

**Breeding and Migratory Birds of the Northern Jaguar Reserve of
East-Central Sonora, Mexico**

FINAL REPORT

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Yellow-green Vireo



White-tipped Dove nest



Military Macaw

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Introduction

Recent acquisition of lands that comprise the Northern Jaguar Reserve offer excellent prospects for conserving, managing, and studying populations of birds in a remote region of east-central Sonora, Mexico. This region is thought to be important to both resident and migratory populations of birds because it supports a diversity of environments, is located near the northern edge of vegetation communities with Neotropical affinities, and is one of the largest and least fragmented wildlands in northwestern Mexico. Furthermore, this area is situated along the Rio Yaqui, a vast lowland corridor through rugged mountains that connects northwest Mexico with the borderlands of Arizona and New Mexico and may thereby provide an important pathway for migratory birds. Despite the significance of this region, little information on bird communities is available.

Much of the information on birds that is available in this region was obtained by Bryan Brown while studying bald eagles (*Haliaeetus leucocephalus*) along the Rios Aros, Bavispe, and Yaqui (Brown and Warren 1985, Brown 1988). Accounts of birds in Brown's unpublished field notes were summarized and mapped by Russell and Monson (1998). More recently, an expedition led by biologists from the University of Arizona described 80 species of birds along a 185 km stretch of the Rios Aros (below Natora) and Yaqui and in adjacent side canyons during July and August of 2005 (O'Brien et al. 2006). Most recently in April 2007, Peter Warshall, Noel Snyder, and others described bird observations in several portions of the reserve (Warshall 2007). To aid management and conservation efforts on the Northern Jaguar Reserve, I studied bird communities in July and September of 2007. I timed my efforts so I could describe communities of breeding birds, record the first fall migrants, and survey migratory birds during the peak of fall migration.

Objectives

I proposed to describe bird communities on the Northern Jaguar Reserve, assess important areas for birds, and to provide information to focus management and guide future land acquisitions and bird studies. My primary objectives were to:

- 1) Estimate bird species presence and abundance.
- 2) Assess passage times for Neotropical migratory landbirds in fall.
- 3) Assess important vegetation resources and areas for Neotropical migratory landbirds.
- 4) Develop and apply standardized repeatable methods to address these objectives and monitor populations over time.

Methods

I selected areas for surveys non-randomly and chose sites that were representative of a wide range of environments present in the reserve. At the lowest elevation, I surveyed riparian and adjacent upland vegetation along the Rio Aros below los Chino. At the highest elevation, I surveyed oak woodland on slopes and in canyons on Mesa Encinosa in the Sierra Zetasora. I established transects along drainages in major canyons in six additional areas: above and below the ranch house at Los Pavos, above the ranch house at Hubaral, above and below the ranch house at Babisal, in Canyon el Huijalo, and from near the reserve's southern boundary to approximately 1 km north of the ranch house at la Ventana (Fig. 1). Canyons at Hubaral, Babisal, and el Huijalo drain the east side of the Sierra Zetasora. La Ventana is located along Arroyo el Sapo, a major valley bottom that drains lowlands southeast of the reserve. Arroyo los Pavos drains a portion of the Sierra los Pavos in the northern portion of the reserve and empties into the nearby Rio Yaqui.

