheses that there is no difference in vegetation structure, bird species richness and abundance, or nesting productivity between an actively grazed and an ungrazed habitat. Our specific objectives were (1) describe and compare habitat characteristics between a currently grazed and ungrazed (20 yr of relief) pinyon–juniper site; and (2) assess and compare songbird species richness, abundance, and nesting success between the 2 treatments.

STUDY AREA

We conducted this study on the National Rifle Association (NRA) Whittington Center and the adjacent V-7 Ranch in Colfax County, northeastern New Mexico. Both sites lie on the eastern slope of the Sangre de Cristo Mountains, 18 km south of Raton, New Mexico. Shortgrass prairie, dominated by blue grama (*Bouteloua gracilis*), occupies the lower zones of these sites (<1,990 m). Woodlands of pinyon pine (*Pinus edulis*) and one-seed juniper (*Juniperis monosperma*) occupy a narrow zone on the lower mountain slopes (1,990–2,130 m). Forests of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) dominate at higher elevations. Climate is temperate and semiarid, averaging 45 cm precipitation annually.

Livestock grazing has been the primary land use in this region for over a century (Murphy 1969). In 1973, the NRA purchased 13,350 ha of rangeland to create the NRA Whittington Center, a private firearm shooting and training facility. At this time, livestock grazing was stopped and natural succession allowed to proceed.

The 8,090-ha V-7 ranch lies north of the NRA Whittington Center and remains an active cattle operation. Most of the ranch consists of open prairie, with pinyon–juniper limited to lower mountain slopes. Cattle primarily grazed on the prairies, but pinyon–juniper was also used regularly for foraging, shade, and rest. The portion of the ranch used in this research is operated as a 3-season (Nov–Jun) cow–calf operation with a stocking rate of 1.3 ha/animal unit month. Annual forage use on the grasslands of this site averaged 45–50%. This livestock management constitutes moderate grazing during the dormant season, with growing season and autumn rest. Similar stocking rates and grazing systems have been used on this site for about the past 50 years and were used on the NRA Whittington Center lands prior to its elimination of livestock in 1973. Wild herbivores, including elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and black-tailed jackrabbit (*Lepus californicus*) were present throughout the study area.

METHODS

Selection of Study Plots

In spring 1992, we established 8 35-ha study plots on 2 treatments that reflected currrent land management practices: currently grazed, and 20 years relief from grazing (hereafter, ungrazed). These plots were randomly chosen in the narrow band of pinyon–juniper woodland. Each plot had some intrusion of shortgrass prairie. Ungrazed plots ranged from 50 m to 4 km away from boundaries of active cattle ranches. We were limited to 1 ungrazed site because of the scarcity of habitat excluded from long-term livestock grazing in northeastern New Mexico.

We recognize the potential complications of pseudoreplication (Hurlbert 1984) based on our site selection procedures. Wester (1992) suggests that pseudoreplication is a matter of scale and challenges classic criticisms of single treatment studies where samples are taken in close proximity. For the purpose of our study, we assumed that bird communities on the NRA Whittington Center and the V-7 Ranch represent independent populations. Plots (replicates) within each treatment were randomly selected from all potential plots within the defined population of the treatment. However, because pseudoreplication remains an unresolved issue, we limit conclusions drawn from our study to the NRA Whittington Center and the V7 Ranch.

Habitat and Vegetation Measurements

We measured habitat and vegetation characteristics on the 8 plots during July and August

1992. We based the habitat sampling scheme on a 12-point grid system on each plot. We arranged points in a 3 × 4 grid separated by 200 m, with outer points located 50 m from plot edges. We measured 4 vegetation sampling subplots at each point. The first subplot was centered on the point, while the remaining 3 were spaced 120° apart, at randomly designated distances (30–50 m) from the point. The location of the first outer subplot was established via a random compass bearing.

We sampled vegetation on subplots at 2 spatial scales: (1) a 5-m-radius subplot (0.008 ha) and, (2) an 11.3-m-radius subplot (0.04 ha). Within the 5-m-radius subplot, we counted shrubs and saplings (woody plants >25 cm tall but <8 cm diameter at breast height [dbh]) by species in 2 height classes (<1.4 m and >1.4 m). Within the 11.3 m radius subplot, we counted trees by species in 2 diameter classes (8–23 cm and >23 cm dbh). We also counted all snags >12 cm dbh.

We established north–south and east–west transects across the 5-m-radius subplot for additional habitat and vegetation measurements. We made measurements of litter depth at 2-m intervals on the transect lines, with 5 readings per line totaling 10 readings in each subplot. We measured slope and average canopy height with a clinometer. We estimated canopy cover at the center of the subplot with 4 readings of a spherical densiometer (Lemon 1956). We measured ground cover using 5 0.82-m-radius sampling hoops. We located 1 hoop on the plot center, with additional hoops randomly located 2–5 m from the center and on the transects in each of the 4 cardinal directions. Within hoops, we visually estimated percent ground cover for the following categories: bare ground, litter, rock, and individual plant species. Vegetation <25 cm tall was considered ground cover.

