

DISTRIBUTION AND STATUS OF BREEDING LANDBIRDS IN NORTHERN SONORA MEXICO

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Abstract. Northern Sonora, Mexico is dominated by steep elevation and rainfall gradients and a variety of vegetation communities with affinity to the Sonoran, Madrean, Sinaloan, and Chihuahuan biogeographic provinces. Despite high environmental diversity and moderate accessibility, current information on distribution and abundance of breeding landbirds is limited throughout much of this vast region. Between 2000 and 2007, I surveyed landbirds in northern Sonora in four of the six primary watersheds that occur within 125 km of the US. I detected 161 species of landbirds that I presumed were breeding (59% confirmed) and four additional species that were possibly breeding during 568 site visits to 306 localities. I did not detect seven species that had been presumed to breed in the past, six of which likely still occur, or 10 species that I suspect may breed locally or irregularly in the study area. Based on probabilistic methods, I estimate that as many as 178 species of landbirds likely breed in the study area. Species richness within each of 16 secondary watershed regions increased as the number of major vegetation communities that were present increased, and presence of broadleaf riparian woodland, Madrean evergreen woodland, and Madrean montane conifer forest had the greatest influence on richness. Geographic ranges of many species that I observed were much larger than that suggested by previous studies likely as a result of increased effort. Evidence for some species however, suggested that distributions have either expanded or contracted, likely as a result of major changes in vegetation and perhaps climate change. Although some populations await discovery, my findings suggest that northern Sonora supports higher richness of breeding landbirds than any other region of similar area in the borderlands of northern Mexico.

Key Words: borderlands, climate change, distribution, distributional change, landbirds, Mexico, Sonora, transboundary conservation, US-Mexico border.

DISTRIBUCIÓN Y ESTADO DE AVES TERRESTRES REPRODUCTIVAS EN EL NORTE DE SONORA, MÉXICO

Resumen. El norte de Sonora, México esta dominado por un marcado gradiente altitudinal y de precipitación pluvial, así como por una variedad de comunidades vegetales con afinidad a las provincias biogeográficas Sonorense, Madreano, Sinaloense y Chihuahuense. A pesar de la alta diversidad ambiental y cierta accesibilidad, la información actual de distribución y abundancia de aves terrestres reproductivas es limitada en gran parte de esta vasta región. Entre 2000 y 2007, realicé monitoreos de aves terrestres en el norte de Sonora, en cuatro de las seis principales cuencas que se ubican a 125 km o menos, de los Estados Unidos. Detecté 161 especies de aves terrestres que asumí estaban reproduciéndose (59% confirmadas), y cuatro especies adicionales que posiblemente estaban reproduciéndose durante 568 visitas a 306 localidades. No detecté siete especies que se presumían en el pasado como reproductoras, seis de las cuales es probable que todavía ocurran, como tampoco 10 especies que sospecho se reproducen localmente o irregularmente dentro del área. Basado en métodos probabilísticos estimé que hasta 178 especies de aves terrestres probablemente se reproducen en el área de estudio. La riqueza de especies dentro de cada una de las 16 subcuencas incremento en la medida en que aumentaba el número de comunidades vegetales, y la presencia de bosques ribereños de hojas anchas, bosques siempre verdes Madreanos y bosques montanos de coníferas Madreanos tuvieron la mayor influencia en la riqueza. Los rangos geográficos de muchas especies que observé fueron mucho más grandes que lo sugerido por estudios previos, muy probablemente como resultado de un esfuerzo mayor. Sin embargo la evidencia para algunas especies, sugiere que ha habido expansión o contracción de sus distribuciones, probablemente como resultado de cambios mayores en la vegetación y quizás por cambios climáticos. Aunque algunas poblaciones esperan ser descubiertas, mis hallazgos sugieren que el norte de Sonora soporta mayor riqueza de aves terrestres reproductivas que cualquier otra región de área similar, en las tierras fronterizas del norte de México.

Information on the status, distribution, and habitat needs of wildlife are essential for efficient conservation and management. In regions where little information is available and rapid environmental changes are anticipated, detailed information may be required to ensure that populations are identified, managed, and

conserved before they are significantly altered or lost. Efforts to identify and manage wildlife populations may be especially challenging near international boundaries because ownership, management objectives, and national priorities often vary and development pressure and security concerns are often high. Despite these

challenges, cooperation among neighboring nations can help achieve conservation objectives in trans-boundary landscapes (Mittermeier et al. 2005, Plumptre et al. 2007).

At approximately 600 km in length, the international boundary between the state of Arizona in the US and the state of Sonora in Mexico bisects a region of exceptional diversity. Spanning nearly a 10-fold range of annual rainfall, this region extends from mountains at the northern edge of the Sierra Madre Occidental west to the delta of the Río Colorado and supports both highland vegetation communities of oaks (*Quercus* sp.) and pines (*Pinus* sp.) and vast lowlands of Sonoran and Chihuahuan desertscrub and grassland (Brown 1982). Complex elevation and moisture gradients and convergence of several major biogeographic provinces foster high regional diversity and result in the distributional limits of both Neotropical and Nearctic species of plants and animals (Halffter 1987, Howell and Webb 1995, Turner et al. 1995, Escalante et al. 2004).

Large areas of the Sonora-Arizona borderlands are managed with explicit conservation directives by the Mexican and US federal governments (Cartron et al. 2005, Felger et al. 2007), yet a number of environmental concerns exist (Liverman et al. 1999, Goodwin 2000). Although human population densities are low in many areas of northern Sonora, groundwater use and urban growth are increasing, significant areas of riparian vegetation have been degraded or lost, and security concerns have culminated in ongoing development along much of the international border (Cartron et al. 2005, Bürquez and Martínez-Yrízar 2007, Cohn 2007). These and other factors may threaten long-term conservation objectives unless their effects are understood and information on the distribution and status of plant and wildlife populations are known and monitored. Information on bird communities may be especially valuable because relative to other vertebrates birds are often good indicators of specific environmental conditions upon which they depend (Canterbury et al. 2000, Bryce et al. 2002) and because birds are relatively easy to detect and survey (Ralph and Scott 1981, Bibby et al. 2000).

Ornithological investigations in Sonora began well over a century ago and continue to this day (Stephens 1885, Moore 1938, van Rossem 1945, Marshall 1957, Short 1974, Russell and Monson 1998, Rojas-Soto et al. 2002, Villaseñor 2006). Despite these efforts, vast portions of northern Sonora remained little studied by the early 1950s (Phillips and Amadon 1952) after which additional work occurred. Marshall

(1957) provided detailed information in pine-oak woodlands in many of the higher mountains in northeast Sonora. Russell and Monson (1998) synthesized information from previous studies and collections from throughout Sonora that they supplemented with field work in some regions of northern Sonora. Since these efforts, Hinojosa-Huerta et al. (2007) summarized status and provided additional records of birds in the lower Colorado River Valley and adjacent areas of extreme western Sonora, Flesch and Hahn (2005) described bird communities in several little-known mountain ranges west of the region visited by Marshall (1957), and Villaseñor (2006) reported on wintering birds at several widely scattered localities. Despite these efforts, the large size of northern Sonora, limited accessibility, and high environmental diversity have precluded a detailed assessment of distribution and status of breeding landbirds.

To provide current information on landbirds in the borderlands of northern Sonora, I surveyed much of the region between 2000 and 2007. Herein I summarize information on distribution and status of breeding landbirds, assess recent distributional changes, and describe patterns of species richness across the region.

METHODS

STUDY AREA

I defined northern Sonora as the area within 125 km of the international boundary with the US. Several major watersheds traverse this region and many originate near the international boundary and flow in a north-south direction (Fig. 1). In northeastern Sonora, the Río Yaqui begins in extreme southeast Arizona and southwest New Mexico and flows south through Sonora toward the Gulf of California. To the west in the Gila watershed, the Ríos San Pedro and Santa Cruz originate in mountains near the border, traverse small portions of Sonora, then flow north into Arizona. To the south, the adjacent Río Sonora, and its tributaries the Ríos Bacanuchi and San Miguel, flow south from mountains within 70 km of the border. Farther west in the Concepción watershed, the Río Altar and Arroyo Sasabe, drain small areas of south-central Arizona and the Río Magdalena and Arroyo Plomo originate immediately south of the border. These and several other tributaries of the Río Concepción flow south before converging and flowing west toward the Gulf of California. In the more arid west, the Río Sonoyta and its tributary the Arroyo Vamori drain a region immediately along the border and empty into the sands of the Gran Desierto

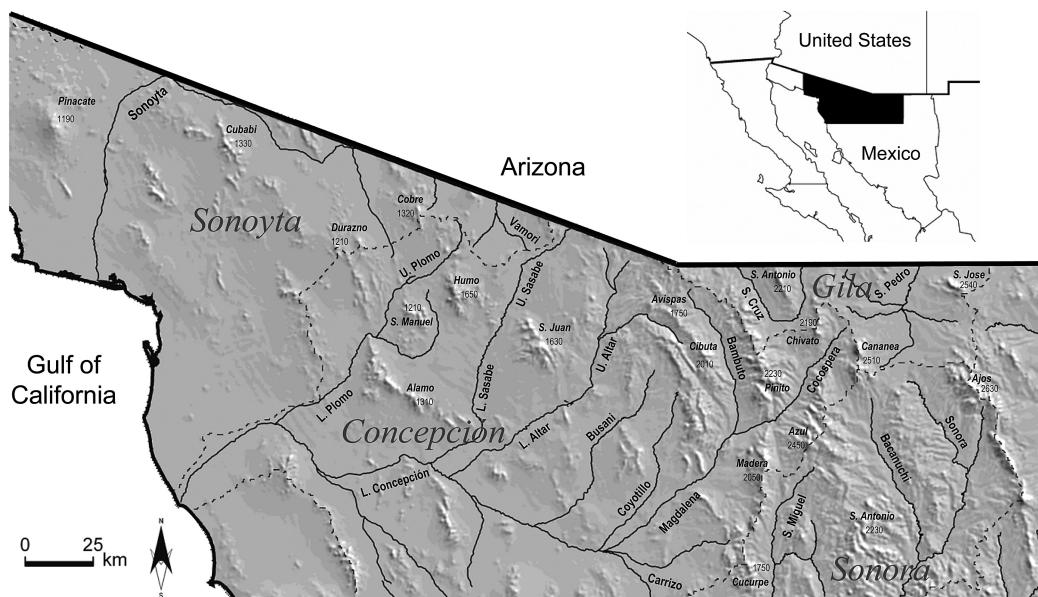


FIGURE 1. Map of study area in northern Sonora Mexico indicating boundaries of primary watersheds (dashed line) and major drainages and mountain ranges. The maximum elevation of each mountain range is in meters. Elevations are based on data from Instituto Nacional de Estadística, Geografía e Informática and my own measurements using a GPS. The small portion of the Yaqui watershed to the east was not considered nor were areas >125 km from the international boundary with the US.

de Altar. Still west is the Río Colorado that drains much of the southwestern US.

In this study, I considered the Sonora, Gila, Concepción, and Sonoita watersheds that together cover approximately 70% of northern Sonora and excluded the extreme western portion of the Sonoita watershed which is predominately sand dunes. I did not consider the Yaqui watershed where field work is not yet complete or the much smaller Río Colorado watershed which has been described elsewhere (Hinojosa-Huerta et al. 2007). To describe distribution of breeding landbirds, I subdivided these four primary watersheds into 16 secondary watershed regions (Table 1) by combining some nearby drainages or subdividing long drainages into upper and lower sections.

Vegetation communities in the region included large expanses of Sonoran desertscrub, semi-desert and plains grassland, and smaller areas of Chihuahuan desertscrub, subtropical thornscrub, and montane forest and woodland. In the west, desertscrub of the Lower Colorado River Valley subdivision of the Sonoran Desert was dominant throughout much of the lower Concepción and Sonoita watersheds and was replaced by desertscrub of the Arizona Upland subdivision at higher elevation. Savannah

dominated the Plains of Sonora subdivision and occurred only in the extreme south-central Concepción watershed (Shreve 1951), whereas to the east, Chihuahuan desertscrub occurred only in the lower San Pedro watershed. In the extreme south, Sinaloan thornscrub occurred locally on slopes in the Coyotillo-Magdalena-Carrizo watersheds and was widespread only in the southern portion of the San Miguel and especially in the Bacanuchi-Sonora watersheds. Semi-desert grassland occurred at elevations above desertscrub in north-central Sonora west to the upper Plomo and Vamori watersheds and more open expanses of plains grassland occurred in the San Pedro and in the upper Santa Cruz and Sonora watersheds. Above grasslands, Madrean evergreen woodland was dominated by oaks at low elevation and by oaks and pines at high elevation; isolated stands of oak woodland occurred in mountains as far west as the upper Sasabe (Sierra San Juan) and upper Plomo (Sierra el Humo) watersheds. Woodland transitioned to Madrean montane conifer forest at high elevations in the Sierras el Pinito, Azul, Cananea (Elenita and Mariquita), los Ajos, and to the east in the Yaqui watershed. These forests were dominated by pine and rarely by Douglas fir (*Pseudostuga menziesii*) or white fir

TABLE 1. SURVEY EFFORT AND SPECIES RICHNESS OF BREEDING LANDBIRDS IN FOUR PRIMARY AND 16 SECONDARY WATERSHED REGIONS IN NORTHERN SONORA, MEXICO 2000–2007. SITE TOTALS INCLUDE TRANSECT AND INCIDENTAL SURVEYS. OBSERVED SPECIES RICHNESS IS THE TOTAL NUMBER OF SPECIES DETECTED IN EACH REGION DURING THE STUDY WHEREAS HISTORICAL RICHNESS INDICATES ADDITIONAL SPECIES THAT WERE NOTED BY RUSSELL AND MONSON (1998) OR BY MARSHALL (1957) BUT WERE NOT OBSERVED DURING THE STUDY. ESTIMATED SPECIES RICHNESS WAS CALCULATED USING THE JACKKNIFE ESTIMATOR (BURNHAM AND OVERTON 1979) AND OBSERVED SPECIES ABUNDANCE DISTRIBUTIONS IN EACH PRIMARY WATERSHED AND FOR THE ENTIRE STUDY AREA. BREEDING SPECIES ARE THOSE PRESUMED AND CONFIRMED BREEDING. ALL DATA ARE BASED ON OBSERVATIONS OBTAINED WITHIN 125 KM OF THE INTERNATIONAL BOUNDARY WITH THE US.

Primary watershed	Watershed region	Effort						Breeding species richness					
		Transects			Site visits			Observed			Historical		
		Transect visits	Sites	Site visits	Sites	Total observed	Historical observed	Total observed	Estimated	SE	95% CI		
Sonoya	31	66	48	85	82	6	88	88	88	3.5	81.2-94.8		
Lower	19	31	28	40	68	5	73	73	73				
Vamori	12	35	20	45	70	3							
Concepción	113	286	197	408	150	4	154	156	3.5	149.2-162.8			
Lower	18	18	24	24	51	14	65	65	65				
Plomo Lower	11	13	14	16	53	6	59	59	59				
Plomo Upper	11	47	15	52	83	0	83	83	83				
Sasabe Lower	3	6	6	12	49	2	51	51	51				
Sasabe Upper	9	38	26	57	90	2	92	92	92				
Altar Lower	13	32	17	46	89	0	89	89	89				
Altar Upper	10	44	25	67	113	3	116	116	116				
Busani	7	22	12	31	73	0	73	73	73				
Coyotillo-Magdalena-Carrizo	21	54	44	87	106	3	109	109	109				
Cocospera-Bambuto	10	12	14	16	128	6	134	134	134				
Gila	6	15	18	27	106	14	120	113	113	3.7	105.7-119.8		
Santa Cruz	3	3	7	7	79	16	95	95	95				
San Pedro	3	12	11	20	91	10	101	101	101				
Sonora	20	28	43	48	134	14	148	142	142	4.0	134.2-148.8		
San Miguel Upper	18	20	26	31	98	5	103	103	103				
Bacanuchi-Sonora Upper	8	8	17	17	120	24	144	167	167	3.2	159.7-172.3		
All regions	176	395	306	568	306	6	161	161	161				

(*Abies concolor*) that were restricted to the highest elevations and mainly on east- and north-facing slopes in the Yaqui watershed. Broadleaf riparian woodland and gallery forest occurred along valley bottoms and in canyons within several other vegetation communities and were dominated by willows (*Salix* sp.), Fremont cottonwood (*Populus fremontii*), and velvet ash (*Fraxinus velutina*) at low elevation and by Arizona sycamore (*Platanus wrightii*), Arizona walnut (*Juglans major*), and bigtooth maple (*Acer grandidentata*) at high elevation.

SITE SELECTION

I used three methods to select sites for surveys: (1) random placement of survey transects, (2) non-random placement of survey transects, and (3) incidental observations. Random sampling provided inference to large portions of the study area whereas non-random sampling allowed the flexibility needed to efficiently locate and survey important environments that had low landscape coverage and otherwise low probability of being sampled.

To randomize placement of transects, I generated a random sample of coordinates at elevations $\leq 1,200$ m that I stratified by major vegetation community and allocated in proportion to the coverage of each community. At each point, I established one transect along the closest drainage that was >2 m wide and within 1 km of a road in each of four possible topographic formations (valley bottoms, lower bajadas, upper bajadas, and mountain canyons) that occurred within 20 km of each point. Selection was constrained to low and moderate elevations because most transects were initially established for surveys of Ferruginous Pygmy-Owls (*Glaucidium brasilianum*; Flesch 2003).

To expand coverage across a broader range of elevations, I selected another sample of transects non-randomly. I placed transects along drainages and occasionally on slopes or trails in riparian areas, large canyons, montane woodland and forest, grassland, and focused in areas that were not adequately covered by random transects or where I suspected the occurrence of rare species with specialized habitat requirements. I selected locations for incidental observations opportunistically by noting observations while scouting, traveling between transects, in camp, and at times of day that were not efficient for transect surveys.

FIELD SURVEYS

I surveyed from February 2000 to June 2007 and focused during the breeding season

between mid-February and late August of each year. I visited some transects only once and visited others up to 11 times depending on timing of initial surveys, accessibility, interest, and the location of other efforts (Flesch and Hahn 2005; Flesch and Steidl 2006, 2007). I prioritized transects for secondary surveys when initial surveys occurred before the anticipated arrival of migratory species and in areas where I suspected occurrence of rare species.

Each transect consisted of a linear search area approximately 1–6 km in length. To survey transects, I walked linear routes that typically followed drainages and temporarily walked in perpendicular directions to investigate bird activity or areas of interest. I recorded all species of birds that I detected during surveys, estimated numbers of individuals or pairs, noted any evidence of breeding, and walked at variable speeds depending on the amount of bird activity and complexity of the terrain. I often noted only presence and breeding behavior of common species so that I could focus on detecting and estimating abundance of less common species and traverse larger areas during morning. I surveyed during mornings but noted observations at other times of day or night. To rouse birds and augment visual and aural detection probabilities, I often mimicked or broadcast recorded territorial calls of pygmy-owls during surveys, which is similar to the method used by Marshall (1957). Along most transects that I selected randomly, I broadcast calls of Ferruginous Pygmy-Owl at 350–600 m intervals while simultaneously surveying for that species (Flesch 2003). Along transects that I selected non-randomly, I mimicked or broadcasted calls of pygmy-owls at less systematic intervals. At night I broadcasted conspecific vocalizations to elicit responses from nocturnal species on an opportunistic basis. I focused incidental observations on species that were uncommon, rare or of interest, and recorded the number of individuals detected and any evidence of breeding.

ANALYSES

To describe status within each region, I estimated relative abundance by dividing the number of transects where a species was present by the total number of transects visited during the breeding season. I used these estimates and incidental observations to classify relative abundance as common (frequently encountered as individuals, pairs, or small groups), fairly common (a few individuals or pairs detected), uncommon (present but may not be found in a day or two of field observations), and rare

(present but rarely detected and often restricted to localized area), as defined by Russell and Monson (1998: 15). Species that were locally common but restricted to environments with low coverage were often considered uncommon. I presumed breeding was occurring if individuals were singing, paired, territorial, or exhibiting other circumstantial evidence of breeding when birds were in typical breeding habitat during the breeding season. For raptors, I presumed breeding was occurring if adults were present in typical breeding habitat during the breeding season. I used more rigorous standards for species that were in atypical breeding habitat by presuming breeding was occurring only when a territorial pair, courtship, or other behaviors indicative of breeding were observed. I did not presume breeding of migratory species unless observations occurred outside periods when populations typically migrate. To confirm breeding, I used criteria of the North American Ornithological Atlas Committee (1990). To define breeding habitat, distribution, and migration and wintering periods, I supplemented my observations with data from northern Sonora (van Rossem 1945, Marshall 1957, Russell and Monson 1998), adjacent portions of southern Arizona (Monson and Phillips 1981, Rosenberg and Witzeman 1998 and 1999, Rosenberg 2001, Corman and Wise-Gervais 2005), and other relevant literature (Poole 2005). I then compared my findings with information from these sources to assess potential changes in status or distribution.