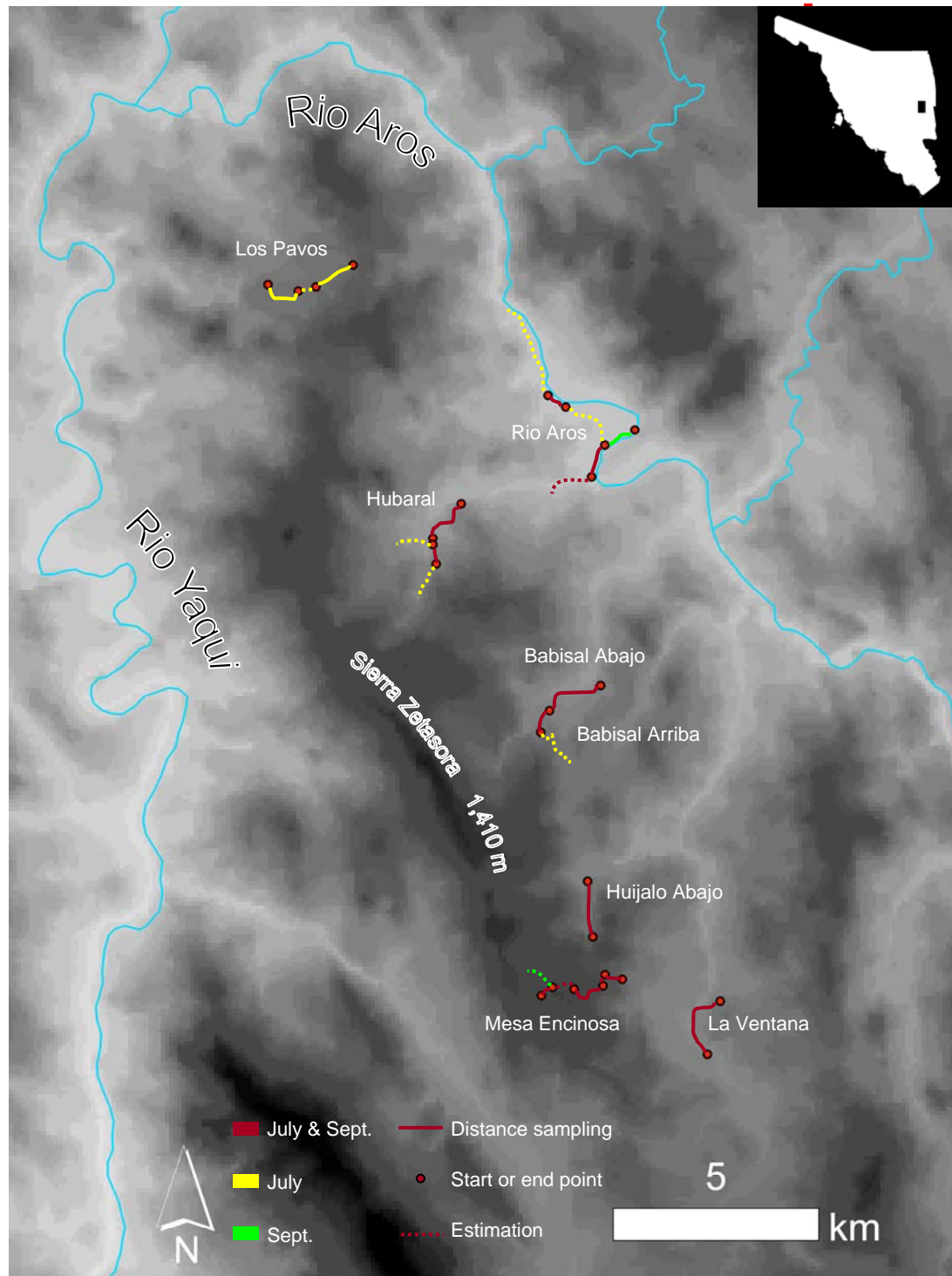


Figure 1: Map of study area on the Northern Jaguar Reserve showing bird transects sampled in July and September 2007. Solid lines indicate transects along which I recorded distances to all birds detected during mornings and dotted lines indicate extensions to these transects along which I estimated numbers. Lighter shading indicates progressively lower elevations.

I used two methods to sample birds along transects. To estimate abundance, I used distance sampling (Buckland et al. 2001), which involves using a rangefinder to measure perpendicular distances to all birds seen or heard from the transect line and using distances to model a detection function that correct estimates of abundance for variation in detectability. I used distance sampling from 30 min before sunrise to approximately four hrs after sunrise and slowly walked transects. To estimate relative abundance, I used a more flexible method that involved counting the number of individuals I detected along each transect. I used this method along transects in conjunction with distance sampling because it allowed me to extend the length of transects and survey across a wider range of times during the morning. I noted species and individuals that I detected incidentally while in camp and while traveling between transects. I broadcast recorded territorial calls of owls and nightjars in camp to assess presence of nocturnal species.

To estimate abundance, I calculated the length of each transect and estimated density during both July and September with use of program DISTANCE (Thomas et al. 2005). To generate season-specific estimates of density, I pooled data from all transects, stratified by season, and fit half normal and hazard key functions with cosine, polynomial, and hermite adjustment terms so as to consider a range of potential detection functions. To select the most appropriate detection function, I used Akaike's information criterion. To quantify the precision of estimates, I calculated a coefficient of variation. I estimated density of 14 species or species groups across a range of encounter rates because 1) resources were insufficient to estimate density for all species and 2) a minimum number of approximately 50 encounters are required for precise estimates of density (Buckland et al. 2001). To assess density of Neotropical migratory species of birds, I pooled detection data for all species that are known to migrate through the reserve and that breed north of the study area such that migratory species that also breed on the reserve were not included. As an exception, I considered Lucy's warblers as Neotropical migrants because, 1) they nest early and migrate soon after, 2) most detections ($n = 25$ or 83%) were in September, and 3) no individuals that I detected in July were singing, territorial, or exhibiting other behavior indicative of breeding. To assess which transects supported the highest densities of Neotropical migrants in September, I stratified by transect and grouped migrants by foraging guild [e.g. foliage gleaners (warblers and vireos) and aerial foragers (flycatchers)] to facilitate comparisons.

To estimate relative abundance, I calculated the number of individuals, pairs, or singing males of each species along each transect. I focused on estimating numbers of rare species or those of interest, and often noted only presence of abundant species along transects. To determine breeding status, I searched for nests during and mainly after surveys and used the criteria of the North American Ornithological Atlas Committee (1990) to classify breeding status of each species as possible, probable, or confirmed. To determine species that were migratory, I supplemented my observations with data from Sonora (van Rossem 1945, Marshall 1957, Russell and Monson 1998, O'Brien et al. 2006, Flesch *in press*, Flesch *unpubl. data*).

I also assessed a method for estimating the importance of vegetation resources for migratory species. Both during and after surveys, I recorded the plant substrate (foliage, flowers, branches, trunk) and plant species in which I observed migratory individuals and estimated bird height to the nearest meter for a sample of individuals that I detected. These observations combined with data on attack rates (e.g. eat, glean, hammer, probe) can allow the quality of each plant substrate and plant species to be assessed across time and space because attack rates are positively associated with prey abundance (Johnson 2000). For each individual, I noted all attacks for up to 10 minutes or as long as an individual could be followed; I only recorded observations >20 sec in length. In this report, I present information only on use of plant substrates because too few samples were obtained for meaningful quantitative comparisons because time and personnel available during this project was limited.

Table 1: Transects names and segments, survey dates, and number of detections during distance sampling on the Northern Jaguar Reserve, 2007.

Transect name	Segment	Survey date		Transect length		Detections	
		July	Sept	July (m)	Sept (m)	July	Sept
Los Pavos	Canyon	12		700		114	
Los Pavos	Road above ranch	12		1050		93	
Rio Aros	Section 1	13	14	900	1720	84	224
Rio Aros	Section 2	13		540		29	
Hubaral	Lower	14	13	1150	1150	172	181
Hubaral	Upper	14		520		64	
Babisal Abajo	Babisal Abajo	15	15	1700	1700	185	134
Babisal Arriba	Babisal Arriba	16	15	700	700	124	64
Hujjalo Abajo	Hujjalo Abajo	17	17	1400	1400	187	138
Mesa Encinosa	Camp to tank	18	16	470	470	66	78
Mesa Encinosa	Road and Mesa	18	16	850	850	61	44
Mesa Encinosa	Hujjalo Arriba	18	16	420	420	92	54
La Ventana	La Ventana	19	12	1600	1600	231	245

Results and Discussion

I detected 124 species, 91 in July and 107 in September (Appendix A). Of these species, 71% (88) were potentially breeding, 25% (31) were migratory, and status of five remaining species (American kestrel, peregrine falcon, northern pygmy-owl, blue-throated hummingbird, and yellow grosbeak) was unknown. Of species that were potentially breeding, 32% (28) were confirmed breeding, 33% (29) were probably breeding, and 35% (31) were possibly breeding (Appendix A). American kestrel and peregrine falcon likely breed on or immediately adjacent to the reserve but were detected after the breeding season.