We summarized vegetation characteristics at the plot and treatment level. We used 1-way analysis of variance (ANOVA) for treatment comparisons of habitat variables (slope, canopy cover, canopy height, litter depth), shrub abundance within the 5-m-radius subplot, and tree abundance within the 11.3-m-radius subplot. We also compared percent ground cover estimates with 1-way ANOVA. Any variables defined as a percentage were arcsine square-root transformed prior to testing. Because 32 different comparisons were made, we used the Bonferroni inequality (Snedecor and Cochran 1980) to control the experimentwise error rate at $\alpha = 0.05$.

Bird Surveys

We used the point count method (Verner 1985) to survey breeding birds on the 12-point grid of each plot between 15 May and 15 June, 1992–95. We used the systematically arranged grid of points to ensure coverage of each plot and to minimize double counting of individual birds. Counts at each point lasted 10 min, and we recorded birds observed or heard within 50 m of the point center, by species, for calculation of abundance indices.

We surveyed 1 plot/morning when winds were low (<15 km/hr), and there was no precipitation during the sampling period. Surveys began 15 min before sunrise and were completed within 3 hr (approx 0530–0830). We censused each plot 4 times in 1992 and 1993, and 3 times in 1994 and 1995. We randomly chose the order of plot visitation with the constraints that visits alternated between grazed and ungrazed plots, and we surveyed all 8 plots before the next series of surveys began. Starting points and paths between the 12 points of each plot varied on each survey to compensate for differences in bird detectability due to time of visitation.

We excluded several species from analyses because their activity or behavioral patterns made point counts an inaccurate survey technique (e.g., raptors and aerial foragers such as swallows [*Tachycineta* spp., *Hirundo* spp.], swifts [*Aeronautes* spp.], nighthawks [*Chordeiles* spp.]), or they were nonbreeding migrants passing through the plots. We calculated species richness for each plot in each year by counting the total number of species detected within 50 m of a point during the surveys. We used 2-way ANOVA to test for treatment and yearly differences in species richness.

We calculated species abundances as the total number of individuals detected on each survey. We then determined a mean abundance value for each year by adding together the observations, by species, for each plot and dividing by the number of surveys. We made statistical comparisons only when species had a mean abundance of >1.0 individuals on either treatment and were detected on at least half the surveys over all years. These criteria excluded species observed on only 1 or 2 plots but included species that were more widespread, even if they were largely limited to 1 treatment. We evaluated differences in abundance between treatments via 2-way ANOVA. Mean abundance of each species on each plot was the dependent variable, while year and treatment were independent variables. Species abundances that demonstrated significant year × treatment interactions were further analyzed, year-by-year, to examine the cause of the interaction.

Nest Searches and Monitoring

We located and monitored nests from early May through early August, 1992–95. We also monitored nests located beyond the plot edges but that could be readily relocated. Four to 7 observers searched for nests each year. To locate the nests of some species (e.g., cavity nesters), we used random searches for specific nesting features. More commonly, we located nests by following birds carrying nesting materials or by following incubating females during foraging bouts (Martin and Guepel 1993).

Upon location of a nest, we made an initial check to determine nest status and contents. To minimize any effect of the observer, we checked nests from as far away as possible and with little disturbance. We used extendable poles with attached mirrors to check nests above 2 m. We revisited nests every 2–4 days to monitor their fate. Checks continued until the nest either fledged young or failed. A nest was considered successful if it fledged ≥1 of the pair's own young. Cause of failure was determined when possible. Nests were considered failed due to cowbird parasitism either when the clutch was deserted within 3 days of a parasitism event or when all host young perished due to competition with a cowbird young.

We tabulated numbers of successful nests, failed nests, and exposure days of nests for all songbird species by treatment and year. We included in our analyses only nests that reached egg-laying stage and were monitored to a known fate. For analyses, we combined data from all 4 years because of the small sample sizes of nests for most species in each year and the lack of large differences in yearly nesting success.

We calculated nesting success and source-specific failure rates for species with ≥20 nests on both treatments via a modified Mayfield method (Heisey and Fuller 1985). Although we located only 15 plain titmouse (*Parus inornatus*) nests on ungrazed sites, titmouse nesting success also was analyzed so that a cavity-nesting species would be represented in the comparisons. We used chi-square analyses to compare survival rates and cause-specific failure rates between ungrazed and grazed sites (Sauer and Williams 1989).