I calculated observed species richness by summing all species that I presumed or confirmed to be breeding during the study within each region and calculated cumulative observed species richness by including species that I did not detect but that had been either presumed or confirmed breeding in the past (Marshall 1957, Russell and Monson 1998). Because all species are not detected perfectly during surveys, I estimated species richness (\hat{N}) based on the abundance distribution I observed and a limiting form of the jackknife estimator (Burnham and Overton 1979) calculated by program SPECRICH (J. E. Hines, available at <http://www.mbr-pwrc.usgs.gov/software.html>). To assess the range of likely values for each estimate, I calculated 95% confidence intervals. I did not estimate species richness at the scale of watershed regions because sample sizes in some regions were small.

To assess the influence of large-scale geographic and environmental factors on cumulative observed species richness, I used linear regression. As explanatory variables, I calculated the geographic position of each watershed region by

estimating latitudinal and longitudinal centers and an index of environmental diversity equaled to the number of major vegetation communities present within each region and considered broadleaf riparian woodland as a community. To determine vegetation communities that had the greatest influence on species richness, I used multiple linear regression with stepwise selection ($P < 0.25$ to enter, $P < 0.10$ to stay). To evaluate adequacy of sampling, I assessed whether observed species richness and the number of species that were at least presumed to breed in the past but not detected during the study varied with effort (site visits).

RESULTS

EFFORT

I completed 395 surveys along 176 transects, 70% of which I located randomly, and 173 incidental surveys at 130 additional localities (Table 1). Number of surveys per transect averaged 2.7 ± 0.1 (\pm SE) with 54% of transects visited \geq two times and 27% of transects visited \geq four times. All effort combined yielded 568 site visits to 306 sites, 92% of which were between 11 February and 31 August and 54% were in May or June. I personally completed 77% of site visits, six observers each completed 3–5%, and an additional four observers completed the remaining 3% of visits all of which were incidental observations.

Number of transects and total effort (site visits) were approximately proportional to the size of primary watersheds (Table 1, Fig. 1). In the Concepción watershed, most effort was in the Altar (28%), Coyotillo-Magdalena-Carrizo (21%), Sasabe (17%), and Plomo (17%) watersheds and least effort was in the Busani (8%), lower Concepción (6%), and Cocospera-Bambuto (4%). Effort was higher in Arizona upland desertscrub (45%) and semi-desert grasslands (36%) than in Madrean evergreen woodland (6%). Effort was low in Lower Colorado River Valley (3%) and Chihuahuan (1%) desertscrub, plains grassland (3%), Sinaloan thornscrub (3%), and in Madrean montane conifer forest (1%), communities that covered much smaller portions of the study area. Effort in broadleaf riparian woodland totaled 15% and most of these sites were in semi-desert grassland (44%), Arizona Upland desertscrub (25%), plains grassland (9%), Sinaloan thornscrub (9%), and Madrean evergreen woodland (9%).

I visited virtually all major vegetation communities that occurred in lowlands within each watershed region and only some that

occurred in highlands. At high elevations, I surveyed portions of the Sierras los Ajos (Bacanuchi-Sonora), el Pinito and Cananea (Cocospera-Bambuto), Cucurpe (San Miguel and Coyotillo-Magdalena-Carrizo), las Avispas (Upper Altar), San Juan (Upper Sasabe), el Humo (Upper Plomo), el Cobre (Vamori), and el Durazno (Lower Sonoyta) (Fig. 1). Difficult access and time constraints prevented surveys at upper elevations in the San Pedro (Sierra San Jose), Santa Cruz (northeast Sierras el Pinito and San Antonio), Coyotillo-Magdalena-Carrizo (Sierra la Madera), Busani (south of Sierra las Avispas), Lower Sonoyta (Sierra Cubabi), and Lower Concepción (Sierra el Alamo) watersheds and in areas above 1,300 m in the Sierra Azul (Cocospera-Bambuto and San Miguel), 1,200 m in the Sierra San Antonio (San Miguel and Bacanuchi-Sonora), and 1,600 m in the Sierra el Chivato (Santa Cruz).

SPECIES RICHNESS

I observed 66 species of landbirds that I presumed were breeding and another 95 species that I confirmed breeding. Four species (Wild Turkey [*Meleagris gallopavo*], Osprey [*Pandion haliaetus*], Fan-tailed Warbler [*Euthlypis lachrymosa*], Western Meadowlark, [*Sturnella neglecta*]) possibly bred but evidence was not sufficient to presume so. I did not detect seven species that had been at least presumed to breed in the past; five were associated with high-elevation forests (Flammulated Owl [*Otus flammeolus*], Blue-throated Hummingbird [*Lampornis clemenciae*], Magnificent Hummingbird [*Eugenes fulgens*], Pygmy Nuthatch [*Sitta pygmaea*], and Red-faced Warbler [*Cardellina rubrifrons*]), one with low desert (Le Conte's Thrasher [*Toxostoma lecontei*]), and one with grassland (Northern Bobwhite [*Colinus virginianus*]) (Tables 1 and 2). I estimate that 171 ± 3.7 species of landbirds at least possibly breed (upper bound of 95% CI = 178) and that 166 ± 3.2 species at least presumably breed (upper bound of 95% CI = 172) in the study area.

Within primary watersheds, species richness was high in the Concepción and Sonora, and low in the Sonoyta watersheds. Estimates of species richness within each primary watershed were similar to observed values (Table 1); observed richness averaged $5.6 \pm 0.6\%$ lower than that estimated and cumulative observed richness differed from that estimated by only $2.9 \pm 1.4\%$.

Cumulative observed richness increased by an average of 15 ± 2 species with each additional vegetation community present in a region ($t_{14} = 6.58$, $P < 0.001$; Fig. 2). Although richness also

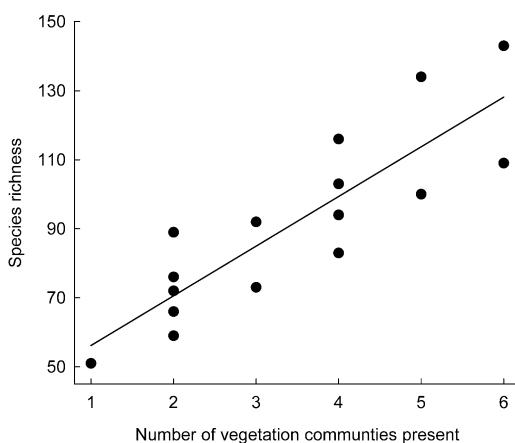


FIGURE 2. Association between species richness and the number of major vegetation communities present within each of 16 watershed regions in northern Sonora, Mexico. Richness equaled the number of landbird species that were presumed or confirmed breeding during the study plus species that I did not detect but that had been presumed or confirmed breeding in the past. Richness increased by 15 ± 2 species with each additional vegetation community ($t_{14} = 6.58$, $P < 0.001$).

increased from west to east (estimate \pm SE = 3 ± 1 species/10 km, $t_{14} = 4.04$, $P = 0.001$), once the effect of vegetation was considered, richness did not vary with longitude ($t_{13} = 1.21$, $P = 0.25$). Presence of broadleaf riparian woodland, Madrean evergreen woodland, and Madrean montane conifer forest ($t_{12} \leq 2.29$, $P \leq 0.04$) influenced species richness more than presence of other vegetation communities ($t_{11} \leq 1.61$, $P \geq 0.14$); when any of these communities were present, richness averaged at least 40 ± 9 species greater than in regions where these communities were absent.

Observed species richness did not vary with effort ($t_{14} = 0.50$, $P = 0.63$), yet the number of species that were at least presumed to breed in the past but not observed during the study decreased as effort increased ($t_{14} = 2.20$, $P = 0.04$). On average, observed richness was $7 \pm 2\%$ lower than cumulative observed richness and differences were greatest in the lower Concepción (21%), Santa Cruz (17%), and Bacanuchi-Sonora (17%) watersheds (Tables 1 and 2).

DISTRIBUTION AND STATUS

I detected six species of breeding landbirds that had not been observed previously in the study area and many others that had been observed at few localities. Of species that had not been observed previously, Short-tailed Hawk

TABLE 2. DISTRIBUTION AND STATUS OF BREEDING LANDBIRDS IN FOUR PRIMARY AND 16 SECONDARY WATERSHED REGIONS IN NORTHERN SONORA, MEXICO 2000-2007. DATA ARE BASED ON OBSERVATIONS OBTAINED WITHIN 125 KM OF THE INTERNATIONAL BOUNDARY WITH THE UNITED STATES. SPECIES STATUS IS NOTED AS RARE (R), UNCOMMON (U), FAIRLY COMMON (F), OR COMMON (C). SPECIES THAT WERE NOTED IN RUSSELL AND MONSON (1998) OR BY MARSHALL (1957) BUT THAT WERE NOT OBSERVED DURING THE STUDY ARE NOTED WITH AN ASTERISK AND STATUS WAS ASSESSED BASED ON PAST DESCRIPTIONS AND THE AMOUNT OF HABITAT THAT WAS AVAILABLE DURING THE STUDY. SPECIES FOR WHICH INSUFFICIENT EVIDENCE WAS OBTAINED TO PRESUME BREEDING ARE NOTED WITH A QUESTION MARK. WATERSHEDS ARE LISTED FROM WEST TO EAST.

TABLE 2. CONTINUED.

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Sonoyta		Concepción				Gila				Sonora	
Sonoyta	Vamori	Lower	Plomo	Sasabe	Altar	Busani	Coyotillo	Cocospera-	Santa	San	Bacanuchi-
		Lower	Upper	Lower	Upper	Magdalena	Bambuto	Cruz	Pedro	Miguel	Sonora
Trogoniformes				R	R				U	U	
Elegant Trogan (<i>Trogon elegans</i>)				R	R				R	R	
Coraciiformes				R	R				U	U	
Green Kingfisher (<i>Chloroceryle americana</i>)				R	R				C	C	
Piciformes				R	R				F	F	
Acorn Woodpecker (<i>Melanerpes formicivorus</i>)	C	C	C	C	C	C	C	C	C	C	
Gila Woodpecker (<i>Melanerpes uropygialis</i>)	C	F	C	F	F	F	F	F	F	F	
Ladder-backed Woodpecker (<i>Picoides scalaris</i>)	F										
Hairy Woodpecker (<i>Picoides villosus</i>)											
Arizona Woodpecker (<i>Picoides arizonae</i>)											
Northern Flicker (<i>Colaptes auratus</i>)	C	C	C	C	C	C	C	C	R	U	
Gilded Flicker (<i>Colaptes chrysoides</i>)									C	U	
Passeriformes				R	U	U	R	U	U	U	
Northern Beardless-Tyramulet (<i>Campylorhina imberbe</i>)				R	R	U	U	R	R*	F	
Greater Pewee (<i>Contopus pertinax</i>)				R	R	U	U	F	F	U	
Western Wood-Pewee (<i>Contopus sordidulus</i>)				R	R	U	U	R	R	R	
Buff-breasted Flycatcher (<i>Empidonax fulvifrons</i>)				R	R	U	U	U	F	F	
Cordilleran Flycatcher (<i>Empidonax occidentalis</i>)				R	R	U	U	U	U	U	
Black Phoebe (<i>Sayornis nigricans</i>)	R			R	R	U	U	U	U	F	
Say's Phoebe (<i>Sayornis saya</i>)	U	R*	U	R	U	F	U	U	U*	R	
Vermilion Flycatcher (<i>Pycnonotus rubinius</i>)	R	R*	R	R	R	U	U	F	C	C	
Dusky-capped Flycatcher (<i>Miarchus tuberculifer</i>)				C	C	C	C	U	U	U	
Ash-throated Flycatcher (<i>Miarchus cinereiceps</i>)	C	C	C	C	C	C	C	C	C	C	
Nutting's Flycatcher (<i>Miarchus nuttingi</i>)	C	F	C	F	C	C	C	U	U	F	
Brown-crested Flycatcher (<i>Miarchus tyrannulus</i>)	C										
Sulphur-bellied Flycatcher (<i>Myiodynastes luteiventris</i>)											
Tropical Kingbird (<i>Tyrannus melancholicus</i>)									R	R*	
Cassin's Kingbird (<i>Tyrannus vociferans</i>)	R	R*	R	R	U	R	U	U	F	F	
Thick-billed Kingbird (<i>Tyrannus crassirostris</i>)	R*	R	R	R	U	U	U	U	U	U	
Western Kingbird (<i>Tyrannus verticalis</i>)											
Rose-throated Becard (<i>Pachyramphus aglaiae</i>)	R	R	R*	R	R	R	R	R	R	R	
Loggerhead Shrike (<i>Lanius ludovicianus</i>)	U	U	R*	R	R	U	U	U	U	U	
Bell's Vireo (<i>Vireo bellii</i>)											
Plumbeous Vireo (<i>Vireo plumbeus</i>)											
Hutton's Vireo (<i>Vireo huttoni</i>)											
Steller's Jay (<i>Cyanocitta stelleri</i>)									R	R*	

TABLE 2. CONTINUED.

Sonoyta		Sonoyta Vamori		Plomo Lower		Plomo Upper		Sasabe Lower		Sasabe Upper		Altar Lower		Altar Upper		Busani Lower		Busani Upper		Coyotillo Magdalena		Cocoperito Bambuto		Santa Cruz		San Pedro		San Miguel		Bacanuchi-Sonora	
Western Scrub-jay (<i>Aphelocoma californica</i>)								R		R		R		R		R*		R		F		F		U		U		U		R*	
Mexican Jay (<i>Aphelocoma ultramarina</i>)								?		F		?		F		?		F		F		F		?		F		F		F	
Chihuahuan Raven (<i>Corvus cryptoleucus</i>)								F		F		F		F		F		F		F		F		F		F		F		R*	
Common Raven (<i>Corvus corax</i>)								R*		R*		R*		R*		R		R*		U*		C		C		C		C		C	
Horned Lark (<i>Eremophila alpestris</i>)								U*		U*		U		F		F		U		R		?		R		R		R		R	
Purple Martin (<i>Progne subis</i>)								Violet-green Swallow (<i>Tachycineta thalassina</i>)		R																					
Northern Rough-winged Swallow (<i>Selasphorus sasin</i>)								R*		R*																					
Cliff Swallow (<i>Petrochelidon pyrrhonota</i>)								Barn Swallow (<i>Hirundo rustica</i>)		U		U		U		U		U		U		U		U		U		U		U	
Bridled Titmouse (<i>Baeolophus wollacei</i>)								Verdin (<i>Auriparus flaviceps</i>)		C		C		C		R		C		C		C		C		C		C			
Verdins (<i>Auriparus minimus</i>)								White-breasted Nuthatch (<i>Sitta carolinensis</i>)																							
Pygmy Nuthatch (<i>Sitta pygmaea</i>)								Brown Creeper (<i>Certhia americana</i>)		C		C		C		R*		C		C		C		C		C		C		R	
Cactus Wren (<i>Campylorhynchus brunneicapillus</i>)								Cactus Wren (<i>Campylorhynchus brunneicapillus</i>)		C		R		R		U		R		U		U		U		U		U			
Rock Wren (<i>Salpinctes obsoletus</i>)								Canyon Wren (<i>Catherpes mexicanus</i>)		?		R		R*		U		U		U		U		U		U		U			
Sinaloa Wren (<i>Ithyothorus stenolaemus</i>)								Sinaloa Wren (<i>Ithyothorus stenolaemus</i>)																							
Happy Wren (<i>Ithyothorus feliz</i>)								Bewick's Wren (<i>Thryomanes bewickii</i>)		?		R		R		U		F		F		U		R		R		R			
House Wren (<i>Troglodytes aedon</i>)								Blue-gray Gnatcatcher (<i>Polioptila caerulea</i>)		C		C		C		C		C		C		C		C		C		C			
Black-tailed Gnatcatcher (<i>Poliopetla melanura</i>)								Black-capped Gnatcatcher (<i>Poliopetla nigriceps</i>)		C		C		C		C		C		C		C		C		C		C			
Eastern Bluebird (<i>Sialia sialis</i>)								American Robin (<i>Turdus migratorius</i>)																							
Northern Mockingbird (<i>Mimus polyglottos</i>)								Bendire's Thrasher (<i>Toxostoma bendirei</i>)		U		U		R*		C		C		C		R		R		R		R			
Curve-billed Thrasher (<i>Toxostoma curvirostre</i>)								Crissal Thrasher (<i>Toxostoma crissale</i>)		C		C		R		U		F		U		R		R		R		R			
Le Conte's Thrasher (<i>Toxostoma lecontei</i>)								European Starling (<i>Sturnus vulgaris</i>)		U*		U		U		F		F		U		R		R		R		R			
Phainopepla (<i>Phainopepla nitens</i>)								Olive Warbler (<i>Psuedocolaptes taeniatus</i>)		C		C		C		R*		C		C		F		F		F		R*			
Lucy's Warbler (<i>Verdinula luciae</i>)								Lucy's Warbler (<i>Verdinula luciae</i>)		F		F		R		C		C		C		U		C		C		C			

TABLE 2. CONTINUED.

	Sonoyta				Concepción				Gila				Sonora				
	Sonoyta	Vanori	Lower	Plomo	Sasabe	Altar	Busani	Coyotillo	Cocospera-	Santa	San	Bacanuchi-	Pedro	Miguel	Pedro	Miguel	Sonora
Yellow Warbler (<i>Dendroica petechia</i>)										R	R				R	R	R
Black-throated Gray Warbler (<i>Dendroica nigrescens</i>)										R	R				R	R	R
Grace's Warbler (<i>Dendroica graciae</i>)										R	R				R	R	R*
Common Yellowthroat (<i>Geothlypis trichas</i>)										R	R				R*	R*	R
Red-faced Warbler (<i>Cardellina rubrifrons</i>)										R	R				R	R	R
Painted Redstart (<i>Myiotheretes pictus</i>)										R	R				R	R	R
Fan-tailed Warbler (<i>Eulithis lachrymosa</i>)										R	R				R*	R*	R
Rufous-capped Warbler (<i>Basileuterus rufifrons</i>)										R	R				R*	R*	R
Yellow-breasted Chat (<i>Icteria virens</i>)										R	R				U	U	U
Hepatic Tanager (<i>Piranga flava</i>)										R	R				R	R	U
Summer Tanager (<i>Piranga rubra</i>)										R	R				F	F	U
Spotted Towhee (<i>Pipilo maculatus</i>)										R	R				F	F	U
Canyon Towhee (<i>Pipilo albiventris</i>)										R	R				C	C	C
Rufous-winged Sparrow (<i>Aimophila carpalis</i>)	R	U	R	R	U	R	U	R	U	U	U	U	U	R	U	U	R
Cassin's Sparrow (<i>Aimophila cassinii</i>)	U	R	R*	R	U	R	U	R	U	R	U	U	U	F	C	R*	U
Boettcher's Sparrow (<i>Aimophila boettteri</i>)	R	R*	R*	R	U	R	U	R	U	R	U	U	U	F	C	R*	U
Rufous-crowned Sparrow (<i>Aimophila ruficeps</i>)	R*	R*	R*	R	R	R	R	R	R	R	R	U	U	F	F	F	F
Five-striped Sparrow (<i>Aimophila quinquesquamata</i>)														U	U	U	U
Lark Sparrow (<i>Chondestes grammacus</i>)														U	U	F	U
Black-throated Sparrow (<i>Amphispiza bilineata</i>)	C	C	C	C	C	C	F	C	F	C	F	C	C	U	U	F	U
Savannah Sparrow (<i>Passerella sandwichensis</i>)	R*																
Grasshopper Sparrow (<i>Ammospizamexicanus</i>)																	
Song Sparrow (<i>Melospiza melodia</i>)	R									U	U	R	R	U	F	C	U
Yellow-eyed Junco (<i>Junco phaeonotus</i>)										U	F	U	U	R	R*	R*	U
Northern Cardinal (<i>Cardinalis cardinalis</i>)	U	U	U	U	U	F	U	U	U	U	U	U	U	U	U	F	U
Pyrhuloxia (<i>Cardinalis sinuatus</i>)	R	U	U	R	U	R	U	R	U	R	U	R	R*	U*	R*	R	R
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	R	R	R*	U*	R	U	U	R	U	R	F	F	U	R	R	R	R
Blue Grosbeak (<i>Passerina caerulea</i>)										R*	R	R	R	F	F	F	F
Indigo Bunting (<i>Passerina cyanea</i>)										F	F	F	F	R	F	F	F
Varied Bunting (<i>Passerina versicolor</i>)	R	R	R*	R	F	R	R	R	R	R	R	R	R*	U	U	F	F
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)															F	F	R
Eastern Meadowlark (<i>Sturnella magna</i>)																	
Western Meadowlark (<i>Sturnella neglecta</i>)	?																
Great-tailed Grackle (<i>Quiscalus mexicanus</i>)	R	F	R	R						U	U	F	F	U	U	U	U

TABLE 2. CONTINUED.