Length of transects along which I employed distance sampling averaged 1,467 m (range = 700-1,750 m) and were somewhat longer in July than in September (Table 1, Fig. 1). Number of individuals, pairs, or flocks that I detected along each transect during distance sampling averaged 161 (range = 59-218; Table 1). I did not survey los Pavos in September because the road was washed out due to intense monsoon storms that preceded my visit. Length, elevation, and start and end coordinates of each transect and segment are summarized in Appendix B.

Along transects where I used distance sampling, I estimate that 9.4 individuals, pairs, or flocks were present per ha in July and 8.5 per ha were present in September (Table 2). In July, densities of yellow-breasted chat (scientific names in Appendix A), broad-billed hummingbird, and hooded oriole were higher than that for other species and densities declined somewhat in September. Density of five-stripped sparrow was also relatively high during July yet this species was not observed along transects during September when only a single individual was detected incidentally (Table 3). Although Gila woodpeckers had the second highest number of encounters during surveys ($n = 101$), density was not particularly high because individuals were detected at relatively long distances compared to other species. In addition to the 11 species for which I estimated density (Table 2), sample sizes were sufficient to estimate density of blue grosbeak (75 encounters), black-headed grosbeak (63), northern cardinal (61), brown-crested flycatcher (55), canyon towhee (54), common ground dove (54), cactus wren (53), and rufous-winged sparrow. Further, I obtained between 44

Table 2: Density (no./ha) and number of encounters of species and species groups on the Northern Jaguar Reserve, 2007. Density estimates are based on distance-sampling methods. Number of species comprising each species group is provided in parentheses.

	July			September		
	Encounters (species)	Density (no./ha)	CV (%)	Encounters (species)	Density (no./ha)	CV (%)
All species	1502 (82)	9.390	6.92	1162 (94)	8.455	10.16
Neotropical migrants	10 (7)	0.132	34.47	236 (27)	3.738	15.11
white-winged dove	78	0.257	16.19	2	0.030	118.10
All hummingbirds	49 (3)	0.988	26.06	66 (6)	1.595	49.64
broad-billed hummingbird	30	0.607	30.39	21	0.510	31.16
Gila woodpecker	61	0.362	26.73	40	0.285	26.57
dusky-capped flycatcher	42	0.191	29.48	18	0.098	32.57
canyon wren	37	0.110	24.57	22	0.078	26.49
Sinaloa Wren	30	0.252	69.76	23	0.257	60.9
yellow-breasted chat	91	0.606	17.50	29	0.231	26.01
summer tanager	25	0.158	47.25	39	0.289	28.30
five-striped sparrow	59	0.424	28.12	0	0.000	
varied bunting	51	0.336	11.35	22	0.174	24.27
hooded oriole	78	0.536	26.64	22	0.217	43.73

and 31 total encounters of nine other species which should allow computation of density estimates with low precision in the future.

Density of Neotropical migratory species of birds was 28 times higher in September than in July; in September I estimated 3.7 individuals per ha. ($n = 27$ species). In September, Neotropical migrants accounted for 44% of total bird abundance whereas in July they accounted for only 1%, patterns that indicated broad shifts in community structure between seasons. In September, density of Neotropical migratory species that were foliage gleaners (warblers and vireos) was much higher in valley bottoms (Rio Aros = 4.04 indiv./ha, la Ventana = 3.23 indiv./ha) than in major canyons or oak woodland (mean \pm SE = 0.77 \pm 0.06 indiv./ha, range = 0.57-0.93). Of the 41 foraging observations that I obtained of Neotropical migratory foliage gleaners, 56% were in mesquite, 15% were in thornscrub species such as *Bursera* spp., 12% were in *Havardia mexicana*, 12% were in *Salix* spp., and only 5% were in *Quercus* spp. These patterns combined with much higher availability of thornscrub species in the study area suggest that densities of foliage gleaners were higher along valley bottoms likely because they harbor higher quality vegetation and perhaps insect resources for these species during migration. In comparison, density of Neotropical migratory species that were aerial foragers (flycatchers) in September varied much less among transects and ranged from 0.32 indiv./ha in Babisal Abajo to 0.71 indiv./ha in Huijalo Abajo.

In July, observed species richness was highest in Babisal Arriba (55 species) and at la Ventana (54 species) and averaged 49 species among all eight transects (Table 2). In September, observed species richness was also highest in Babisal Arriba (59 species) and at Hubaral (58 species) and averaged 53 species among seven transects. Relative abundance and frequency of occurrence of each species varied markedly among transects both within a season and along the same transects

Table 3: Distribution and abundance of birds detected on the Northern Jaguar Reserve, July and September 2007. Numbers indicate singles, singing males, or pairs, x indicates common species for which abundance was not estimated, C = colony, J = juvenile, M = male, P = pair, S = sign, Y = young, NE = nest with eggs, NY = nest with young, UN = used nest, ON = occupied nest. For example a 6, 2Y indicates I observed six individuals two of which were dependant young. Asterick indicates observed only by Gerardo Carreon A.