For host species, we calculated the percentage of nests parasitized by cowbirds. This estimate included only host nests monitored through at least that portion of their incubation stage necessary to ensure adequate time for parasitism to occur, and because it was often impossible to confirm parasitism status of nests found with only nestlings. We used *G*-tests of independence to compare frequency of parasitism on grazed and ungrazed sites for hosts with at least 15 nests/treatment (Sokal and Rolf 1981).

RESULTS

Habitat and Vegetation Measurements

Comparisons of habitat and vegetation features revealed no differences between the current land management practices of grazed and ungrazed plots, even without adjusting the error rate with the Bonferroni correction (Table 1). Pinyon pine dominated the overstory in both treatments, composing >90% of the trees. Oak was the dominant shrub on most plots, representing >50% of the shrubs on both treatments. Understory vegetation generally was sparse on both treatments. Blue grama, fringed sage (*Artemisia frigida*), and western ragweed (*Ambrosia psilostachya*) dominated on flatter, open areas, while side-oats grama (*Bouteloua curtipendula*), galleta grass (*Hilaria jamesii*), and colombian needlegrass (*Stipa columbiana*) were more common on slopes.

Bird Surveys

Of the 41 breeding species in our species richness analyses, we detected 39 species on ungrazed sites and 36 on grazed sites (see Table 2 for scientific names of all bird species). We observed 34 species on both the grazed and ungrazed sites, with 5 species unique to the ungrazed sites and 2 unique to the grazed sites. All 7 species unique to a treatment were observed infrequently (mean abundance <0.15 detections/survey). Species richness did not differ between ungrazed and grazed plots ($P >$ 0.05; Table 2).

The abundance of bird species differed little between grazed and ungrazed sites (Table 2).

Table 1. Habitat and vegetation characteristics of grazed and ungrazed pinyon–juniper plots in Colfax County, New Mexico, 1992.

Habitat–vegetation categories		Ungrazed		Grazed	
		$\bar{x}$[a]	SE	$\bar{x}$	SE
Habitat characteristics					
Canopy height (m)		4.6	1.8	4.8	1.6
Slope (degrees)		9.7	0.9	12.5	0.6
Canopy cover (%)		38.7	2.2	37.0	2.3
Litter depth (mm)		14.6	0.8	14.3	0.8
Ground cover (%)					
Leaf litter		40.9	3.4	43.3	3.9
Rock		18.8	3.2	19.6	2.0
Bare ground		12.2	2.1	9.1	2.4
Grass		16.2	0.7	19.1	1.4
Forb		8.3	0.5	6.2	1.3
Shrub		3.8	0.4	3.0	0.2
Total green vegetation		28.3	0.9	28.2	2.7
Blue grama		6.5	0.9	7.2	1.9
Sideoats grama		2.2	0.6	3.5	0.5
Galleta grass		2.2	0.4	1.5	0.3
Woody stems >25 cm tall and <8 cm dbh (stems/0.008 ha)					
Oak (*Quercus* spp.)	<1.4 m tall	43.4	8.8	36.1	7.3
	>1.4 m tall	5.5	1.3	2.9	0.6
Skunkbush sumac	<1.4 m tall	4.3	1.7	5.5	2.6
(*Rhus aromatica*)	>1.4 m tall	1.7	1.3	0.4	0.3
Alder-leaf mountain mahogany,	<1.4 m tall	16.6	5.9	12.0	2.2
(*Cercocarpus montanus*)	>1.4 m tall	3.4	0.7	4.4	2.2
Conifers	<1.4 m tall	0.9	0.1	1.1	0.3
	>1.4 m tall	1.9	0.2	2.4	1.0
Cacti	Total	0.7	0.4	0.7	0.2
All Species	<1.4 m tall	67.0	10.8	56.0	7.1
	>1.4 m tall	12.6	1.8	10.2	3.7
Trees >8 cm dbh (stems/0.04 ha)					
Pinyon pine (*Pinus edulis*)	<23 cm dbh	15.5	0.6	15.8	1.6
	>23 cm dbh	0.7	0.1	0.7	0.1
Juniper (*Juniperis* spp.)	<23 cm dbh	0.8	0.3	1.3	0.9
	>23 cm dbh	0.1	0.1	0.1	0.1
Other species	<23 cm dbh	0.2	0.1	0.1	0.1
	>23 cm dbh	0.1	0.1	0.1	0.1
Snags (stems per 0.04 ha)					
All species	>12 cm dbh	0.5	0.9	0.7	0.4

[a] Means for all ungrazed and grazed characteristics did not differ (analysis of variance; 1, 6 df; $P > 0.05$).

Four of the 5 most abundant species on ungrazed treatments (spotted towhee, chipping sparrow, bushtit, cowbird) also were among the 5 most abundant on grazed sites. Spotted towhees dominated both sites, accounting for 29.8% of detections on ungrazed plots and 23.8% on grazed plots. The 15 most abundant species of either treatment represented >85% of all birds detected.