	Sonoyta				Concepción								Gila			
	Sonoyta	Vamori	Lower	Plomo	Plomo	Sasabe	Sasabe	Altar	Coyotillo	Cocospera-	Santa	San	Bacanuchi-			
			Lower	Upper	Lower	Upper	Lower	Upper	Magdalena	Bambuto	Cruz	Pedro	Miguel	Sonora		
Bronzed Cowbird (<i>Molothrus aeneus</i>)	U	U	R	R	F	F	R	R	F	F	R*	U	R			
Brown-headed Cowbird (<i>Molothrus ater</i>)	U	U	U	U	U	U	U	U	F	F	F	F	F			
Hooded Oriole (<i>Icterus cucullatus</i>)	U	U	R	U	?	U	R	R	U	U	U	U	F	U		
Streak-backed Oriole (<i>Icterus pustulatus</i>)															R*	
Bullock's Oriole (<i>Icterus bullockii</i>)	R	U	R	R	U	R	U	U	U	U	?	U	F	?		
Scott's Oriole (<i>Icterus parisorum</i>)	U	C	R	R	C	C	C	C	C	C	U	U	U	U	U	
House Finch (<i>Carpodacus mexicanus</i>)	R	U	R*	U	U	U	U	U	F	F	C	C	C	C	U	
Lesser Goldfinch (<i>Carduelis psaltria</i>)	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	
House Sparrow (<i>Passer domesticus</i>)																

(*Buteo brachyurus*), Eurasian Collared-Dove (*Streptopelia decaocto*), Violet-green Swallow (*Tachycineta thalassina*), and Happy Wren (*Thryothorus felix*) were presumed breeding in at least two watershed regions, and Fan-tailed Warbler and Western Meadowlark were possibly breeding in one. Of species that had been observed previously at only a single locality, I presumed breeding by Cordilleran Flycatcher (*Empidonax occidentalis*) in one additional watershed region, White-tailed Kite (*Elanus leucurus*), White-tipped Dove (*Leptotila verreauxi*), and Nutting's Flycatcher (*Myiarchus nuttingi*) in two, Sinaloa Wren (*Thryothorus sinaloa*) and Rufous-capped Warbler (*Basileuterus rufifrons*) in three, Thick-billed Kingbird (*Tyrannus crassirostris*) in four, and Five-striped Sparrow (*Aimophila quinquestriata*) in five additional watershed regions. Of species that had been observed previously at only two localities, I presumed breeding by Elegant Quail (*Callipepla douglasii*) in one, Streak-backed Oriole (*Icterus pustulatus*) in three, and Buff-collared Nightjar (*Caprimulgus ridgwayi*) in four additional regions (Table 2). All of these species were rare or uncommon.

Breeding distribution of many species was much broader than that suggested by previous studies. For example, I detected several species that typically breed in riparian woodlands including Gray Hawk (*Buteo nitida*), Yellow Warbler (*Dendroica petechia*), and Summer Tanager (*Piranga rubra*) at numerous localities in the Altar, Santa Cruz, and San Pedro watersheds where they had either not been documented or had been presumed to breed at only single localities. Similarly, I detected several species that typically breed in oak woodlands including Whiskered Screech-Owl (*Megascops trichopsis*), Hutton's Vireo (*Vireo huttoni*), and Hepatic Tanager (*Piranga flava*) in the upper Altar and upper Sasabe watersheds which is west of areas where they had been presumed to breed; Northern Flicker (*Colaptes auratus*), Arizona Woodpecker (*Picoides arizonae*), and Dusky-capped Flycatcher (*Myiarchus tuberculifer*) occurred still farther west in oak woodlands in the upper Plomo watershed. I detected species that typically breed in grasslands including Swainson's Hawk (*Buteo swainsoni*) and Botteri's Sparrow (*Aimophila botteri*) west to the Vamori watershed and Cassin's Sparrow (*Aimophila cassini*) west to the upper Plomo watershed. American Kestrel (*Falco sparverius*), Brown-crested Flycatcher (*Myiarchus tyrannulus*), Bell's Vireo (*Vireo bellii*), and Lucy's Warbler (*Vermivora luciae*) were at least presumed breeding in all 16 watershed regions despite lack of previous records in many of these regions.

Distribution and abundance varied widely among watersheds. Scaled Quail (*Callipepla squamata*), Botteri's Sparrow, Grasshopper Sparrow (*Ammodramus savannarum*), and Eastern Meadowlark (*Sturnella magna*) were restricted mainly to the San Pedro and occasionally the Santa Cruz and Vamori watersheds; Scaled Quail occurred locally west to the upper Plomo watershed. White-tipped Dove and Nutting's Flycatcher were restricted to the Bacanuchi-Sonora, San Miguel, and Coyotillo-Magdalena-Carrizo watershed regions, whereas Sinaloa Wren and Black-capped Gnatcatcher (*Polioptila nigriceps*) occurred in these and the Cocospera-Bambuto watershed. I observed Happy Wren at only single localities in both the Bacanuchi-Sonora and Coyotillo-Magdalena-Carrizo watersheds. Sharp-shinned Hawk (*Accipiter striatus*), Northern Goshawk (*Accipiter gentilis*), and Broad-tailed Hummingbird (*Selasphorus platycercus*) presumably bred only in the Sierra los Ajos (Bacanuchi-Sonora watershed); Cordilleran Flycatcher, Buff-breasted Flycatcher (*Empidonax fulvifrons*), and Plumbeous Vireo (*Vireo plumbeus*) occurred in the Sierra los Ajos and to the west in one–two mountain ranges in the Cocospera-Bambuto watershed.

DISCUSSION

SPECIES RICHNESS

Northern Sonora, Mexico supports a wide range of environments and a rich and varied avifauna. Between 2000 and 2007, I recorded 161 species of landbirds that I at least presumed were breeding in the Sonoyta, Concepción, Gila, and Sonora watersheds within 125 km of the international boundary with the US. Including seven additional species that had been recorded previously, 168 species of landbirds have been at least presumed to breed in the region, and all except Northern (Masked) Bobwhite likely still occur. In comparison to estimates from neighboring Arizona between 1993 and 2000 (Corman and Wise-Gervais 2005), northern Sonora supports approximately 35% fewer species of breeding landbirds in an area approximately one-tenth the size and with 45% less elevation range; including additional species in the adjacent northern Yaqui watershed lowers this estimate to at most 31% (Marshall 1957, Russell and Monson 1998; A. D. Flesch, unpubl. data). Although estimates are not available for other regions of northern Mexico, large-scale patterns of bird distribution (Howell and Webb 1995) suggests that northern Sonora supports higher richness of breeding landbirds than any

other region of similar area in the borderlands of northern Mexico.

Using probabilistic methods, I estimated that as many as 178 species of landbirds likely breed in the study area. Information from Sonora (Russell and Monson 1998; A. D. Flesch, unpubl. data) and neighboring southern Arizona (Corman and Wise-Gervais 2005), combined with vegetation associations that I observed, suggest 10 additional species may breed locally or irregularly in the study area (Ruddy Ground Dove [*Columbina talpacoti*], Long-eared Owl [*Asio otus*], White-eared Hummingbird [*Hylocharis leucotis*], Berylline Hummingbird [*Amazilia beryllina*], Lucifer Hummingbird [*Calothorax lucifer*], Flame-colored Tanager [*Piranga bidentata*], Chipping Sparrow [*Spizella passerina*], Black-chinned Sparrow [*Spizella atrogularis*], Red Crossbill [*Loxia curvirostra*] and Pine Siskin [*Carduelis pinus*]). Rusty Sparrow (*Aimophila rufescens*) was once detected just south of the study area (Thayer and Bangs 1906) and could also breed locally in the Bacanuchi-Sonora region. Although I obtained evidence that Hermit Thrush (*Catharus guttatus*) and Western Tanager (*Piranga ludoviciana*) breed in mixed-conifer forest just east of the Yaqui-Sonora divide (A. D. Flesch, unpubl. data), in Sonora these species and possibly Warbling Vireo (*Vireo gilvus*) are likely restricted to the upper Yaqui watershed. Breeding species that have been observed combined with those I expect may occur suggest estimates of species richness that I calculated are accurate.

Not surprisingly, species richness increased markedly with the number of major vegetation communities that were present in a region. As such, regions in the east that had broader elevation ranges and therefore greater environmental diversity had higher richness. Presence of broadleaf riparian woodland, Madrean evergreen woodland, and Madrean montane conifer forest had the greatest influence on species richness indicating that these vegetation communities supported more species with specialized requirements than other communities in the region. In contrast, although richness was also high in regions with Sinaloan thornscrub, this community likely had less of an overall effect on richness because many species that are associated with thornscrub, such as Buff-collared Nightjar, Black-capped Gnatcatcher, and Five-striped Sparrow, also occurred away from thornscrub in dense desertscrub and woodland.

DISTRIBUTION PATTERNS

Bird species that occurred in desertscrub were universally more common and widespread

than species that were typically associated with grassland, thornscrub, oak woodland, or conifer forest. Species that were found predominantly in oak woodland, grassland, and broadleaf riparian woodland were typically rare and had much narrower and more fragmented distributions. Species associated with conifer forest were rarest and were largely restricted to high elevations in the Sierra los Ajos, Cananea, Pinito, and as described by Marshall (1957), in the Sierra Azul. Grassland species were especially rare in the west with some species reaching the western edge of their distribution on the east sides of the Sierras el Humo and el Cobre. Grassland species were more abundant and widespread in the upper Santa Cruz and especially in the upper San Pedro watersheds where plains grassland with high levels of horizontal and vertical vegetation cover still persist. Breeding populations of species that occurred only in broadleaf riparian woodland did not occur west of the Río Altar and were largely restricted to the Ríos Altar, Bambuto, Magdalena, and portions of other major valley bottoms to the east.

Northern Sonora supports the westernmost and northernmost patches of some vegetation communities and these patterns have important implications for bird distribution. Isolated stands of oak woodland in the Sierra el Humo for example, are the westernmost Madrean evergreen woodland in the Madrean Sky Islands, mountains that form the northern and western extensions of Sierra Madre Occidental (Marshall 1957, Warshall 1995). As such, populations of birds that are associated with oak woodland in the Sierra Madre Occidental, such as Arizona Woodpecker, reach the western edge of their global distribution in the Sierra el Humo (Flesch and Hahn 2005). Similarly, oak woodland in the nearby Sierra San Juan supported several additional species of birds that I did not detect to the west in the Sierra el Humo, including Whiskered Screech-Owl, which reach the northwestern edge of their global distribution here and in the neighboring Baboquivari Mountains of Arizona (Phillips et al. 1964). Species typically associated with Neotropical environments such as Elegant Quail, White-tipped Dove, Nutting's Flycatcher, and Sinaloa Wren were restricted mainly to three or four watersheds in the more humid south-central and southeast portions of the study area. The northernmost patches of Sinaloan thornscrub that had similar structure and composition to that found further south occurred in and northeast of the Sierra Cucurpe and at low to moderate elevations in the Bacanuchi-Sonora region and these were the only regions where I observed Happy Wren.

CHANGES IN DISTRIBUTION AND STATUS

Patterns of animal distribution represent a complex response to a range of factors including the arrangement and size of resource patches, physiological tolerances, and biotic interactions that vary in space and time (Andrewartha and Birch 1954, MacArthur 1972, Brown 1995). In northern Sonora, my observations indicate that a wide range of species are distributed across much larger areas than suggested by previous studies. Determining whether these patterns are due to actual changes in bird distribution or limited effort during past studies is difficult because few data on localities where species were undetected are available and because there are few historical accounts of vegetation conditions and change in Sonora.

Limited fieldwork in many regions of northern Sonora likely explains the wider patterns of distribution that I observed of a broad range of species. Russell and Monson (1998) for example, cited just four records of Brown-crested Flycatcher west of the Río Bambuto, north of the Río Concepción, and east of the Río Sonoyta, yet this species and its habitat are common or fairly common in all 11 watershed regions in this vast region. Distribution of other widespread migratory species such as Bell's Vireo and Lucy's Warbler were also understated, yet this pattern was somewhat less evident for resident species, suggesting that survey effort during the breeding season had been limited. Similarly, many rare species that occurred in isolated or otherwise disjunct vegetation communities had also gone undetected. If Phillips and Amadon (1952) or Russell and Monson (1998) had visited oak woodlands in the Sierra San Juan and Sierra el Humo during the breeding season rather than in fall, they probably would have detected many of the same species that I recorded. Previous fieldwork seems to have been most limited in the San Pedro, Altar, Busani, Sasabe, Vamori, and Plomo watersheds where many breeding species had not been previously documented.

Where known, patterns of vegetation change in northern Sonora have been complex and variable (Bahre and Hutchinson 2001, Turner et al. 2003), and these changes have likely influenced bird distribution. In high-elevation pine forests in the Cocospera-Bambuto watershed for example, presence of Cordilleran Flycatcher, Buff-breasted Flycatcher, and Plumbeous Vireo in mountain ranges where they were not observed by Marshall (1957) is likely attributable to recovery of these forests following extensive logging that occurred just prior to Marshall's visits. In contrast, although presence of species that are associated with oak woodland in the Sierras San

Juan and el Humo could also be related to vegetation change, evidence suggests distribution of these woodlands has been largely stable in the region during recent times (Bahre and Minnich 2001) despite some recession at lower elevations (Turner et al. 2003).

In vegetation communities that are typically more dynamic, such as broadleaf riparian woodland (Webb et al. 2007), attributing changes in bird distribution to vegetation change is more difficult. In the San Pedro Valley for example, many riparian species such as Gray Hawk, Yellow Warbler, and Summer Tanager may not have been widely documented because gallery forests were once rare or absent. In 1892 and 1893, Mearns (1907) observed only scattered broadleaf trees along the Río San Pedro at the international boundary, and gallery forests of cottonwood and willow did not develop until the 1960s and especially in the late 1970s and 1980s (Webb et al. 2007).

In the Altar Valley, however, where most species of riparian birds had been described only in the extreme upper watershed at Rancho la Arizona (van Rossem 1931), broadleaf riparian woodland has likely been present for some time. Nentvig et al. (1980) for example, described presence of permanent surface water along many portions of the Río Altar in 1764 and Shreve (1951) noted that virgin mesquite woodlands persisted near Tubutama into the 1950s despite elimination from virtually all other major valley bottoms in the Sonoran Desert at that time. Therefore, despite only recent description of breeding bird communities in the cottonwood-willow forests along the Río Altar, these communities have likely been present for some time.

Although lack of previous effort and vegetation change may explain why I observed much broader patterns of distribution for some species, distribution and abundance of many of these same species may in fact be much more limited than in the past. Along the Río Altar, for example, completion of the Cuauhtémoc Dam and Reservoir (Presa Cuauhtémoc) in 1950 diverted surface water and likely contributed to increased vegetation clearing for agriculture, degradation of gallery forests, and subsequent declines in distribution and abundance of birds associated with these forests. Early descriptions of birds and vegetation along the lower Río Concepción are available (Stephens 1885, Neff 1947, Phillips and Amadon 1952). Undoubtedly, complete elimination of the once extensive mesquite woodland near Pitiquito and Caborca caused the local extirpation of many species of birds and in part, explains why I failed to detect 21% of species that had been at least presumed

to breed in this region in the past. Similarly, although I found small, localized populations of some grassland birds south and west of Sasabe, these species were likely much more abundant and widespread before these grasslands were largely degraded or lost (Brown 1900, 1904; Bahre 1991, Turner et al. 2003), as suggested by Stephens' (1885) observation of the now extirpated Northern Bobwhite.

More widespread distributions of some species are likely the results of range expansion that has occurred largely independent of major changes in vegetation. Comparing my findings with previous observation from Sonora (Russell and Monson 1998) and the southwestern US suggests recent range expansions of the following species: White-tailed Kite (Monson and Phillips 1981, Gatz et al. 1985), Short-tailed Hawk (Corman and Wise-Gervais 2005, Williams et al. 2007), Buff-collared Nightjar (Bowers and Dunning 1997), Thick-billed Kingbird (Phillips 1968, Monson and Phillips 1981), Sinaloa Wren (Russell and Monson 1998), Rufous-capped Warbler (Rosenberg and Witzeman 1999), Five-striped Sparrow (Groschupf 1994), and Streak-backed Oriole (Corman and Monson 1995, Corman and Wise-Gervais 2005). Eurasian Collared-Dove rapidly expanded across much of North America since arriving in Florida in the early 1980s (Romagosa and McEneaney 1999) and recent arrival in Sonora since at least 2004 (Gómez de Silva 2004) is not surprising. Although I found Zone-tailed Hawk (*Buteo albonotatus*) to be much more common and widespread in western Sonora than had been described previously, its presence in western Arizona since at least 1939 (Phillips et al. 1964) suggests distribution has been largely static in this region despite recent expansion to the north (Johnson 1994, Corman and Wise-Gervais 2005). In contrast, although I also found Gray Hawk at many new localities, especially in the west and at somewhat higher elevations, this species has likely expanded its range due to vegetation change and other factors. Gray Hawk were not documented along the Río San Pedro until 1963 (Phillips et al. 1964) and have recently expanded into central Arizona (Corman and Wise-Gervais 2005).

Most species that I found to be more widely distributed or present for the first time in northern Sonora have likely expanded their geographic ranges from more tropical regions to the south (e.g., Short-tailed Hawk, White-tipped Dove, Buff-collared Nightjar, Thick-billed Kingbird, Sinaloa Wren, Happy Wren, and Rufous-capped Warbler). Although wider occurrence of some of these species could be attributable to increased effort, this

seems unlikely, because many of these same species have recently occurred for the first time or become regular summer residents in southern Arizona where effort has been much more extensive (Monson and Phillips 1981, Rosenberg and Witzeman 1999, Corman and Wise-Gervais 2005). These patterns and those in other areas of western North America (Johnson 1994) and southern Texas (Brush 2005) suggest some southern species are expanding northward possibly in response to changing resource distributions resulting from climate change and a widening of tropical atmospheric circulations during recent decades (Seidel et al. 2008). Although poleward shifts in species distributions in response to climate change have been observed on nearly every continent (Parmesan and Yohe 2003, Root et al. 2003, Parmesan 2006), time and additional study are required to further elucidate these trends in northern Mexico.

EFFORT—PAST, PRESENT, AND FUTURE

Although my coverage was extensive, it was limited in some regions. After comparing my findings with those of previous studies, I failed to detect an average of 7% of all species that had been at least presumed to breed in a watershed region, and this quantity varied with effort (Tables 1 and 2). Although some species that I failed to detect may no longer occur, more effort especially at high elevations would have produced additional data, particularly in the Santa Cruz, Bacanuchi-Sonora, San Pedro, and San Miguel watershed regions. Upper elevations in several mountain ranges in northern Sonora have likely never been visited by ornithologists including the Sierras San Antonio, San Jose, el Chivato, la Madera, Cucurpe, Cubabi, el Alamo, and San Manuel. Aside from my efforts, bird observations at upper elevations in the Sierras el Pinito, Cananea, and los Ajos had not been reported for over five decades (Marshall 1957) and other lower yet regionally significant mountains such as the Sierras San Juan and el Humo had not been visited during the breeding season. Additional effort in these and other areas of northern Sonora will yield new and valuable information especially when the adjoining Yaqui watershed is considered.

Despite more than a century of ornithological work in northern Sonora, Mexico (van Rossem 1945, Russell and Monson 1998) status and distribution of many species had remained little known in some regions. This is in sharp contrast to neighboring portions of Arizona where a great deal of historical (Swarth 1914, Brandt 1951, Phillips et al. 1964) and recent (Monson and Phillips 1981, Rosenberg and Witzeman

1998 and 1999, Rosenberg 2001, Corman and Wise-Gervais 2005) information is available. Availability of biological information in many areas of northern Sonora should increase as accessibility is improved and as interest in the diversity, uniqueness, and preservation of this region is enhanced.