	July								September						
	Los Pavos	Rio Aros	Hubaral	Babisal Abajo	Babisal Arriba	Hujjalo Abajo	Mesa Encinosa	La Ventana	Rio Aros	Hubaral	Babisal Abajo	Babisal Arriba	Hujjalo Abajo	Mesa Encinosa	La Ventana
Day of month	12	13	14	15	16	17	18	19	14	13	15	15	17	16	12
greater white-fronted goose									1						
wild turkey														S	
elegant quail	25		2	2	2			6	10	2	10				2
Montezuma quail	2						8	1						1	
great blue heron		4							1						
black vulture	x		3		2		3	x			x	x			x
turkey vulture	x		10	x	15		3	x		5	x	x		x	x
sharp-shinned hawk														1	
Cooper's hawk													1		
common black-hawk		3,1Y			1P,UN			1	1			1P	1		1J
gray hawk					1,2Y	1		1			1	1	1		1
red-tailed hawk	1	3,1Y	2,1Y		2			2	2	1	1				
peregrine falcon		1						1							
spotted sandpiper									8						
white-winged dove	75,NE	x	70	x	x	35	25	20	4	4	3	2	2		
mourning dove	2	4			x		3	1	8	5	15	10		30	8
common ground-dove	10	x	40	x		5	2	10	60	20	25	8	3	12	20
white-tipped dove	5	3	1	8	x,NE	14	10	3	1	10		1			2
military macaw		6,2Y		2											
yellow-billed cuckoo	1	1	3	3	3	4	8	4		2	3				
greater roadrunner	2	2	2				4	1							
western screech-owl	1		1		1	1	3	1		1		2		2	
whiskered screech-owl					1		2							1	
great horned owl		1	1												
northern pygmy-owl										1					
elf owl	1		2		3										
lesser nighthawk		1													
buff-collared nightjar	3				1		2			1		2			
unknown hummingbird										20	2	5	3	1	6
broad-billed hummingbird	1	15	8	20	10	25	10	10	6	15	6	6	3		5
Berylline hummingbird										1					
violet-crowned hummingbird	1	5		2	2	3	1	4	2	1	1	1	1		
blue-throated hummingbird						1*									
black-chinned hummingbird									1		3	3	1		
rufous hummingbird				1					3	10		2	1		
elegant trogon	3		4	3		3				2		2	1		
green kingfisher		1P							1						

	July								September							
	Los Pavos	Río Aros	Hubaral	Babisal Abajo	Babisal Arriba	Huijalo Abajo	Mesa Encinosa	La Ventana	Río Aros	Hubaral	Babisal Abajo	Babisal Arriba	Huijalo Abajo	Mesa Encinosa	La Ventana	
acorn woodpecker			2				10			1				6		
Gila woodpecker	12	15	20,ON	20,1Y	10	15,ON	4	10	x	12	x	x	8	2	x	
ladder-backed woodpecker	6	2	5	3	2	3	5	1	x	3	x	x	7	3	x	
Arizona woodpecker							4							1		
gilded flicker	8	1	3	2				1		1		1		1		
white-striped woodcreeper					4							1				
northern beardless-tyrannulet	1		3	3	3	4	4	2	1	2		1		1		
greater pewee												1	1			
western wood-pewee			5		5	6				6	1	5	1		2	
unknown empidonax										10	12	12	5	5	10	
Hammond's flycatcher										1		1	1	2		
gray flycatcher									1	?	1	?				
dusky flycatcher									6	5		3	1		6	
pacific-slope flycatcher													3			
black phoebe		4		2				1	6	2	2	2		1	3	
vermillion flycatcher		6		3	2			10	8	1	8	2	1	1	6	
dusky-capped flycatcher	2		8	5	3	5		5		2	1	5	4	5	3	
ash-throated flycatcher	12,1Y	8	10	5	2	1		1	10	1	3			3	2	
Nutting's flycatcher		2	2			5			2	6	1	2	6	6	3	
brown-crested flycatcher	5	1	6,ON	5	3	3		5		3			2		5	
sulphur-bellied flycatcher			1		2	6							2,1Y			
tropical kingbird		4P						1								
thick-billed kingbird			2	3	3	1	10N	2		2	1	3	3	1	2	
western kingbird	1							5	1	1		1			8	
rose-throated becard					5,ON	6,ON						10,2Y				
Bell's vireo		18						1	6						1	
plumbeous vireo									1	3	2	6			3	
Cassin's vireo									1		1					
Hutton's vireo													2			
warbling vireo						1			6	6	2	1	1			
yellow-green vireo						1										
Mexican jay							15							8		
common raven	15	5,2Y	2	x	x		4	3,2Y		1	1	1				
northern rough-winged swallow		3														
cliff swallow		UN														
bridled titmouse							4									
verdin	5	x	8	3	3	2	4	2,NY	2	2					2	
cactus wren	4	10	12	10	4	2	10	5	6	8	2			3	4	
rock wren		1	6						2	2						
canyon wren	3	5	15,1Y	2	4	5	10	10	8	3		3	8	10	8	
Sinaloa Wren			5,ON	UN	10,ON	9,ON		4		3,1Y	1	6	10,1Y		2	
house wren									5	8	4	4	3	10	6	
blue-gray gnatcatcher							5							3		
black-tailed gnatcatcher	2P	1P		4			1		2					1		