We detected 11 species in sufficient numbers to warrant analyses (Table 2). One species, the western scrub-jay, was more abundant on ungrazed sites. The spotted towhee was more abundant on ungrazed sites in 1992 and 1993, but its abundance did not differ between the treatments in 1994 or 1995 (Table 2). No species was more abundant on grazed sites in any year.

Nesting Success

We located and monitored 850 nests of 36 songbird species over the 4 years of the study (444 on ungrazed, 406 on grazed). Success rates and cause-specific failure rates did not differ by treatment for any of the 7 species examined (Table 3). However, large confidence intervals around success rates, particularly for species with smaller sample sizes, suggest tests of treatment differences often had low power. No nests failed as a direct result of cattle grazing or activity.

Cowbirds parasitized 81 nests of 6 species on

Table 2. Mean detections of songbird species present on ungrazed and grazed pinyon–juniper plots in Colfax County, New Mexico, 1992–95.

Species	Ungrazed		Grazed		
	$\bar{x}$[a]	SE	$\bar{x}$	SE	P[b]
Neotropical migrants					
Broad-tailed hummingbird (*Selasphorus platycercus*)	0.97	0.14	0.53	0.12	
Western kingbird (*Tyrannus verticalis*)	0.02	0.02	0.02	0.02	
Ash-throated flycatcher (*Myiarchus cinerascens*)	0.30	0.10	0.58	0.12	
Gray flycatcher (*Empidonax wrightii*)	0.10	0.05	0.68	0.25	
Western wood-pewee (*Contopus sordidulus*)	0.97	0.27	0.81	0.17	
House wren (*Troglodytes aedon*)	0.11	0.07			
Blue-gray gnatcatcher (*Polioptila caerulea*)	1.56	0.29	1.63	0.19	0.91
Solitary vireo (*Vireo solitarius*)	1.01	0.27	1.02	0.25	0.98
Virginia's warbler (*Vermivora virginiae*)	1.66	0.34	1.88	0.30	0.76
Black-throated gray warbler (*Dendroica nigrescens*)	0.06	0.04	0.43	0.17	
Black-headed grosbeak (*Pheucticus melanocephalus*)	0.56	0.14	0.78	0.19	
Blue grosbeak (*Guiraca caerulea*)	0.02	0.02			
Green-tailed towhee (*Pipilo chlorurus*)	0.02	0.02			
Chipping sparrow (*Spizella passerina*)	3.22	0.41	3.21	0.47	0.99
Western tanager (*Piranga ludoviciana*)	1.09	0.26	1.08	0.18	0.98
Hepatic tanager (*Piranga flava*)	0.07	0.05	0.02	0.02	
Short-distance migrants					
Mourning dove (*Zenaida macroura*)	0.39	0.10	0.13	0.05	
American robin (*Turdus migratorius*)	0.65	0.23	0.80	0.18	
Western bluebird (*Sialia mexicana*)	0.22	0.06	0.32	0.13	
Mountain bluebird (*Sialia curucoides*)	0.19	0.11	0.33	0.11	
Spotted towhee (*Pipilo maculatus*)	10.41	0.80	7.81	0.57	INT[c]
Lark sparrow (*Chondestes grammacus*)	0.28	0.07	0.26	0.07	
Brown-headed cowbird (*Molothrus ater*)	2.17	0.41	3.00	0.33	0.30
Pine siskin (*Carduelis pinus*)	0.06	0.06	0.06	0.05	
Lesser goldfinch (*Carduelis psaltria*)	0.25	0.07	0.32	0.11	
Residents					
Northern flicker (*Colaptes auratus*)	0.16	0.04	0.19	0.07	
Hairy woodpecker (*Picoides villosus*)	0.02	0.02	0.02	0.02	
Downy woodpecker (*Picoides pubescens*)	0.04	0.04	0.02	0.02	
Steller's jay (*Cyanocitta stelleri*)	0.16	0.10	0.05	0.03	
Western scrub-jay (*Aphelocoma californica*)	2.26	0.26	0.97	0.18	0.04
Pinyon jay (*Gymnorhinus cyanocephalus*)	1.02	0.38	0.95	0.37	0.93
Black-billed magpie (*Pica pica*)			0.02	0.02	
Mountain chickadee (*Parus gambeli*)	0.95	0.27	0.78	0.19	
Plain titmouse (*Parus inornatus*)	1.09	0.19	1.44	0.24	0.42
Bushtit (*Psaltriparus minimus*)	1.94	0.32	1.85	0.30	0.81
Pygmy nuthatch (*Sitta pygmaea*)	0.11	0.07			
Red-breasted nuthatch (*Sitta canadensis*)	0.56	0.26	0.56	0.26	
White-breasted nuthatch (*Sitta carolinensis*)	0.09	0.04	0.29	0.08	
Rock wren (*Salpinctes obsoletus*)	0.02	0.02			
Canyon towhee (*Pipilo fuscus*)			0.03	0.03	
Red crossbill (*Loxia curvirostra*)	0.08	0.06	0.03	0.03	
Total abundance	34.88	1.45	32.91	1.46	0.52
Species richness	19.06	0.60	20.31	0.76	0.43