CONSERVATION AND THREATS

Information on distribution and abundance of wildlife is essential for conservation. Without these data, conservation priorities may be misguided and important populations may be lost or degraded before they can be managed and protected. Prospects for conserving, managing, and enhancing populations of landbirds in northern Sonora are promising because human population densities throughout much of the region are low and because vast areas of natural vegetation remain relatively intact and unfragmented (Stoleson et al. 2005, Felger et al. 2007). Further, recent federal laws in Mexico have created a system that could aid landowners in conservation and sustainable use of wildlife especially once these programs are improved and additional resources are provided (Valdez et al. 2006, Weber et al. 2006, Sisk et al. 2007). In recent years there has also been an increase in activity by private conservation organizations in northern Sonora. These efforts have been led by Biodiversidad y Desarrollo Armónico, Naturalia, and The Nature Conservancy in northeast Sonora, by Pronatura in northwest Sonora, and assisted by partnerships with public agencies through organizations such as Sonoran Joint Venture. When enhanced by data on distribution, status, and habitat needs of landbirds, these efforts can produce valuable results.

Despite good prospects for conservation, significant threats exist. Loss and degradation of riparian areas due to agriculture, unsustainable grazing practices, and excessive groundwater pumping are having a profound influence on the structure and function of these systems. Cottonwood forests along the Río Magdalena between Magdalena de Kino and Santa Ana have been steadily declining for some time and no longer occur more than a few kilometers below Magdalena de Kino (A. D. Flesch, pers. obs.). Riparian forests throughout much of the Santa Cruz Valley have been highly degraded and although conditions are generally better in the San Pedro Valley, regeneration of broadleaf trees is limited in many areas. Riparian forest along the Río Altar is also declining locally above Tubutama and especially near Saric where quantity of surface water declined greatly

between 2000 and 2007. Other significant threats to landbirds in northern Sonora include overgrazing and degradation of grasslands, limited regeneration of important nest-cavity substrates such large trees and saguaros (*Carnegiea gigantea*), excessive fuel-wood cutting, and urbanization on a local scale (Flesch 2003, Bürquez and Martínez-Yrízar 2007). Grazing intensity in northern Sonora is generally much higher than in adjacent Arizona (Ballinger 1988), and if better managed could reduce the ecological costs and enhance the economic benefits of this nearly ubiquitous land use.

Cross-border partnerships between government and non-governmental organizations, scientists, and private citizens have the potential to optimize conservation, management, and restoration efforts in the borderlands. This need for coordination is emphasized by the ecological connections we share across the border and our joint stake in conserving natural resources for future generations. The international border is a political, not a biological boundary and as such, persistence of many populations depends on the actions and priorities of our two nations.

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LITERATURE CITED

- ABARCA, F. J., M. F. INGRALDI, AND A. VARELA-ROMERO. 1993. Observaciones del perrito del desierto (*Cyprinodon macularius*), palmoteador de Yuma (*Rallus longirostris yumanensis*) y comunidades de aves playeras en la Ciénega de Santa Clara, Sonora México. Non-game and Endangered Wildlife Program Technical Report. Arizona Game and Fish Department, Phoenix, AZ.
- ABLE, K. P. 1977. The flight behaviour of individual passerine nocturnal migrants: A tracking radar study. *Animal Behaviour* 25: 924–935.
- ALBERS, M. T., AND F. R. GEHLBACH. 1990. Choices of feeding habitat by relict Montezuma Quail in central Texas. *Wilson Bulletin* 102: 300–308.
- ALLRED, K. 1988. A field guide to the flora of the Jornada plain. New Mexico State University. Agricultural Experiment Station. Las Cruces, NM.
- AMERICAN ORNITHOLOGISTS' UNION. 1998. Checklist of North American birds. Seventh Edition. American Ornithologists' Union. Washington, DC.
- ANDERSEN, D. C. 1994. Demographics of small mammals using anthropogenic desert riparian habitat in Arizona. *Journal of Wildlife Management* 58:445–454.
- ANDERSON, B. W., AND R. D. OHMART. 1977. Vegetation structure and bird use in the Lower Colorado River. Pp. 23–34 in R. R. Johnson, and D. A. Jones, Jr. (editors). Importance, preservation and management of riparian habitat: a symposium. USDA Forest Service General Technical Report RM-43. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- ANDERSON, B. W., R. D. OHMART, AND J. RICE. 1983. Avian and vegetation community structure and their seasonal relationships in the Lower Colorado River Valley. *Condor* 85:392–405.
- ANDERSON, B. W., P. E. RUSSELL, AND R. D. OHMART. 2004. Riparian revegetation: an account of two decades of experience in the arid Southwest. Avvar Books, Blythe, CA.
- ANDERSON, D., J. KEITH, E. PALACIOS, E. VELARDE, F. GRESS, AND K. A. KING. 1999. El Niño 1997–98: Seabird responses from the southern California Current and Gulf of California. *Pacific Seabirds* 26:22.
- ANDERSON, D. R., AND K. P. BURNHAM. 2002. Avoiding pitfalls when using information-theoretic methods. *Journal of Wildlife Management* 66:912–918.
- ANDERSON, D. R., K. P. BURNHAM, AND G. C. WHITE. 1994. AIC model selection in over-dispersed capture-recapture data. *Ecology* 75:1780–1793.
- ANDREWARTHA, H. G., AND L. C. BIRCH. 1954. The distribution and abundance of animals. University of Chicago Press, Chicago, IL.
- ARIZMENDI, M. DEL C., AND L. MÁRQUEZ V. 2000. Areas de importancia para la conservación de las aves en México. CIPAMEX, Mexico City, Mexico.
- AUTOMOBILE CLUB OF SOUTHERN CALIFORNIA. 1998. Baja California: U.S. border to Cabo San Lucas. Map 2401. Los Angeles, CA.
- AVISE, J. C., AND D. WALKER. 1998. Pleistocene phylogeographic effects on avian populations and the speciation process. *Proceedings of the Royal Society B: Biological Sciences* 265:457–463.
- BAHRE, C. J. 1991. A legacy of change: historic human impact on vegetation in the Arizona borderlands. University of Arizona Press, Tucson, AZ.
- BAHRE, C. J. 1995. Human impacts on the grasslands of southeastern Arizona. Pp. 230–264 in M. P. McClaran, and T. R. Van Devender (editors). The desert grassland. University of Arizona Press, Tucson, AZ.
- BAHRE, C. J., AND C. F. HUTCHINSON. 2001. Historic vegetation change in la Frontera west of the Rio Grande. Pp. 67–83 in G. L. Webster, and C. J. Bahre (editors). Changing plant life of la Frontera: observations on vegetation in the United States/Mexico borderlands. University of New Mexico Press, Albuquerque, NM.
- BAHRE, C. J., AND R. A. MINNICH. 2001. Madrean oak woodlands along the Arizona/Sonora boundary. *Desert Plants* 17:3–14.
- BAHRE, C. J., AND M. L. SHELTON. 1993. Historic vegetation change, mesquite increases and climate in southeastern Arizona. *Journal of Biogeography* 20:489–504.
- BAILEY, V. 1905. Biological survey of Texas. North. American Fauna No. 25. Washington, DC.
- BAJA ALMANAC PUBLISHERS. 2003. Baja California almanac. Baja Almanac Publishers, Las Vegas, NV.
- BALLING, R. C. JR. 1988. The climate impact of a Sonoran Desert vegetation discontinuity. *Climate Change* 13:99–109.

- BALLING, R. C., AND G. B. GOODRICH. 2007. Analysis of drought determinants for the Colorado River Basin. *Climatic Change* 82: 179–184.
- BANCROFT, G. 1927a. Breeding birds of Scammons Lagoon, Lower California. *Condor* 29: 29–57.
- BANCROFT, G. 1927b. Notes on the breeding coastal and insular birds of central lower California. *Condor* 29:188–195.
- BARNETT, T., R. MALONE, W. PENNELL, D. STAMMER, B. SEMTNER, AND W. WASHINGTON. 2004. The effects of climate change on water resources in the West: introduction and overview. *Climatic Change* 62:1–11.
- BAUMGARTNER, J., T. COMENDANT, A. ERICKSON, J. HARDESTY, P. HARDY, M. HODGKINS, A. LEHNHOFF, M. LIPPARD, C. MACDONALD, AND B. NORTHRUP. 2006. Conservation by design: a strategic framework for mission success. The Nature Conservancy, Arlington, VA.
- BEASON, R. C. 1995. Horned Lark (*Eremophila alpestris*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 195. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- BEERWINKLE, K. R., J. LOPEZ, J. D., J. A. WITZ, P. G. SCHLEIDER, R. S. EYSTER, AND P. D. LINGREN. 1994. Seasonal radar and meteorological observations associated with nocturnal insect flight at altitudes to 900 meters. *Environmental Entomology* 23:676–683.
- BENDER, D. J., T. A. CONTRERAS, AND L. FAHRIG. 1998. Habitat loss and population decline: a meta-analysis of the patch size effect. *Ecology* 79:517–533.
- BENKMAN, C. W., AND H. R. PULLIAM. 1988. The comparative feeding rates of North American sparrows and finches. *Ecology* 69: 1195–1199.
- BENSON, K. L. P., AND K. A. ARNOLD. 2001. The Texas breeding bird atlas. Texas A&M University System, College Station and Corpus Christi, TX. <<http://txtbba.tamu.edu>> (22 March 2008).
- BIBBY, C. J., N. D. BURGESS, D. A. HILL, AND S. MUSTOE. 2000. Bird census techniques. Second Edition. Academic Press, London, UK.
- BLENDINGER, P. G., AND R. A. OJEDA. 2001. Seed supply as a limiting factor for granivorous bird assemblages in the Monte Desert, Argentina. *Austral Ecology* 26:413–422.
- BOAL, C. W., T. S. ESTABROOK, AND A. E. DUERR. 2003. Productivity and breeding habitat of Loggerhead Shrikes in a southwestern urban environment. *Southwestern Naturalist* 48:557–562.
- BOCK, C. E., AND J. H. BOCK. 1988. Grassland birds in southeastern Arizona: impacts of fire, grazing, and alien vegetation. Pp. 43–58 in P. D. Goriup (editor). *Ecology and conservation of grassland birds*. International Council for Bird Preservation, Technical Publication No. 7, Cambridge, UK.
- BOCK, C. E., AND J. H. BOCK. 1999. Response of winter birds to drought and short-duration grazing in southeastern Arizona. *Conservation Biology* 13:1117–1123.
- BOCK, C. E., AND Z. F. JONES. 2004. Avian habitat evaluation: should counting birds count? *Frontiers in Ecology and the Environment* 2:403–410.
- BOCK, C. E., AND B. WEBB. 1984. Birds as grazing indicator species in southeastern Arizona. *Journal of Wildlife Management* 48:1045–1049.
- BOCK, C. E., Z. F. JONES, AND J. H. BOCK. 2008. The oasis effect: response of birds to exurban development in a southwestern savanna. *Ecological Applications* 18:1093–1106.
- BOCK, C. E., J. H. BOCK, W. R. KENNEY, AND V. M. HAWTHORNE. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. *Journal of Range Management* 37:239–242.
- BOJÓRQUEZ-TAPIA, L. A., R. AGUIRRE, AND A. ORTEGA. 1985. Rio Yaqui watershed, northwestern Mexico: use and management. Pp. 475–478 in R. R. Johnson, C. D. Ziebell, P. F. Patton, P. F. Ffolliott, and R. E. Hamre (editors). *Riparian ecosystems and their management: reconciling conflicting issues*. USDA Forest Service General Technical Report RM-12., USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- BOWERS, R. K., AND J. B. DUNNING. 1997. Buff-collared Nightjar (*Caprimulgus ridgwayi*). In A. Poole, P. Stettenheim, and F. Gill (editors). *The Birds of North America*, No. 267. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- BRANDT, H. W. 1940. Texas bird adventures. The Bird Research Foundation, Cleveland, OH.
- BRANDT, H. 1951. Arizona and its bird life. The Bird Research Foundation, Cleveland, OH.
- BRODRICK, H. 1960. Check-list of the birds of Big Bend National Park. Big Bend Natural History Association, Big Bend National Park, TX.
- BRODRICK, H., C. P. ALLEN, AND A. LE SASSIER. 1966. Check-list of Birds of Big Bend National Park. Big Bend Natural History Association, Big Bend National Park, TX.
- BROWN, D. 1982. Biotic communities of the America southwest United States and Mexico. *Desert Plants* 4:123–179.

- BROWN, D. E. (EDITOR). 1994. Biotic communities: southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, UT.
- BROWN, D. E., P. J. UMACK, AND T. C. BRENNAN. 2007. Digitized map of biotic communities for plotting and comparing distributions of North American animals. *Southwestern Naturalist* 52:610–616.
- BROWN, H. 1900. The conditions governing bird life in Arizona. *Auk* 17:31–34.
- BROWN, H. 1904. Masked Bob-white (*Colinus ridgwayi*). *Auk* 21:209–213.
- BROWN, J. H. 1995. Macroecology. University of Chicago Press, Chicago, IL.
- BROWN, J. H., O. J. REICHMAN, AND D. W. DAVIDSON. 1979. Granivory in desert ecosystems. *Annual Review of Ecology and Systematics* 10:201–227.
- BROWN, S., C. HICKEY, B. HARRINGTON, AND R. GILL (EDITORS). 2001. The U.S. shorebird conservation plan, 2nd edition. Manomet Center for Conservation Sciences, Manomet, MA.
- BROWNING, K. A., AND R. WEXLER. 1968. The determination of kinematic properties of a wind field using Doppler radar. *Journal of Applied Meteorology* 7:105–113.
- BRUDERER, B. 1997. The study of bird migration by radar, Part 2: Major achievements. *Naturwissenschaften* 84:45–54.
- BRUSH, T. 2000. Nesting of Rose-throated Becard *Pachyramphus aglaiae* (Passeriformes: *Incertae sedis*) and Clay-colored Robin *Turdus grayi* (Passeriformes: Turdidae) in Hidalgo County, Texas. *Texas Journal of Science* 52:165–168.
- BRUSH, T. 2005. Nesting birds of a tropical frontier, the Lower Rio Grande Valley of Texas. Texas A&M University Press, College Station, TX.
- BRUSH, T., AND A. CANTU. 1998. Changes in the breeding bird community of subtropical evergreen forest in the Lower Rio Grande Valley of Texas, 1970s–1990s. *Texas Journal of Science* 50:123–132.
- BRUSH, T. In press. Range expansions and new breeding records of birds in Tamaulipas, Mexico. *Southwestern Naturalist* 53.
- BRYAN, K. B., AND J. KARGES. 2001. Recent changes to the Davis Mountains avifauna. *Texas Birds* 3:41–53.
- BRYCE, S. A., R. M. HUGHES, AND P. R. KAUFMANN. 2002. Development of a bird integrity index: using bird assemblages as indicators of riparian condition. *Environmental Management* 30:294–310.
- BUCKLEY, F. G., AND P. A. BUCKLEY. 1972. The breeding ecology of Royal Terns *Sterna (Thalasseus) maxima maxima*. *Ibis* 114: 344–359.
- BUCKLEY, F. G., AND P. A. BUCKLEY. 1974. Comparative feeding ecology of wintering adult and juvenile Royal Terns (Aves: Laridae: Sterninae). *Ecology* 55:1053–1063.
- BUCKLEY, P. A., AND F. G. BUCKLEY. 1977. Hexagonal packing of Royal Tern nests. *Auk* 94:36–43.
- BUCKLEY, P. A., AND F. G. BUCKLEY. 2002. Royal Tern (*Sterna maxima*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 700. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- BUFFINGTON, L. C., AND C. H. HERBEL. 1965. Vegetational changes on a semidesert grassland range from 1858 to 1963. *Ecological Monographs* 35:139–164.
- BURNHAM, K. P., AND D. R. ANDERSON. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, NY.
- BURNHAM, K. P., AND W. S. OVERTON. 1979. Robust estimation of population size when capture probabilities vary among animals. *Ecology* 60:927–936.
- BÚRQUEZ, A. A., AND A. MARTÍNEZ-YRÍZAR. 2007. Conservation and landscape transformations in northwestern Mexico. Pp. 537–547 in R. S. Felger, and B. Broyles (editors). Dry borders: great nature reserves of the Sonoran Desert. University of Utah Press, Salt Lake City, UT.
- CADE, T. J., AND C. P. WOODS. 1997. Changes in distribution and abundance of the Loggerhead Shrike. *Conservation Biology* 11:21–31.
- CANTERBURY, G. E., T. E. MARTIN, D. R. PETIT, L. J. PETIT, AND D. F. BRADFORD. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. *Conservation Biology* 14:544–558.
- CARLISLE, J. D., S. L. STOCK, G. S. KALTENECKER, AND D. L. SWANSON. 2004. Habitat associations, relative abundance and species richness of autumn land-bird migrants in southwestern Idaho. *Condor* 106:549–566.
- CARTRON, J.-L. E., G. CEBALLOS, AND R. S. FELGER (EDITORS). 2005. Biodiversity, ecosystems, and conservation in northern Mexico. Oxford University Press, New York, NY.
- CASTELLANOS, A., F. SALINAS, AND A. ORTEGA-RUBIO. 2001. Inventory and conservation of breeding waterbirds at Ojo de Liebre and Guerrero Negro Lagoons, Baja California Sur, Mexico. *Ciencias Marinas* 27:351–373.
- CHRISTENSEN, N. S., A. W. WOOD, N. VOISIN, D. P. LETTENMAIER, AND R. N. PALMER. 2004. The effect of climate change on the hydrology and water resources of the Colorado Basin. *Climatic Change* 62:337–363.