	July								September							
	Los Pavos	Río Aros	Hubaral	Babisal Abajo	Babisal Arriba	Huijalo Abajo	Mesa Encinosa	La Ventana	Río Aros	Hubaral	Babisal Abajo	Babisal Arriba	Huijalo Abajo	Mesa Encinosa	La Ventana	
black-capped gnatcatcher	3P	2P	5P	2	3	3P	3	2		4	4	3	2	3	3	
northern mockingbird	50	x												?		
curve-billed thrasher	10	UN	10	6	2	2	3	2	13	8		2	1	12	8	
phainopepla		3														
orange-crowned warbler									1						1	
Nashville warbler									20	3	1	1		3	2	
Lucy's warbler	3				1				18		1				8	
yellow warbler									4						1	
black-throated gray warbler									2				2	6		
MacGillivray's warbler									10	1		1		1	10	
Wilson's warbler									2		1	4		1	6	
painted redstart												1		1		
fan-tailed warbler					2	2						2	1			
rufous-capped warbler			3	2	4	6	3	4			1	8,2Y	4	3	1	
yellow-breasted chat	30	50	40,UN	25	10	10	10		10	25	12	6	6	6	4	
hepatic tanager							2								?	
summer tanager	1	1	2	2	6,2Y	8,2Y		6,1Y	10,3Y	8	6	5	8	5,2Y	8,3Y	
western tanager						1			6	6	4	7	10	15	4	
canyon towhee	10	x	4	10	5	3	10	5	x	x	12	x	x	16	6	
rufous-winged sparrow	5	x	20	10	3			4	x	5	x	x		20	10	
rufous-crowned sparrow		1					20	3						30	2	
rusty sparrow														1		
five-striped sparrow	30		20	15	5	25	8	6						1		
chipping sparrow														25		
clay-colored sparrow									2						4	
lark sparrow															3	
white-crowned sparrow															1	
northern cardinal	5	x	30	15	3	2	1	1	x	8,1Y	12,3Y	x		x	2	
pyrrhuloxia	1P															
yellow grosbeak					1M											
black-headed grosbeak	3		6		5	7	25,NE	1				2	5	6		
blue grosbeak	10	x	8	8	2	2	5	6	x	10,1Y	x	3	4	15	8	
lazuli bunting															2	
varied bunting	8	x	25	25	4	25	10	10	x	x	x	10,2Y	10,3Y	10	15,3Y	
bronzed cowbird	3	x	1	x	3			10,NE								
brown-headed cowbird	8	x	20	x	10		1	10								
black-vented oriole	1		4	1	1	4						1				
hooded oriole	15,ON	5P	50,ON	25,NE	10	25,ON		8,NE	15	15	10	3		1	2	
streak-backed oriole	UN				UN	3,ON										
Bullock's oriole	1								2	2	1				3	
Scott's oriole				1		2	2	1								
house finch	10	NE	x	x	x	x	x	x	x	x	20	x	x	x	x	
lesser goldfinch		5	x	x	3	x	x	x	x	x	2	x	x	x	x	

between seasons (Table 2), patterns that reflected differences in environmental conditions among transects and broad shifts in community structure between seasons.

Species of note included two singing fan-tailed warblers in both Babisal Arriba and Huijalo Abajo during July. Fan-tailed warblers were detected at points roughly 300-400 m apart along each transect but were not detected simultaneously and may therefore have been the same individuals; only one single song was heard in both locations in September. I observed one male yellow grosbeak calling from slopes above and east of the waterfall in Babisal Arriba in July. This individual was located in the best-developed thorn forest that I observed on the reserve and although no evidence of breeding was obtained this species could potentially breed in the area. I detected military macaw in three locations: a pair was observed flying over Babisal Abajo, a pair was heard calling from Arroyo los Chinos near the junction between the roads to Hubaral and los Pavos, and six individuals were on and around the large limestone cliffs above the Rio Aros below Lola's house (cover photo; Table 3) at the same location where they were observed in 2005 (O'Brien et al. 2006). Vocalizations and behavior of two of these six macaws along the Rio Aros suggested they were juveniles (Gerardo Carreon A., *pers. comm.*). I did not detect macaws in September. Rufous-capped warblers were fairly common along several transects with as many as six territories along the 1,400 m transect at Huijalo Abajo. I observed two adult rufous-capped warblers feeding two recently fledged young in Babisal Arriba on 15 September. I observed two white-striped woodcreepers chasing another individual in upper Babisal Arriba on 16 July that may have been a family group; this species vocalized very infrequently during both surveys and seemed especially secretive compared to during spring when they typically vocalize more frequently. Although Sinaloa wren were fairly common along four (50%) transects in July (Table 3), happy wren was not detected and are not expected to occur away from extremely dense patches of shrubby riparian vegetation that occurs very locally along the Rios Yaqui and Aros (O'Brien et al. 2006). I detected one yellow-green vireo (cover photo) that was vigorously singing in *Quercus tuberculata* in Huijalo Abajo in July; behavior of this individual suggested that it was not paired.

Communities of flycatchers and orioles were especially diverse. I observed as many as nine species of flycatchers and four species of orioles along a single transect and all of them were either presumed or confirmed breeding. Sulphur-bellied flycatchers were fairly common in riparian woodland of *Q. tuberculata*, *Lysiloma watsoni*, and palm along Huijalo Abaja where I detected six pairs, one of which was likely nesting in a palm cavity. In comparison, I detected only one family group of sulphur-bellied flycatchers in September (15th), which is the second latest date known for this species in Sonora (Russell and Monson 1998). Rose-throated becard occurred along only two transects where they were relatively common (Table 3). I observed four species of *Myiarchus* flycatchers all of which were presumed breeding along two transects. Hooded orioles were remarkably abundant in the dense palm groves along Hubaral where I estimated that over 50 pairs were present in July. In comparison, although black-vented orioles often occurred along side hooded orioles in the same stands of palms, there was only approximately one pair of black-vented for every ten pairs of hooded orioles. Although I observed recently used nests of streak-backed oriole along two transects, I only observed birds in Huijalo Abajo where three active nests were present. Few detections of singing Scott's orioles suggest they are somewhat rare on the reserve. However, because Scott's orioles typically occurred in uplands with dense stands of *Yucca grandifolia* and scattered open stands of short trees that were not sampled adequately along transects, I suspect they are much more common than the few observations suggest.

In Canyon Huijalo Arriba and in other areas on Mesa Encinosa I documented communities of birds that were associated with oak woodlands (Table 3), yet several species that typically occur in these environments were not detected such as bushtit and Hutton's vireo. In Huijalo Arriba, woodlands dominated by *Quercus albocincta*, *Q. chihuahuensis*, *Q. tuberculata*, *Q. arizonica*, *Q. viminea*, and *Faxinus* spp. were present along the drainage and on adjacent slopes. On the mesa top, more open woodlands of *Quercus chihuahuensis*, *Q. albocincta*, *Q. tuberculata*, scattered patches of

thornscrub, and short-tree woodland and scrub of *Q. toumeyi*, *Q. chihuahuensis*, and *Dodonaea viscosa* were present. Common bird species in these environments included acorn woodpecker, Mexican jay, rufous-crowned sparrow, and black-headed grosbeak which had three nests with eggs in *Q. arizonica* along the canyon bottom. In September, I heard one singing rusty sparrow on a densely vegetated slope at 1,150 m approximately 500 m northwest of the start point of the Huijalo Arriba transect segment.