[a] Mean number of individuals detected/survey. Species richness is mean number of species detected/survey.
[b] P-values of tests for treatment effects using 2-way analysis of variance with 1, 6 df.
[c] Year × treatment interaction (INT). Spotted towhees were more abundant on ungrazed sites in 1992 and 1993 ($P < 0.05$) but showed no differences in 1994 or 1995.

ungrazed plots (western wood-pewee, blue-gray gnatcatcher, solitary vireo, Virginia's warbler, western tanager, chipping sparrow) and 97 nests of 8 species on grazed plots (western wood-pewee, gray flycatcher, blue-gray gnatcatcher, solitary vireo, black-throated gray warbler, western tanager, spotted towhee, lesser goldfinch). Parasitism rates were extremely high on both treat-

Table 3. Nesting success and cause-specific rates of nest failure for species in ungrazed and grazed pinyon–juniper woodlands in Colfax County, New Mexico, 1992–95.

Species	Treatment	*n*	No. nests successful	Exposure days	Daily survival (SE)[a]	Nest outcome (%)[a]				
						Success (95% CI)	Depredation	Parasitism	Weather	Other
Tree, open nesters:										
Blue-gray gnatcatcher	Ungrazed	43	10	471.0	0.930 (0.012)	14 (7–27)	26	52	0	8
	Grazed	44	7	469.5	0.921 (0.012)	11 (5–22)	19	63	0	7
Western wood-pewee	Ungrazed	46	21	898.5	0.972 (0.006)	39 (27–57)	39	5	10	7
	Grazed	35	18	761.0	0.978 (0.005)	47 (33–68)	37	6	3	6
Solitary vireo	Ungrazed	32	5	395.0	0.932 (0.013)	11 (5–25)	39	49	0	0
	Grazed	37	1	476.0	0.924 (0.012)	9 (4–19)	28	41	5	18
Western tanager	Ungrazed	23	9	313.5	0.955 (0.012)	29 (15–55)	30	25	5	10
	Grazed	25	15	379.0	0.973 (0.008)	48 (30–76)	31	10	10	0
Tree, closed nester:										
Bushtit[b]	Ungrazed	56	50	815.0	0.993 (0.003)	80 (66–95)	0	0	0	20
	Grazed	41	39	631.0	0.997 (0.002)	90 (79–100)	5	0	0	5
Ground nester:										
Spotted towhee	Ungrazed	36	20	432.0	0.963 (0.009)	37 (23–60)	59	0	0	4
	Grazed	31	16	297.5	0.950 (0.013)	26 (13–51)	59	5	5	5
Cavity nester:										
Plain titmouse	Ungrazed	15	13	193.5	0.989 (0.007)	66 (37–100)	0	0	17	17
	Grazed	20	18	407.5	0.995 (0.003)	82 (63–100)	0	0	18	0

[a] Nesting outcome estimates and confidence intervals calculated using a modified Mayfield method described by Heisey and Fuller (1985). Daily survival rates and cause-specific failure rates (depredation, cowbird parasitism, failed due to weather, failed due to all other causes) were compared with species × treatment using chi-square tests described by Sauer and Williams (1989). No rates differed ($P > 0.05$).
[b] Bushtits build an enclosed, pendant nest that only has a small entrance hole.

Table 4. Cowbird parasitism rates (%) of host species nesting in grazed and ungrazed pinyon–juniper woodlands in Colfax County, New Mexico, 1992–95.

Species	Treatment	No. of nests	No. parasitized	% nests parasitized
Solitary vireo	Ungrazed	29	25	86
	Grazed	36	31	86
Western tanager	Ungrazed	19	17	89
	Grazed	20	16	80
Blue-gray gnatcatcher	Ungrazed	41	31	76
	Grazed	41	31	76
Spotted towhee[a]	Ungrazed	30	0	0
	Grazed	23	6	26
Western wood-pewee	Ungrazed	41	5	12
	Grazed	33	8	24

[a] Towhee nests were parasitized more frequently on grazed plots than ungrazed (G_1 = 11.03, P = 0.001). Parasitism frequency did not differ by treatment for any other species (P > 0.05).

ments (>75%) for blue-gray gnatcatchers, solitary vireos, and western tanagers (Table 4). Nests of these 3 species were also commonly parasitized with >1 cowbird egg. Spotted towhees were infrequent hosts but were parasitized more frequently on grazed sites (Table 4).