- CLEVELAND, C. J., M. BETKE, P. FEDERICO, J. D. FRANK, T. G. HALLAM, J. HORN, J. LÓPEZ, J. D., G. F. McCACKEN, R. A. MEDELLÍN, A. MORENO-VALDEZ, C. G. SANSONE, J. K. WESTBROOK, AND T. H. KUNZ. 2006. Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas. *Frontiers in Ecology and the Environment* 4:238–243.
- COGSWELL, H. L. 1977. *Waterbirds of California*. University of California Press, Los Angeles, CA.
- COHN, J. P. 2007. The environmental impacts of a border fence. *BioScience* 57:96.
- COLEMAN, B. D., M. A. MARES, M. R. WILLIG, AND Y. HSIEH. 1982. Randomness, area and species richness. *Ecology* 63:1121–1133.
- COLLINS, C. T. 2006. Banding studies of Elegant Terns in southern California. *North American Bird Bander* 31:17–22.
- COLLINS, C. T., AND P. F. DOHERTY, JR. 2006. Survival estimates for Royal Terns in southern California. *Journal of Field Ornithology* 77:310–314.
- COLLINS, C. T., W. A. SCHEW, AND E. BURKETT. 1991. Elegant Terns breeding in Orange County, California. *American Birds* 45:393–395.
- CONANP. 2007. Plan de Conservación y Manejo de la Reserva de la Biosfera Alto Golfo de California y delta del Río Colorado. Comisión Nacional de Áreas Naturales Protegidas, México, D.F.
- CONLEY, W., AND M. R. CONLEY. 1984. New Mexico State University College Ranch and Jornada Experimental Range: a summary of research 1900–1983. Special report. New Mexico State Agricultural Experimental Station, Las Cruces, NM.
- CONWAY, C. 2002. Standardized protocols for monitoring marshbirds in North America. Arizona Cooperative Fish and Wildlife Research Unit, USGS and School of Renewable Natural Resources, University of Arizona, Tucson, AZ.
- CONWAY, C. J., AND J. P. GIBBS. 2005. Effectiveness of call-broadcast surveys for monitoring marshbirds. *Auk* 122:26–35.
- CONWAY, C. J., AND C. P. NADEAU. 2005. Effects of fire on Yuma Clapper Rails and California Black Rails, 2004 Annual Report. Wildlife Research Report Number 2005-01. Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.
- COOKE, W. W. 1915. Bird migration. *USDA Bulletin* 185:1–47.
- COOPER, B. A., A. A. STICKNEY, AND T. J. MABEE. 2004. A radar study of nocturnal bird migration at the proposed Chautauqua Wind Energy Facility, New York, Fall 2003: Final Report for Chautauqua Windpower LLC. ABR Inc. Environmental Research and Services, Forest Grove, OR.
- COPPEDGE, B. R., D. M. ENGLE, R. E. MASTERS, AND M. S. GREGORY. 2001. Avian response to landscape change in fragmented southern Great Plains grasslands. *Ecological Applications* 11:47–59.
- CORMAN, T. E., AND G. MONSON. 1995. First United States nesting records of the Streak-backed Oriole. *Western Birds* 26:49–53.
- CORMAN, T. E., AND C. WISE-GERVAIS (EDITORS). 2005. *Arizona breeding bird atlas*. University of New Mexico Press, Albuquerque, NM.
- COTERA, M., E. GUADARRAMA, J. BRENNER, A. M. ARANGO, M. E. GARCIA GARZA, G. P. BELL, S. YANOFF, T. SULLIVAN, S. NAJERA, P. GRONEMEYER, J. WEIGEL, J. KARGES, B. MCCREADY, D. MEHLMAN, J. BERGAN, J. KING, M. GALLYOUN, D. L. CERTAIN, R. POTTS, J. WRINKLE, J. BEZAURY, H. M. ARIAS, J. ATCHLEY MONTOYA, I. E. PARRA, E. MULDAVIN, T. NEVILLE, AND G. KITTEL. 2004. Ecoregional conservation assessment of the Chihuahuan Desert, 2nd edition. Pronatura Noreste, Monterrey, N.L., Mexico.
- CRUM, T. D., R. L. ALBERTY, AND D. W. BURGESS. 1993. Recording, archiving, and using WSR-88D data. *Bulletin of the American Meteorological Society* 74:645–653.
- CRUMPTON, L. S. 1991. *Baja explorer topographic atlas directory*. ALTI Publishing, La Jolla, CA.
- CRUMPTON, L. S. 1997. *Baja California Sur almanac: topographic maps*. Baja Almanac Publishers, Las Vegas, NV.
- CUETO, V. R., L. MARONE, AND J. LOPEZ DE CASENAVE. 2006. Seed preferences in sparrow species of the Monte Desert, Argentina: implications for seed-granivore interactions. *Auk* 123:358–367.
- DANEMANN, G. D., AND R. CARMONA. 2000. Breeding birds of the Guerrero Negro saltworks, Baja California Sur, Mexico. *Western Birds* 31:195–199.
- DANEMANN, G. D., AND J. R. GUZMAN. 1992. Notes on the birds of San Ignacio Lagoon, Baja California Sur, Mexico. *Western Birds* 23: 11–19.
- DAUBENMIRE, R. F. 1959. Canopy coverage method of vegetation analysis. *Northwest Scientist* 33:43–64.
- DAVIS, F., S. ANDELMAN, AND D. STOMS. 2002. SITES: an analytical toolbox for ecoregional planning. <Internet site:<http://www.biogeog.ucsb.edu/projects/tnc/toolbox.html> (9 April 2008).
- DAVIS, L. I. 1945. Yellow-green Vireo nesting in Cameron County, Texas. *Auk* 62:146.
- DAVIS, L. I. 1966. *Birds of the Rio Grande delta, an annotated checklist*. Published by the author, Austin, TX.

- DAVIS, L. I. 1974. Birds of the Rio Grande delta, an annotated checklist. Published by the author, Austin, TX.
- DAVIS, S. K. 2004. Area sensitivity in grassland passerines: effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. *Auk* 121:1130–1145.
- DEBANO, L. F. (EDITOR). 1995. Biodiversity and management of the Madrean Archipelago: the sky islands of southwestern United States and northwestern Mexico. USDA Forest Service General Technical Report RM-GTR-264. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- DESANTE, D. F., AND T. L. GEORGE. 1994. Population trends in the landbirds of western North America. *Studies in Avian Biology* 15:173–190.
- DESMOND, M. J. 2004. Effects of grazing practices and fossorial rodents on a winter avian community in Chihuahua, Mexico. *Biological Conservation* 116:235–242.
- DESMOND, M. J., K. YOUNG, B. THOMPSON, R. VALDEZ, AND A. LAFÓN TERRAZAS. 2005. Habitat associations and conservation of grassland birds in the Chihuahuan Desert region: two case studies in Chihuahua Mexico. Pp. 439–451 in J. L. E. Carton, G. Ceballos, and R. S. Felger (editors). *Biodiversity, ecosystems and conservation in northern Mexico*. Oxford University Press, New York, NY.
- DIARIO OFICIAL DE LA FEDERACIÓN. 2002. Norma Oficial Mexicana NOM-059-ECOL-2001, Protección ambiental—especies nativas de México de flora y fauna silvestres—categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista de especies en riesgo. Secretaría de Medio Ambiente y Recursos Naturales. México, D.F.
- DIAZ, M. 1990. Interspecific patterns of seed selection among granivorous passerines: effects of seed size, seed nutritive value and bird morphology. *Ibis* 132:467–476.
- DICK-PEDDIE, W. A. 1993. New Mexico vegetation: past, present, and future. University of New Mexico Press, Albuquerque, NM.
- DICK-PEDDIE, W. A., W. H. MOIR, AND R. SPELLENBERG. 1993. New Mexico vegetation: past, present, and future. University of New Mexico Press, Albuquerque, NM.
- DIEHL, R. H., AND R. P. LARKIN. 2005. Introduction to the WSR-88D (NEXRAD) for ornithological research. Pp. 876–888 in C. J. Ralph, and T. D. Rich (editors). *Bird conservation implementation and integration in the Americas: Proceedings of the Third International Partners in Flight Conference* 2002. USDA Forest Service General Technical Report PSW-GTR-191. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. <http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/876-888.pdf> (10 April 2008).
- DIENI, J. S., W. H. HOWE, S. L. JONES, P. MANZANO-FISCHER, AND C. P. MELCHER. 2003. New information on wintering birds of northwestern Chihuahua. *American Birds* 103:26–31.
- DINERSTEIN, E., D. OLSON, J. ATCHLEY, C. LOUCKS, S. CONTRERAS-BALDERAS, R. ABELL, E. IÑIGO, E. ENKERLIN, C. WILLIAMS, AND G. CASTILLEJA. 2000. *Ecoregion-based conservation in the Chihuahuan Desert: a biological assessment*. World Wildlife Fund, Washington, DC.
- DINSMORE, J. J., AND S. J. DINSMORE. 1993. Range expansion of Great-tailed Grackles in the 1900s. *Journal of the Iowa Academy of Science* 100:54–59.
- DOOLEY, J. L., AND M. A. BOWERS. 1998. Demographic responses to habitat fragmentation: experimental tests at the landscape and patch scale. *Ecology* 79:969–980.
- DUNNING, J. B., AND J. H. BROWN. 1982. Summer rainfall and winter sparrow densities: a test of the food limitation hypothesis. *Auk* 99: 123–129.
- ECTON, K. 2003. Spatial and temporal migration patterns of Wilson's Warblers revealed by stable hydrogen isotopes. M.S. thesis, Northern Arizona University, Flagstaff, AZ.
- EDDLEMAN, W. R. 1989. Biology of the Yuma Clapper Rail in the southwestern U.S. and northwestern México. Final Report. Intra-Agency of Agreement No. 4-AA-30-02060. U.S. Bureau of Reclamation, Yuma Projects Office, Yuma, AZ.
- EDDLEMAN, W. R., AND C. J. CONWAY. 1998. Clapper Rail (*Rallus longirostris*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 340. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- EITNIAR, J. C. 1997. White-collared Seedeater (*Sporophila torqueola*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 278. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- EITNIAR, J. C. 2004. Diet of the white-collared seedeater *Sporophila torqueola* (Passeriformes: Emberizidae) in Texas. *Texas Journal of Science* 56:77–80.
- ELLISON, K., AND S. G. SEALY. 2007. Small hosts infrequently disrupt laying by Brown-headed

- Cowbirds and Bronzed Cowbirds. *Journal of Field Ornithology* 78:379–389.
- ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. 1990. PC ARC/INFO Version 3.2. Environmental Systems Research Institute, Redlands, CA.
- ERWIN, R. M. 1977. Foraging and breeding adaptations to different food regimes in three seabirds: Common Tern, *Sterna hirundo*, Royal Tern, *S. maxima*, and Black Skimmer, *Rynchops niger*. *Ecology* 58:389–397.
- ERWIN, R. M. 1979. Species interactions in a mixed colony of Common Terns, *Sterna hirundo*, and Black Skimmers, *Rynchops niger*. *Animal Behaviour* 27:1054–1062.
- ESCALANTE, T., G. RODRÍGUEZ, AND J. J. MORRONE. 2004. The diversification of Nearctic mammals in the Mexican transition zone. *Biological Journal of the Linnean Society* 83: 327–339.
- EVERETT, W. T., AND D. W. ANDERSON. 1991. Status and conservation of the breeding seabirds of offshore Pacific Islands of Baja California and the Gulf of California. Pp. 115–139 in J. P. Croxall (editor), *Seabird status and conservation: a supplement*. ICBP Technical Publication 11. International Council for Bird Preservation, Cambridge, UK.
- FARLEY, G. H., L. M. ELLIS, J. N. STUART, AND N. J. SCOTT. 1994a. Avian species richness in different-aged stands of riparian forest along the middle Rio Grande, New Mexico. *Conservation Biology* 8:1098–1108.
- FARLEY, G. H., L. M. ELLIS, J. N. STUART, AND N. J. SCOTT. 1994b. Birds of restored and mature riparian woodlands in the middle Rio Grande Valley. *New Mexico Ornithological Society Bulletin* 22:25–33.
- FELGER R. S., B. BROYLES, M. F. WILSON, G. P. NABHAN, AND D. S. TURNER. 2007. Six grand reserves, one grand desert. Pp. 3–26 in R. S. Felger, and B. Broyles (editors). *Dry borders: great nature reserves of the Sonoran Desert*. University of Utah Press, Salt Lake City, UT.
- FINCH, D. M. (EDITOR). 2004. Assessment of grassland ecosystem conditions in the southwestern United States, Volumes 1 and 2. USDA Forest Service General Technical Report RMRS-GTR-135. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- FINCH, D. M., AND W. YONG. 2000. Landbird migration in riparian habitats of the Middle Rio Grande: a case study. *Studies in Avian Biology* 20:88–98.
- FLEISHMAN, E., G. T. AUSTIN, P. F. BRUSSARD, AND D. D. MURPHY. 1999. A comparison of butterfly communities in native and agricultural riparian habitats in the Great Basin, USA. *Biological Conservation* 89:209–218.
- FLEISHMAN, E., N. McDONALD, R. MACNALLY, D. D. MURPHY, J. WALTERS, AND T. FLOYD. 2003. Effects of floristics, physiognomy, and non-native vegetation on riparian bird communities in a Mojave Desert watershed. *Journal of Animal Ecology* 72:484–490.
- FLESCH, A. D. 1997. Distribution and abundance of breeding grassland birds on the Buenos Aires National Wildlife Refuge: a monitoring program. Report prepared for USDI Fish and Wildlife Service, Sasabe, AZ.
- FLESCH, A. D. 2003. Distribution, abundance, and habitat of Cactus Ferruginous Pygmy-Owls in Sonora Mexico. M.S. thesis, University of Arizona, Tucson, AZ.
- FLESCH, A. D. 2008. Status and population size of breeding grassland birds on Rancho Los Fresnos, northern Sonora, Mexico. Report. School of Natural Resources, University of Arizona, Tucson, AZ.
- FLESCH, A. D., AND L. A. HAHN. 2005. Distribution of birds and plants at the western and southern edges of the Madrean Sky Islands in Sonora, Mexico. Pp. 80–87 in G. J. Gottfried, B. Gebow, L. G. Eskew, and E. Carleton (editors). *Connecting mountain islands and desert seas: biodiversity and management of the Madrean Archipelago II*. USDA Forest Service General Technical Report RMRS-P-36. USDA Forest Service, Rocky Mountain Research Station, Ft. Collins, CO.
- FLESCH, A. D., AND R. J. STEIDL. 2006. Population trends and implications for monitoring Cactus Ferruginous Pygmy-Owls in northern Mexico. *Journal of Wildlife Management* 70:867–871.
- FLESCH, A. D., AND R. J. STEIDL. 2007. Detectability and response rates of Ferruginous Pygmy-Owls. *Journal of Wildlife Management* 71: 981–990.
- FORD, H. A., N. FORDE, AND S. HARRINGTON. 1982. Non-destructive methods to determine the diets of birds. *Corella* 6:6–10.
- FREDRICKSON, E., K. M. HAVSTAD, R. ESTELL, AND P. HYDER. 1998. Perspectives on desertification: southwestern United States. *Journal of Arid Environments* 39:191–207.
- FRETTWELL S. D. 1972. *Populations in a seasonal environment*. Princeton University Press, Princeton, NJ.
- FUERTES, L. A. 1903. With the Mearns's Quail in southwestern Texas. *Condor* 5:113–116.
- GALLOP, F. N., AND B. H. BAILEY. 1960. Elegant and Royal Terns nesting in California. *Condor* 62:65–66.
- GARCÍA-HERNÁNDEZ, J., O. HINOJOSA-HUERTA, E. GLENN, D. BAUMGARTNER, S. DESTEFANO, AND W. SHAW. 1999. Impacts of salinity increase

- in the bypass drain (MODE) on the ecology of the Cienega de Santa Clara wetland. Report to USDI, Bureau of Reclamation, Yuma Office. Yuma, AZ.
- GARRETT, K., AND J. DUNN. 1981. The Birds of southern California. Los Angeles Audubon Society, Los Angeles, CA.
- GARZA-TORRES, H. A., J. R. HERRERA-HERRERA, G. ESCALONA-SEGURE, J. A. VARGAS-CONTRERAS, AND A. G. NAVARRO-S. 2003. New bird records from Tamaulipas, Mexico. *Southwestern Naturalist* 48:707–710.
- GATZ, T. A., M. D. JAKLE, R. L. GLINSKI, AND G. MONSON. 1985. First nesting record and current status of the Black-shouldered Kite in Arizona. *Western Birds* 16:57–61.
- GAUTHREAUX, S. A., AND C. G. BELSER. 1998. Displays of bird movements on the WSR-88D: patterns and quantification. *Weather and Forecasting* 13:453–464.
- GAUTHREAUX, S. A., C. G. BELSER, AND D. VAN BLARICOM. 2003. Using a network of WSR-88D weather surveillance radars to define patterns of bird migration at large spatial scales. Pp. 335–346 in P. Berthold, E. Gwinner, and E. Sonnenschein (editors). *Avian migration*. Springer-Verlag, Berlin, Germany.
- GIBBENS, R. P., AND R. F. BECK. 1988. Changes in grass basal area and forb densities over a 64-year period on grassland types of the Jornada Experimental Range. *Journal of Range Management* 41:186–192.
- GIBBENS, R. P., J. M. TROMBLE, J. T. HENNESY, AND M. CARDENAS. 1983. Soil movement in mesquite dune lands and former grass grasslands of southern New Mexico from 1933 to 1980. *Journal of Range Management* 36: 145–148.
- GIBBENS, R. P., R. P. MCNEELY, K. M. HAVSTAD, R. F. BECK, AND B. NOLEN. 2005. Vegetation changes in the Jornada Basin from 1858 to 1998. *Journal of Arid Environments* 61: 651–668.
- GIBBS, J. P. 1995. Users manual for MONITOR 6.2. Yale University, New Haven, CT.
- GINTER, D. L., AND M. J. DESMOND. 2005. Influence of foraging and roosting behavior on home-range size and movement patterns of Savannah Sparrows wintering in south Texas. *Wilson Bulletin* 117:63–71.
- GLENN, E. P., AND P. L. NAGLER. 2005. Comparative ecophysiology of *Tamarix ramosissima* and native trees in western U.S. riparian zones. *Journal of Arid Environments* 61:419–446.
- GLENN, E. P., C. LEE, R. FELGER, AND S. ZENGEL. 1996. Effects of water management on the wetlands of the Colorado River delta, Mexico. *Conservation Biology* 10:1175–1186.
- GLENN, E. P., F. ZAMORA-ARROYO, P. L. NAGLER, M. BRIGGS, W. SHAW, AND K. FLESSA. 2001. Ecology and conservation biology of the Colorado River delta, Mexico. *Journal of Arid Environments* 49:5–15.
- GLÜCK, E. E. 1985. Seed preference and energy intake of Goldfinches *Carduelis carduelis* in the breeding season. *Ibis* 127:421–429.
- GÓMEZ DE SILVA, H. 2004. Mexico. *North American Birds* 58:607–610.
- GÓMEZ DE SILVA, H. 2007. The nesting season; Mexico. *North American Birds* 60:584–587.
- GOODWIN, S. L. 2000. Conservation connections in a fragmented desert environment: the U.S.-Mexico border. *Natural Resource Journal* 40:898–1016.
- GORDON, C. E. 2000. Movement patterns of wintering grassland sparrows in Arizona. *Auk* 117:748–759.
- GRAHAM, C. H., AND J. G. BLAKE. 2001. Influence of patch- and landscape-level on bird assemblages in a fragmented tropical landscape. *Ecological Applications* 11:1709–1721.
- GRANT, P. R. 1966. Preliminary experiments on the foraging of closely related species of birds. *Ecology* 47:148–151.
- GREENBERG, R. 1995. Insectivorous migratory birds in tropical ecosystems: the breeding currency hypothesis. *Journal of Avian Biology* 26:260–264.
- GREENBERG, R., P. BICHIER, AND J. STERLING. 1997. Acacia, cattle and migratory birds in southeastern Mexico. *Biological Conservation* 80: 235–247.
- GREGORY, S. V., F. J. SWANSON, W. A. MCKEE, AND K. W. CUMMINS. 1991. An ecosystem perspective of riparian zones. *BioScience* 41:540–551.
- GREIG-SMITH, P. W., AND D. R. CROCKER. 1986. Mechanisms of food size selection by bullfinches (*Pyrrhula pyrrhula* L.) feeding on sunflower seeds. *Animal Behaviour* 34:843–859.
- GREIG-SMITH, P. W., AND M. F. WILSON. 1985. Influence of seed size, nutrient composition and phenolic content on the preference of bullfinches feeding in ash trees. *Oikos* 44: 47–54.
- GRINNELL, J. 1928. A distributional summation of the ornithology of Lower California. *University of California Publications in Zoology* 32:1–300.
- GRINNELL, J., AND A. H. MILLER. 1944. The distribution of the birds of California. *Pacific Coast Avifauna* 27:1–608.
- GRISCOM, L., AND M. S. CROSBY. 1926. Birds of the Brownsville region, southern Texas. *Auk* 43: 18–36.
- GROSCHUPE, K. 1994. Current status of Five-striped Sparrow in Arizona. *Western Birds* 25:192–197.