In July and September, I heard one whiskered screech-owl calling from the same slope on the east side of Mesa Encinosa at 1,080 m. This slope was dominated by open stands of *Quercus chihuahuensis*, *Q. albocincta*, and by extensive patches of thornscrub that included *Cecropia*, *Acacia*, and *Bursera*. Notably, in July another whiskered screech-owl was calling simultaneously yet much less emphatically, at lower volume, and in a somewhat broken fashion from the flats below this slope at 1,010 m. On both occasions western screech-owls called simultaneously from thornscrub at elevations below 1,000 m. I heard another calling whiskered screech-owl on the evenings of 14 and 15 July in the canyon bottom at Babisal Arriba at only 740 m in an area dominated by *Platanus*, *Q. tuberculata*, and *Cephalanthus*. Elevation at this location is 530 m lower than the lowest observation reported by Russell and Monson (1998) or Marshall (1957). This owl and the individual that I detected at 1,010 m on Mesa Encinosa did not respond to broadcasted vocalizations in September and were likely not present. I suspect that both of these individuals were dispersing juveniles although observation dates seemed somewhat early. I heard a northern pygmy-owl calling at dawn near the ranch house at Hubaral in September in an area dominated by thornscrub. This individual's territory may have been mainly in oak woodland that occurs on the hydrothermal soils within 500 m above the house.

Several observations of migratory species were of note. Observations of western kingbird, warbling vireo, and Bullock's oriole in mid July are among the earliest records of these species known for Sonora during fall migration (Russell and Monson 1998, Fleisch, *unpubl. data*).

Conclusions

The Northern Jaguar Reserve supports diverse communities of both breeding and migratory birds. Although my efforts were based on only 16 days of effort, I documented 124 bird species including several species that have not been widely reported in this region of Sonora (Russell and Monson 1998, O'Brien 2006, Warshall 2007). Furthermore, I provided the first estimates of density of breeding and migratory birds in this region, information that is not readily available anywhere in Sonora. Notable additions to the avifauna known on the Northern Jaguar Reserve included birds that were associated with oak woodlands on Mesa Encinosa, migratory species such as greater pewee, painted redstart, and clay-colored sparrow, presumed breeding species such as fan-tailed warbler and rusty sparrow, and other species such as yellow grosbeak that may breed but additional information is needed to determine status. Furthermore, I confirmed breeding of 28 species many of which had not been confirmed breeding in this region of Sonora.

Importantly, differences in density and species composition between seasons indicated broad changes in community structure that were expected given the large number of migrants that use this region during late summer. In September, I estimated that almost half of all individuals that were present were Neotropical migratory species and the vast majority of these individuals were warblers, vireos, and flycatchers (mainly *Empidonax* spp.). This relatively large proportion of migratory species was bolstered by departure of some common breeding species such as five-striped sparrow. Density of species that are predominately foliage gleaners was much higher in valley bottoms where foraging was concentrated in mesquite, chino, and willow rather than in thornscrub species. These patterns suggest that some plant species likely support higher quality or quantity of insect resources

that are consumed by migratory birds. In comparison, density of aerial foragers (flycatchers) was more similar across space in September.

Because my descriptions of breeding bird communities were restricted to July, I failed to estimate density of several species that breed earlier in the season and that are likely relatively common at these times such as Lucy's warbler. To obtain a more realistic perspective on the entire breeding bird community on the reserve, counts should be replicated at least two or three times between late April and mid to late July.

High diversity of breeding and migratory birds on the Northern Jaguar Reserve is likely fostered by the wide range of environments that occur in a relatively small area. Perhaps the most interesting and diverse environment for birds on the reserve is located in Babisal Arriba. This canyon supports a unique vegetation association and several species of both montane (e.g. *Platanus*) and subtropical (e.g. *Sideroxylon persimile*) affinity that are exceptionally rare in the region both individually and especially in association (O'Brien 2006, Flesch, *unpubl. data*). Further, upland thorn forest on the eastern slopes of the canyon is exceptionally tall for this region and at this latitude of Sonora and has similar structure to tropical deciduous forests of the south. None of the more than 20 canyons that I have explored in this region of Sonora are comparable.

Transects that I established and methods that I used to sample bird communities on the reserve should allow populations of relatively common species to be monitored across time. These methods should also be sufficient to monitor some populations of birds that were uncommon after an approximate doubling of sample effort. To document peak passage times and important vegetation resources for migratory birds, increased effort and sampling across a broader temporal scale are required. Future studies on the reserve should emphasize visiting additional environments such as high-elevation oak woodlands and potentially grasslands in the Sierra Zetasora, limestone cliffs used by macaws and falcons, and tropical lowlands. Several canyons on the west and perhaps north sides of the Sierra los Pavos for example, may support *Ficus pertusa*, which provides an important source of food and cover for birds. Further, additional effort is required to determine the breeding status and distribution of several rare species, to document species that winter on the reserve, and to assess the relative value of vegetation resources to Neotropical migrants so that these data can be applied to management and conservation.

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Appendix A: Presence, breeding status, and scientific names of 124 species of birds detected between 11 and 19 July 2007 (trip 1) and 11 and 17 September 2007 on the Northern Jaguar Reserve in east-central Sonora. All observations were obtained by Aaron D. Fleisch unless noted otherwise. List includes species that were not detected along transects.