DISCUSSION

The influence of livestock grazing on bird populations is usually evaluated in terms of number of bird species and their relative abundance. This evaluation is used because livestock grazing often leads to changes in habitat structure (Holechek et al. 1989), and songbirds tend to be highly responsive to vegetation change (Cody 1985). We found no differences between the habitat characteristics of pinyon–juniper woodlands that experienced moderate, 3-season cattle grazing and woodlands that were ungrazed for 20 years. These results suggest that a land management practice of moderate livestock grazing did not alter the vegetation structure of the woodlands. However, at least 2 alternative explanations for these results may be proposed. First, it is possible we failed to measure the correct habitat variables, or we measured variables with inadequate precision. Second, 20 years relief from grazing may not allow adequate time for habitat recovery. Our sampling effort of habitat was both extensive and intensive. Thus, we believe our sampling was adequate, and had there been true treatment differences, we would have detected them. Alternatively, the successional status of our ungrazed site is unknown. Given the slow recovery time for pinyon–juniper habitat (Holechek et al. 1989), it is possible that considerable habitat recovery has yet to occur. With this uncertainty, conclusions concerning the effect of grazing on habitat structure on our study site are inconclusive.

Given the similarities of the habitats, it is not surprising that we also found few treatment differences in the composition of bird species. Other researchers studying songbird abundance in western riparian systems have also found instances of grazing systems with few apparent effects (Sedgwick and Knopf 1987, Medin and Clary 1991). The effect of livestock grazing can vary depending on the species of livestock, habitat, timing, and intensity (Holechek et al. 1989). Hence, the moderate, 3-season grazing system used on our study area possibly had minimal direct effects on the bird communities.

Habitat quality, however, cannot be evaluated solely on abundance estimates, because nesting productivity is an essential component (Van Horne 1983, Donovan et al. 1995). Grazing can directly affect nesting success by physically disturbing the nesting substrate or by damaging the contents of active nests (Weller et al. 1958, Barker et al. 1990). These effects should be most important for species nesting in low substrates and in areas where livestock are present during the breeding season. Although cattle were present on our grazed sites during the peak of the breeding season (May–Jun), we detected no differences between treatments in nesting success of any species. These findings differ from Weller et al. (1958) and Koerth et al. (1983) who demonstrated negative effects of grazing on nesting success where livestock were concentrated in heavily grazed grasslands and around watering facilities. We believe that the low cattle densities among the trees on our sites reduced the chances that cattle directly damaged nests or nest sites.

Moderate sample sizes in comparisons of nesting success in this study required large (>25%) differences in success for high probabilities of detecting differences (i.e., high power). In most instances, the similarity between treatments was obvious, and lack of power was probably not an issue. Nesting success differed between treatments by >15% only for the plain titmouse and western tanager, but our sample sizes were smallest for these species; hence, additional nesting studies are necessary for better comparisons. Regardless of treatment or power considerations, our nest-monitoring studies are the key findings of our research. First, some species (e.g., solitary vireo, blue-gray gnatcatcher) reproduce very poorly within pinyon–juniper habitats on our sites. Second, the poor nesting success of these species is largely due to cowbird parasitism.

Cowbird parasitism rates on our sites were among the highest observed, and cowbirds clearly imposed a considerable drain on the productivity of the bird community within our pinyon–juniper woodlands. High parasitism rates were not unexpected for our grazed sites, given the close association of cowbirds with cattle (Mayfield 1965). However, cowbird abundance and parasitism rates did not differ between treatments.

Cowbirds are unusual among passerines because their parasitic nature allows them to uncouple the location of their feeding and breeding activities (Rothstein et al. 1984). Cowbirds also are highly mobile, commuting up to 7 km daily between breeding and feeding sites (Rothstein et al. 1984, Thompson 1994). Within our study area, all ungrazed plots were <4 km from cattle grazing. This information suggests that female cowbirds could spend part of their day engaged in breeding activities in an ungrazed woodland, and part on a grazed area foraging with cattle several kilometers away. Because cowbird parasitism rates were extreme (>75%) and because these rates did not differ between treatments, we believe our inability to detect a direct influence of grazing may be a matter of scale. Specifically, the scale at which our study plots were distributed among treatments is finer than the scale of cowbird movements. As a result, both the ungrazed and grazed plots may uniformly experience a consequence of grazing, whereby a real treatment consequence of cattle grazing may be a regionwide increase in cowbird abundance and parasitism rates.