- GROSS, K. L., AND K. A. RENNER. 1989. A new method for estimating seed numbers in the soil. *Weed Science* 37:836–839.
- GROVES, C. 2003. Drafting a conservation blueprint: A practitioner's guide to planning for biodiversity. Island Press, Washington, DC.
- GROVES, C., L. VALUTIS, D. VOSICK, B. NEELY, K. WHEATON, J. TOUVAL, AND B. RUNNELS. 2000. Designing a geography of hope: a practitioner's handbook to ecoregional conservation planning, second edition. The Nature Conservancy, Arlington, VA.
- GRZYBOWSKI, J. A. 1982. Population structure in grassland bird communities during winter. *Condor* 84:137–152.
- GRZYBOWSKI, J. A. 1983. Sociality of grassland birds during winter. *Behavioral Biology and Sociobiology* 13:211–219.
- GUTIÉRREZ-LACAYO, M., AND O. HINOJOSA-HUERTA. 2007. Manual de Adquisición de Derechos de Agua en el delta del Río Colorado. Technical Publication of Pronatura Noroeste. San Luis Río Colorado, Sonora, México.
- GUTZWILLER, K. J., AND W. C. BARROW. 2002. Does bird community structure vary with landscape patchiness? A Chihuahuan Desert perspective. *Oikos* 98:284–298.
- HALFFTER, G. 1987. Biogeography of the montane entomofauna of Mexico and Central America. *Annual Review in Entomology* 32:95–114.
- HARPER, J. L., P. H. LOVELL, AND K. G. MOORE. 1970. The shapes and sizes of seeds. *Annual Review of Ecology and Systematics* 1: 327–356.
- HAVSTAD, K. M., J. E. HERRICK, AND W. H. SCHLESINGER. 2000. Desert rangelands, degradation and nutrients. Pp. 77–87 in O. Arnalds, and S. Archer (editors). *Rangeland desertification*. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- HEALD, W. F. 1993. The Chiricahuas sky island. Bantlin Publishers, Tucson, AZ.
- HEGLUND, P. J., AND S. K. SKAGEN. 2005. Ecology and physiology of en route Nearctic–Neotropical migratory birds: a call for collaboration. *Condor* 107:193–196.
- HELZER, C. J., AND D. E. JELINSKI. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. *Ecological Applications* 9:1448–1458.
- HENDERSON, C. B. 1990. The influence of seed appärence, nutrient content and chemical defenses on dietary preference in *Dipodomys ordii*. *Oecologia* 82:333–341.
- HERKERT, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. *Ecological Applications* 4: 461–471.
- HERKERT, J. R., AND F. L. KNOPF. 1998. Research needs for grassland bird conservation. Pp. 273–282 in J. M. Marzluff, and R. Sallabanks (editors) *Avian conservation: research and management*. Island Press, Washington, DC.
- HERRICK, J. E., K. M. HAVSTAD, AND D. P. COFFIN. 1997. Rethinking remediation technologies for desertified landscapes. *Journal of Soil and Water Conservation* 52:220–225.
- HIGGINS, J., R. UNNASCH, AND C. SUPPLES. 2007. Ecoregional status measures version 1.0: framework and technical guidance to estimate effective conservation. The Nature Conservancy, Arlington, VA.
- HINES, J. E. 1996. SPECRICH software to compute species abundance from empirical species abundance distribution data. USGS Patuxent Wildlife Research Center, Patuxent, MD. <<http://www.mbr-pwrc.usgs.gov/software/specrich.html>> (5 April 2008).
- HINOJOSA-HUERTA, O. 2000. Abundance, distribution, and habitat use of the Yuma Clapper Rail (*Rallus longirostris yumanensis*) in the Colorado River delta, Mexico. M.S. thesis, University of Arizona, Tucson, AZ.
- HINOJOSA-HUERTA, O., S. DESTEFANO, AND W. SHAW. 2001. Abundance and distribution of the Yuma Clapper Rail (*Rallus longirostris yumanensis*) in the Colorado River delta, Mexico. *Journal of Arid Environments* 49: 171–182.
- HINOJOSA-HUERTA, O., J. GARCÍA-HERNÁNDEZ, Y. CARRILLO-GUERRERO, AND E. ZAMORA-HERNÁNDEZ. 2007. Hovering over the Alto Golfo: status and conservation of birds from the Rio Colorado to the Gran Desierto. Pp. 383–407 in R. S. Felger, and B. Broyles (editors). *Dry borders: great natural areas of the Sonoran Desert*. University of Utah Press, Salt Lake City, UT.
- HINOJOSA-HUERTA, O., M. GUTIÉRREZ-LACAYO, Y. CARRILLO-GUERRERO, AND F. ZAMORA-ARROYO. 2007. Water acquisition for wetland restoration in the Colorado River delta. Final Report from Pronatura Noroeste presented to the USDI Fish and Wildlife Service, Grant MX-N391. San Luis Río Colorado, Sonora, México.
- HINOJOSA-HUERTA, O., Y. CARRILLO-GUERRERO, S. DESTEFANO, W. SHAW, AND C. VALDÉS-CASILLAS. 2004. Waterbird communities and associated wetlands of the Colorado River delta, Mexico. *Studies in Avian Biology* 27: 52–60.
- HINOJOSA-HUERTA, O., H. ITURRIBARRÍA-ROJAS, Y. CARRILLO-GUERRERO, M. DE LA GARZA-TREVÍNO, AND E. ZAMORA-HERNÁNDEZ. 2004.

- Bird conservation plan for the Colorado River delta. Pronatura Noroeste, Dirección de Conservación Sonora. San Luis Río Colorado, Sonora, México.
- HOLDERMANN, D. A., S. SOROLA, JR., AND R. SKILES. 2007. Recent photo and audio-documentation of Montezuma Quail from the Chisos Mountains, Big Bend National Park (BBNP), Texas. *Bulletin of the Texas Ornithological Society* 40:62–67.
- HOLMES, R. T., AND T. W. SHERRY. 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: importance of habitat change. *Auk* 118:589–609.
- HORN, M. H., P. A. COLE, AND W. E. LOEFFLER. 1996. Prey resource base of the tern and skimmer colonies at the Bolsa Chica Ecological Reserve, Orange County, and the Western Saltworks, south San Diego Bay. Final Report to USDI Fish and Wildlife Service, Carlsbad, CA.
- HORN, M. H., W. E. LOEFFLER, J. F. WILSON, AND P. A. COLE. 1994. Monitoring of foraging patterns of terns and skimmers at the Bolsa Chica Ecological Reserve in 1994. Final Report to USDI Fish and Wildlife Service, Carlsbad, CA.
- HOWELL, A. B. 1917. Birds of the islands off the coast of southern California. *Pacific Coast Avifauna* 12:1–127.
- HOWELL S. N. G., AND S. WEBB. 1995. A guide to the birds of Mexico and northern Central America. Oxford University Press, New York, NY.
- HUBBARD, J. P. 1971. The summer birds of the Gila Valley, New Mexico. *Neumoria Occasional Papers of the Delaware Museum of Natural History* 2:1–35.
- HUNT, C. 1985. The need for riparian habitat protection. *National Wetlands Newsletter* 7:5–8.
- HUTTO, R. L. 1980. Winter habitat distribution of migratory land birds in western Mexico, with special reference to small foliage-gleaning insectivores. Pp. 181–203 in A. E. Keast, and E. S. Morton (editors). *Migrant birds in the Neotropics*. Smithsonian Institution Press, Washington, DC.
- HUTTO, R. L. 1985. Habitat selection by non-breeding, migratory land birds. Pp. 455–476 in M. L. Cody (editor). *Habitat selection in birds*. Academic Press, Inc., Orlando, FL.
- HUTTO, R. L. 1995. Can patterns of vegetation change in western Mexico explain population trends in western neotropical migrants? Pp. 48–58 in M. H. Wilson, and S. A. Sader (editors). *Conservation of neotropical migratory birds in Mexico*. Maine Agricultural and Forest Experiment Station, Misc. Publ. 727. Orono, ME.
- HUTTO, R. L. 1998. On the importance of stopover sites to migrating birds. *Auk* 115:823–825.
- HUTTO, R. L. 2000. On the importance of enroute periods to the conservation of migratory landbirds. *Studies in Avian Biology* 20: 109–114.
- HUTTO, R. L., S. M. PLETSCHET, AND P. HENDRICKS. 1986. A fixed-radius point count method for nonbreeding and breeding season use. *Auk* 103:593–602.
- HYLANDER, K. 2006. Riparian zones increase regional species richness by harboring different, not more, species: comment. *Ecology* 87:2126–2128.
- HYRENBACH, K. D., AND R. R. VEIT. 2003. Ocean warming and seabird communities of the southern California Current System (1987–98): response at multiple temporal scales. *Deep-Sea Research II* 50:2537–2565.
- IGL, L. D., AND B. M. BALLARD. 1999. Habitat associations of migrating and over wintering grassland birds in southern Texas. *Condor* 101:771–782.
- INEGI. 2000. *Síntesis de Información Geográfica del Estado de Sonora*, Second edition. Instituto Nacional de Estadística, Geografía e Informática INEGI, Aguascalientes, Ags. México.
- INTERNATIONAL BOUNDARY AND WATER COMMISSION. 2007. Colorado River at southerly international boundary. <<http://www.ibwc.state.gov/wad/ddqsibco.htm>> (14 April, 2008).
- JOHNSON, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61:65–71.
- JOHNSON, M. D., A. M. STRONG, AND T. W. SHERRY. 2006. Migrants in tropical bird communities: the balanced breeding limitation hypothesis. *Journal of Avian Biology* 37:229–237.
- JOHNSON, M. D., T. W. SHERRY, A. M. STRONG, AND A. MEDORI. 2005. Migrants in Neotropical bird communities: an assessment of the breeding currency hypothesis. *Journal of Animal Ecology* 74:333–341.
- JOHNSON, N. K. 1994. Pioneering and natural expansion of breeding distributions in western North American birds. *Studies in Avian Biology* 15:27–44.
- JONES, Z. F., AND C. E. BOCK. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. *Condor* 104: 643–651.
- JORNADA BASIN LONG TERM ECOLOGICAL RESEARCH NETWORK. 2006. Jornada Basin long term ecological research. <<http://jornada-www.nmsu.edu/>> (5 April 2008).
- KARL, J. W., AND J. HOTH. 2005. North American grassland priority conservation areas:

- technical report and documentation. Commission for Environmental Cooperation, Montreal, Quebec, Canada and The Nature Conservancy, Arlington, VA.
- KELLY, J. F., AND R. L. HUTTO. 2005. An east-west comparison of migration in North American wood warblers. *Condor* 107:197–211.
- KELLY, J., D. L. HAWKSWORTH, AND R. A. MEYER. 2006. Abundance of non-breeding Horned Larks and Chestnut-collared Longspurs on grazed and rested semiarid grassland. *Southwestern Naturalist* 51:172–180.
- KELLY, J., R. SMITH, D. D. FINCH, F. MOORE, AND W. YONG. 1999. Influence of summer biogeography on Wood Warbler stopover abundance. *Condor* 101:76–85.
- KENYON, K. W. 1947. Notes on the occurrence of birds in Lower California. *Condor* 49: 210–211.
- KERLEY, G. I., AND W. G. WHITFORD. 2000. Impact of grazing and desertification in the Chihuahuan Desert: plant communities, granivores and granivory. *American Midland Naturalist* 144:78–91.
- KIRKPATRICK, C., S. DESTEPHANO, R. W. MANNAN, AND J. LLOYD. 2002. Trends in abundance of grassland birds following a spring prescribed burn in southern Arizona. *Southwestern Naturalist* 47:282–292.
- KNOPF, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Pp.105–111 in R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. E. Hamre (editors). Riparian ecosystems and their management: reconciling conflicting issues. First North American Riparian Conference. USDA Forest Service General Technical Report RM-120. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- KNOPF, F. L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology* 15: 247–257.
- KNOPF, F. L. 1996. Prairie legacies—birds. Pp. 135–148 in F. B. Samson, and F. L. Knopf (editors). Prairie conservation: preserving North America's most endangered ecosystem. Island Press, Washington, DC.
- KNOPF, F. L., AND F. B. SAMSON. 1994. Scale perspectives on avian diversity in western riparian ecosystems. *Conservation Biology* 8:669–676.
- KNOPF, F. L., R. R. JOHNSON, T. RICH, F. B. SAMSON, AND R. C. SZARO. 1988. Conservation of riparian ecosystems in the United States. *Wilson Bulletin* 100:272–284.
- KOSTECKE, R. M., K. ELLISON, AND S. G. SUMMERS. 2004. Continued range expansion by Bronzed Cowbird in the southwestern United States. *Southwestern Naturalist* 49: 487–492.
- KRICHER, J. C., AND W. E. DAVIS. 1992. Patterns of avian species richness in disturbed and undisturbed habitats in Belize. Pp. 240–246 in J. M. Hagan, and D. W. Johnston (editors). *Ecology and Conservation of Neotropical Migrant Landbirds*. Smithsonian Institution Press, Washington, DC.
- KRUUPER, D., J. BART, AND T. RICH. 2003. Response of vegetation and breeding birds to the removal of cattle on the San Pedro River, Arizona (U.S.A.). *Conservation Biology* 17: 607–615.
- KUSHLAN, J. A., M. J. STEINKAMP, K. C. PARSONS, J. CAPP, M. ACOSTA CRUZ, M. COULTER, I. DAVIDSON, L. DICKSON, N. EDELSON, R. ELLIOT, R. M. IRWIN, S. HATCH, S. KRESS, R. MILKO, S. MILLER, K. MILLS, R. PAUL, R. PHILLIPS, J. E. SALIVA, B. SYDEMAN, J. TRAPP, J. WHEELER, AND K. WOHL. 2002. Waterbird conservation for the Americas. The North American Conservation Plan. Version 1. Waterbird Conservation for the Americas, Washington, DC.
- LAND, H. C. 1970. Birds of Guatemala. Livingston Publishing Company, Wynnewood, PA.
- LARISON, B., S. A. LAYMON, P. L. WILLIAMS, AND T. B. SMITH. 2001. Avian responses to restoration: nest-site selection and reproductive success in Song Sparrows. *Auk* 118: 432–442.
- LARKIN, R. P. 1991. Flight speeds observed with radar, a correction: slow "birds" are insects. *Behavioral Ecology and Sociobiology* 29: 221–224.
- LARKIN, R. P. 2005. Radar techniques for wildlife biology. Pp. 448–464 in C. E. Braun (editor). *Techniques for wildlife investigations and management*. The Wildlife Society, Bethesda, MD.
- LATTA, M. J., C. J. BEARDMORE, AND T. E. CORMAN. 1999. Arizona Partners in Flight Bird Conservation Plan. Version 1.0. AGFD Nongame and Endangered Wildlife Program Technical Report 142. Arizona Game and Fish Department, Phoenix, AZ.
- LITTELL, R. C., W. W. STROUP, AND R. J. FREUND. 2002. *SAS for linear models*. Fourth Edition. SAS Institute, Inc., Cary, NC.
- LIVERMAN, D. M., R. G. VARADY, O. CHÁVEZ, AND R. SÁNCHEZ. 1999. Environmental issues along the United States-Mexico border: drivers of change and responses of citizens and institutions. *Annual Review of Energy and the Environment* 24:60–643.
- LOCKWOOD, M. W. 2002. Texas Bird Records Committee report for 2001. *Bulletin of the Texas Ornithological Society* 35:1–10.

- LOCKWOOD, M. W. 2004. Texas Bird Records Committee report for 2003. Bulletin of the Texas Ornithological Society 37:17–24.
- LOCKWOOD, M. W. 2005. Texas Bird Records Committee report for 2004. Bulletin of the Texas Ornithological Society 38:21–28.
- LOCKWOOD, M. W. 2006. Texas Bird Records Committee report for 2005. Bulletin of the Texas Ornithological Society 39:33–42.
- LOCKWOOD, M. W. 2007. Texas Bird Records Committee report for 2006. Bulletin of the Texas Ornithological Society 40:41–49.
- LOCKWOOD, M. W., AND B. FREEMAN. 2004. The Texas Ornithological Society handbook of Texas birds. Texas A&M University Press, College Station, TX.
- LOCKWOOD, M. W., R. PINKSTON, AND R. WEEKS. 2006. Texas. North American Birds 59:620–624.
- LONARD, R. L., AND F. W. JUDD. 1991. Comparison of the effects of the severe freezes of 1983 and 1989 on native woody plants of the Lower Rio Grande Valley, Texas. Southwestern Naturalist 36:213–217.
- LORENZ, S., C. BUTLER, AND J. PAZ. 2006. First nesting record of the Gray-crowned Yellowthroat (*Geothlypis poliocephala*) in the United States since 1894. Wilson Journal of Ornithology 118:574–576.
- LOWTHER, P. E., C. CELADA, N. K. KLEIN, C. C. RIMMER, AND D. A. SPECTOR. 1999. Yellow Warbler (*Dendroica petechia*). In A. Poole, and F. Gill (editors). The Birds of North America, No. 454. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- MACARTHUR, R. H. 1964. Environmental factors affecting bird species diversity. American Naturalist 68:387–397.
- MACARTHUR, R. H. 1972. Geographical ecology: patterns in the distribution of species. Harper and Row, New York, NY.
- MACCALL, A. D. 1979. Population estimates for the waning years of the Pacific sardine fishery. California Cooperative Fisheries Investigations Report 20:72–82.
- MACMYNOWSKI, D. P., T. L. ROOT, G. BALLARD, AND G. R. GEUPEL. 2007. Changes in spring arrival of Nearctic-Neotropical migrants attributed to multiscalar climate. Global Change Biology 13:1–13.
- MANLY, B. F. J. 2004. Multivariate statistical methods: a primer. Third Edition, Chapman and Hall /CRC. Boca Raton, FL.
- MANNAN, R. W., M. L. MORRISON, AND E. C. MESLOW. 1984. Comment: the use of guilds in forest bird management. Wildlife Society Bulletin 12:426–430.
- MANVILLE, A. M. II. 2001. The ABCs of avoiding bird collisions at communication towers: next steps. Pp. 85–103 in R. L. Carlton (editor). Avian interactions with utility and communication structures. EPRI Technical Report. Concord, CA.
- MANZANO-FISCHER, P., R. LIST, G. CEBALLOS, AND J.-L. E. CARTRON. 2006. Avian diversity in a priority area for conservation in North America: The Janos-Casas Grandes prairie dog complex and adjacent habitats in northwestern Mexico. Biodiversity and Conservation 15:3801–3825.
- MARESH, J. 2004. Survey of Black-capped Vireo, Big Bend National Park, Brewster County, Texas, Spring 2004. Report to Big Bend National Park, TX.
- MARONE, L., B. E. ROSSI, AND J. LOPEZ. 1998. Granivore impact on soil-seed reserves in the central Monte Desert Argentina. Functional Ecology 12:640–645.
- MARSHALL, J. T. JR. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna 32:1–125.
- MARTIN, T. G., S. MCINTYRE, C. P. CATTERALL, AND H. P. POSSINGHAM. 2006. Is landscape context important for riparian conservation? Birds in grassy woodland. Biological Conservation 127:201–214.
- MASON, L., M. J. DESMOND, AND M. S. AGUDELO. 2005. Influence of grassland type, nest type and shrub encroachment on predation of artificial nests in Chihuahuan Desert grasslands. Western North American Naturalist 65:196–201.
- MASSEY, B. W., AND E. PALACIOS. 1994. Avifauna of the wetlands of Baja California, Mexico: current status. Studies in Avian Biology 15: 45–57.
- MASSEY, B. W., D. W. BRADLEY AND J. L. ATWOOD. 1992. Demography of a California Least Tern colony including effects of the 1982–1983 El Niño. Condor 94:976–983.
- MAURER, B. A. 1985. Avian community dynamics in desert grasslands: observational scale and hierarchical structure. Ecological Monographs 55:295–312.
- McCLARAN, M. P., AND T. R. VAN DEVENDER (EDITORS). 1995. The desert grassland. University of Arizona Press, Tucson, AZ.
- MCOMB, B. C., D. BILSLAND, AND J. J. STEINER. 2005. Associations of winter birds with riparian condition in the lower Calapooia watershed, Oregon. Northwest Science 72: 164–171.
- MCCREADY, B., D. MEHLMAN, D. KWAN, AND B. ABEL. 2005. The Nature Conservancy's Prairie Wings project: a conservation strategy for the grassland birds of the western Great Plains. Pp. 1158–1161 in C. J. Ralph and T. D. Rich (editors). Bird conservation