Common name	Scientific name	Trip 1	Trip 2	Breeding status
greater white-fronted goose	<i>Anser albifrons</i>		X	migrant
wild turkey	<i>Meleagris gallopavo</i>		X	feathers and sign only
elegant quail	<i>Callipepla douglasii</i>	X	X	paired
Montezuma quail	<i>Cyrtonyx montezumae</i>	X	X	paired
great blue heron	<i>Ardea herodias</i>	X	X	present in suitable breeding habitat
black vulture	<i>Coragyps atratus</i>	X	X	present in suitable breeding habitat
turkey vulture	<i>Cathartes aura</i>	X	X	present in suitable breeding habitat
sharp-shinned hawk	<i>Accipiter striatus</i>		X	migrant
Cooper's hawk	<i>Accipiter cooperii</i>		X	migrant
common black-hawk	<i>Buteogallus anthracinus</i>	X	X	fledged young
gray hawk	<i>Asturina nitida maxima</i>	X	X	fledged young
red-tailed hawk	<i>Buteo jamaicensis</i>	X	X	fledged young
American kestrel	<i>Falco sparverius</i>		X	pair after or very late in breeding season
peregrine falcon	<i>Falco peregrinus</i>	X		in suitable breeding habitat after season
spotted sandpiper	<i>Actitis macularia</i>		X	migrant
white-winged dove	<i>Zenaida asiatica</i>	X	X	nest with eggs
mourning dove	<i>Zenaida macroura</i>	X	X	paired
common ground-dove	<i>Columbina passerina</i>	X	X	paired
white-tipped dove	<i>Leptotila verreauxi</i>	X	X	nest with eggs
military macaw	<i>Ara militaris</i>	X		juvenile, paired
yellow-billed cuckoo	<i>Coccyzus americanus</i>	X	X	singing
greater roadrunner	<i>Geococcyx californianus</i>	X	X	singing
western screech-owl	<i>Megascops kennicottii</i>	X	X	calling in suitable breeding habitat
whiskered screech-owl	<i>Megascops trichopsis</i>	X	X	calling in suitable breeding habitat
great horned owl	<i>Bubo virginianus</i>	X	X	calling in suitable breeding habitat
northern pygmy-owl	<i>Glaucidium gnoma</i>		X	calling in possibly suitable breeding habitat
elf owl	<i>Micrathene whitneyi</i>	X		calling in suitable breeding habitat
lesser nighthawk	<i>Chordeiles acutipennis</i>	X		present in suitable breeding habitat
buff-collared nightjar	<i>Caprimulgus ridgwayi</i>	X	X	calling in suitable breeding habitat
broad-billed hummingbird	<i>Cynanthus latirostris</i>	X	X	nest building
berylline hummingbird	<i>Amazilia beryllina</i>		X	migrant
violet-crowned hummingbird	<i>Amazilia violiceps</i>	X	X	present in suitable breeding habitat
blue-throated hummingbird	<i>Lampornis clemenciae</i>	X		reported by Gerardo, likely not migrant
black-chinned hummingbird	<i>Archilochus alexandri</i>		X	migrant
rufous hummingbird	<i>Selasphorus rufus</i>	X	X	migrant
elegant trogon	<i>Trogon elegans</i>	X	X	singing
green kingfisher	<i>Chloroceryle americana</i>	X	X	carrying food, paired
acorn woodpecker	<i>Melanerpes formicivorus</i>	X	X	present in suitable breeding habitat
Gila woodpecker	<i>Melanerpes uropygialis</i>	X	X	occupied nest
ladder-backed woodpecker	<i>Picoides scalaris</i>	X	X	calling in suitable breeding habitat
Arizona woodpecker	<i>Picoides arizonae</i>	X	X	calling in suitable breeding habitat
gilded flicker	<i>Colaptes chrysoides</i>	X	X	calling in suitable breeding habitat
white-striped woodcreeper	<i>Lepidocolaptes leucogaster</i>	X	X	paired, possible dependent young

northern beardless-tyrannulet	<i>Camplostoma imberbe</i>	X	X	calling in suitable breeding habitat
greater pewee	<i>Contopus pertinax</i>		X	migrant, possibly winter resident
western wood-pewee	<i>Contopus sordidulus</i>	X	X	paired, courtship
Hammond's flycatcher	<i>Empidonax hammondii</i>		X	migrant
gray flycatcher	<i>Empidonax wrightii</i>		X	migrant, possibly winter resident
dusky flycatcher	<i>Empidonax oberholseri</i>		X	migrant, possibly winter resident
pacific-slope flycatcher	<i>Empidonax difficilis</i>		X	migrant
black phoebe	<i>Sayornis nigricans</i>	X	X	fledged young
vermillion flycatcher	<i>Pyrocephalus rubinus</i>	X	X	paired
dusky-capped flycatcher	<i>Myiarchus tuberculifer</i>	X	X	paired
ash-throated flycatcher	<i>Myiarchus cinerascens</i>	X	X	paired
Nutting's flycatcher	<i>Myiarchus nuttingi</i>	X	X	paired
brown-crested flycatcher	<i>Myiarchus tyrannulus</i>	X	X	occupied nest
sulphur-bellied flycatcher	<i>Myiodynastes luteiventris</i>	X	X	paired, nests, fledged young
tropical kingbird	<i>Tyrannus melancholicus</i>	X		paired
thick-billed kingbird	<i>Tyrannus crassirostris</i>	X	X	occupied nest
western kingbird	<i>Tyrannus verticalis</i>	X	X	migrant
rose-throated becard	<i>Pachyramphus aglaiae</i>	X	X	occupied nest
loggerhead shrike	<i>Lanius ludovicianus</i>		X	in suitable breeding habitat maybe after season
Bell's vireo	<i>Vireo bellii</i>	X	X	fledged young
plumbeous vireo	<i>Vireo plumbeus</i>		X	migrant, possibly winter resident
Cassin's vireo	<i>Vireo cassinii</i>		X	migrant, possibly winter resident
Hutton's vireo	<i>Vireo huttoni</i>		X	migrant, possibly winter resident
warbling vireo	<i>Vireo gilvus</i>	X	X	migrant
yellow-green vireo	<i>Vireo flavoviridis</i>	X		singing
Mexican jay	<i>Aphelocoma ultramarina</i>	X	X	juvenile
common raven	<i>Corvus corax</i>	X	X	juvenile
northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>	X		present in suitable breeding habitat
cliff swallow	<i>Petrochelidon pyrrhonota</i>	X		used nest
bridled titmouse	<i>Baeolophus wollweberi</i>	X		present in suitable breeding habitat
verdin	<i>Auriparus flaviceps</i>	X	X	nest with young
cactus wren	<i>Campylorhynchus brunneicapillus</i>	X	X	nest
rock wren	<i>Salpinctes obsoletus</i>	X	X	singing
canyon wren	<i>Catherpes mexicanus</i>	X	X	fledged young
Sinaloa Wren	<i>Thryothorus sinaloa</i>	X	X	nest
house wren	<i>Troglodytes aedon</i>		X	migrant, possibly winter resident
blue-gray gnatcatcher	<i>Poliophtila caerulea</i>	X	X	possible dependent young
black-tailed gnatcatcher	<i>Poliophtila melanura</i>	X	X	paired
black-capped gnatcatcher	<i>Poliophtila nigriceps</i>	X	X	paired
northern mockingbird	<i>Mimus polyglottos</i>	X	X	paired
curve-billed thrasher	<i>Toxostoma curvirostre</i>	X	X	used nest
phainopepla	<i>Phainopepla nitens</i>	X		present in suitable breeding habitat
orange-crowned warbler	<i>Vermivora celata</i>		X	migrant
Nashville warbler	<i>Vermivora ruficapilla</i>		X	migrant
Lucy's warbler	<i>Vermivora luciae</i>	X	X	in suitable breeding habitat after season
yellow warbler	<i>Dendroica petechia</i>		X	migrant
black-throated gray warbler	<i>Dendroica nigrescens</i>		X	migrant
MacGillivray's warbler	<i>Oporornis tolmiei</i>		X	migrant