Elevated rates of cowbird parasitism have been previously documented in forest-edge habitats associated with agricultural landscapes (Brittingham and Temple 1983, Robinson 1992, Hahn and Hatfield 1995). In these localities, open agricultural areas provide cowbird feeding habitats, while adjacent forested habitats provide high host densities that may attract breeding cowbirds. Pinyon–juniper habitat on our site represents a natural edge between prairie and forest. In addition to existing in close proximity to cowbird feeding sites (i.e., cattle), pinyon–juniper also provides an abundance of available hosts. Thus, the high parasitism pressure observed in our woodlands has likely resulted from a natural habitat interface coupled with the presence of grazing.

MANAGEMENT IMPLICATIONS

A recent rise in public opinion against livestock grazing on public lands has caused land managers to reevaluate how grazing-oriented management strategies affect rangeland ecosystems and biodiversity (Cooperider 1990). There is little doubt that some grazing regimes can alter the characteristics of rangeland vegetation components sufficiently to influence songbird communities (Ryder 1980, Bock et al. 1993). In our study, however, moderate, 3-season cattle grazing has either had little effect on habitat structure, or 20 years relief from grazing is an insufficient amount of time for the habitat to recover from the effects of previous grazing regimes. This level of grazing may be inconsequential to songbird use and compatible with the goal of maintaining both songbird communities and populations in pinyon–juniper woodlands.

Unfortunately, examination of habitat effects is only a partial evaluation of the role of grazing. The most important finding of our research, evidence of indirect effects of grazing on the bird communities via cowbird parasitism, necessitates careful consideration. Livestock grazing provides the primary cowbird feeding habitat in our study region. This situation, combined with high cowbird mobility, leads to indirect effects on bird communities far beyond the grazing "fenceline." Researchers have begun to take landscape-scale approaches in studying patterns of cowbird distribution and effects of parasitism on hosts (Thompson 1994, Coker and Capen 1995, Donovan et al. 1995, Hahn and Hatfield 1995, Robinson et al. 1995). Thus, the typical approach of evaluating grazing effects by studying only the bird communities present in the habitat where grazing occurs may underestimate the actual influence of grazing by ignoring indirect effects occurring in surrounding habitats. We recommend that future studies of songbird–livestock interactions recognize the close association of cowbirds and livestock and take into consideration the potential landscape-level influence of cowbirds.

Considerable gaps still exist in knowledge of threats on the breeding grounds for many western Neotropical migrant songbirds (Finch

1991). On our site, the high rates of nest failure due to cowbird parasitism were suffered by the solitary vireo and the blue-gray gnatcatcher and likely made both the grazed and ungrazed pinyon–juniper habitats population sinks (sensu Pulliam 1988) for these small species. The ubiquity of livestock grazing in the western United States, the close link of cowbirds to livestock, and the vulnerability of many songbird species to cowbird parasitism suggests many other western bird populations could be experiencing similar scenarios. Additional monitoring studies of nests will be important in evaluating the extent of cowbird parasitism as a major constraint on nesting productivity of songbirds in western habitats.

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LITERATURE CITED

BALDA, R. P., AND D. L. MASTERS. 1980. Avian communities in the pinyon–juniper woodland: a descriptive analysis. Pages 146–169 *in* R. M. DeGraaf, technical coordinator. Proceedings of the management of western forests and grasslands for nongame birds. U.S. Forest Service General Technical Report INT-86.

BARKER, W. T., K. K. SEDIVEC, T. A. MESSMER, K. F. HIGGINS, AND D. R. HERTEL. 1990. Effects of specialized grazing systems on waterfowl production in southcentral North Dakota. Transactions of the North American Wildlife and Natural Resources Conference 55:462–474.

BOCK, C. E., V. A. SAAB, T. D. RICH, AND D. S. DOBKIN. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296–309 *in* D. M. Finch and P. W. Stangel, editors. Status and management of Neotropical migratory birds. U.S. Forest Service General Technical Report RM-229.

BOWEN, B. S., AND A. D. KRUSE. 1993. Effects of grazing on nesting by upland sandpipers in southcentral North Dakota. Journal of Wildlife Management 57:291–301.

BRITTINGHAM, M. C., AND S. A. TEMPLE. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31–35.

BUCKMAN, R. E., AND G. L. WOLTERS. 1987. Multiresource management of pinyon–juniper woodlands. Pages 2–4 *in* R. L. Everett, compiler. Proceedings of the pinyon–juniper conference. U.S. Forest Service General Technical Report INT-215.

CODY, M. L. 1985. An introduction to habitat selection in birds. Pages 3–56 *in* M. L. Cody, editor. Habitat selection in birds. Academic Press, New York, New York, USA.

COKER, D. R., AND D. E. CAPEN. 1995. Landscape-level habitat use by brown-headed cowbirds in Vermont. Journal of Wildlife Management 59:631–637.