- implementation and integration in the Americas: Proceedings of the third international partners in flight conference. USDA Forest Service General Technical Report PSW-GTR-191. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.
- MCCUNE, B., AND M. J. MEFFORD. 1997. Multivariate analysis of ecological data. PC-ORD. Version 3.17. MJM Software, Gleneden Beach, OR.
- MEARNS, E. A. 1907. Mammals of the Mexican boundary of the United States. Bulletin of the United States National Museum, 56:1-530.
- MEENTS, J. K. 1979. Avian community structure in Chihuahuan Desert grasslands. Ph.D. dissertation, New Mexico State University, Las Cruces, NM.
- MELLINK, E., E. PALACIOS, AND E. AMADOR. 2007. Colonies of four species of terns and the Black Skimmer in western Mexico. *Waterbirds* 30:358-366.
- MEROLA-ZWARTJES, M. 2004. Biodiversity, functional processes, and the ecological consequences of fragmentation in southwestern grasslands. Pp. 49-85 in D. M. Finch (editor). Assessment of grassland ecosystem conditions in the southwestern United States Volume 1. USDA Forest Service General Technical Report RMRS-GTR-135. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- MILLS, G. S. 1982. Status report: *Ammodramus savannarum ammolegus* (H. C. Oberholser). Arizona Natural Heritage Program, Tucson, Report to Office of Endangered Species, USDI Fish and Wildlife Service, Albuquerque, NM.
- MISENHELTER, M. D., AND R. T. ROTENBERRY. 2000. Choices and consequences of habitat occupancy and nest site selection in Sage Sparrows. *Ecology* 81:2892-2901.
- MITTERMEIER, R. A., C. F. KORMOS, C. G. MITTERMEIER, P. R. GIL, T. SANDWITH, AND C. BESANÇON. 2005. Transboundary conservation: a new vision for protected areas. University of Chicago Press, Chicago IL.
- MONSON, G., AND A. R PHILLIPS. 1981. An annotated checklist of the birds of Arizona. University of Arizona Press, Tucson, AZ.
- MOORCROFT, D., M. J. WHITTINGHAM, R. B. BRADBURY, AND J. D. WILSON. 2002. The selection of stubble fields by wintering granivorous birds reflects vegetation cover and food abundance. *Journal of Applied Ecology* 39: 535-547.
- MOORE, F. R. (EDITOR). 2001. Stopover ecology of Nearctic-Neotropical landbird migrants: habitat relations and conservation implications. *Studies in Avian Biology* 20.
- MOORE, F. R., AND T. R. SIMONS. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345-355 in J. M. Hagan, and D. H. Johnson (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, DC.
- MOORE, F. R., P. KERLINGER, AND T. R. SIMMONS. 1990. Stopover on a gulf coast barrier island by spring trans-gulf migrants. *Wilson Bulletin* 102:487-500.
- MOORE, F. R., S. A. GAUTHREAUX, JR., P. KERLINGER, AND T. R. SIMONS. 1995. Habitat requirements during migration: important link in conservation. Pp. 121-144 in T. E. Martin, and D. M. Finch (editors). *Ecology and management of Neotropical migratory birds, a synthesis and review of critical issues*. Oxford University Press, New York, NY.
- MOORE, R. T. 1938. Unusual birds and extensions of ranges in Sonora, Sinaloa, and Chihuahua. *Condor* 40:23-28.
- MOSCONI, S. L., AND R. L. HUTTO. 1982. The effect of grazing on the land birds of a western Montana riparian habitat. Pp. 221-233 in L. Nelson, and J. M. Peek (editors). *Proceedings of the wildlife-livestock relationships symposium*. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID.
- NABHAN, G. P., AND A. R. HOLDSWORTH. 1999. State of the desert biome: uniqueness, biodiversity, threats and the adequacy of protection in the Sonoran bioregion. Arizona-Sonora Desert Museum, Tucson, AZ.
- NACLER, P. L., O. HINOJOSA-HUERTA, E. P. GLENN, J. GARCÍA-HERNÁNDEZ, R. ROMO, C. CURTIS, A. R. HUETE, AND S. G. NELSON. 2005. Regeneration of native trees in the presence of invasive saltcedar in the Colorado River delta, Mexico. *Conservation Biology* 19:1842-1852.
- NAIMAN, R. J., H. DÉCAMPS, AND M. E. MCCLAIN. 2005. *Riparia: ecology, conservation, and management of streamside communities*. Elsevier Academic Press, Burlington, MA.
- NATURESERVE. 2007. NatureServe conservation status. <<http://www.natureserve.org/explorer/ranking.htm>> (9 April 2008).
- NEFF, J. A. 1947. Notes on some birds of Sonora, Mexico. *Condor* 49:32-34.
- NELSON, S. M., AND B. W. ANDERSON. 1999. Butterfly (Papilioidea and Hesperoidea) assemblages associated with natural, exotic, and restored riparian habitats along the Lower Colorado River, USA. *Regulated Rivers: Research and Management* 15: 485-504.
- NENTVIG, J., A. F. PRADEAU, AND R. R. RASMUSSEN. 1980. *Rudo Ensayo: a description of Sonora*

- and Arizona in 1764. University of Arizona Press, Tucson AZ.
- NEW MEXICO PARTNERS IN FLIGHT. 2007. New Mexico bird conservation plan. Version 2.1. C. Rustay, and S. Norris (compilers). New Mexico Partners in Flight, Albuquerque, NM.
- NIELSON, R. P. 1986. High resolution climatic analysis and southwest biography. *Science* 232:27–33.
- NIEMELA, S. A. 2002. The influence of habitat heterogeneity and seed distribution on a Chihuahuan Desert avifauna. M.S. thesis, New Mexico State University, Las Cruces, NM.
- NOAA. 2002. NOAA Satellite and Information Service and the National Climatic Data Center. <<http://www.ncdc.noaa.gov/oa/climate/stationlocator.html>> (18 April 2008).
- NOAA. 2003. NOAA Satellite and Information Service and the National Climatic Data Center. <<http://www.ncdc.noaa.gov/oa/climate/stationlocator.html>> (18 April 2008).
- NORRIS, D. R., P. P. MARRA, T. K. KYSER, T. W. SHERRY, AND L. M. RATCLIFFE. 2004. Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. *Proceedings of the Royal Society of London* 271:59–64.
- NORTH AMERICAN ORNITHOLOGICAL ATLAS COMMITTEE. 1990. Handbook for atlasing North American breeding birds. <<http://www.bsc-eoc.org/norac/atlascont.htm>> (4 April 2008).
- NORWINE, J., AND K. JOHN (EDITORS). 2007. The changing climate of south Texas, 1900–2100: problems and prospects, impacts and implications. Texas A & M University-Kingsville, Kingsville, TX.
- OBERHOLSER, H. C. 1902. Some notes from western Texas. *Auk* 19:300–301.
- OBERHOLSER, H. C. 1942. Description of a new race of the Grasshopper Sparrow. *Proceedings of Biological Society, Washington* 55:15–16.
- OBERHOLSER, H. C. 1974. The bird life of Texas. University of Texas Press, Austin, TX.
- OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY. 1997. Federal meteorological handbook No. 3, Rawinsonde and Pibal Observations. FCM-H3-1997. <<http://www.ofcm.gov/fmh3/text/default.htm>> (10 April 2008).
- OHMART, R. D. 1994. The effects of human-induced changes on the avifauna of western riparian habitats. *Studies in Avian Biology* 15:273–285.
- PALACIOS, E., AND E. MELLINK. 1993. Additional records of breeding birds from Montague Island, northern Gulf of California. *Western Birds* 24:259–262.
- PANJABI, A. 2007a. RMBO launches initiative to monitor wintering grassland birds in Mexico. *The Primary Source* 24:1, 3
- PANJABI, A. 2007b. Wintering grassland bird inventory and monitoring in northern Mexico: an interim narrative report. Rocky Mountain Bird Observatory, Brighton, CO.
- PANKRATZ, C. 1994. PREFER—Preference assessment program. v5.1. Northern Prairie Science Center, Jamestown, ND.
- PARKES, K. C., AND R. W. DICKERMAN. 1967. A new subspecies of Mangrove Warbler (*Dendroica petechia*) from Mexico. *Annals of Carnegie Museum* 39:85–89.
- PARMESAN, C. 2006. Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology, Evolution, and Systematics* 37:637–669.
- PARMESAN, C., AND G. YOHE. 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421:37–42.
- PATTEN, M. A., E. MELLINK, H. GÓMEZ DE SILVA, AND T. E. WURSTER. 2001. Status and taxonomy of the Colorado desert avifauna of Baja California. *Monographs in Field Ornithology* 3:29–63.
- PAXTON, K. L., C. VAN RIPER III, T. C. THEIMER, AND E. H. PAXTON. 2007. Spatial and temporal patterns of Wilson's Warbler (*Wilsonia pusilla*) in the Southwest as revealed by stable isotopes. *Auk* 124:162–175.
- PEARSON, S. M., AND T. R. SIMONS. 2002. Spatial analysis of stopover habitats of Neotropical migrant birds. Pp. 581–593 in J. M. Scott, P. Heglund, and M. Morrison (editors). *Predicting species occurrences: issues of scale and accuracy*. Island Press, Washington, DC.
- PETERJOHN, B. G., AND J. R. SAUER. 1999. Population status of North American grassland birds from the North American breeding bird survey, 1966–1996. *Studies in Avian Biology* 19:27–44.
- PETERSON, J. J., G. W. LASLEY, K. B. BRYAN, AND M. LOCKWOOD. 1991. Additions to the breeding avifauna of the Davis Mountains. *Bulletin of the Texas Ornithological Society* 24:39–48.
- PHILLIPS, A. R. 1968. The instability of the distribution of land birds in the Southwest. Pp. 129–162 in A. H. Schroeder (editor). *Collected papers in honor of Lyndon Lane Hargrave, Papers of the Archaeological Society of New Mexico*: 1.
- PHILLIPS, A. R. 1986. The known birds of North and Middle America. Part I. Published by the author, Denver, CO.
- PHILLIPS, A. R. 1991. The known birds of North and Middle America. Part II. Published by the author, Denver, CO.

- PHILLIPS, A. R., AND D. AMADON. 1952. Some birds of northwestern Sonora, Mexico. *Condor* 54: 163–168.
- PHILLIPS, A. R., J. T. MARSHALL, JR., AND G. MONSON. 1964. The birds of Arizona. University of Arizona Press, Tucson, AZ.
- PIDGEON, A. M., N. E. MATHEWS, R. BENOIT, AND E. NORDHEIM. 2001. Response of avian communities to historic habitat change in northern Chihuahuan Desert. *Conservation Biology* 15:1772–1788.
- PIDGEON, A. M., V. C. RADEOFF, AND N. E. MATHEWS. 2006. Contrasting measures of fitness to classify habitat quality for the Black-throated Sparrow (*Amphispiza bilineata*). *Biological Conservation* 132:199–210.
- PLUMPTRE, A. J., D. KUJIRAKWINJA, A. TREVES, I. OWIUNJI, AND H. RAINER. 2007. Transboundary conservation in the greater Virunga landscape: its importance for landscape species. *Biological Conservation* 134:279–287.
- POIANI, K. A., B. D. RICHTER, M. G. ANDERSON, AND H. E. RICHTER. 2000. Biodiversity conservation at multiple scales: functional sites, landscapes, and networks. *BioScience* 50: 133–146.
- POOLE, A. (EDITOR). 2005. The Birds of North American. Cornell Laboratory of Ornithology, Ithaca, NY. <<http://bna.birds.cornell.edu/BNA/>> (4 April 2008).
- POWELL, B. F., AND R. J. STEIDL. 2000. Nesting habitat and reproductive success of southwestern riparian birds. *Condor* 102:823–831.
- PROUDFOOT, G. A., AND R. R. JOHNSON. 2000. Ferruginous Pygmy-Owl (*Glaucidium brasilianum*). In A. Poole, and F. Gill (editors). The Birds of North America, No. 498. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- PULICH, W. M., SR., AND W. M. PULICH, JR. 1963. The nesting of the Lucifer Hummingbird in the United States. *Auk* 80:370–371.
- PULLIAM, H. R. 1975. Coexistence of sparrows: a test of community theory. *Science* 189: 474–476.
- PULLIAM, H. R. 1980. Do Chipping Sparrows forage optimally? *Ardea* 68:75–82.
- PULLIAM, H. R. 1985. Foraging efficiency, resource and partitioning, and the coexistence of sparrow species. *Ecology* 66:1829–1836.
- PULLIAM, H. R. 1986. Niche expansion and contraction in a variable environment. *American Zoologist* 26:71–79.
- PULLIAM, H. R., AND G. S. MILLS. 1977. The use of space by wintering sparrows. *Ecology* 58: 1393–1399.
- PULLIAM, H. R., AND J. B. DUNNING. 1987. The influence of food supply on local density and diversity of sparrows. *Ecology* 68: 1009–1014.
- PULLIAM, H. R., AND M. R. BRAND. 1975. The production and utilization of seeds in plains grassland of southeastern Arizona. *Ecology* 56:1158–1166.
- PULLIAM, H. R., AND T. A. PARKER III. 1979. Population regulation of sparrows. *Fortschritte der Zoologie* 25:137–147.
- RAITT, R. J., AND S. L. PIMM. 1976. Dynamics of bird communities in the Chihuahuan Desert, New Mexico. *Condor* 78:427–442.
- RALPH, C. J. 1981. Age ratios and their possible use in determining autumn routes of passerine migrants. *Wilson Bulletin* 93:164–188.
- RALPH, C. J., AND J. M. SCOTT (EDITORS). 1981. Estimating numbers of terrestrial birds. *Studies in Avian Biology* 6.
- RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service General Technical Report PSW-GTR-144. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.
- RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, D. F. DESANTE, AND B. MILA. 1996. Manual de métodos de campo para el monitoreo de aves terrestres. USDA Forest Service General Technical Report PSW-GTR-159. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.
- RAMÍREZ-ALBORES, J. E., F. MARTÍNEZ V., AND J. CLEMENTE VÁSQUEZ S. 2007. Listado avifaunístico de un matorral tamaulipeco del noreste de México. *Huitzil* 8:1–10.
- RANGO, A., L. HUENNEKE, M. BUONOPANE, J. HERRICK, AND K. M. HAVSTAD. 2005. Using historic data to assess effectiveness of shrub removal in southern New Mexico. *Journal of Arid Environments* 62:75–91.
- RENFREW, R. B., AND C. A. RIBIC. 2002. Influence of topography on density of grassland passerines in pastures. *American Midland Naturalist* 147:315–325.
- REYNOLDS, J. F., R. A. VIRGINIA, P. R. KEMP, A. G. DESOYZA, AND D. C. TREMMEL. 1999. Impact of drought on desert shrubs: effects of seasonality and degree of resource island development. *Ecological Monographs* 69: 69–106.
- RICH, T. D., C. J. BEARDMORE, H. BERLANGA, P. J. BLANCHER, M. S. W. BRADSTREET, G. S. BUTCHER, D. W. DEMAREST, E. H. DUNN, W. C. HUNTER, E. E. INIGO-ELIAS, J. A. KENNEDY, A. M. MARTELL, A. O. PANJABI, D. N. PASHLEY, K. V. ROSENBERG, C. M. RUSTAY, J. S. WENDT, AND T. C. WILL. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

- RICHARDSON, J. W. 1978. Timing and amount of bird migration in relation to weather: A review. *Oikos* 30:224-272.
- RICHTER, B. D., AND H. E. RICHTER. 2000. Prescribing flood regimes to sustain riparian ecosystems along meandering rivers. *Conservation Biology* 14:1467-1478.
- RISING, J. D. 2005. A guide to the identification and natural history of the sparrows of the United States and Canada. Academic Press, Inc., San Diego, CA.
- ROBBINS, M. B., AND D. A. EASTERLA. 1981. Range expansion of the Bronzed Cowbird with the first Missouri record. *Condor* 83:270-272.
- ROBERSON, D. 2002. Monterey Birds. 2nd Edition, Monterey Peninsula Audubon Society, Carmel, CA.
- ROJAS-SOTO, O., F. PUEBLA-OLIVARES, E. M. FIGUEROA-ESQUIVEL, L. A. SÁNCHEZ-GONZÁLEZ, Y. J. NAKAZAWA-UJI, C. A. RÍOS-MUÑÓZ, AND A. G. NAVARRO S. 2002. Avifauna de Isla Tiburón, Sonora, México. *Anales del Instituto de Biología. Serie Zoología* 73: 73-89.
- ROMAGOSA, C. M. 2002. Eurasian Collared-Dove (*Streptopelia decaocto*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 630. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.
- ROMAGOSA, C. M., AND T. MCENEANEY. 1999. Eurasian Collared-Dove in North America and the Caribbean. *North American Birds* 53:348-353.
- ROOT, T. L., J. T. PRICE, K. R. HALL, S. H. SCHNEIDER, C. ROSENZWEIG, AND J. A. POUNDS. 2003. Fingerprints of global warming on wild animals and plants. *Nature* 421:57-60.
- ROSENBERG, G. H. 2001. Arizona Bird Committee report: 1996-1999 records. *Western Birds* 32: 50-70.
- ROSENBERG, G. H., AND J. L. WITZEMAN. 1998. Arizona Bird Committee report, 1974-1996: part 1 (nonpasserines). *Western Birds* 29: 199-224.
- ROSENBERG, G. H., AND J. L. WITZEMAN. 1999. Arizona Bird Committee report, 1974-1996: part 2 (passerines). *Western Birds* 30: 94-120.
- ROSENBERG, K. V., AND R. J. COOPER. 1988. Approaches to avian diet analysis. *Studies in Avian Biology* 13:80-90.
- ROSENBERG, K. V., R. D. OHMART, W. C. HUNTER, AND B. W. ANDERSON. 1991. Birds of the lower Colorado River valley. University of Arizona Press, Tucson, AZ.
- RUIZ-CAMPOS, G., AND M. RODRÍGUEZ-MERAZ. 1997. Composición taxonómica y ecológica de la avifauna de los ríos El Mayor y Hardy, y áreas adyacentes, en el Valle de Mexicali, Baja California, México. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología* 68:291-315.
- RUSSELL, K. R., AND S. A. GAUTHREAUX. 1998. Use of weather radar to characterize movements of roosting Purple Martins. *Wildlife Society Bulletin* 26:5-16.
- RUSSELL, S. M., AND D. W. LAMM. 1978. Notes on the distribution of birds in Sonora, Mexico. *Wilson Bulletin* 90:123-131.
- RUSSELL, S. M., AND G. MONSON. 1998. *The birds of Sonora*. University of Arizona Press, Tucson, AZ.
- RUTH, J. M. (EDITOR). 2007. Applying radar technology to migratory bird conservation and management: strengthening and expanding a collaborative. U.S. Geological Survey, Biological Resources Discipline, Open-File Report 2007-1361. Fort Collins, CO.
- RUTH, J. M., W. C. BARROW, R. S. SODJA, D. K. DAWSON, R. H. DIEHL, A. MANVILLE, M. T. GREEN, D. J. KRUEPER, AND S. JOHNSTON. 2005. Advancing migratory bird conservation and management by using radar: an interagency collaboration. USGS Biological Resources Discipline, Open-File Report 2005-1173. USGS Fort Collins Science Center. <http://www.fort.usgs.gov/Products/Publications/pub_abstract.asp?PubID=21469> (10 April 2008).
- SAAB, V. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. *Ecological Applications* 9:135-151.
- SAAB, V. A., C. E. BOCK, T. D. RICH, AND D. S. DOBKIN. 1995. Livestock grazing effects in western North America. Pp. 311-353 in T. E. Martin, and D. M. Finch (editors). *Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues*. Oxford University Press, New York, NY.
- SABO, J. L., AND C. SOYKAN. 2006. Riparian zones increase regional richness by supporting different, not more, species: reply. *Ecology* 87:2128-2131.
- SALL, J., AND A. LEHMAN. 1996. *JMP start statistics*. Duxbury Press, Belmont, CA.
- SANDERS, T. A., AND W. D. EDGE. 1998. Breeding bird community composition in relation to riparian vegetation structure in the western United States. *Journal of Wildlife Management* 62:461-473.
- SAS INSTITUTE. 1990. *SAS/STAT user's guide*, version 6, fourth edition. SAS Institute Inc., Cary, NC.
- SAS INSTITUTE. 1999. *SAS/STAT user's guide*. Version 8. SAS Institute Inc., Cary, NC.