Wilson's warbler	<i>Wilsonia pusilla</i>		X	migrant
painted redstart	<i>Myioborus pictus</i>		X	migrant
fan-tailed warbler	<i>Euthlypis lachrymosa</i>	X	X	singing
rufous-capped warbler	<i>Basileuterus rufifrons</i>	X	X	feeding recently fledged young
yellow-breasted chat	<i>Icteria virens</i>	X	X	used nest
hepatic tanager	<i>Piranga flava</i>	X		singing
summer tanager	<i>Piranga rubra</i>	X	X	feeding recently fledged young
western tanager	<i>Piranga ludoviciana</i>		X	migrant
canyon towhee	<i>Pipilo fuscus</i>	X	X	paired
rufous-winged sparrow	<i>Aimophila carpalis</i>	X	X	singing
rufous-crowned sparrow	<i>Aimophila ruficeps</i>	X	X	singing
rusty sparrow	<i>Aimophila rufescens</i>		X	singing in breeding habitat
five-striped sparrow	<i>Aimophila quinquestriata</i>	X	X	singing, paired
chipping sparrow	<i>Spizella passerina</i>		X	migrant
clay-colored sparrow	<i>Spizella pallida</i>		X	migrant
lark sparrow	<i>Chondestes grammacus</i>		X	migrant
white-crowned sparrow	<i>Zonotrichia leucophrys</i>		X	migrant
northern cardinal	<i>Cardinalis cardinalis</i>	X	X	fledged young
pyrrhuloxia	<i>Cardinalis sinuatus</i>	X		paired
yellow grosbeak	<i>Pheucticus chrysopheplus</i>	X		male calling in potential breeding habitat
black-headed grosbeak	<i>Pheucticus melanocephalus</i>	X	X	nest with eggs
blue grosbeak	<i>Passerina caerulea</i>	X	X	fledged young
lazuli bunting	<i>Passerina amoena</i>		X	migrant
varied bunting	<i>Passerina versicolor</i>	X	X	feeding recently fledged young
bronzed cowbird	<i>Molothrus aeneus</i>	X		eggs
brown-headed cowbird	<i>Molothrus ater</i>	X		singing
black-vented oriole	<i>Icterus wagleri</i>	X	X	paired
hooded oriole	<i>Icterus cucullatus</i>	X	X	nest with eggs
streak-backed oriole	<i>Icterus pustulatus</i>	X		occupied nest
Bullock's oriole	<i>Icterus bullockii</i>	X	X	migrant
Scott's oriole	<i>Icterus parisorum</i>	X	X	paired
house finch	<i>Carpodacus mexicanus</i>	X	X	nest with eggs
lesser goldfinch	<i>Carduelis psaltria</i>	X	X	paired, courtship

Appendix B: Location of start and end points of transects along which I counted all birds detected with use of distance sampling methods.

Transect	Segment	Point	UTM E 12N NAD 27 Mex	UTM N 12N NAD 27 Mex	Elevation (m)
Los Pavos	Canyon	start	674627	3263157	830
Los Pavos	Canyon	end	673891	3263314	819
Los Pavos	Road above ranch	start	675060	3263260	849
Los Pavos	Road above ranch	end	675961	3263801	896
Rio Aros	Section 1	start	681760	3258640	470
Rio Aros	Section 1	end	682083	3259407	475
Rio Aros	Section 1	end Sept	682815	3259779	465
Rio Aros	Section 2	start	681134	3260338	500
Rio Aros	Section 2	end	680702	3260618	508
Hubaral	Lower	start	678589	3257977	600
Hubaral	Lower	end	677900	3257141	633
Hubaral	Upper	start	677903	3256984	635
Hubaral	Upper	end	677980	3256511	685
Babisal Abajo	Babisal Abajo	start	680742	3252932	725
Babisal Abajo	Babisal Abajo	end	681983	3253554	688
Babisal Arriba	Babisal Arriba	start	680742	3252932	725
Babisal Arriba	Babisal Arriba	end	680525	3252415	790
Huijalo Abajo	Huijalo Abajo	end	681791	3247423	910
Huijalo Abajo	Huijalo Abajo	start	681667	3248780	760
Mesa Encinosa	Camp to tank	start	682508	3246386	1000
Mesa Encinosa	Camp to tank	end	681339	3246149	1000
Mesa Encinosa	Road and Mesa	start	682043	3246231	1050
Mesa Encinosa	Huijalo Arriba	end	680541	3245992	1150
Mesa Encinosa	Huijalo Arriba	start	680811	3246192	1100
Mesa Encinosa	Road and Mesa	end	682091	3246501	1100
La Ventana	La Ventana	start	684579	3244563	740
La Ventana	La Ventana	end	684888	3245860	730