COOPERIDER, A. Y. 1990. Conservation of biological diversity on western rangelands. Transactions of the North American Wildlife and Natural Resources Conference 55:451–461.

DONOVAN, T. M., F. R. THOMPSON, III, J. FAABORG, AND J. R. PROBST. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conservation Biology 9:1380–1395.

FINCH, D. M. 1991. Population ecology, habitat requirements, and conservation of Neotropical migratory birds. U.S. Forest Service General Technical Report RM-205.

HAHN, D. C., AND J. S. HATFIELD. 1995. Parasitism at the landscape scale: cowbirds prefer forests. Conservation Biology 9:1415–1424.

HEISEY, D. M., AND T. K. FULLER. 1985. Evaluation of survival and cause specific mortality rates using telemetry data. Journal of Wildlife Management 49:668–674.

HOLECHEK, J. L., R. P. PIEPER, AND C. H. HERBEL. 1989. Range management: principles and practices. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

HURLBERT, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187–211.

KIRSCH, L. M., AND K. F. HIGGINS. 1976. Upland sandpiper nesting and management in North Dakota. Wildlife Society Bulletin 4:16–20.

KOERTH, B. H., W. M. WEBB, F. C. BRYANT, AND F. S. GUTHERY. 1983. Cattle trampling of simulated ground nests under short duration and continuous grazing. Journal of Range Management 36:385–386.

LEMON, P. E. 1956. A spherical densiometer for estimating forest overstory density. Forest Science 2:314–320.

MARTIN, T. E., AND G. R. GEUPEL. 1993. Nest-monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithithology 64:507–519.

MAYFIELD, H. A. 1965. The brown-headed cowbird with old and new hosts. Living Bird 4:13–28.

MEDIN, D. E., AND W. P. CLARY. 1991. Breeding bird populations in a grazed and ungrazed riparian habitat in Nevada. U.S. Forest Service Research Paper INT-441.

MURPHY, L. 1969. Out in God's country: a history of Colfax County, New Mexico. Springer Publication Company, Springer, New Mexico, USA.

PULLIAM, H. R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652–661.

PUTNAM, R. J., P. J. EDWARDS, J. C. E. MANN, R. C. HOW, AND S. D. HILL. 1989. Vegetational and faunal changes in an area of heavily grazed woodland following relief from grazing. Biological Conservation 47:13–32.

ROBINSON, S. K. 1992. Population dynamics of breeding Neotropical migrants in a fragmented Illinois landscape. Pages 408–418 *in* J. M. Hagan, III, and D. W. Johnston, editors. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C., USA.

———, F. R. THOMPSON, III, T. M. DONOVAN, D. WHITEHEAD, AND J. FAABORG. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987–1990.

ROTHSTEIN, S. I., J. VERNER, AND E. STEVENS. 1984. Radio-tracking confirms a unique diurnal pattern of spatial occurrence in the parasitic brown-headed cowbird. Ecology 65:77–88.

RYDER, R. A. 1980. Effects of grazing on bird habitats. Pages 51–64 *in* R. M. DeGraaf, technical coordinator. Proceedings of the management of western forests and grasslands for non-game birds. U.S. Forest Service General Technical Report INT-86.

SABADELL, J. E. 1982. Desertification in the United States. Bureau of Land Management, Washington, D.C., USA.

SAUER, J. R., AND B. K. WILLIAMS. 1989. Generalized procedures for testing hypotheses about survival or recovery rates. Journal of Wildlife Management 53:137–142.

SEDGWICK, J. A., AND F. L. KNOPF. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. Journal of Wildlife Management 51: 230–237.

SNEDECOR, G. W., AND W. G. COCHRAN. 1980. Statistical methods. Seventh edition. Iowa State University Press, Ames, Iowa, USA.

SOKAL, R. R., AND F. J. ROLF. 1981. Biometry: the principles and practices of statistics in biological research. W. H. Freeman, San Francisco, California, USA.

THOMPSON, F. R., III. 1994. Temporal and spatial patterns of breeding brown-headed cowbirds in the midwestern United States. Auk 111:979–990.

TIDWELL, D. P. 1987. Pinyon–juniper woodlands: times have changed, but do we know it? Pages 5–8 *in* R. L. Everett, compiler. Proceedings of the pinyon–juniper conference. U.S. Forest Service General Technical Report INT-215.

VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893–901.

VERNER, J. 1985. Assessment of counting techniques. Current Ornithology 2:247–302.

WELLER, M. W., B. H. WINGFIELD, AND J. B. LOW. 1958. Effects of habitat deterioration on bird populations of a small Utah marsh. Condor 60: 220–226.

WESTER, D. B. 1992. Replication, randomization and statistics in range research: a viewpoint. Journal of Range Management 45:285–290.

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