- SAS INSTITUTE. 2003. SAS/STAT user's guide. Version 9.1 SAS Institute Inc., Cary, NC.
- SAUER, J. R., J. E. HINES, AND J. FALLON. 2006. The North American breeding bird survey, results and analysis 1966–2006. Version 6.2.2006. USGS Patuxent Wildlife Research Center, Laurel, MD.
- SCHAFFNER, G. W. 1976. Radar observations of insect flight. Pp. 157–197 in R. C. Rainey (editor). Insect flight. Blackwell Scientific Publications, London, UK.
- SCHAFFNER, F. C. 1985. Royal Tern nesting attempts in California: isolated or significant incidences? *Western Birds* 16:71–80.
- SCHLESINGER, W. H. 1994. Long term ecological studies in the Chihuahuan Desert. The Jornada LTER - III Consortium, Duke University, Durham, NC.
- SCHLESINGER, W. H. 2002. Desertification. Pp. 253–256 in A. S. Goudie, and D. J. Cuff (editors). Encyclopedia of global change. Oxford University Press, New York, NY.
- SCHLESINGER, W. H., J. F. REYNOLDS, G. L. CUNNINGHAM, L. F. HUENNEKE, W. M. JARRELL, R. A. VIRGINIA, AND W. G. WHITFORD. 1990. Biological feedbacks in global desertification. *Science* 247:1043–1048.
- SCHLUTER, D., and R. R. Repasky. 1991. Worldwide limitation of finch densities by food and other factors. *Ecology* 72: 1763–1774.
- SCHMITT, C. G. 1976. Summer birds of the San Juan Valley, New Mexico. New Mexico Ornithological Society Bulletin 4.
- SCOTT, M. L., S. K. SKAGEN, AND M. F. MERIGLIANO. 2003. Relating geomorphic change and grazing to avian communities in riparian forests. *Conservation Biology* 17:284–296.
- SEIDEL, D. J., Q. FU, W. J. RANDEL, AND T. J. REICHLER. 2008. Widening of the tropical belt in a changing climate. *Nature Geoscience* 1: 21–24.
- SEMARNAT. 2002. Norma Oficial Mexicana NOM-059-SEMARNAT-2001, Protección ambiental—especies nativas de México de flora y fauna silvestres—categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—lista de especies en riesgo. Diario Oficial de la Federación 582(4) wa. Sección:1–80.
- SENNETT, G. B. 1878. Notes on the ornithology of the lower Rio Grande of Texas, from observations made during the season of 1877. *Bulletin of the U.S. Geological and Geographical Survey of the Territories* 4:1–66.
- SEXTON, C. S. 2001. Texas. *North American Birds* 55:321–325.
- SHACKELFORD, C. E., AND M. W. LOCKWOOD. 2000. Rare and declining birds of Texas: conservation needed. Texas Parks and Wildlife Department, Austin, TX.
- SHER, A. A., D. L. MARSHALL, AND S. A. GILBERT. 2000. Competition between native *Populus deltoides* and invasive *Tamarix ramosissima* and the implications for reestablishing flooding disturbance. *Conservation Biology* 14:1744–1754.
- SHERBROOKE, W. C. 1974. Differential acceptance of toxic jojoba seed (*Simmondsia chilensis*) by four Sonoran Desert heteromyid rodents. *Ecology* 57:596–602.
- SHERRY, T. W., AND R. T. HOLMES. 1995. Summer versus winter limitation of populations: what are the issues and what is the evidence? Pp. 85–120 in T. E. Martin, and D. M. Finch (editors). *Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues*. Oxford University Press, New York, NY.
- SHORT, L. L. 1974. Nesting of southern Sonora birds during the summer rainy season. *Condor* 76:21–32.
- SHREVE, F. 1951. Vegetation of the Sonoran Desert. Carnegie Institute of Washington, Publication Number 591. Washington DC.
- SILLETT, T. S., AND R. T. HOLMES. 2002. Variation in survivorship of a migratory songbird throughout its annual cycle. *Journal of Animal Ecology* 71:296–308.
- SIMS, P., J. S. SINGH, AND W. K. LAUENROTH. 1978. The structure and function of ten western North American grasslands. *Journal of Ecology* 66:251–285.
- SISK, T. D., A. E. CASTELLANOS V, AND G. W. KOCH. 2007. Ecological impacts of wildlife conservation units policy in Mexico. *Frontiers in Ecology and the Environment* 5:209–212.
- SKAGEN, S. K., C. P. MELCHER, W. H. HOWE, AND F. L. KNOPP. 1998. Comparative use of riparian corridors and oases by migrating birds in southeast Arizona. *Conservation Biology* 12:896–909.
- SKAGEN, S. K., J. F. KELLY, C. VAN RIPER III, R. L. HUTTO, D. M. FINCH, D. J. KRUEPER, AND C. P. MELCHER. 2005. Geography of spring landbird migration through riparian habitats in southwestern North America. *Condor* 107: 212–227.
- SMALL, A. 1994. California birds: their status and distribution. Ibis Publishing Co., Vista, CA.
- SNELL-ROOD, E. C., AND D. A. CRISTOL. 2003. Avian communities of created and natural wetlands: bottomland forests in Virginia. *Condor* 105:303–315.
- SOGGE, M. K., R. M. MARSHALL, S. J. SFERRA, AND T. J. TIBBITS. 1997. A southwestern Willow Flycatcher natural history summary and

- survey protocol. USGS Colorado Plateau Research Station, Northern Arizona University, Flagstaff, AZ.
- SPSS. 2002. Data analysis software. SPSS, Inc., Chicago, IL.
- STALLCUP, R. 1990. Ocean birds of the nearshore Pacific. Point Reyes Bird Observatory, Stinson Beach, CA.
- STAMP, N. E. 1978. Breeding birds of riparian woodland in south-central Arizona. Condor 80:64-71.
- STEPHENS, F. 1885. Notes of an ornithological trip in Arizona and Sonora. Auk 2:225-231.
- STOLESON, S. H., R. S. FELGER, G. CEBALLOS, C. RAISH, M. F. WILSON, AND A. BURQUEZ. 2005. Recent history of natural resource use and population growth in northern Mexico. Pp. 52-86 in J.-L. E. Cartron, G. Ceballos, and R. S. Felger (editors). Biodiversity, ecosystems, and conservation in northern Mexico. Oxford University Press, NY.
- STROMBERG, J. C., AND M. K. CHEW. 2002. Flood pulses and restoration of riparian vegetation in the American Southwest. Pp. 11-50 in B. A. Middleton (editor). Flood pulsing in wetlands: restoring the natural hydrological balance. John Wiley and Sons, New York, NY.
- STRONG, T. R. 1988. Status of the Arizona Grasshopper Sparrow (*Ammodramus savannarum ammolegus* Oberholser). Arizona Game and Fish Department, report to Office of Endangered Species, USDI Fish and Wildlife Service, Albuquerque, NM.
- STRONG, T. R., AND C. E. BOCK. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor 92:866-885.
- SWARTH, H. S. 1914. A distributional list of the birds of Arizona. Pacific Coast Avifauna 10: 1-133.
- SWETNAM, T. W., AND J. L. BETANCOURT. 1998. Mesoscale disturbance and ecological response to decadal climatic variability in the American Southwest. Journal of Climate 11: 3128-3147.
- SYKES, G. 1937. The Colorado delta. American Geographical Society Special Publication 19.
- TEJAS, A., R. SERVÍN, AND S. GALLINA. 1991. Delimitación, zonificación y tenencia de la tierra. Pp. 53-68 in A. Ortega, and L. Arriaga (editors), La reserva de la biosfera El Vizcaino en la península de Baja California. Centro de Investigaciones Biológicas de Baja California Sur, A.C. No. 4. La Paz, B.C.S., México.
- TERRILL, S. B. 1981. Notes on the winter avifauna of two riparian sites in northern Sonora, Mexico. Continental Birdlife 2:11-18.
- THAYER, J. E., AND O. BANGS. 1906. Breeding birds of the Sierra de Antonez, north central Sonora. Proceedings of the Biological Society of Washington 19:17-22.
- THE NATURE CONSERVANCY. 2000. The five-S framework for site conservation: a practitioner's handbook for site conservation planning and measuring conservation success. The Nature Conservancy, Arlington, VA.
- THOMAS, L., J. L. LAAKE, S. STRINDBERG, F. F. C. MARQUES, S. T. BUCKLAND, D. L. BORCHERS, D. R. ANDERSON, K. P. BURNHAM, S. L. HEDLEY, AND J. H. POLLARD. 2002. Distance 5.0. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. <<http://www.ruwpa.st-and.ac.uk/distance/>> (4 April 2008).
- TROY, J. R. 2006. Survey of Black-capped Vireo, Big Bend National Park, Brewster County, Texas, Spring 2006. Report to Big Bend National Park, TX.
- TUNNELL, J. W., JR., AND F. W. JUDD (EDITORS). 2002. The Laguna Madre of Texas and Tamaulipas. Texas A&M University Press, College Station, TX.
- TURNER, R. M., J. E. BOWERS, AND T. L. BURGESS. 1995. Sonoran Desert plants: an ecological atlas. University of Arizona Press, Tucson, AZ.
- TURNER, R. M., R. H. WEBB, J. E. BOWERS, AND J. R. HASTINGS. 2003. The changing mile revisited. University of Arizona Press, Tucson, AZ.
- U.S. BUREAU OF RECLAMATION. 2005. Report to the Congress: the Yuma Desalting Plant and other actions to address alternatives. Colorado River Basin Salinity Control Act, Title I, August 2005. U.S. Bureau of Reclamation, Washington, DC.
- UNITED NATIONS. 1992. Managing fragile ecosystems: combating desertification and drought, chapter 12 of Agenda 21. United Nations. New York, NY.
- UNITT, P. 1984. The birds of San Diego County. San Diego Society of Natural History, Memoir 13:1-276.
- UNITT, P. 2004. San Diego County bird atlas. Proceedings of the San Diego Society of Natural History 39:1-645.
- USDI BUREAU OF LAND MANAGEMENT. 1996. Birds of the San Pedro Riparian National Conservation Area and upper San Pedro River Valley. BLM/AZ/GI-96/006. San Pedro National Conservation Area, Bureau of Land Management, Safford, AZ.
- USDI BUREAU OF LAND MANAGEMENT. 1998. Birds as indicators of riparian vegetation condition in the western U.S. BLM/ID/PT-98/004+6635. Bureau of Land Management, Partners in Flight, Boise, ID.

- USDI BUREAU OF RECLAMATION. 2007. Colorado River interim guidelines for lower basin shortages and coordinated operations for Lake Powell and Lake Mead final environmental impact statement. USDI Bureau of Reclamation, Upper and Lower Colorado Regions, Boulder City, NV.
- USDI FISH AND WILDLIFE SERVICE. 2000. Yuma Clapper Rail revised survey protocol, memorandum to Yuma Clapper Rail interested parties. USDI Fish and Wildlife Service, Arizona Ecological Services Field Office, Phoenix, AZ.
- USDI FISH AND WILDLIFE SERVICE. 2002. Birds of conservation concern 2002. USDI Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, VA. <<http://www.fws.gov/migratorybirds/reports/BCC2002.pdf>> (26 March 2008).
- USDI FISH AND WILDLIFE SERVICE. 2004. North American waterfowl management plan: Strengthening the biological foundation, 2004 strategic guidance. North American Waterfowl Management Plan, USDI Fish and Wildlife Service, Arlington, VA.
- USGS NATIONAL GAP ANALYSIS PROGRAM. 2004. Provisional digital land cover map for the southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University, Logan, UT.
- VALDEZ, R., J. C. GUZMAN-ARANDA, F. J. ABARCA, L. A. TARANGO-ARAMBULA, AND F. CLEMENTE-SANCHEZ. 2006. Wildlife conservation and management in Mexico. *Wildlife Society Bulletin* 34:270-282.
- VAN DER MEIJ, M. A. A., AND R. G. BOUT. 2000. Seed selection in the Java Sparrow (*Padda oryzivora*): preference and mechanical constraint. *Canadian Journal of Zoology* 78: 1668-1673.
- VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. *Journal of Wildlife Management* 47:893-901.
- VAN ROSSEM, A. J. 1931. Report on a collection of land birds from Sonora, Mexico. *Transactions of the San Diego Society of Natural History* 6:237-304.
- VAN ROSSEM, A. J. 1945. A distributional survey of the birds of Sonora, Mexico. *Occasional Papers Museum of Zoology, Louisiana State University* 21:1-379.
- VAN TYNE, J. 1936. The discovery of the nest of the Colima Warbler (*Vermivora crissalis*). *Miscellaneous Publications of the University of Michigan* 33, Flint, MI.
- VAN TYNE, J., AND G. M. SUTTON. 1937. The birds of Brewster County, Texas. *Miscellaneous Publications of the University of Michigan* 37, Flint, MI.
- VELARDE, E., J.-L. E. CARTRON, H. DRUMMOND, D. W. ANDERSON, F. R. GARRARDO, E. PALACIOS AND C. RODRIGUEZ. 2005. Nesting seabirds of the Gulf of California's offshore islands: diversity, ecology, and conservation. Pp. 452-470 in J.-L. Catron, G. Ceballos, and R. S. Felger (editors). *Biodiversity, ecosystems and conservation in northern Mexico*. Oxford Univ. Press, New York, NY.
- VICKERY, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*). In A. Poole, and F. Gill (editors). *The Birds of North America*, No. 239. The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists' Union, Washington, DC.
- VICKERY, P. D., M. L. HUNTER, JR., AND J. V. WELLS. 1992. Is density an indicator of breeding success? *Auk* 109:706-710.
- VICKERY, P. D., P. L. TUBARRO, J. M. CARDOSO DA SILVA, B. G. PETERJOHN, J. R. HERKERT, AND R. B. CAVALCANTI. 1999. Conservation of grassland birds in the western hemisphere. *Studies in Avian Biology* 19:2-26.
- VILLASEÑOR, J. F. 2006. Habitat use and the effects of disturbance on wintering birds using riparian habitats in Sonora, Mexico. Ph.D. dissertation, University of Montana, Missoula MT.
- VILLASEÑOR-GÓMEZ, J. F., AND R. L. HUTTO. 1995. The importance of agricultural areas for the conservation of neotropical migratory landbirds in western Mexico. Pp. 59-80 in M. H. Wilson, and S. A. Sader (editors). *Conservation of Neotropical migratory birds in Mexico*. Maine Agricultural and Forest Experiment Station, Misc. Publ. 727.
- WARKENTIN, I. G., R. GREENBERG, AND J. S. ORTIZ. 1995. Songbird use of gallery woodlands in recently cleared and older settled landscapes of the Selva Lacandona, Chiapas, Mexico. *Conservation Biology* 9:1095-1106.
- WARSHALL, P. 1995. The Madrean Sky Island Archipelago: a planetary overview. Pp. 7-18 in L. F. DeBano, P. F. Ffolliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B. Edminster (editors). *Biodiversity and management of the Madrean Archipelago: the Sky Islands of southwestern United States and northwestern Mexico*. USDA Forest Service General Technical Report RM-GTR 264. USDA Forest Service, Rocky Mountain Research Station, Ft. Collins, CO.
- WAUER, R. H. 1973. *Birds of Big Bend National Park and vicinity*. University of Texas Press, Austin, TX.
- WAUER, R. H. 1996. *A field guide to birds of the Big Bend*. Gulf Publishing, Houston, TX.

- WAUER, R. H. 1998. Avian population survey of a Tamaulipan scrub habitat, Tamaulipas, Mexico. *Cotinga* 10:13–19.
- WAUER, R. H., AND DAVIS, D. G. 1972. Cave Swallows in Big Bend National Park, Texas. *Condor* 74:482.
- WAUER, R. H., AND D. J. LIGON. 1977. Distributional relations of breeding avifauna of four southwestern mountain ranges. Pp. 567–578 in R. H. Wauer, and D. H. Riskind (editors). *Transactions of the symposium on the biological resources of the Chihuahuan Desert region, U.S. and Mexico*. USDI National Park Service, Transactions and Proceedings Series, No. 3. Washington, DC.
- WEBB, R. H., S. A. LEAKE, AND R. M. TURNER. 2007. *The ribbon of green: change in riparian vegetation in the southwestern United States*. University of Arizona Press, Tucson, AZ.
- WEBER, M., G. GARCÍA-MARMOLEJO, AND R. REYNA-HURTADO. 2006. The tragedy of the commons: wildlife management units in southeastern Mexico. *Wildlife Society Bulletin* 34: 1480–1488.
- WEBSTER, G. L., AND C. J. BAHRE (EDITORS). 2001. *Changing plant life of La Frontera: observations on vegetation in the United States/Mexico borderlands*. University of New Mexico Press, Albuquerque, NM.
- WELLS, D., B. W. ANDERSON, AND R. D. OHMART. 1979. Comparative avian use of southwestern citrus orchards and riparian communities. *Journal of the Arizona-Nevada Academy of Science* 14:58.
- WHITFORD, W. G. 1997. Desertification and animal biodiversity in the desert grasslands of North America. *Journal of Arid Environments* 37:709–720.
- WHITFORD, W. G. 2002. *Ecology of desert systems*. Elsevier Science Ltd., London, UK.
- WHITMORE, R. C. 1979. Temporal variation in the selected habitats of a guild of grassland sparrows. *Wilson Bulletin* 91:592–598.
- WHITMORE, R. C. 1981. Structural characteristics of Grasshopper Sparrow habitat. *Journal of Wildlife Management* 45:811–814.
- WILBUR, S. A. 1987. *Birds of Baja California*. University of California Press, Los Angeles, CA.
- WILLIAMS, S. O. III. 1991. Discovery and status of the Arizona Grasshopper Sparrow in New Mexico. *New Mexico Ornithological Society Bulletin* 19:32–33.
- WILLIAMS, S. O. III. 1997. Trends in Arizona Grasshopper Sparrow breeding populations in New Mexico: value of long-term studies. *New Mexico Ornithological Society Bulletin* 25:35.
- WILLIAMS, S. O. III. 2007. Status of the Arizona Grasshopper Sparrow on the Diamond A (Gray) Ranch, Hidalgo County, New Mexico. New Mexico Department of Game and Fish, Santa Fe, NM.
- WILLIAMS, S. O. III, J. P. DELONG, AND W. H. HOWE. 2007. Northward range expansion by the Short-tailed Hawk, with first nesting records for New Mexico and Chihuahua. *Western Birds* 38:2–10.
- WINTER, M., D. JOHNSON, AND J. FAABORG. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. *Condor* 102:256–266.
- WITH, K. A., AND T. CRIST. 1995. Critical thresholds in species responses to landscapes structures. *Ecology* 76:2446–2459.
- WOLF, S. B. 2002. The relative status and conservation of island breeding seabirds in California and northwest Mexico. M.S. thesis, University of California, Santa Cruz, CA.
- WOLF, S. B., B. KEITT, A. AGUIRRE-MUNOZ, B. TERSHY, E. PALACIOS, AND D. CROLL. 2006. Transboundary seabird conservation in an important North American marine ecoregion. *Environmental Conservation* 33:294–305.
- WOODIN, M. C., M. K. SKORUPPA, AND G. C. HICKMAN. 1998. Breeding bird surveys at the Galvan Ranch, Webb County, Texas. Final report, prepared for the Ed Rachal Foundation, Corpus Christi, TX.
- WOODIN, M. C., M. K. SKORUPPA, G. W. BLACKLOCK, AND G. C. HICKMAN. 1999. Discovery of a second population of White-collared Seedeaters (Passeriformes: Emberizidae) along the Rio Grande in Texas. *Southwestern Naturalist* 44:535–537.
- WOODREY, M. 2000. Age-dependent aspects of stopover biology of passerine migrants. *Studies in Avian Biology* 20:43–52.
- YAHNER, R. H. 1993. Effects of long term forest clear cutting on wintering and breeding birds. *Wilson Bulletin* 105:239–255.
- YONG, W., AND D. M. FINCH. 2002. Stopover ecology of landbirds migrating along the Middle Rio Grande in spring and fall. USDA Forest Service General Technical Report RMRS-GTR-99. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.
- YUMA DESALTING PLANT/CIENEGA DE SANTA CLARA WORKGROUP. 2005. Balancing water needs in the Lower Colorado Basin: recommendations of the Yuma Desalting Plant/Ciénega de Santa Clara Workgroup. White Paper of the Yuma Desalting Plant/Ciénega de Santa Clara Workgroup, Yuma, AZ.
- ZAMORA-ARROYO, F., P. CULP, AND O. HINOJOSA-HUERTA. 2006. Looking beyond the border: environmental consequences of the All-American Canal project in Mexico and potential binational solutions. Pp. 21–57 in V. Sánchez-Mungía (editor). Lining the

- All-American Canal: competition or cooperation for the water in the U.S.-Mexican Border? San Diego State University Press, San Diego, CA.
- ZAMORA-ARROYO, F., P. L. NAGLER, M. BRIGGS, D. RADTKE, H. RODRÍGUEZ, J. GARCÍA, C. VALDÉS, A. HUETE, AND E. P. GLENN. 2001. Regeneration of native trees in response to flood releases from the United States into the delta of the Colorado River, Mexico. *Journal of Arid Environments* 49:49–64.
- ZAMORA-ARROYO, F., J. PITI, S. CORNELIUS, E. GLENN, O. HINOJOSA-HUERTA, M. MORENO, J. GARCÍA, P. NAGLER, M. DE LA GARZA, AND I. PARRA. 2005. Conservation priorities in the Colorado River delta, Mexico and the United States. Prepared by the Sonoran Institute, Environmental Defense, University of Arizona, Pronatura Noroeste Dirección de Conservación Sonora, Centro de Investigación en Alimentación y Desarrollo (CIAD) and World Wildlife Fund-Gulf of California Program, Tucson, AZ.
- ZAR, J. H. 1999. Biostatistical analysis, 4th ed. Prentice Hall, Upper Saddle River, NJ.
- ZENGEL, S., V. MERTETSKY, E. GLENN, R. FELGER, AND D. ORTIZ. 1995. Ciénega de Santa Clara, a remnant wetland in the Rio Colorado delta (Mexico): vegetation distribution and the effects of water flow reduction. *Ecological Engineering* 4:19–36.